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систем управления и радиоэлектроники»**

ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 26-2

“ Polarimetric Radar ”
(«Поляриметрическая радиолокация»)

Публикации в трудах конференций

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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 26-2

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"Ship Detection after Removal of Ambiguities by Using PolSAR Images"

Ambiguities in SAR image are very common phenomena. For maritime applications, as the high intensities of the ambiguities in low radar backscatter background of sea environments, they can be mistaken as targets and cause false alarms in ship detection. Thus, through the analysis of polarimetric characteristics of ships and ambiguities, we propose a ship detection method which applies the eigenvalue to differentiating the ship target and azimuth ambiguities. One set of Cband JPL AIRSAR polarimetric data covered Kojimawan Bay, Japan has been chosen to evaluate the method that can effectively remove false alarms caused by the azimuth ambiguities. [C1]

"A Novel Polarimetric CFAR Target Detection Method"

A new polarimetric synthetic aperture radar (PolSAR) image CFAR target detector is proposed in this paper. By introducing the inverse Gamma distribution which is extensively used in modeling, the distribution of polarimetric matched filter (PMF) metric, denoted as P_G0, is derived on the product model; Furthermore, a fast and exact parameter estimation method of P_G0distribution is presented using the "second kind statistics" based on the Mellin transform; Finally the formula of the CFAR detection threshold is deduced, and the target detection using the proposed constant alarm rate (CFAR) detector is performed on the RADARSAT-2 PolSAR data. Experimental results demonstrate the great efficiency of the P_G distribution and the corresponding parameter estimation method in data fitting of areas with different degree of homogeneity. Moreover, the successive CFAR detector can successfully complete the automatic target detection with low false alarm rate and high detection rate in complex clutter environment where the homogeneity of terrain varies sharply. [C2]

"POLSAR Image Classification Based on Polarimetric Decomposition and Generalized Discriminant Analysis"

In this paper, a new classification scheme of fully polarimetric SAR images is proposed. This is based on the joint use of the Freeman-Durden decomposition and generalized discriminant analysis, a new method for Feature extraction. After getting the powers of the three scattering mechanism components through Freeman-Durden decomposition, the Feature extraction algorithm is introduced to well exploit the information available in the full polarimetric coherency matrix. The experimental results show that using this exploited information as new features of Fisher classification, can provides fine performance and good compactness. [C3]

"Comparison between ESPRIT Algorithm and Three-Stage Algorithm for PolinSAR"

This paper presents a polarimetric SAR interferometric SAR data analysis based on ESPRIT algorithm and three-stage inversion algorithm. The formulations of ESPRIT algorithm and three stages inversion algorithm are presented firstly. The experimental results based on ESPRIT algorithm and three-stage algorithm have been compared and analyzed then. And we point out that direct conversion of the retrieved height of the scattering center corresponding to a single polarimetric channel to the forest height, will lead to underestimation. Therefore, it is important for the conversion to be carried out on the basis of a coherence scattering model of forest, which expresses radar observations in terms of a small number of vegetation and underlying-surface parameters. The experiment data is from PolSARpro software at L band. [C4]

"The Equivalence Analysis for SDH Decomposition and Cameron Decomposition Based on a Unified Three-Component Scattering Model"

In 1996, Cameron proposed an approach to decompose an arbitrary polarization scattering matrix into three orthogonal components, including nonreciprocal scattering component, maximum symmetric scattering component, and minimum symmetric scattering component. In this paper, based on the analysis of the characteristics of the maximum symmetric scattering component and the minimum symmetric scattering

component in Cameron decomposition, a unified three-component scattering model for polarimetric coherent target decomposition is proposed. Pauli decomposition, SDH decomposition and Cameron decomposition can be expressed as a simplified form of the unified model with some certain restriction respectively. In addition, we can prove that SDH decomposition and Cameron decomposition to be equivalent by verification of restrictions consistency. [C5]

"Polarimetric Characteristics Analysis of Ship Target and Its Azimuth Ambiguities Based on PolSAR Images"

Azimuth ambiguities in SAR image are very common phenomena. The ambiguities are visually identifiable due to their high intensities in low radar backscatter background of sea environment. The ambiguities can be mistaken as ships and cause false alarms in ship detection. Therefore, for maritime applications (i.e. ship target detection), it is important to analyze the characteristic of azimuth ambiguities of targets. By using Eigenvalue-Eigenvector decomposition method, we analyze the polarimetric characteristics of ships and ambiguities. We conclude that the eigenvalues can be used to differentiate ship target and its azimuth ambiguities. One C-band JPL AIRSAR polarimetric data has been chosen to validate the conclusions. [C6]

"Multi-Temporal Polarimetric SAR and Optical Data Fusion for Land Cover Mapping in Southwest China"

Zhazuo area located in Guizhou Province of southwest China was selected as the test site of this study. Based on six polarimetric RADARSAT-2 images, this paper presents the analysis on polarimetric and temporal variation backscattering behavior of typical targets such as residential areas, farmlands, forests and water bodies within the test site. The multi-temporal polarimetric SAR data fusion, as well as SAR and optical data fusion was conducted to improve the land cover classification. The analysis shows that there are significant differences of polarimetric backscattering and temporal variation behavior among different land cover types. The fusion of the multi-temporal polarimetric SAR data highlights the significant reduction of speckle noises, better land cover discrimination and improved visual appearance of SAR image. The fusion of SAR images with QuickBird data efficiently improves the land cover classification. This study demonstrates that high-precision land cover thematic mapping with SAR data in combination with optical remote sensing image in cloudy and rainy areas is feasible. [C7]

"A Study on Extraction of Man-Made Targets Using SVM Method from High Resolution PolInSAR Data"

This paper studies a man-made target extraction technique using SVM (Support Vector Machine) method from high resolution PolInSAR(polarimetric Interferometric synthetic aperture radar) data. Fully polarimetric interferometric data in X band was acquired by a China-made airborne SAR system in January 2010, over the Linshui area in Hainan province. This study focuses on man-made targets extraction in Linshui area, where the ground survey allows the validation of the final extraction results. Different PolSAR (polarimetric SAR) and PolInSAR(polarimetric interferometric SAR) feature indicators, such as H/A/α,based on the Pauli formalism or an optimal set of coherences are subsequently analyzed and the representatives of features are selected. In order to consider effect of man-made targets extraction with different feature indicators, the SVM method is investigated. The results based on PolSAR, PolInSAR and combined PolSAR and PolInSAR features are respectively compared, the best result is obtained via combining PolSAR and PolInSAR features. [C8]

"Polarimetric through-the-wall imaging"

A novel full polarimetric beamforming algorithm for Through-the-wall imaging (TWI) is proposed in this paper. The far field layered medium Green's functions are incorporated in the beamformer for the quad-polarizations (VV, HV, VH and HH). Due to the incorporation of the layered medium Green's function, the imaging algorithm not only takes into account the wall reflection, bending, and delay effects but also accounts for the complex EM scattering mechanism due to the presence of the wall. By employing the Green's functions, the solving of a nonlinear equation, needed to find the wave propagation path, is avoided. Similar method can also be generalized to multilayered composite walls such as a hollow-core concrete wall. Simulation results show that the proposed method can provide high quality focused images for TWI applications. [C9]

"Segmentation of Polarimetric SAR images using graph partitioning active contours"

In this paper, a novel segmentation method for Polarimetric Synthetic Aperture Radar (PolSAR) images is proposed. Image segmentation is formulated as a graph partitioning problem which is addressed by curve evolution. Graph partitioning active contours (GPAC) [1], which is flexible and can be classified as a region-

based active contour framework, is applied to PolSAR images. In order to apply GPAC to PolSAR image segmentation, the pairwise dissimilarity between two arbitrary pixels in the image should be measured appropriately. The selection of dissimilarity measures is discussed. Synthetic and real PolSAR images are both used in the experiments to verify the proposed approach. A quantitative evaluation and comparisons of segmentation results, including iteration times of curve evolution, segmentation accuracies in term of pixel and object count, are provided. The proposed scheme has shown to be promising for PolSAR image segmentation. [C10]

"Simulation studies on data fusion algorithms for forest structure from lidar and SAR data"

The NASA's DESDynI mission will provide global systematic lidar point-sampling data and areal coverage of L-band SAR data with polarimetric capabilities for 3-D structural studies of vegetation. The combined use of lidar's direct sampling measurements and radar's global areal mapping capabilities creates a real opportunity to map global ecosystem structures and functions that link to carbon dynamics. However, the relationship of the lidar point-sample data and corresponding areal SAR data is yet to be established. In this study the data fusion algorithms for the estimation of parameters of forest structure from Lidar and SAR Data is investigated. The results show that SAR intensity data is sensitive to forest biomass which is less than 15kg/m2(or 150 ton/ha) and insensitive to the maximum forest height. Lidar data can be used to provide the information of forest height and the introduction of the information of forest height is helpful in the estimation of forest biomass. [C11]

"Analysis of Faraday rotation on spaceborne CTLR compact polarimetric SAR image reconstruction"

The CTLR (circular transmit and linear receive) compact polarimetric (CP) synthetic aperture radar (SAR) system transmits only right or left circular polarized signal and receives H and V linear polarized signal. CP SAR mode has significant advantage of doubled swath width compared to the traditional full-polarimetry (FP) mode. In this paper, the effective FP data are reconstructed using Souyris' iteration algorithm from the covariance matrix of the CTLR mode CP SAR data. Then the performance of the algorithm is analyzed. Moreover, the ionospheric effect of Faraday rotation (FR) on longer wavelength (i.e. P-band) spaceborne CP SAR was introduced in the simulation. After simulating the impacts of FR on SAR image reconstruction, an information-theoretical evaluation method was proposed for analyzing the quality of SAR image reconstruction. The mutual information between the original FP data and the reconstructed FP data (namely, from the CTLR CP SAR image) as a function of FR was illustrated, for quantitatively evaluating FR on longer wavelength (e.g. P-band) spaceborne CTLR CP SAR image reconstruction. [C12]

"Water objects extraction from polarimetric SAR imagery based on blind source separation and morphological reconstruction"

The SOMMR nonlinear blind source separation (BSS) method is proposed for speckle noise suppression and water objects extracting from synthetic aperture radar (SAR) imagery based on self-organizing maps (SOM) neural networks and morphological reconstruction (MR). The multiplicative speckle noise and image data are separated from multipolarimetric imagery by means of SOM neural networks. Morphological reconstruction is employed to remove the residual noise. The experimental results using ENVISAT ASAR polarimetric imagery show that the proposed method can extract water objects accurately, and the speckle noise index is better than ICA and SOM method. [C13]

"Simulation of Faraday rotation on longer wavelength spaceborne polarimetric InSAR"

The effects of Faraday rotation (FR) on longer wavelength (i.e. L or P-Band) spaceborne linearly full-polarized inferfermetry synthetic aperture radar (Pol-InSAR) processing are addressed. A model for linearly full-polarimetric InSAR data subject to Faraday rotation is investigated. Due to Faraday rotation, the received signal in each channel will be contaminated by backscattering signals from other polarimetric channels, which consequently reduce the coherence of the two single look complex SAR images received by the same channel for PolInSAR processing. The numerical simulation results are presented, which indicates that Faraday Rotation has significant impact on the coherence of the interferograms, especially for the spaceborne longer wavelength Pol-InSAR system. [C14]

"Simulation of the PARSAX dual-channel FMCW polarimetric agile radar system"

Polarimetric agile radar can be used to estimate all elements of the polarization-dependent backscattering matrix (BSM) simultaneously. Stringent requirements, such as amplitude and phase matching between channels, cross-channel isolation and polarization isolation, for a dual-channel polarimetric agile radar system have to be

investigated. The radar system simulation is a practical and effective approach to evaluate these requirements. This paper presents the modelling and simulation of the dual-channel FMCW polarimetric agile radar system by using Agilent Advanced Design System (ADS) simulation software. The paper focuses on investigating the limitations of cross-channel isolation and estimating the error of BSM components in polarimetric agile radar system simulations. [C15]

"Simulation study of relationships between Doppler-polarimetric parameters at microwave remote sensing of precipitation"

This paper studies the relationships between recently introduced differential Doppler velocity and other parameters of radar signal reflected from rain. Analytical calculation and simulation methods are used mostly. The results are checked by measurements in special cases. Some possibilities to derive information on distributed object structure are shown. [C16]

"MetaSensing compact, high resolution interferometric SAR sensor for commercial and scientific applications"

For the first time in the world airborne Frequency Modulated Continuous Wave (FMCW) Synthetic Aperture Radar (SAR) images have been acquired in interferometric mode. The paper reports on the X-band images collected by the new high resolution, compact MetaSensing interferometric SAR sensors in 2009. MetaSensing approach allows cost-effective SAR mapping by employing small, readily available Cessna 172/182 or similar in order to drastically cut the costs of current radar campaigns for scientific and commercial applications. MetaSensing X-band SAR sensor is able to transmit more than 1.4 GHz of bandwidth and its versatile two receiving channels allow along-track and cross-track interferometric acquisitions. A fully polarimetric L-band sensor is in the final test stage and is available from the third quarter of 2010. The new MetaSensing approach is an optimal solution for commercial and scientific application which requires SAR mapping on local areas. [C17]

"Reconfigurable digital receiver for polarimetric radar with dual-orthogonal signals"

This paper outlines the work on the design of a reconfigurable receiver for the PARSAX radar. The FPGA based digital receiver samples incoming signals at intermediate frequency (IF) and processes signals digitally instead of using more conventional analog approaches. In this way it offers more robust system stability and avoids unnecessary multi-channel calibrations of analog circuits. The processing algorithms implemented in the FPGA chips can be reconfigured adaptively regarding to different transmitted waveforms, and without changing of hardware. The successful development of reconfigurable receiver has been verified by experiment and yields maximum flexibility for the whole radar system. [C18]

"Inter-period compensation algorithm in full-polarimetric FMCW radar"

This paper describes a new type of sounding signals for polarimetric FMCW radar and the corresponding signal processing technique. The inter-period compensation (IPC) algorithm is proposed for isolation increase in radar channels. The novelty concerns the use of orthogonal polarizations of two bi-cyclic LFM-signals having an additional phase shift every second sweep. Summation units proposed for use in the receiver channels allows for reducing the effects of interfering signals due to the specified phase of received signals over two consecutive sweep times. [C19]

"Radar polarimetry using sounding signals with dual orthogonality-PARSAX approach"

The article describes specific aspects of the radar polarimetry using sounding signals with dual-orthogonality. Such signals provide the unique opportunity to measure all elements of the polarization back-scattering matrix simultaneously, during one sweep/pulse period of radar signal. This approach has been implemented in the IRCTR PARSAX radar system, the fully polarimetric high-resolution Doppler FMCW radar. The digital architecture of the radar starts from intermediate frequency and makes the radar fully reconfigurable in terms of sounding waveforms and processing algorithms. [C20]

"The Application of Optimal Polarization Theory in Polarimetric SAR Change Detection"

In recent years, SAR is developing to multitemporal, multi-band, high resolution and full polarization. So the study of polarization SAR change detection technology is the trend of the SAR. The traditional change detection methods have disadvantages either low accuracy, serious noise or can't determine changes types. In order to improve the detection accu-racy of polarization SAR data, a new change detection method is presented in this paper. Firstly, we use optimal polarization theory and optimization of polarimetric contrast enhancement (OPCE) theory to enhance change phenomenon respectively. Then, the probability relaxation iteration algorithm is made

use of to extract change information automatically. This method can not only improve the accuracy, decrease noise, but also can determine the change type, it is a kind of ideal change detection method. [C21]

"Paddy Rice Identification Using Polarimetric SAR Data in Southern China"

Rice is one of the largest food grains in the world, providing food for more than one third of globe population. The radar remote sensing has been proved as an effective tool for rice mapping. With the emergence of spaceborne polarimetric SAR satellite, researches on polarization backscattering behavior and identification methods of paddy rice are of great significance and attract attention of remote sensing communities. Zhazuo Area located in Guizhou Province of southwest China was selected as the test site of this study. The RADARSAT-2 polarimetric data acquired at four dates were used to analyze the polarization backscattering behaviors and temporal variation characteristics of rice, and identification method for rice based on optimal polarization combination was established. This study shows that HH with HH/HV is the best polarization combination for rice identification under the adoption of linear polarization combination. [C22]

"Sea ice monitoring in the Baltic Sea using dual-pol C and L band SAR data"

Summary form only given. Monitoring of ice dynamics and ice type classification is an important task for understanding environmental changes as well as for safe winter navigation. SAR (Synthetic Aperture Radar) is a powerful spacebourne instrument to detect ridged ice regions as the radar backscatter is strongly influenced by geometrical properties of the ice surface. Data from polarimetric (or dual-pol) SAR sensors like Radarsat-2 and ALOS/Palsar enables to determine more precisely ice types as it contains more information about the ice surface geometry than single polarization images. Use of dual polarization SAR imagery also known as compact polarimetry has shown to be useful as it has reduced the complexity, cost and data rate of SAR image while preserving most of the capabilities of fully polarimetric image. A study for sea ice monitoring and characterization was carried out in the Baltic Sea from January to March 2009. The focus of current study was on enhanced monitoring of small scale changes/processes (ice types and dynamics) in the western Estonian archipelago sea. Secondary objective was to compare the backscatter characteristics at different frequencies (C-band and L-band) and polarizations (HH, HV, W) from various ice types (ridges, fast ice, water etc.) using data from different SAR sensors. Considering the objectives of the study high resolution SAR data from the following sensors was included: RADARSAT-2 (fine mode, HH/HV), ALOS/Palsar (fine mode, HH), ERS (image mode, W) and ASAR (wide swath, HH). Also optical remote sensing data from MODIS (Moderate Resolution Imaging Spectroradiometer) sensor was used to carry out non SAR dependent ice type classification. In addition to remote sensing imagery the meteorological data (wind measurements, air temperature, precipitation etc) from three different stations near the study area was analyzed to determine the cause of backscatter variations. A sea ice classification from C-band dual-pol Radarsat-2 imagery-- was performed. The classification on SAR image was based on entropy/alpha differences that were caused by ice type variations. Analysis showed that four ice types (level ice, fast ice, ridged ice, deformed ice and water) were identifiable from dual-pol data. Also two independent analyses that were performed on optical remote sensing imagery (MODIS) supported the classification results from Radarsat-2 data. Ice types were also determined from L-band SAR data and single polarization C-band data to characterize dependence of backscatter properties on surface type (roughness). The backscatter properties of ice types detected from RADARSAT-2 (C-band, HH/HV) were compared with single-pol data from Palsar L-band (HH), ERS (W), and ASAR (HH). Results showed that while C-band data was better for monitoring small scale ice deformations, the inclusion of L-band data improved significantly the analysis in snow covered ice regions in the coastal zone. The study provides additional information for enhanced ice monitoring in small areas (e.g. harbours, coastal zone) using high resolution data at multiple bands and polarizations. [C23]

"Modular RF design for QUASAR Ku-band polarimetric SAR system"

A new compact fully polarimetric Ku band SAR system (SBK) is being developed by INTA radar Laboratory as an advanced payload for QUASAR project, which involves INTA new SAR developments for small platforms and UAV's. SBK design is based on previous developments of INTASAR program for his X-band SAR prototypes, RIX and RBX, focusing work on units miniaturization and new RF payload development. SBK RF development comprises the design of a modular KU-band RF payload mostly consisting on a highly stable Tx/Rx module, a Ku-band front-end and a planar antenna. RF design for the whole system and each of the RF related modules is shown including RF internal calibration capabilities of SBK. [C24]

"Radar polarimetry for security applications"

We analyse micro-Doppler techniques and the improved performance that fully polarimetric radar techniques can add. We perform fully polarimetric measurements of the varying micro-Doppler signatures of humans as a function of elevation angle and azimuthal angle in order to try to optimize this type of system for the detection of

arm motion, especially for the determination of whether someone is loaded. We determine that polarimetric measurements can isolate and highlight the arm motion for a classification as loaded or unloaded. Second, the azimuthal angle of the motion is a critical parameter to consider in ground-based systems. For choke-point observations where the direction of motion is more controlled, polarimetric radar has the potential to determine who is not loaded inappropriately and who should be checked. [C25]

"Polarimetric scattering analysis for accurate observation of stricken man-made targets using a rotated coherency matrix"

This paper investigates polarimetric scattering features generated from man-made targets for accurately observing stricken residential area by making full use of quad. polarimetric SAR data set. First, we propose a simple improvement of the scattering power decomposition method by introducing a unitary rotation of the coherency matrix. It is found from the results of the POLSAR image analysis for a mountainous region including some stricken residential areas that by carrying out the rotation procedure, double-bounce scattering contribution can be enhanced even when the targets are oriented and/or set on small inclined ground plane. This peculiar scattering feature is utilized as a useful marker for precisely detecting man-made targets. To verify the generating and enhancing mechanism of the double-bounce scattering, we also carry out the Finite-Difference Time-Domain (FDTD) polarimetric scattering analysis for a simplified man-made target model. The dependency of the polarimetric scattering feature on the variation of squint angle is investigated. It is confirmed from the FDTD analysis for oblique squint angular range that by applying the rotation procedure before the scattering power decomposition, the double-bounce scattering contribution tends to be enhanced, and the volume scattering becomes small. [C26]

"Estimation of the degree of polarization in compact polarimetry"

The degree of polarization (DoP) has long been recognized as one of the most important parameters characterizing partially polarized electromagnetic waves. This parameter can be effectively used to describe the information content of polarimetric images collected by synthetic aperture radar (SAR) systems. Estimation of DoP is standardly performed using four measurements. In SAR compact polarimetry (CP), however, only two measurements are available. In this paper, we develop maximum likelihood estimators of the DoP, in SAR CP modes, based on only two intensity images. We evaluate and compare the performance of these estimators for different CP modes on RADARSAT-2 polarimetric data, over various terrain types such as urban, vegetation, and ocean. [C27]

"A scattering similarity based classification scheme for land applications of polarimetric SAR image"

In this paper, a new classification scheme, which extracts the main scattering mechanism with target scattering similarities, is proposed. This approach not only leads to improved understanding of scattering mechanisms, but also has good performance in discriminating different scattering type of land cover. The NASA/JPL AIRSAR data is used for validating its effectiveness. [C28]

"Calibration accuracy enhancement in the field experiment with a ground-based scatterometer"

An improved field-measurement technique for enhancing the calibration accuracy of a ground-based scatterometer is proposed in this paper. The automatic two-dimensional (2-D) measurement of a calibration target, so-called `2-D target scanning technique (2DTST)', gives a precise alignment between a point calibration target and an antenna bore-sight. Averaging of the calibration-target measurements increases further the accuracy and reliability of the automatic alignment. The measurement results show that the correlation among the measurements is larger than 0.95 and the error-rate is below 5% at a frequency range from 9.4 GHz to 9.9 GHz. The evaluation of the calibration accuracy using the STCT (Single Target Calibration Technique) shows that 2DTST in the field experiment can secure the precise calibration accuracy within 0.5 dB for magnitude correction and 4° for phase correction. [C29]

"Retriveval of soll moisture under vegetation using Polarimetric Scattering Cubes"

Soil moisture inversion from polarimetric SAR data has attracted significant attention for the past twenty years. Comparing with the simple case of bare surface, it is extremely complicated for vegetated terrain to invert soil moisture because of a larger number of scattering mechanisms that contributes to the observation. In this paper, we show how polarimetric decomposition technique, which decomposes SAR observations into preferred scattering mechanisms, can be used for the inversion. The result leads us to give up the use of polarimetric decomposition because of an unknown attenuation ratio caused by the canopy. Then a new inversion algorithm

using Polarimetric Scattering Cubes (PSC) is introduced with simulation results to show a sensitivity to physical parameter such as vegetation distribution. Finally, we also discuss how the technique should be implemented for the real SAR data. [C30]

"A polarimetric two-scale model for soil moisture retrieval"

A polarimetric two-scale surface scattering model employed to retrieve the surface parameters of bare soils from polarimetric SAR data is proposed. The scattering surface is considered as composed of slightly rough randomly tilted facets, for which the Small Perturbation Method holds. The facet random tilt causes a random variation of the local incidence angle, and a random rotation of the local incidence plane around the line of sight, which in turn causes a random rotation of the facet scattering matrix. Unlike other similar already existing approaches, our method considers both these effects. The proposed scattering model is then used to retrieve bare soil moisture and (large-scale) roughness from the co-polarized and cross-polarized ratios. The performances of the resulting retrieval algorithm is finally assessed by comparing obtained results to "in situ" measurements. To this aim, data from Little Washita campaign available in literature is employed. [C31]

"Advanced classification of UXO using fully polarimetric GPR and frequency-polarization features"

The classification of buried UXO has been a difficult task due to the large amount of false alarms resulted from troublesome clutter objects. This paper closely examined scattering characteristics of such clutter objects by using numerical simulations. From the numerical study, we found that some clutter objects, which mainly causes the false alarms, produce multiple resonances at different frequencies and different polarizations. Based on these observations, we developed new classification algorithms which utilize the frequency-polarization dependent responses of complex targets in order to discriminate UXO-like objects form such trouble some clutters. The developed algorithms were tested by experiments in a test plot. In the test, the new classification algorithms clearly discriminated such clutters from UXO-like targets. In this paper, we present the simulation results for scattering characteristics of complex clutters and the new classification algorithm based on frequency-polarization dependent responses will be discussed. Finally, results from experimental verification will be presented. [C32]

"Use of PALSAR polarimetric data for tropical forest stratification and comparison of simulated dual and compact polarimetric modes"

This paper presents a case study addressing the comparison between different SAR polarimetric mode for tropical forest stratification: Full polarimetry (FP), Dual Polarimetry (DP) and Compact Polarimetry (CP). These 2 latter modes are simulated using FP data acquired by the L band PALSAR sensor over 2 study sites. Cayenne in French Guyana and the Fazenda Saio Nicolau in Brazil. The classification approach used to evaluate each mode based on Support Vector Machine (SVM) algorithm shows the good capabilities of the FP mode to discriminate different kinds of vegetation. The choice of one DP mode that gives twice bigger swath than FP mode depends on the study classes. In this tropical environment the hh/hv existing mode seems to be a good choice and CP mode show a good alternative to all the actual DP modes. [C33]

"Tandem-L: And innovative interferometric and polarimetric SAR mission to monitor earth system dynamics with high resolution"

Tandem-L is a proposal for an innovative interferometric and polarimetric radar mission that enables the systematic monitoring of dynamic processes on the Earth surface. Important mission objectives are global forest height and biomass inventories, large scale measurements of millimetric displacements due to tectonic shifts, and systematic observations of glacier movements. The innovative mission concept and the high data acquisition capacity of Tandem-L provide a unique data source to observe, analyze and quantify the dynamics of a wide range of mutually interacting processes in the bio-, litho-, hydro- and cryosphere. By this, Tandem-L will be an essential step to advance our understanding of the Earth system and its intricate dynamics. [C34]

"Estimation of sea ice thickness in the Arctic Sea using polarimetric parameters of C- and X-band space-borne SAR data"

In this study, we derived the relationship between target depolarization factor and physical parameters of sea ice in order to estimate the thickness using dual-polarization C-and X-band space-borne Synthetic Aperture Radar (SAR) data. The target depolarization factor, the cross-polarized ratio of C-band SAR data, which can explain the target depolarization effect, were strongly related to changes in surface roughness of thick First-Year Ice (FYI) and Multi-Year Ice (MYI), and were almost insensitive to variations in the surface dielectric constant of thick FYI and MYI and the incidence angle of C-band SAR data. This relationship showed a high correlation

between target depolarization factor of C-band SAR data, the cross-polarized ratio, and thick FYI and MYI thickness. We validated the estimated method using RADARSAT-2 and TerraSAR-X data and ground-truth data acquired in the Arctic Sea off the northern coast of Greenland. [C35]

"Dual-polarization performance of the phase-tilt antenna array in a casa dense network radar"

In this paper the evaluation of dual-polarized scanning performance of a large planar array antenna for a solid state radar for weather is discussed. The antenna array is designed to operate at 9.36 GHz ±50 MHz, and the transmission and reception mode is configured to work alternatively. The antenna array architecture based on a series-fed array configuration of Dual-Polarized Aperture Coupled Patch Antennas (DP-ACPA) was designed and implemented to achieve the required radar polarimetric performance at low cost. Measured patterns of the array in the elevation and azimuth plane are used to evaluate the two principal polarimetric radar parameters (Zdrand LDR) over the scanning range in azimuth plane. It is shown that the biases in the differential reflectivity due the cross-polarization of this antenna configuration are negligible in comparison with the biases produced for the mismatch antenna patterns (H and V). [C36]

"The snowscat ground-based polarimetric scatterometer: Calibration and initial measurements from Davos Switzerland"

The COld REgions Hydrology High-resolution Observatory (CoReH20) Mission proposes a dual frequency radar operating at 9.6 and 17 GHz utilizing VV and VH polarization [1]. By combining Xand Ku-Band with both coand cross-polarization diversity it is possible to estimate the Snow Water Equivalent of dry snow. To support this proposed mission, ESA has sponsored the development of a ground-based coherent polarimetric scatterometer operating over the 9-18 GHz frequency range. ESA is supporting campaigns to acquire and process data using SnowScat for validation of Snow Water Equivalent (SWE) retrieval algorithms. [C37]

"Potentials of a compact polarimetric SAR system"

The goal of this study is to show the potential of a compact-pol SAR system for vegetation applications. Compact-pol concept has been suggested to minimize the system design while maximize the information and is declined as the π/4, π/2 and hybrid modes. In this paper, the applications such as classification, Faraday rotation and soil moisture estimates are first reminded, then, biomass estimation from CP data is presented and a calibration procedure using external targets is proposed. Finally, the interferometry concept is added to assess the capabilities of a compact-pol system to retrieve vegetation height. [C38]

"Metallic objects and oil spill detection with multi-polarization SAR"

In this study, two innovative physically-based approaches have been developed to detect man-made metallic objects and oil slicks in polarimetric SAR data. They are based on the different sea surface scattering mechanisms expected with and without oil slicks and metallic objects. Experiments, accomplished over Single Look Complex (SLC) Level 1.1 quad-pol L-band ALOS PALSAR SAR data, demonstrate the effectiveness of the two approaches for oil slick and metallic target detection purposes and witness the capability of ALOS PALSAR data for such applications. [C39]

"Oil-slick observation using single look complex TerraSAR-X dual-polarized data"

In this study single look complex (SSC) TerraSAR-X dual-polarized data are firstly exploited for sea oil slick observation purposes. An electromagnetic model which, based on the Co-polarised Phase Difference between the HH and VV channels (CPD), allows describing the X-band sea surface scattering with and without surface slicks is proposed. Following this rationale, the polarimetric approach is firstly developed and applied to X-band Synthetic Aperture Radar (SAR) data in which both certified oil slicks and look-alikes are present. Experimental results demonstrate, for the first time, that X-band dual-polarimetric SAR data are suitable for sea oil slicks observation purposes and witness the paramount importance of the TerraSAR-X dual-polarimetric mode for such application. [C40]

"Exploitation of the additive component of the polarimetric noise model for speckle filtering"

Ratio filters for speckle noise reduction in SAR imagery are recursive filters where the image structure is iteratively recovered from an initial oversmoothed image. We show that the MBPolSAR filter could be interpreted as a ratio filter applied to the off-diagonal terms of the covariance/coherency matix. From this observation, we propose a new polarimetric ratio filter allowing us to recover the image structure from all the terms of the covariance matrix. In addition, we briefly look at how the additive noise component could also be exploited for the image structure extraction. Filtering results on both simulated and real PolSAR images are shown. [C41]

"Coupling polarimetric L-Band insar and airborne lidar to characterize the geomorphological deformations in the piton de la fournaise volcano"

Until recently the coarse resolution of topographic mapping acted as a break on understanding the forces and processes that shape the Earth's surface. However, active surface deformation is an important indicator for the earth crustal dynamics since it is directly linked to earthquakes, volcanic eruptions and landslides. Both airborne laser scanning systems (LiDAR) and spaceborne interferometric synthetic aperture radars (InSAR) have provided valuable information for many case studies requiring highresolution characterization of ground movement in relatively large areas to assess the threat and impact of natural hazards especially for volcanic eruptions. The Piton de la Fournaise volcano (Reunion Island, France) is one of the most active basaltic shield volcanoes in the world. It has reached an anomalous activity level in the past years with a major eruption occurring in April 2007. In this paper, we explore the statistical, spatial and temporal behavior of the L-Band backscattering coefficient at both HH and HV polarizations over different type of terrains in the Fournaise lava field as a function of the LiDAR intensity data. The correlation will be used in setting empirical models to correct for the L-Band phase distortion on ash and rough surfaces in volcanic terrains. [C42]

"Oblique polarimetric SAR processor based on signal and interference subspace models"

We develop a new SAR processor based on oblique projection. We take into account the scattering properties of the target and the interferences by using subspace models. To detect the target and to reject the interferences, we process images with the oblique projection of the received signal into the target subspace along the interference one. This new SAR processor is applied to realistic simulated data for FoPen (Foliage Penetration) application. [C43]

"Monitoring sea-ice and dry snow with GNSS reflections"

GPS reflected signals have become a source of opportunity for remote sensing of the Earth's suface. In this work, we present several capabilities of this technique in two different polar environments: Greenland and Antarctica. The first part is dedicated to the retrieval of sea-ice properties, giving emphasis to the study of the coherent phase for altimetric and roughness estimations, and polarimetric measurements for the determination of the ice salinity variation. The results show good agreement with a tide model and daily ice charts. On the second part, some preliminary results and analysis strategies to retrieve dry snow signatures are presented. [C44]

"Applications of polarimetric decomposition technology in a dried up lake evolution"

This paper presents fundamental reason to Lop Nur "Ear" feature based on polarimetric decomposition technology. Lop Nur is located at the east Tarim Basin in China, and in history, all the major rivers running in Tarim Basin converged to this lowest place. Lop Nur belongs to arid region, and satisfies penetration conditions for SAR signals. Through comparison between decomposed volume scattering contribution and sub-surface salinity, it is found that subsurface properties (such as salinity) is the fundamental reason to "Ear" feature. And dynamic mechanism of geomorphology builds the relationship between surface and subsurface evolution processes, and indirectly unifies previous points on the reasons to formation of Lop Nur "Ear". Polarimetric technology is anticipated to be used to retrieve more information and to help extend applications in environment of arid region. [C45]

"Polarimetric sar image visualization and interpretation with covariance matrix invariants"

In this study we give short overview of polarimetric SAR image visualization with colors. By studying the color models and polarization visualization models we propose basic principles which should be followed when presenting polarimetric information in color. We show that for different polarimetric parameters, different color models should be used, and give guidelines for color model selection. We present also two visualization schemes which are suitable for interpretation and browsing of large polarimetric SAR images. [C46]

"Fully polarimetric ALOS PALSAR data applications for snow and ice studies"

In this study, the capability assessment of fully polarimetric L-band ALOS PALSAR data has been carried out for snow discrimination from other targets. Eigenvaluve based polarization fraction value has been determined for assessing the capability of PALSAR data for snow discrimination. Radar snow index has been developed using polarization fraction and normalized third eigenvalue of coherency matrix. It has been found that radar snow index is more robust and simple to implement that supervised classification. [C47]

"Calibration of a Digital phased Array for polarimetric Radar"

When an active phased array is used for polarimetric radar applications, the system must be calibrated to reflect the fact that polarization of the transmitted and received fields is dependent on the scan angle. This paper discusses the challenges of polarimetric phased array calibration, and demonstrates these techniques using a linear array of eight S-band dual-polarized antennas connected to an active Digital Array Radar (DAR) pro-totype system. The ability to accurately measure polarimetric scattering matrices is demonstrated after using direct far-field measurements to compensate for polarization errors on receive and target reflection measurements to compensate for transmit polarization errors. [C48]

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"ICA-based information extraction method for PolSAR images"

Identifying and characterizing objects in PolSAR images rely on proper backscattered signal models, correct segmentation algorithms and on exploiting the connections between the physical structure of the considered objects and their radar echos. The paper presents an ICA-based approach for characterizing physical properties of the objects on the Earth surface. Segmentation of PolSAR image is based on stochastic models. Each segment is assimilated to an object or surface type and pixels of the segment are treated like realizations of the underlying target scattering mechanism. This scattering mechanism is characterized through ICA-based approach, thus providing information about the corresponding target. The TSVM decomposition is used to analyze the mixing matrix issued from ICA and to link its values to physical properties of the target. [C50]

"Scattering analysis of flat electric dipoles on multilayer chiral structures"

Identification of natural targets out of polarimetric SAR data can be made from their scattering matrices, once they are determined. The methodology outlined here permits the spectral domain analysis of a confined chiral layer stacked up between free space and ground, containing flat electric and magnetic elements at any layer interface, and illuminated by an elliptically polarized plane wave at oblique incidence. From the closed-form field expressions so obtained, scattering parameters, including the scattering matrix, of an electric dipole atop the chiral layer are readily determined and analyzed. [C51]

"UWB antenna element for a full-polarimetric antenna array"

Two Ku-band antenna elements to be used in full-polarimetric UWB arrays are introduced. Both antenna elements consist of four linearly polarized UWB radiators. It is demonstrated that both elements have over 100% fractional bandwidth, good impedance matching, linear phase (almost constant group delay) and uni-directional patterns. [C52]

"PARSAX: High-resolution Doppler-polarimetric FMCW radar with dual-orthogonal signals"

The article describes the IRCTR PARSAX radar system. It is an S-band high-resolution Doppler polarimetric FMCW radar utilizing dual-orthogonal sounding signals. The signals allow for measuring in one sweep all elements of the radar targets polarization scattering matrix simultaneously. PARSAX characteristics are: modular system set-up, highly-optimised linearity and sensitivity of the RF front-end receiver, use of a flexible multi-channel arbitrary waveform generator as sounding waveforms source, high-resolution analogue to digital conversion of the received signals at sufficiently high intermediate frequency and FPGA-based programmable digital multi-channel receiver. The paper shows that PARSAX is a unique radar research platform for studying arbitrary sounding waveforms with bandwidth up to 50 MHz and processing algorithms in Doppler-polarimetric radar. [C53]

"Session C9: Polarimetric and Doppler Radars"

{no data available} [C54]

"Comparison of hybrid-polarization with Quad-polarization schemes based on airborne SAR images"

Now-a-days there has been growing interest in dual-pol systems, especially in hybrid-pol mode. In comparison to quad-pol system, the dual-pol system has the advantage of halved average transmitted power and double swath coverage. In this paper, we have discussed, in brief, the benefits of using hybrid-pol scheme. We also present comparisons of hybrid-pol and Quad-pol data based on the amount of information content. The airborne multi-polarization GTRI data set is used for demonstration. [C55]

"Inter-period compensation of the unambiguity range degradation in polarimetric FMCW radar with time-shifted dual-orthogonal signals"

This paper describes a new type of sounding signals for polarimetric FMCW radar and the corresponding signal processing technique. This technique coordinates continuous transmission of two bi-cyclic LFM-signals on orthogonal polarizations and applies an advanced de-ramping processing on receive. The first signal consists of two identical LFM-signals; the second one has time shift relatively first and is composed by the same LFM-signal and its copy having negative sign. The time between the components of sounding signal prevents the frequency overlap between polarimetric components of scattered signal in the branches of every polarimetric radar channel. Thanks to this frequency gap between the signals in every time instant, a high-isolation level in polarimetric FMCW radar channels can be provided. However, the use of two LFM-signals having the same form but a relative time shift can decrease the unambiguity range, because the delayed signals scattered by far-located objects (interfering signals) can be determined as useful signals scattered by close-located objects in a cross branch in a polarimetric radar channel. The use of the proposed bi-cyclic LFM-signals and the additional summation units in the de-ramping filter allows the suppression of these interfering signals due to the phase sign change of the beat signals. As result, the developed de-ramping processing technique can be used in polarimetric FMCW radar receiver providing high-level cross-channels isolation without unambiguity range degradation for estimation of all elements of the radar target scattering matrix. [C56]

"A novel approach applied for the internal and semi-external calibration of the PARSAX dual-channel polarimetric agile radar system"

Polarimetric agile radar is able to measure all elements of the polarization-dependent backscattering matrix (BSM) simultaneously. Polarimetric calibration is an important issue to determine the BSM accurately. This paper focuses mainly on the internal and semi-external calibration of the dual-channel polarimetric agile radar system. The paper presents a novel approach based on very up to date methods used for cross-validation between simulations and measurements. Error models of all parts of the radar system will be derived from the approach and implemented in the radar system calibration. After calibration, the good matching performance for relative measurement between two channels demonstrates the validity of the here-proposed calibration approach. [C57]

"FPGA based IF digital receiver for the PARSAX-Polarimetric agile radar"

An FPGA-based digital receiver has been developed to perform real-time processing for the PARSAX radar. It is a fully polarimetric FMCW radar with dual-orthogonal sounding signals, which has the possibility to measure all elements of the radar targets polarization scattering matrix simultaneously, in one sweep. This paper presents the design principles including the range profile interpretation, optimal parameters selection and processing gain analysis. A novel parallel deramping processing architecture suitable for FPGA implementation is introduced; the overall digital de-ramping processing has been implemented in one chip of FPGA and verified by experimental results. [C58]

"Parameters extraction of crop based on PolSAR Data"

It is beneficial to extract the parameters of the objects by rich information of PolSAR (Polarimetric Synthetic Aperture Radar) data. With polSAR data of Radarsat-2, the polarimetric character of winter wheat in booting and milk stage is studied based on polarization theory. The results show that: there is a great difference between the polarimetric characters of two stages due to the change of wheat structure. Winter wheat growth can be retrieved by entropy, which changes in different way in the two stages. In booting stage, with LAI increasing, the scattering mechanism tends to be more complex. While in milk stage, with plant density increasing, the scattering mechanism tends to be simpler. The eigenvalue of λ2 is a valuable parameter to retrieve soil moisture with crop cover. Results show the potential advantage of polarimetric radar. [C59]

"Measurement and mitigation of the ionosphere in L-band Interferometric SAR data"

Satellite-based repeat-pass Interferometric Synthetic Aperture Radar (InSAR) provides a synoptic high spatial

resolution perspective of Earth's changing surface, permitting one to view large areas quickly and efficiently. By measuring relative phase change from one observation to the next on a pixel-by-pixel basis, maps of deformation and change can be derived. Variability of the atmosphere and the ionosphere leads to phase/time delays that are present in the data that can mask many of the subtle deformation signatures of interest, so methods for mitigation of these effects are important. Many of these effects have been observed in existing ALOS PALSAR data, and studies are underway to characterize and mitigate the ionosphere using these data. Since the ionosphere is a dispersive medium, it is possible in principle distinguish the ionospheric signatures from the non-dispersive effects of deformation and the atmosphere. In this paper, we describe a method for mapping the ionosphere in InSAR data based on a multi-frequency split-spectrum processing technique. We examine a number of PALSAR data sets, including fully polarimetric and single-polarization 28 MHz bandwidth data, where anomalous effects in phase, amplitude and image registration have been observed. We demonstrate the estimation of the ionosphere by means of the split spectrum technique for estimating differential TEC, whereby a radar waveform is transmitted over the full PALSAR spectral band and widely separated portions of the receive spectrum are processed independently and compared for dispersive effects, and quantify its performance. [C60]

"Parameters analysis for polarimetric SAR Based on classification accuracy"

As a multi-channel microwave remote sensing imaging radar system, polarimetric Synthetic Aperture Radar (SAR) enhances the information extraction ability for material scene in the observation area, in which the design and state monitoring for parameters play an important role in polarimetric SAR system and equipments management. This paper presents an analysis method for three typical polarimetric SAR system parameters: channel noise, polarization imbalance, and polarization isolation. We explore the polarimetric SAR image classification accuracy ratio and the relationship with three parameters above, review the statistic model of each parameter, and propose an analysis model between each parameter and the classification accuracy ratio measurement. By the polarimetric SAR image experiment, the comparative curve between each parameter and the influence on classification performance is obtained, which shows an application reference for polarimetric SAR system design and management. [C61]

"Neural network-assisted reconstruction of full polarimetric SAR information"

This paper describes a novel approach to the reconstruction of synthetic aperture radar (SAR) fully polarimetric data from compact polarimetry (CP) Г‚Вї/4 mode. A method is developed which utilises a multi-layer perceptron (MLP) based neural network, to perform reconstruction of scenes with various ground-cover types. In particular, the approach shows potential for the reconstruction of full polarimetry for built-up areas as a complement to existing techniques which are more suitable for natural land cover areas. Performance assessment is presented, using both L-band and C-band data, involving comparison with existing techniques using mean-squared and mean-squared-log measures. [C62]

"A new method based on the BP neural network to improve the accuracy of inversion of the vegetation height"

The error in the estimation of the ground interferometric phase will reduce the accuracy of the inversion of the vegetation height in three-stage vegetation inversion method. Aiming at this problem, the new vegetation height inversion method based on the BP neural network is proposed. The new method directly fits the nonlinear mapping relationship between the complex correction coefficients and the vegetation height, so it reduces the height inversion error caused by the error in the estimated ground interferometric phase. The new method has better performance than the three-stage vegetation height inversion method, and the experiment results validate the superiority of the new method. [C63]

"Characterization of UWB Radar targets: Time domain vs. frequency domain description"

In this paper a characterization of UWB Radar targets is provided, both in the frequency domain and in the time domain. This is done by firstly giving a mathematical description of the Radar target in the UWB case, then providing measurement results. The proposed characterization allows for discerning and classifying UWB targets. Moreover, in this paper a full polarimetric analysis is taken into account. [C64]

"Pol-SAR images classification using texture features and the complex Wishart distribution"

In this paper, a new method for supervised classification of terrain types in polarimetric Synthetic Aperture Radar (Pol-SAR) images is proposed. This technique is a combination of the texture classification and the maximum likelihood classification based on the complex Wishart distribution for the polarimetric covariance matrix. The texture features are first extracted from the span image based on co-occurrence matrices; and then the classifier combines the texture features with the distance measure based on polarimetric information to obtain the results.

Using a NASA/JPL AIRSAR image, the effectiveness of the proposed method is demonstrated. [C65]

"A SAR images despeckling method based on adaptive bandelet thresholding"

In this paper, we have presented an adaptive bandelets based on Bayesshrink soft-thresholding despeckling method for polarimetric SAR images. Experimental results demonstrate that our algorithm has a good despeckling performance in polarimetric SAR images and typically preserves even the minor edges comparing with wavelet transform. Besides, the quantitative analysis of evaluation parameters is not difficult to find that the algorithm proposed in this paper is the optimal speckle reduction. [C66]

"SKP-shrinkage estimator for SAR multi-baselines applications"

The physical properties that can be inferred from Radar data are strictly related to the kind of diversity that characterizes the data itself. Spatial (i.e.: baseline) diversity provides information about target locations, temporal diversity provides information about target displacement, whereas polarimetric diversity provides information about the target electromagnetic behavior. In all cases, covariance matrix estimation is a key issue in the framework of coherent SAR analysis of scenarios characterized by the presence of distributed targets, such as bare or rock surfaces, forested areas, or ice shelves. In this paper we consider the case where two different kinds of diversities are present within the data, such as spatial and temporal or spatial and polarimetric, and investigate the effectiveness of the shrinkage estimator for the data covariance matrix. The shrinkage estimator is obtained as an optimum convex combination between the sample covariance matrix and the structured estimator. The structured estimator is based on the hypothesis of separability of the coherence losses due to the different kinds of diversities within the data, for each target that contributes to the received signal. This hypothesis leads to expressing the data covariance matrix as a Sum of Kronecker Products (SKP), for the estimation of which fast algebraic techniques exist. [C67]

"Simulated SAR system for maritime target imaging using a PO-based approach"

This contribution deals with the simulation of a SAR system for imaging complex scenes made of targets (boats) over a sea surface. A physical optics and method of equivalent currents-based method is investigated to model the complex targets in its maritime environment. The considered global radar radio-link model gives full polarimetric information. In order to validate some parts of the model and to illustrate the proposed global SAR model, some simulations are proposed. [C68]

"SAR imaging of forest structure at longer wavelengths"

This paper is focused on the recovery of the vertical structure of forested areas from multi-baseline and multi-polarimetric SAR surveys at P-Band and L-Band. Baseline diversity provides sensitivity to the vertical structure of the vegetation layer, resulting in the possibility to yield Tomographic reconstructions of forested areas. Yet, far more information can be inferred basing on the joint exploitation of baseline and polarization diversity, which allows the decomposition of the SAR signal into ground-only and volume-only contributions. Ground-only contributions provide an easy and viable way to phase calibrate the data stack. Volume-only contributions, if correctly identified, allow a direct imaging of the vegetation layer. Results are shown basing on both P-Band and L-Band airborne data collected in the framework of the ESA campaign BioSAR 2008. The spaceborne case is also considered, basing on simulated BioMass data. [C69]

"On the detection of marine mammals with ship-borne polarimetric microwave radar"

Collisions between ships and whales are not rare occurrences. Apart from constituting a major cause of death for whale species which frequent busy oceanic areas such as the North Atlantic, such collisions often result in damage to ships. Thus there is keen interest in finding reliable means of detection of whales at sufficient range to ensure successful collision avoidance. In this paper we present the results of experiments aimed at establishing the potential of polarimetric microwave radar to provide such a means. The key element in our approach is the construction of a polarimetric filter which enhances the contrast between the disturbed sea surface around the whale and the ambient sea. The results suggest that detection can be achieved under conditions where conventional uni-polar radars such as those normally found on merchant ships would fail. [C70]

"A unique calibration method testified by X-band polarimetric radar"

This paper explores a unique calibration method for polarimetric radar without requiring any calibration targets. The error of the polarimetric scattering matrix measurement is modeled as antenna distortion matrices and channel distortion matrices. These distortion matrices can be determined using a signal generator in anechoic chamber. The performance of the calibration method is analyzed by simulation. Its validity is verified through the

experiment of an X-band polarimetric radar system. [C71]

"Comparison of ship detectors for polarimetric SAR imagery"

This paper examines the benefits of using fully polarimetric SAR imagery for ship detection. There are three related aspects to the work. First, RadarSat-2 quad-pol stripmap imagery is used to compare the performance of various ship detection algorithms/methods. The comparison is based on the use of ROC curves. Second, circular spotlight SAR imagery is used to examine how detector performance varies with the azimuth angle. Owing to the small number of available ship samples, this analysis has limitations. Third, again using the circular spotlight SAR imagery, the variation, with respect to azimuth angle, of the elements of the polarimetric covariance matrix of both the ship and the ocean are analysed. The results are as follows. Using the stripmap imagery, it is found that exploiting both polarimetry and spatial correlations greatly improves detection performance. Using the circular spotlight imagery, it is found that detection performance is variable with respect to azimuth angle and trends are hard to discern. Moreover, the performance of the Pauli double bounce detector is generally poor. It is conjectured that ship pitching motion degrades the polarimetric backscatter response in the circular spotlight imagery. Finally, the covariance matrix analysis confirms known trends for the ocean backscatter. The implication of these trends is that the polarimetric covariance matrix is sensitive to changes in azimuth angle and hence detectors based on them are also. The data indicate the extent to which this is the case. [C72]

"Unsupervised classification of forest from polarimetric interferometric SAR data using fuzzy clustering"

Fuzzy clustering algorithms have been successfully applied to POLSAR classification, but not to POLInSAR. In this paper, a Fuzzy C Means (FCM) clustering algorithm integrating the complementary physical information and statistical property contained in both polarimetric and interferometric data, is used for POLInSAR classification. At first, the area dominated by volume scattering is extracted from polarimetric information using unsupervised H-A-Alpha k-means Wishart classifier with the physical scattering mechanisms of different terrain types; and the volume scattering area (forest area) is further segmented in the feature space of the relative optimal interferometric coherence spectrum A1and A2. Then a robust unsupervised fuzzy C means (FCM) classifier initialized with the results of the segmentation is applied to the polarimetric interferometric coherency data sets corresponding to the volume scattering area. This will not only take into account the scattering mechanisms of the data, so that the results of the classification have definite physical meaning, but also avoid the problem that the initial value of FCM algorithm is difficult to identify. The proposed method is evaluated and compared with k-means Wishart classifier using repeat pass E-SAR L band polarimetric interfer-ometric SAR data and the corresponding auxiliary image. Preliminary results show that the proposed method has better performance. [C73]

"Classification of Polarimetric SAR Images Using Evolutionary RBF Networks"

This paper proposes an evolutionary RBF network classifier for polar metric synthetic aperture radar (SAR) images. The proposed feature extraction process utilizes the full covariance matrix, the gray level co-occurrence matrix (GLCM) based texture features, and the backscattering power (Span) combined with the H/α/A decomposition, which are projected onto a lower dimensional feature space using principal component analysis. An experimental study is performed using the fully polar metric San Francisco Bay data set acquired by the NASA/Jet Propulsion Laboratory Airborne SAR (AIRSAR) at L-band to evaluate the performance of the proposed classifier. Classification results (in terms of confusion matrix, overall accuracy and classification map) compared to the Wish art and a recent NN-based classifiers demonstrate the effectiveness of the proposed algorithm. [C74]

"Front matter"

The following topics are dealt with: power electronics; digital circuits; data converters; video and image processing; wired communication; digital signal processing; analogue circuit; pipelined ADCs; RFID; RF and antenna; MEMS and sensors; biomedical circuits and systems; CMOS power regulator; GPS signal; telephone remote control system; VLSI interconnects; continuous-time delta-sigma modulator; optical transmission; FPGA; X-band polarimetric radar; wireless-LAN transceiver; nanoMOSFET; single-electron transistor hybrid circuit; and implantable medical devices. [C75]

"Calibration of panelized polarimetric phased array radar antennas: A case study"

Demand for improvements in the performance and capabilities of new polarimetric radar systems beyond those of their predominantly mechanically-rotated predecessors has led to an effort to realize large, dual-polarized phased array an-tennas. These arrays have changing polarization characteristics with scan angle, requiring calibration and compensation. This paper provides a qualitative discussion of the challenge in meeting polarime-

tric weather radar requirements, such as a low bias in differential reflectivity (ZDR) and integrated cross polarization ratio (ICPR). A case study is presented using low-cost, aperture-coupled, stacked-patch antennas, a representative example of what may be used in large polarimetric phased array applications, to predict quantitatively the performance that can be achieved through suitable calibration and size constraints. [C76]

"Polarimetric phased array weather radar: Concepts for polarimetric calibration"

The National Severe Storms Laboratory (NOAA-NSSL) and the Advanced Radar Research Center at the University of Oklahoma (OU-ARRC) are presently involved in the design, development and construction of a cylindrical polarimetric phased array radar (CPPAR) to demonstrate polarimetric capabilities for weather sensing within the Multi-function Phased Array Radar (MPAR) project. The bias in radar meteorological polarimetric variables is dependent on a number of parameters like cross-to-copolar gain ratio, integrated cross-polarization level, cross-to-copolar phase, copolar beam-width mismatch and beam pointing angle mismatch [1-2]. In the first part we present a preliminary system design for CPPAR, in the second part we present a procedure for polarimetric calibration using a target of opportunity, namely rain. Polarimetric calibration such as this one is extremely important for polarimetric phased arrays, since calibration needs be done on a beam by beam basis. [C77]

"Statistical estimation of polarimetric method potential for dangerous turbulence detection in rain"

In this paper the polarimetric approach for wind phenomena detection and study is proposed and analyzed. The polarimetric estimation of turbulence intensity is made with single unipolarized antenna radar system. The statistical estimation of proposed method is made. [C78]

"Design of high-speed digital correlator in fully polarimetric microwave radiometer"

Fully polarimetric microwave radiometer is a new type of passive microwave sensor for measuring ocean wind vector. Digital correlation technology is used in it to get all the four Stokes parameters of ocean emission in this paper. Digital correlator is the main part of fully polarimetric radiometer. In the paper, design of a novel digital correlator is presented. Two high-speed, dual A/D converters are used to sample four signals, and the sampling results are operated in FPGA-Vertex5 to make both self- and cross-correlation calculations. The test results of the correlator are given. The four channels are sampled at 360 MHz. For both 100 MHz and 150 MHz input, the correlation coefficient between the measurements and their ideal results is above 0.9999999. The whole power of digital correlator is 11.3 W. [C79]

"Polarimetric suppression of early-time scattering for late-time target identification"

One can suppress the strong signal amplitude of the early-time scattering, relative to the late-time signal containing the natural resonances (for target identification) using various techniques. This paper discusses the use of polarization for the early-time suppression. [C80]

"Drop shape, size and canting angle Distributions in stratiform and convective rain: Some examples and their impact on XPD-CPA relation"

1-minute drop size distributions in rain from measurements using 2D video disdrometer are used to identify stratiform and convective rain, and the respective drop shapes are examined separately. Canting angle distributions have also been determined in stratiform rain, under low wind conditions and confirmed independently using polarimetric radar based estimates. Studies are ongoing in this area. [C81]

"Research on supervised classification of fully polarimetric SAR image using BP neural network trained by PSO"

Supervised classification of fully polarimetric SAR image using neural network is a common method nowadays. As an effective learning method of neural network, BP algorithm is the most widespread one in the neural network algorithms. However, BP network is easy to fall into local extremum and exists shortcomings such as the slow training process. To this end, this paper presents a method of supervised classification of fully polarimetric SAR image based on particle swarm optimization algorithm and BP algorithm. This method can improve BP algorithm using PSO and increase the convergence speed as well as the training accuracy of BP network. Experiment using fully polarimetric SAR image show that the supervised classification result of this method is better than the traditional BP algorithm classification result. [C82]

"Exploiting polarimetric diversity to mitigate the effect of interferences in FM-based passive radar"

In this paper the effect of interfering sources is characterized on the performance of a passive bistatic radar exploiting a FM radio broadcast transmitter. The signals emitted on same/adjacent frequency channels by other potential transmitters located in the surveillance area are shown to significantly affect the performance of the considered system in terms of both disturbance cancellation and target detection capability. To mitigate the effect of such interferences, the exploitation of different polarizations is considered for the surveillance antenna. A preliminary approach is proposed to jointly exploit the diversity of information conveyed by different polarizations. The results are shown against a real data set collected by an experimental multi-channel passive radar prototype developed and fielded at the Infocom Dept. of the University of Rome "La Sapienza" (Italy). [C83]

"A frequency selective magnetodielectric layer in polarimetric radar antenna track"

A periodically stratified medium consisting of alternating layers of two magnetodielectric media is considered. In the long wavelength limit such a medium might be treated as uniaxial effective substrate. For oblique incidence of TE and TM type electromagnetic waves, the reflection and transmission coefficients are found. On the basis of numerical solution of associated periodic boundary-value problem, finite scale homogenization model is discussed. Prospective applications of the slab treated for designing frequency selective structure situated in the track of polarimetric radar antenna is pointed out. [C84]

"Design of prospective spaceborne multi-aperture UWB polarimetric high performance SAR system"

Multi-aperture synthetic aperture radar (SAR) systems ensure high performance SAR imaging that is unachievable for conventional SAR. Application of modern technological capabilities in ultra-wide-band radar signals digital forming and processing (including optional modulation modes) enables realizing high performance characteristics and using operational flexibility of the SAR system. This report presents technical pattern and characteristics of the SAR, that is based on segmented polarimetric wide-band active phased array and multichannel digital subsystem for signal parameters control. The system uses technologies of 'multidimensional waveform encoding' for transmitted signal and 'digital beam forming' (DBF) for echoed signal receiving. The design main qualitative characteristics are estimated for multichannel remote sensing modes. [C85]

"Radio frequency interferences investigation using the airborne L-band full polarimetric radiometer CAROLS"

In the present paper, different methods are proposed for the detection and mitigation of the undesirable effects of radio frequency interference (RFI) in microwave radiometry. The first of these makes use of kurtosis to detect the presence of non-Gaussian signals, whereas the second imposes a threshold on the standard deviation of brightness temperatures, in order to distinguish natural emission variations from RFI. Finally, the third approach is based on the use of a threshold applied to the third and fourth Stokes parameters. All of these methods have been applied and tested, with a CAROLS radiometer operating in the L-band, on data acquired during airborne campaigns made in spring 2009 over the South West of France. The performance of each, or of two combined approaches is analyzed with our database. We thus show that the kurtosis method is well adapted to pulsed RFI, whereas the method based on the second moment is well adapted to continuous-wave RFI. [C86]

"Estimation of wetland aboveground biomass based on SAR image: A case study of Honghe National Natural Reserve in Heilongjiang, China"

Wetland is a significant component of the land ecosystems to discover the characteristics and ecological laws. Presently, a common method to estimate a regional wetland biomass is normally based on optical remote sensing images. The estimation of wetland biomass by Synthesize Aperture Radar (SAR) is a novel subject. As a new type sensor, SAR has advantages for wetland applications, therefore, it can be apply for generating some important information about wetland ecology and hydrology, especially with the complex ecological habitat of the transitional place between land and water, radar images can be significant tool for wetland biomass estimation. In this paper, as a case study of SAR application on Honghe National Natural Reserve (HNNR), the wet weight and dry weight field data of 28 quadrats of diverse vegetation in a growing season from the study area in 2009 were gathered, the ASAR image was acquired at the same time with field work. The backscattering coefficient of polarimetric radar and wet weight and dry weight data was taken as correlation variable, the fitting equations of regression models and water cloud model were built to estimate the wet weight and dry weight, a validation was made from 9 measured plots. The research shows the estimation of the wetland biomass by SAR image can be a supplement to optical image with a scientific significance in ecology studying. [C87]

"Multitemporal polarimetric SAR data fusion for land cover mapping"

With the development of the polarimetric Synthetic Aperture Radar (SAR), the research on the land cover classification using SAR data has developed rapidly. But the classification accuracy is serious affected by the speckle noises on the SAR image. A new method which combines the advantages of multi temporal SAR data and quad-polarization SAR data was presented in this paper. A method of multitemporal SAR data fusion was used to eliminate the effect of the speckle noises on the SAR image. An area of 12 Ч 17 km was selected as test area. 6 multi temporal RADARSAT-2 images were used in this study to contact the land cover classification. The results show that different land cover type denote different backscattering mechanism and the backscattering coefficient value of different land cover type varies as function of time. Based on the fusion result of multi temporal polarimetric SAR data, the land cover classification was fulfilled and the results show this method can effectively distinguish the man-made buildings, forest, farm land and water. The speckle noise was obviously reduced and the visual appearance of the SAR fusion image well improved. [C88]

"Unsupervised classification for polarimetric Synthetic Aperture Radar image using the fuzzy possibilistic C-means clustering"

The polarimetric Synthetic Aperture Radar (POLSAR) image data has the problems of the noisy pixels and vague category boundaries because of its complex scattering mechanism and statistical property, which strongly influence the classification quality, while the fuzzy possibilistic C-means (FPCM) is robust in detecting the noisy pixels and modeling the uncertainty. Hence, we tried FPCM algorithm combined with the four scattering features (entropy (H), anisotropy (A), scattering angle (α) and total power (SPAN)) to classify the POLSAR data. The feasibility of this approach was tested on the JPL/AIRSAR POLSAR data, and the experiment result shows that the clustering algorithm can perform the classification more effectively in contrast to its counterparts FCM and PCM clustering algorithms. [C89]

"CAROLS campaigns 2009: First Results"

The CAROLS, L band radiometer, is built and designed as a copy of EMIRAD II radiometer of DTU team. It is a Correlation radiometer with direct sampling and fully polarimetric (i.e 4 Stockes). It will be used in conjunction with other airborne instruments (in particular the C-Band scatterometer (STORM) and IEEEC GPS system, Infrared CIMEL radiometer and one visible camera), in coordination with in situ field campaigns for SMOS CAL/VAL. The instruments are implemented on board the French research airplane ATR42. A scientific campaign with thirteen flights is realized over south-western France, Valencia site and Bay of Biscay (Atlantic Ocean) in spring 2009. In order to qualify the radiometer data, different types of aircraft movements were realized: circle flights, wing and nose wags. Simultaneously to flights, different ground measurements were made over continental surfaces and ocean. Results show a good quality of data. For continental surfaces, important Radio-Frequency Interferences (RFI) were observed over a large part of the studied region. [C90]

"Full polarimetric calibration of a GB-SAR system with a thin wire"

In this paper, we present the full polarimetric calibration of GB-SAR system with a thin wire whose orientation angle is 0 degree, 45 degree and 90 degree. At first we measured 0 degree, 45 degree and 90 degree inclined thin wire in order to derive calibration parameters. We also measured 30 degree and 60 degree wire in order to confirm this calibration method works well or not by using the estimated parameters. Calibration results of 30 and 60 degree wire cases are also described in this paper. [C91]

"Eigen decomposition parameter based forest mapping using Radarsat-2 PolSAR data"

In this paper, a set of polarimetric eigenvalue and eigenvector based parameters, e.g. entropy and anisotropy, are investigated for forest application. The correlation terms of the eigenvectors, μ1and μ2, are found to be better for forest mapping in both summer and winter using Radarsat-2 quad-polarimetric space borne SAR data. These are used to automatically identify forest class pixels from the volume scattering category of a Freeman-Durden Wishart unsupervised segmentation map. The algorithm scheme was developed and implemented using fully polarimetric Radarsat-2 SAR (PolSAR) data acquired in July and October and the validity was evaluated using the ground reference data created from SPOT5 K-clustering classification map. [C92]

"Polarimetric SAR tomography of natural environments using hybrid spectral estimators"

SAR tomography is the extension of conventional two dimensional SAR imaging principle to three dimensions. In order to improve the vertical resolution with respect to classical Fourier-based methods, high resolution approaches are used in this paper to perform SAR tomography. Both nonparametric spectral estimators, like beamforming and Capon and parametric ones, like MUSIC, maximum likelihood, are applied to real data sets and compared in terms of scatterer location accuracy and resolution. This paper addresses the discrimination of coherent scatterers presented in the natural environment and a joint approach of estimation and detection is

proposed. [C93]

"Polarimetric decomposition for forest biomass retrieval"

In this paper, the decomposition of fully polarimetric SAR data into three canonical scattering mechanisms is investigated with respect to forest biomass retrieval. It is demonstrated that the dominant backscattering contribution depends strongly on the frequency, incidence angle, and stand condition. The relation between in-situ biomass measurements and the individual decomposition components is examined. [C94]

"Quasar SBK accurate internal calibration"

A new compact fully polarimetric Ku band SAR system (SBK) is being developed by INTA radar Laboratory as an advanced payload for QUASAR project, which involves INTA new SAR developments for small platforms and UAV's. As an operative system, SBK shall allow precise calibration of the obtained data in order to achieve high products quality. The present paper shows SBK internal calibration concept focusing on internal calibration facility description, on ground characterization task overview and in flight calibration method. Furthermore, internal calibration accuracy estimation based on first prototypes measurements is also presented. [C95]

"Extraction of typhoon-damaged forests from multi-temporal high-resolution polarimetric SAR images"

The purpose of this study is to extract the forests destroyed by typhoons and to quantitatively estimate the damage levels by using high-resolution polarimetric synthetic aperture radar (SAR) data. The study area is located in Tomakomai, Hokkaido, Japan. Two sets of data were acquired before and after the typhoon by the L-band airborne Pi-SAR (Polarimetric-interferometric SAR) with 3m Ч 3m resolution (4-look in azimuth direction). It was found that the values of RCS (Radar Cross Section) averaged over the whole image after the typhoon damage changed by -0.47 dB, 0.05 dB, and 0.64 dB at HH-, HV-, and VV-polarization respectively in comparison with those before the damage. To fully utilize the data, a scattering model of the linear combination of the cross- and co-polarization RCS changes was developed to estimate the damage levels. Similar analytical approaches were also applied using the three-component decomposition analysis. The changes in RCS of double-, volume- and surfacescattering mechanisms after the damage were respectively 27.5 dB, -0.20 dB and -20.3 dB. Finally, by comparing the results with the ground survey data, the accuracies of 64.1% and 77.7% were obtained for the RCS and decomposition analyses respectively. [C96]

"Mean-shift and hierarchical clustering for textured polarimetric SAR image segmentation/classification"

Image segmentation and unsupervised classification are difficult problems. We propose to combine both. A clustering process is applied over segment mean values. Only large segments are considered. The clustering is composed of a mean-shift step and a hierarchical clustering step. The hierarchical grouping is based upon a powerful segmentation technique previously developed. The approach is applied on a 9-look polarimetric SAR image. Textured and non-textured image regions are considered. The K and Wishart distributions are used respectively. The unsupervised classification results can be very useful for image analysis and further supervised classification. The obtained region groups constitute an important simplification of the image. [C97]

"Maximum Likelihood texture tracking in highly heterogeneous PolSAR clutter"

This paper introduces a generalisation of the conventional Maximum Likelihood (ML) texture tracking algorithm in the context of highly heterogeneous PolSAR clutter. The statistical criterion is defined in both uncorrelated and correlated texture cases. Some results on simulated data are computed and an application on temperate glaciers velocity estimation is processed. Finally, some additional improvements are performed: an adaptative sliding windows is set and a basic Bayes inference for flow model constraint is added. [C98]

"A comparative study of polarimetric and non-polarimetric lidar in deciduous-coniferous tree classification"

As an important active remote sensing tool in forest remote sensing, lidar is able to provide information on tree height, canopy structure, aboveground biomass, among other parameters. It has become desirable to be able to classify tree species using lidar data during recent years. Research has been performed using commercial non-polarimetric lidar in tree species classification, at either dominant species level or individual tree level. The objective of this research is to classify deciduous and coniferous trees using the newly developed polarimetric lidar system. Lidar data from five different tree species were collected in the field. These included ponderosa

pine, Austrian pine, blue spruce, green ash and maple. Data were preprocessed and artificial neural network method was developed for classification. Data analysis demonstrated that the classification performance using polarimetric lidar data was far better than that using the non-polarimetric lidar data. [C99]

"Integrating object-oriented image analysis and decision tree algorithm for land use and land cover classification using RADARSAT-2 polarimetric SAR imagery"

Traditional pixel-based classification methods yield poor results when applied to SAR imagery because of the presence of speckle and limited information in backscatter coefficients. A novel classification method, integrating polarimetric target decomposition, object-oriented image analysis, and decision tree algorithms, is proposed for the classification of polarimetric SAR data (PolSAR). The polarimetric target decomposition is aimed at extracting physical information related to the scattering mechanism of targets for the classification of scattering data. The main purposes of the object-oriented image analysis are delineating objects and extracting various spatial and textural features. The decision tree algorithm provides an efficient way to select features and create a decision tree for the classification. A comparison between the proposed method and the Wishart supervised classification was made. The overall accuracies of these two methods were 89.34% and 79.36%, respectively. The results show that the proposed method is an effective method for the classification of PolSAR data. [C100]

"Polarimetric SAR estimation based on non-local means"

During the past few years, the non-local (NL)means have proved their efficiency for image denoising. This approach assumes there exist enough redundant patterns in images to be used for noise reduction. We suggest that the same assumption can be done for polarimetric synthetic aperture radar (PolSAR) images. In its original version, the NLmeans deal with additive white Gaussian noise, but several extensions have been proposed for non-Gaussian noise. This paper applies the methodology proposed in ato PolSAR data. The proposed filter seems to deal well with the statistical properties of speckle noise and themulti-dimensional nature of such data. Results are given on synthetic and L-Band E-SAR data to validate the proposed method. [C101]

"Towards fully automatic generation of land cover maps from polarimetric and metric-resolution SAR data"

Information mining from heavy SAR images is considered from the point of view of the procedure automatization. Two schemes based on Neural Networks are evaluated, one based on the Self Organizing Map method exploiting polarimetric information and oriented to land cover classification, the other based on the Pulse-Coupled Neural Networks aiming at characterizing the imaged buildings. [C102]

"Tropical land cover change detection with polarimetric SAR data"

There is an increasing need for fast and accurate data on tropical land cover status, and a baseline for land cover monitoring. Remotely sensed SAR data are not sensitive to cloud cover and can be useful for such purpose. Polarimetric SAR data are available in orbital systems, such as RADARSAT-2, and still have to be tested for the classification of tropical land cover and the detection of land cover change, particularly forest conversion. This work presents a study of RADARSAT-2 polarimetric images, acquired in two different dates (September 2008 and October 2009), to assess their potential in classifying forest and non-forest classes in Brazilian Amazonia. SAR images were acquired following different orbit and incidence angles, which anticipated varied conditions for images interpretation and classes discrimination. The complex SAR data were classified based on the distance of Wishart, and information from field campaigns was used for the training and test samples. Classification results were compared to evaluate possibilities for change detection in the forest cover. Classification accuracy figures were around 80%. The use of RADARSAT-2 images allowed the mapping of land cover and land cover change, considering forest and non-forest classes. [C103]

"Extension of the Target Scattering Vector Model to the bistatic case"

The polarimetric information has been widely used to interpret the Synthetic Aperture Radar (SAR) scene. Hence, many decompositions have been introduced to extract polarimetric parameters with a physical meaning. Nevertheless, for most of them, the reciprocity assumption is assumed. For a bistatic PolSAR sensor, the cross-polarization terms of the scattering matrix are not equal. This paper presents a generalization of the Target Scattering Vector Model (TSVM) to the bistatic case. [C104]

"Detecting depolarizing targets with satellite data: A new geometrical perturbation filter"

Target detectors using polarimetry are often focused on single (coherent) targets, since these are the ones that can be more simply characterized polarimetrically. The new proposed algorithm is aimed at the more difficult

problem of partial target detection (i.e. targets with any degree of polarization). A new feature vector is defined starting from the coherency matrix, and then a perturbation method is performed. Starting from the partial target detection, a novel classification algorithm is proposed. The validation is carried out against fully polarimetric satellite data. In particular, X band TerraSAR-X and L band ALOS PALSAR are employed, providing significant agreement with the expected results and the supervised Wishart classifier. [C105]

"Decomposition methods for the estimation of bare soil surface parameters using fully polarimetric SAR data 1"

This study wants to demonstrate that two different polarimetric target decomposition methods can improve SAR data accuracy for estimating the parameters of bare soil surface. To achieve this goal, two experiments are conducted: (1) both Freeman and Cloude decomposition methods are performed on JPL/AIRSAR L-band fully polarimetric data; and (2) Advanced Integral Equation Model (AIEM) is used to simulate backscatting coefficients. The root mean square errors (RMSEs) of σ0hh, σ0vvbetween original data and AIEM simulated data are 1.96 and 1.25 dB. However, if Cloude method is used to decompose original data, the RMSEs will be reduced to 1.45 and 1.14dB, respectively; for Freeman method, the RMSEs are 1.64 and 1.35 dB. Therefore, polarimetric target decomposition compensation, especially Cloude method, can help to improve the accuracy of SAR data for estimating the parameters of bare soil surface. [C106]

"Spaceborne P-band SAR for BIOMASS mission"

In the frame of the BIOMASS mission promoted by ESA for evaluating and monitoring Earth biomass, the expected performance of a P-band SAR instrument based on very large Direct Radiating Array antenna is addressed, as well as its architecture and the accommodation challenge on a platform. [C107]

"Ground topography estimation over forests considering Polarimetric SAR Interferometry"

The work detailed in this paper analyzes the topographic phase retrieval process on forested areas by means of Polarimetric Interferometric SAR data. On the basis of the Random Volume over Ground scattering model, an alternative implementation for the retrieval of the topographic phase, avoiding the bias introduced by the volumetric scattering components is presented. [C108]

"Peatland subsurface water flow monitoring using polarimetric L-band PALSAR"

The potential of L-band PALSAR for monitoring water flow beneath the peat surface is demonstrated on a bog near Lac Saint Pierre (Canada). Two polarimetric ALOS acquisitions collected at spring and fall under different water conditions are used. The Touzi decomposition, which was shown to be very promising for peatland characterization using the C-band Convair 580 SAR, is applied. Like in, the information provided by the multi-polarization (HH, HV, and VV), the scattering type magnitude (the Cloude α or the Touzi αs), the single scattering eigenvalues and the entropy, cannot detect the presence of water underneath the peat surface. The Touzi scattering phase is shown to be the only target scattering decomposition parameter that can detect water flow variations beneath the peat surface. The fall acquisition that took place after two days rain permits demonstrating that the wave can penetrate deep into the acrotelm layer to detect the rain water that has sinked rapidly into the peat layer of high hydraulic conductivity. The spring acquisition at dry conditions permits better discrimination of poor fen from bog. The wave, which cannot detect deep water flow in the bog sublayer of low hydraulic conductivity (the catotelm), is more sensitive to the shallower fen subsurface water and this makes possible the separation of poor fen from shrub bog. The requirement for polarimetric PALSAR acquisition during summer is brought out for more effective exploitation of PALSAR unique long wavelength penetration capabilities in monitoring arctic peatland transformations related to climate change stress. [C109]

"POLSAR image classification using BP neural network based on Quantum Clonal Evolutionary Algorithm"

POLSAR image classification plays an important role in remote sensing. POLSAR data are a type of mass data and have more independent features which can represent different physical significances than optical image. Therefore, POLSAR image classification is actually a high dimensional nonlinear mapping problem. Because of the nonlinear mapping function of BP neural network, it can be used to classify POLSAR image. But BP neural network classifier is sensitive to initial weights and thresholds. Quantum Clonal Evolutionary Algorithm (QCEA) can converge to an optimal value quickly and can be used to optimize the initial weights and thresholds of BP neural network. Therefore, in this paper, BP classifier based on QCEA was used for POLSAR image classification. Firstly, optimize the initial weights and thresholds of BP neural network using QCEA. Secondly, train the optimized BP neural network classifier by gradient descent algorithm. Finally, classify the POLSAR

image using the trained classifier. The validity test is demonstrated using Danish EMISAR L-band fully polarimetric data of Foulum Area (DK), Denmark. The preliminary result indicates that this method can classify most of the areas correctly. [C110]

"Ice sheet anisotropy measured with polarimetric ice sounding radar"

For polar ice sheets, valuable stress and strain information can be deduced from crystal orientation fabrics (COF) and their prevailing c-axis alignment. Polarimetric radio echo sounding is a promising technique to measure the anisotropic electromagnetic propagation and reflection properties associated with COFs. In this paper, fully polarimetric P-band data acquired with the airborne POLARIS system near the ice divide of the Greenland ice sheet are analyzed. Based on a simple electromagnetic model, these data are interpreted, and a pronounced birefringence is found. [C111]

"Filtering and segmentation of polarimetric SAR images with Binary Partition Trees"

A new multi-scale PolSAR data filtering technique, based on a Binary Partition Tree (BPT) representation of the data, is proposed. Different alternatives for the construction and the exploitation of the BPT for filtering and segmentation are presented. Results with simulated and experimental PolSAR data are presented to shown the capabilities of the BPT-filtering strategy to maintain both spatial details and the polarimetric information. [C112]

"Roll invariant target detection based on PolSAR clutter models"

Based on the Kennaugh-Huynen decomposition, the Target Scattering Vector Model (TSVM) allows to extract four roll-invariant parameters. Those parameters are necessary for an unambiguous description of the target scattering mechanism. The proposed method consists in applying the TSVM prior to the GLRT-LQ detector for the detection of any oriented target. [C113]

"Microwave backscatter of ship signatures on SAR imagery"

Speckle characteristics was analyzed by computing the ENL (Equivalent Number of Looks) for sub images of 30 by 30 pixels from four RADARSAT-2 dual polarization products, two single look complex (SLC) products acquired in wide swath single beam mode with dual polarization of HH+HV and two ScanSAR Wide (SCW) products acquired in ScanSAR Wide beam mode with dual polarization of HH+HV, which lie in the sea area around Iberian Peninsula. The speckle analysis indicates that ENL value combined with the intensity value of the SAR image should be a feasible short cut to find ship signatures out of SAR image. Based on the ENL analysis of speckle characteristics, a data set for ship signature has been derived, from which the ship signature was measured by polarimetric synthesis since the polarimetric SAR signature is an effective way of utilizing the amplitude and phase information to characterize the polarization properties of microwave backscatter. Driven by the need for a realistic microwave backscatter of ship signature model, the detailed behavior of a single ship in different polarizations and different incidence angles will be investigated by the Ray-Optical method which was developed by Burkholder et al. The purpose of this paper is to pave the way for a further improved scatter matrix model. [C114]

"Full polarimetric SAR classification based on Yamaguchi decomposition model and scattering parameters"

The full polarimetric information of the target from polarized Synthetic Aperture Radar (POLSAR) enables us to implement recognition and classification of remote sensing images more effectively. Based on the analysis of typical polarized target decomposition and classification, the issue proposes a new scheme for iterative classification of polarimetric SAR image, which blends the outcomes of Yamaguchi decomposition and H/α decomposition. This technique extracts four decomposition coefficients of four scattering mechanism components through Yamaguchi decomposition, the scattering entropy and angle through H/α decomposition first; then the initial classification of the POLSAR images is done by the combination of the 6 parameters mentioned above. The final result is obtained by iterative classification due to coherence scattering matrix following wishart distribution. The effectiveness of this method plus less computation required is demonstrated by the experimental results of polarimetric SAR data. [C115]

"A Hybrid Polarimetric Decomposition Method Based on Combination of Scattering-Model and Eigenvector-Decomposition"

Polarimetric decomposition methods are divided into two basic categories: Scattering-model based decomposition and eigenvector-based decomposition. The former has a clear physical meaning but may lead to negative power coefficient, while the latter is the opposite. So, a hybrid Polarimetric decomposition method

based on combination of these two methods is proposed, avoiding the negative power coefficient and retaining physical meaning to some extent. The preliminary results of the experiment confirmed that the proposed method is effective for analysis of polarimetric sar images. [C116]

"Feature evaluation and selection for polarimetric SAR image classification"

This paper presents an evaluation of different features for polarimetric SAR (PolSAR) image classification. Firstly, we select several of the polarimetric features to give a summary on them. Then we give an insight into their classification performance together with a texture feature using the support vector machine (SVM). Finally, we employ a feature combination and selection strategy that optimizes the trade-off between the feature dimension and precision. The experimental results on PolSAR data of the CETC38 demonstrate: i) the strategy works effectively in the reduction of redundant feature dimensions; ii) in comparison with the unselected feature, the classification performance and computation efficiency of the selected one are improved by this approach. [C117]

"Unsupervised classification of PolInSAR image based on Shannon Entropy Characterization"

In this paper, we propose a new method for unsupervised classification of polarimetric synthetic aperture radar interferometry (PolInSAR) images based on Shannon Entropy Characterization. Firstly, we use polarimetric H (entropy) and a parameters to classify the image initially. Then, we reclassify the image according to the span of Shannon Entropy Characterization. Finally, we fuse the results of the two previous steps and merge them to the specified number of clusters. The effectiveness of this method is demonstrated on CETC38 PolInSAR data and E-SAR PolInSAR data. [C118]

"Theory and simulation of statistical representation of the Stokes parameters in multilook fields based on polarization basis transformation"

A novel analytical representation of polarimetric Stokes parameters' distributions and their lower-order statistics are derived via the joint Wishart distribution of the covariance matrix of the stochastic multi-look speckle fields by using the polarization basis transformation. The last three Stokes parameters are expressed as a universal form by three parameters of the number samples, the degree of polarization and the polarization weight, which is an extension and generalization of R. Touzi and Y.Q. Jin by considering multiple look radar images, and can be used directly to describe the radiometric data in low resolution radar with polarimetric capabilities. The physical meanings of Stokes parameters via polarization basis transformation bring a short cut for solving the probability density function (PDF) of Stokes parameters. The simulated and experimental data are calculated to justify the expressions derived by us, which provide an excellent match with the novel representation. The conclusion can be useful to speckle reduced, classification and target recognition in complex environments or other applications. [C119]

"Adaptive polarimetric MIMO radar detection"

This paper mainly deals with the target detecting problem using polarimetric Multiple Input and Multiple Output (MIMO) radar with unknown covariance matrix. And the GLRT-based receiver is devised by resorting to the two-step design procedure. Specifically, the GLRT is devised with known covariance, and then, a suitable estimate of covariance is obtained using secondary data to plug into the derived test. The performance is assessed by several numerical examples, and the results show that polarimetric diversity can be exploited to enhance the performance of detection. Moreover, the adaptive loss is acceptable. [C120]

"Retrieval of oriented vegetation parameters based on experimental data of PolInSAR"

Polarimetric SAR interferometry (PolInSAR) can be used to inversion of vegetation parameters and a two-layer coherent scattering model composed of a random volume over the ground is applied usually. However, the propagation of the electromagnetic waves is anisotropic because the extinction coefficients are highly polarization dependent, the random model is inapplicable. In this paper, a new vegetation model composed of an oriented volume over the ground is employed and experimental data about the true scence can be gained through the microwave anechoic chamber. Finally, the oriented vegetation parameters are retrievaled by using three-stage method. [C121]

"Composite polarimetric scattering of cuboidal target on sea surface"

Composite polarimetric scattering of cuboidal target on sea rough surface are studied in this paper. A composite dihedral corner reflector (DCR) is formed by a sea rough surface and a vertical planar face of a cuboidal target on the sea surface. The polarimetric scattering from the composite DCR is divided into three main components which are direct scattering on the sea rough surface, double scattering on the sea surface from specular

reflection on the vertical planar face of the cuboid and double specular reflection on the vertical planar face from direct scattering field on the sea rough surface. A solution of dihedral polarimetric scattering between the sea surface and the planar face of the target is calculated through Kirchhoff approximation. Finally, the properties of the polarized radar cross-section (RCS) of the composite model are investigated and analyzed in different conditions. [C122]

"Parameters estimation of polarimetric Gp 0 distribution with MoLDC method"

Gp0distribution has recently been proposed as a good model for characterizing multilook polarimetric SAR images of different homogeneity. Nevertheless, parameters estimation has always been a problem that hinders its use in practical application. In this paper, we first describe the shortcomings of classical maximum likehood method(ML) and moment based method(MoM), then starting from the second kind statistics and Mellin transform, we derive a new and simple method to estimate parameters. Experiments on real SAR images demonstrate its validity and superiority over the ML and MoM methods. [C123]

"A novel polarimetric FM-CW radar system for laboratory remote sensing experiments"

With the advantage of compact, low cost and high resolution, the frequency-modulated continuous wave (FM-CW) radar equipped in airborne or unmanned aerial vehicles (UAVs) has been well applied to small-scale remote sensing measurements. To make laboratory experiment, our Key Laboratory of Wave Scattering and Remote Sensing Information (KLWSRSI) has developed a fully polarimetric FM-CW synthetic aperture radar (SAR) system. This system can be applied to analysis and demonstration of targets scattering mechanism and polarimetric radar imaging. [C124]

"Analyzing tomographic SAR data of a forest with respect to frequency, polarization, and focusing technique"

In this paper, two fully-polarimetric tomographic SAR data sets of a forested area, at L-band and P-band, are analyzed with respect to the localization of scattering sources and scattering mechanisms. In particular, the 3D SAR data is examined regarding the performance of three different tomographic focusing techniques multilook standard beamforming, robust Capon beamforming, and MUSIC, as well as for both, the two frequency bands and the different polarimetric channels. [C125]

"Spaceborne fully polarimetric time-series datasets for land cover analysis"

The objective of this paper is to make a review of the current status of the project entitled Evaluation of RADARSAT-2 quad-pol data for functional assessment of wetlands (Id6842), developed in the frame of the CSA-ESA SOAR-EU (Science and operational applications research for Europe) program by a consortium comprising I.E.T.R at the University of Rennes 1 and COSTEL-LETG at the University of Haute-Bretagne. The main objective of this project concerns in evaluating fully polarimetric RADARSAT-2 time-series datasets to delineate precisely effective and potential wetlands, map detailed vegetation distribution, identify agricultural practices and determine water cycle and waterlevels. [C126]

"Monitoring tree farms and coastal environments using RADARSAT-2 PolSAR data"

This paper addresses the feasibility of using RADARSAT-2 fine Quad-Pol mode to monitor coastal environment and young tree growth. It will be shown that interferometric coherence may not be high enough for the height estimation of young trees at C-band, but polarimetric sensitivity could be used for tree and crop classification. For coastal environment, we found that polarimetric signature of oyster farm reveals the effect of double bounce scattering and the orientation angle effects. [C127]

"Optimal parameter estimation in heterogeneous clutter for high resolution polarimetric SAR data"

This paper presents a new estimation scheme for optimally deriving clutter parameters with high resolution POLSAR data. The heterogeneous clutter in POLSAR data was described by the Spherically Invariant Random Vectors model. Three parameters were introduced for the high resolution POLSAR data clutter: the span, the normalized texture and the speckle normalized covariance matrix. The asymptotic distribution of the novel span estimator is also investigated. The proposed method is tested with airborne POLSAR images provided by the ONERA RAMSES system. [C128]

"Rotated dihedral and volume scattering behavior in cross-polarimetric SAR"

In this study we analyze Radarsat-2 quadruple polarization (quad-pol) mode data acquired over the Everglades

wetlands in south Florida. We analyzed the phase information of each polarization mode independently, and obtained similar fringe patterns representing water level changes in all four interferograms. It is surprising, because common scattering theories indicate that cross-polarization (cross-pol) observations reflect volume scattering due to the interaction of the radar signal with upper sections of the vegetation. However, our cross-pol interferometric observations suggest that the cross-pol signal reached the water surface and scattered back to the satellite by a rotated dihedral double bounce mechanism. Based on these new observations, we developed a new scattering formulation that accounts also for double bounce component in cross-pol. [C129]

"Target decomposition for fully polarimetric wideband radar system"

For fully polarimetric wideband radar system, a novel method of radar target recognition using polarimetric feature is proposed. First, polarimetric scattering matrix is obtained from fully polarimetric high resolution range profiles(HRRPs). Then, two different kinds of polarimetric features are extracted by polarimetric target decomposition theorem. At last, K-Nearest Neighbors(KNN) classifier is applied to verify the recognition performance of these two features. The simulation experiments indicate target recognition via polarimetric features can reach a higher recognition performance in different experimental scenarios. [C130]

"New approach for improving Mutual Information in POLSAR image registration"

Aiming at the problem that information source of similarity measure is limited to image intensity usually in multi-polarization SAR registration, we propose an improved Mutual Information(MI) based on the multiple correlation information between the same polarized channels (HH, VV) in multi-polarization SAR images. In this method, by analyzing the correlation characteristics of three polarized channels in multi-polarization SAR, and using channel correlation information extracted from polarimetric covariance matrix, we compute MI in multi-polarization SAR to improve the similarity measure. Finally, the simulation results show that, in the multi-polarization SAR image registration, similarity measure information sources affect the performance of similarity measure. We compare the similarity measures with different information sources in curve sharpness and noise immunity. The results prove that the measure based on the correlation of the same polarized channels for multi-polarization SAR performs excellently. [C131]

"New target detection method in strong active jamming background for polarimetric radar"

A new method of target detection for polarimetric radar in the presence of strong active jamming is proposed. Based on analysis of the polarization characterizations of the signals received by polarimetric radar, the target detection is achieved through testing on the polarization information. Comparing with the traditional method of target detection made in time-frequency domain, the detection performance of the new method is improved because the influence of the strong active jamming is avoided. The performance of the new method is analyzed by simulation. Its validity is verified through outdoor experiment carried out by X-band polarimetric radar. [C132]

"Oil spill detection from polarimetric SAR image"

A new combined feature is proposed based on polarimetric features extraction. Moreover, a new oil spills detection method is developed based on the combined feature and max entropy segmentation. The application to NASA/JPL SIR-C data shows that the new combined feature and detection method are effective to oil spills detection. [C133]

"Urban area extraction from Polarimetric SAR imagery using only positive samples"

In this paper, we present a study of extracting urban areas from Polarimetric Synthetic Aperture Radar (PolSAR) images using only positive samples. We solve this problem by learning a standard binary classifier (urban/non-urban) given an incomplete set of positive samples (urban) and a set of unlabeled samples (some of which are urban and some of which are non-urban) based on the work of Elkan and Noto. Our experiments on RADARSAT-2 fully PolSAR data show that learning with only positive samples can significantly reduces the manual work to select completed positive and negative samples that required by a traditional binary classifier, while providing satisfactory results. Meanwhile, multiple diverse features can be effectively combined for better extraction accuracy. [C134]

"Research of unsupervised image change detection algorithm based on 2-D histogram"

Change detection in images of a given scene acquired at different times is one of the most interesting topics of remote image processing. In this paper, a novel image change detection algorithm is proposed based on the clustering characteristic of 2-D histogram. First, the best segmentation direction of 2-D histogram is ascertained by using Fisher criterion. Secondly, a kind of new 2-D entropy is defined to search the best threshold and

segment the 2-D histogram into unchanged region and change region. Then the change area in different image is detected based on the change region of 2-D histogram. Finally, the proposed algorithm is compared to traditional algorithm. The theoretical analysis and experiment results confirm the effectiveness of the proposed means. [C135]

"Polarimetric and structural properties of forest scenarios as imaged by longer wavelength SARS"

SAR data gathered from forested areas collect contributions coming from the vegetation layer, from the ground below and from other scattering mechanisms (SMs). Multi-baseline data allow a tomographic analysis thus retrieving information about the vertical structure of the target. Multi-polarimetric acquisitions enrich the data, providing ways to identify the targets basing on their electromagnetic properties. The joint exploitation of multi-polarimetric and multi-baseline data suggests the possibility of linking the estimation of the vertical structure of different SMs with their polarimetric signature. A formal framework in which this task can be accomplished is provided by the Algebraic Synthesis (AS) technique, which extends the concepts within PolInSAR through the assumption of the Sum of Kronecker Products (SKP) structure. By assuming the presence of two SMs (for example ground and volume scattering), the SKP assumption leads to a cross dependence between the polarimetric and interferometric coherences, in that ground structure is shown to be related to volume polarimetry, and dually volume structure is shown to be related to ground polarimetry. The aim of this paper is to investigate the implications of this cross relation. Experimental results will be shown basing on a data-set of multi-polarimetric and multi-baseline SAR images at P-band acquired by DLR's E-SAR over the Krycklan catchment, in northern Sweden, in the framework of the ESA campaign BioSAR 2008. [C136]

"Comparison of crop classification capabilities of spaceborne multi-parameter SAR data"

With the arisen spaceborne multi-parameter Synthetic Aperture Radar (SAR) systems, such as Envisat ASAR, TerraSAR-X, ALOS PALSAR, and RADARSAT-2, the interest of crop mapping has been increasing. The present study compares the capabilities of the multi-parameter SAR in discriminating the main crop types by object-based classification in Haian county of Jiangsu province, South China. Two kinds of information, SAR intensity based and SAR statistical properties based are used for Maximum Likelihood Classification (MLC) and Minimum Distance Classification (MDC) respectively. The results show that, the L-band SAR can uniquely identify mulberry from dry-land crops, such as maize and vegetable and C-band SAR has some advantages in mapping rice. Specifically, the polarimetric RADARASAT-2 data can identify the rice with accuracy about 75% ~ 80% which is similar as the result from X-band TerraSAR-X Spotlight data but higher than that from C-band dual-polarization Envisat ASAR data. Nevertheless, both of X- and C-band can hardly separate the mulberry from the other dry-land crops. [C137]

"Multi-frequency and polarimetric measurements of bare and vegetated soils microwave reflection and emission by C- and Ku-band, combined scatterometer-radiometer systems"

In this paper the results of simultaneous and spatially coincident, multi-frequency, polarimetric, spatio-temporally collocated measurements of bare, dry vegetated and ash covered soils microwave reflective (radar backscattering coefficient) and emissive (brightness temperature) characteristics angular dependences at ~5.6GHz and ~15GHz are presented. During these experiments the observed area was set ablaze and multi-frequency, multi-polarization, microwave active and passive measurements at 300incidence angle were continued for smock, fire and ash situations. For these measurements C-, and Ku-band, polarimetric, combined scatterometric-radiometric systems were used, set jointly on a mobile buggy moving along the measuring platform. Structures, operational features and the main technical characteristics of the utilized systems are presented too. The paper has an aim as well to attract attention of interested researchers and to invite them to perform their own or joint researches using available devices and facilities. [C138]

"Evaluation of the self-consistency principle for calibration of the CASA radar network using properties of the observed medium"

The Center for Collaborative and Adaptive Sensing of the Atmosphere (CASA) has deployed a Distributive, Adaptive and Collaborative Sensing (DCAS) network of four radars in central Oklahoma. The radars operate at the X-band frequency and are capable of polarimetric and Doppler measurements. The radar network is being evaluated for Quantitative Precipitation Estimation (QPE). QPE algorithms based on radar power measurements (e.g. ZHand ZDR) require bias correction. The polarimetric self-consistency principle is applied to the CASA radar data to estimate any bias in ZH. Results show a ZHcalibration accuracy of 0.6 dBZ or less for two the analyzed events. ZHbias estimates from the self-consistency principle in rainfall are compared and validated with ZHbias estimated from the comparison of the X-band and the S-band radars' data. Comparison of the two approaches shows a difference in the ZHbias estimation of 0.61 dBZ or less and validates the use of the self-

consistency principle in rainfall for the absolute radar calibration of the CASA radars. [C139]

"Multi-frequency and polarimetric measurements of snow microwave reflection and emission by C- and Ku-band, combined scatterometer-radiometer systems"

In this paper the results of simultaneous and spatially coincident, dual-frequency (at C- and Ku-band), multi-polarization measurements will be represented, of bare soil and snow microwave reflective (radar backscattering coefficient) and emissive (brightness temperature) characteristics angular dependences at 5.6GHz and 15GHz. [C140]

"A fully polarimetric borehole radar based numerical modelling: Fully polarimetric response to synthetic fractures and "fluid substitution""

A fully polarimetric borehole radar system with four combinations of dipole and cylindrical slot antennas was developed to acquire fully polarimetric data sets in drilled boreholes. To better under the fully polarimetric response to subsurface fractures with different roughness, in this study, synthetic fractures with different roughness are generated on a computer via fractal theory based simulation techniques. Quantitative assessment for the roughness of synthetic fractures is possible by use of three main parameters: the fractal dimension, the rms roughness at a reference length, and a length scale describing the degree of mismatch between the two fracture surfaces, allowing future detailed study of mechanical and transport properties of fractures and fully polarimetric radar response on them. Next, a 3D sub-grid FDTD numerical simulation is used to synthesize fully polarimetric data sets with synthetic fractures as primary reflectors. Based on the synthetic data sets, it is possible to evaluate the applicability of different radar polarimetry analysis approaches to physical characterization of subsurface fractures in future. [C141]

"On the use of transponder measurements for high precision assessment and calibration of polarimetric Radarsat-2"

An independent assessment and calibration of polarimetric RADARSAT-2 (RS2) are conducted using transponder measurements extracted from uncalibrated data collected at various incidence angles between 20° and 40°. It is shown that RS2 antenna is highly isolated (better than -32 dB), and only crosschannel relative phase correction is required to provide calibrated data that meet comfortably the CEOS Cal-Val requirements. To take full advantage of the excellent RS2 performance in terms of low noise floor (-38 dB), transponder measurements are used for high precision assessment of RS2 calibration parameters. It is shown that the antenna cross-talks are stable with incidence angle, and only one transmitter-receiver distortion matrix is required for accurate calibration of the 20 modes of RS2 (Right looking) from 20° to 40°. A new method based on high precision transponder measurements is introduced for polarimetric RS2 calibration. Data collected at various incidence angles are used to validate the calibration. Transponder measurements using calibrated data indicate a residual cross-talk lower than -43 dB. The residual cross-channel error is lower than 0.3 dB in radiometry, and 5° in phase. [C142]

"Biomass retrieval based on UAVSAR polarimetric data"

Parameters of vegetation spatial structure have important effect on the carbon cycle and biodiversity of the ecosystems. How to estimate above-ground biomass is still a problem need to be worked out. In this paper we tried to use UAVSAR datasets to discuss the relation between backscattering coefficient and local incidence angle in different forest types. By the relation, a method based on scattering mechanism for correcting radiometric distortion caused by large range of incidence angle is developed. Biomass retrieval is based on incidence angle correction. The result shows good correlation between biomass and backscattering coefficient in 1 ha scale. [C143]

"Modeling attenuation of melting hydrometeors with a method based on volume integral equations"

The attenuation of spheroidal melting hydrometeors is simulated in C-, Ku- and Ka-band utilizing a microphysical melting layer model. The scattering properties are obtained with Mie scattering solution. In C-band the polarimetric radar parameters are computed utilizing a method based on volume integral equation. Polarization difference is detectable, but reflectivity values are regularly smaller than those calculated with Mie solution. This is dependent on the process of formatting the particle structure according to the change in liquid water mass fraction. [C144]

"Ship detection with RadarSat-2 Quad-Pol sar data using a notch filter based on perturbation analysis"

Target detection of marine feature is a major topic for the security and monitoring of coastlines. Synthetic Aperture Radar (SAR) has been shown to be particularly useful for this application because of its all-weather and night capability. In this paper a new ship and iceberg detection methodology is described. The algorithm proposed is based on a perturbation analysis in the target space recently developed and published by the authors, which was focused on land based target detection. The algorithm can be considered to be a negative filter focused on sea. Consequently, all the features which have a polarimetric behaviour different from the sea are detected. To demonstrate and validate the technique two RadarSat Fine Quad-Pol mode scenes were acquired off the south coast of the UK at Portsmouth harbour. An extensive ground truth campaign was also conducted that was coincident with these acquisitions. Portsmouth is one of the busiest harbours in the UK and this afforded the opportunity to capture a wide range of vessel sizes and types for analysis. [C145]

"Investigation of forest height retrieval using SRTM-DEM and ASTER-GDEM"

Interferometric SAR (InSAR)data have been used to measure canopy height. Polarimetric interferometric SAR (PolInSAR) data can be used to derive canopy height without using ground surface elevation data. But in most cases, only single polarization InSAR data are available and the elevation of ground surface in the forested areas is needed to get the height of the scattering phase center. On contrary, the elevation of canopy surface is relatively easy to obtain by Stereo imagery. In this study the feasibility of the estimation of forest height using SRTM-DEM and ASTER- GDEM was investigated. The ASTER-GDEM was firstly resampled to the pixel size of SRTM-DEM (3 arc-second) and then was registered to SRTM- DEM using the points selected from their aspect maps. The results showed that the registration is necessary because the geolocation error at east-west direction is about half of the pixel size. The relationship between the forest height and the elevation difference was analyzed. The results showed that the elevation difference between registered ASTER-GDEM and SRTM-DEM is positively correlated with the forest height. Although there are some problems when the terrain is rough, it provides us a way to estimate the height of mature forest in flat terrain. [C146]

"Preliminary result of polarization property analysis using fully polarimetric GB-SAR images"

Korea Institute of Geoscience and Mineral Resources (KIGAM) and Kangwon National University (KNU) ground-based synthetic aperture radar (GB-SAR) team has been developed a fully polarimetric and interferometric GB-SAR system over past several years. The objective of this paper is to investigate an application of the obtained fully polarimetric GB-SAR images and an effective polarimetric analysis method to extract polarization properties from different terrain targets as a preliminary study. We utilized an unsupervised classification method for analyzing of a fully polarimetric GB-SAR image, in particular, Cloude and Pottier's method and a combined H/A/α_ and the complex Wishart classifier method based on the H/A/α_ polarimetric decomposition theorem. [C147]

"Evaluation of two region based classifications in Tapajys National Forest using the ALOS/PALSAR polarimetric and interferometric coherences"

The use of phase information present in complex multi polarized images may increase the classification results. Thus, the coherence is one attribute that may be extracted from these images and used to distinguish some land cover classes. Therefore, its discriminatory capability for land use and land cover classification is analyzed. The analysis is based on the classification results of a region classifier, which needs a segmented image as one input. The influence of this kind of image input is also evaluated using of two segmentation algorithms, the SegSAR and the SPRING region growing. Two ALOS/PALSAR images acquired over Tapajos National Forest in the Brazilian Amazon were classified. The classifications were quantified by the overall accuracy, the kappa values and its variance. The classification improvement using the coherence information with intensity images was noticed for every image set. [C148]

"Topography effects on forest radar scattering, consequences on biomass retrieval"

Ground topography under vegetated area is liable to bring significant changes on radar backscattering and thereby on the associated standard retrieval algorithms dedicated to forest biomass. Within the framework of the ESA BIOMASS mission, this paper evinces the evolution of P-band polarimetric intensities with a tilted underlying ground. For that purpose, electromagnetic simulations have been achieved using our model MIPERS which theoretical specificities accounting for the topographic effects are herein described. Its originality lies mainly in the 3D characterization of the ground and the volume, as well as the coupling effects between both. This description is followed by a sensitivity analysis in order to further-on quantify the possible consequences on biomass retrieval, conducted with the two standard approaches, namely the P-HV intensity technique and the Pol-InSAR one assuming the RVoG model. This investigation have been also undertaken for a better understanding of experimental data, particularly with the BioSAR and the TropiSAR airborne campaigns over

boreal and tropical forests. [C149]

"Supporting precision agriculture with dual-polarimetric TerraSAR-X-yield prediction and identification of in-field variations to generate fertilizer prescription maps"

This paper presents studies carried out over 2 growing season in South Australia to evaluate the suitability of TerrSAR-X dual-polarimetric imagery for crop growth monitoring and yield prediction. End of season crops were observed in 2008 and significant correlation with yield was noted. Mid-season crops were observed in 2009 and due to the lower biomass no significant in field trends were observed in the SAR when compared with concurrently acquired ground NDVI sensor and multispectral optical data. Separability between different crop types is evident in both studies, but crop biomass has to be significant for any in-field variations to be apparent. [C150]

"Estimation of pasture biomass and soil-moisture using dual-polarimetric X and L band SAR-accuracy assessment with field data"

This paper presents the results of a study conducted to relate X and L band polarimetric SAR backscatter to pasture soil moisture and biomass as part of an environmental monitoring program. Extensive field data was collected concurrently with satellite SAR data acquisition-including dry/wet above ground biomass, soil moisture, surface roughness profiles and EM-38 electromagnetic sensor data. This data is used for both electromagnetically modeling the surface to work out the theoretical backscatter as well as empirical fitting regression models to the recorded SAR data and validation of existing inversion models. [C151]

"The Slope Imaging Multi-polarization Photon-counting Lidar: Development and performance results"

The Slope Imaging Multi-polarization Photon-counting Lidar is an airborne instrument developed to demonstrate laser altimetry measurement methods that will enable more efficient observations of topography and surface properties from space. The instrument was developed through the NASA Earth Science Technology Office Instrument Incubator Program with a focus on cryosphere remote sensing. The SIMPL transmitter is an 11 KHz, 1064 nm, plane-polarized micropulse laser transmitter that is frequency doubled to 532 nm and split into four push-broom beams. The receiver employs single-photon, polarimetric ranging at 532 and 1064 nm using Single Photon Counting Modules in order to achieve simultaneous sampling of surface elevation, slope, roughness and depolarizing scattering properties, the latter used to differentiate surface types. Data acquired over ice-covered Lake Erie in February, 2009 are documenting SIMPL's measurement performance and capabilities, demonstrating differentiation of open water and several ice cover types. ICESat-2 will employ several of the technologies advanced by SIMPL, including micropulse, single photon ranging in a multi-beam, push-broom configuration operating at 532 nm. [C152]

"A test statistic for high resolution polarimetric SAR data classification"

Modern SAR systems have high resolution which leads the backscattering clutter to be non-Gaussian. In order to properly classify images from these systems, a non-Gaussian noise model is considered: the SIRV model. A statistical test of equality of covariance matrices is used to classify pixels, taking into account the critical region of the test which rejects the likeliness of a covariance matrix to any of the class centers. This test is applied on experimental data obtained with the ONERA RAMSES system in X-band. The results show a good separation between natural and man-made areas of the image. [C153]

"Evaluation of the influence of the polarimetric calibration process on the H/A/alpha decomposition"

The objective of this article is to evaluate the influence of the cross-talk and channel imbalance calibration on the estimation of the entropy and the alpha images. Few studies can be found in SAR literature concerning the influence of the polarimetric image calibration process on the target decomposition methods and their consequences on the characterization and discrimination of different ground targets. This influence is illustrated here by using a methodology based on an L-band fully polarimetric SAR data acquired by the SIPAM (Amazon Protection System) airborne R99-SAR over two areas of study, located in the Brazilian Amazon Forest and urban area regions. [C154]

"Retrieval of raindrop shape-size relation using dual polarization radar measurements"

Dual polarization radar measurements of rainfall parameters are based on the assumption of a mean shape-size relationship of raindrops. This paper focuses on retrieving and interpreting the mean raindrop shape-size relation from polarimetric radar observations. A procedure to retrieve the drop shape-size relation that governs the

polarimetric radar observations of reflectivity (Zh) differential reflectivity (Zdr) and specific differential propagation phase (Kdp) is presented. The mean drop shape-size relations retrieved from measurements collected by the NCAR SPOL radar during three campaigns are analyzed to explore whether the natural raindrop shape-size relation can be described by a unique model. [C155]

"Assessment of compact polarimetry over different tropical environment and dataset"

This paper presents different radar polarimetric modes over different study sites in Tropical environment: Full polarimetry (FP), Dual Polarimetry (DP) and Compact Polarimetry (CP). By using SVM classification, we show the capabilities of each polarimetric mode linked to the scattering model assumption of the fully polarimetric reconstruction for CP mode proposed by Souyris et al.. We are focused on 3 study sites which have different landscape: Tubuai in French Polynesia (AIRSAR data), the Fazenda Saio Nicolau in Brazil and Cayenne in French Guyana (PALSAR data). It shown that the reflection symmetry assumption may not be verified due to spatial heterogeneity or due to the definition of the study classes. Even if the choice of the DP modes is strongly dependant of the study site, the CP mode have shown equivalent or better overall accuracy than the other DP modes, particularly when the study area are very homogeneous. [C156]

"An overview of recent advances in Polarimetric SAR information extraction: Algorithms and applications"

Recent advances in Polarimetric SAR information extractions are reviewed. Papers published in IEEE Transactions on Geoscience and Remote Sensing and IGARSS proceedings over the last five years were included. We found that PolSAR technology has reached a certain degree of maturity. The availability of high-resolution multi-frequency PolSAR data from space borne and airborne SAR systems will stimulate significant PolSAR applications. [C157]

"Application of aspect angle normalized polsar images for urban building detection"

Variation in the building aspect angle, defined as the angle between the flight direction of a satellite (azimuth direction) and the vertical wall of a building, is a significant cause of accuracy reduction in building detection and terrain classification from Polarimetric Synthetic Aperture POLSAR (POLSAR) images. However, the existing building detection methods usually are effective for the buildings with a limited aspect angle range. Considering the relationship between the aspect angle of the building and the orientation angle shift, an aspect angle normalization method is introduced to remove the disadvantageous influences caused by the aspect angle. From a comparison between the double-bounce building detection results of the original and aspect angle normalized RadarSat-2 data acquired in Beijing, China, buildings with any aspect angle can be detected effectively from aspect angle normalized data. [C158]

"Investigations on the full polarimetric PALSAR data to discriminate macrophytes species in the Amazon floodplain wetland"

The purpose of this work is to evaluate the capacity of full polarimetric L band data to discriminate macrophyte species in Amazon wetland. Fieldwork was carried out almost simultaneously to the acquisition of the full polarimetric PALSAR data. Coherent and incoherent attributes were extracted from the image, and macrophyte morphological variables were measured on the ground. The image attributes and the macrophyte variables were compared in order to evaluate their application for discriminating macrophytes species. The findings suggest that polarimetric information could be adopted to discriminate plant species based on morphology, and that estimation of plant biomass and productivity could be improved by using the polarimetric information. [C159]

"Estimation of sea ice concentration in the Sea of Okhotsk using PALSAR polarimetric data"

The objective of this research is mainly in estimating sea ice concentration from Phased-Array L-band SAR (PALSAR) polarimetric data. This paper shows the results of estimating sea ice concentration from PALSAR data acquired from 2008 to 2010. The AMSR-E sea ice concentration data are also used to verify the result of sea ice concentration derived from PALSAR data. The difference in two sea ice concentrations was found especially in AMSR-E low concentration area. The high resolution backscattering and scattering entropy images give us an idea that there is some difficulty in AMSR-E to detect thin sea ice in the Sea of Okhotsk. [C160]

"Recent advances in the development of the open source Toolbox for Polarimetric and Interferometric Polarimetric SAR Data Processing: The PolSARpro v4.1.5 Software"

The objective of this paper is to make a review of the current status of the PolSARpro v4.0 Software

(Polarimetric SAR Data Processing and Educational Toolbox), developed under contract to ESA. The objective of this current project is to provide Educational Software that offers a tool for self-education in the field of Polarimetric SAR data analysis at University level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. The PolSARpro v4.0 Software establishes a foundation for the exploitation of Polarimetric techniques for scientific developments and stimulates research and applications developments using PolSAR and PolInSAR data. [C161]

"Orthogonal polarimetric SAR processor based on signal and interference subspace models"

We develop a new SAR processor based on several orthogonal projections.We take into account the scattering properties of the target and the interferences by using subspace models. To detect the target without detecting the interferences, we process images from the orthogonal projection of the received signal into the target subspace and from the orthogonal projection of the received signal into a part of the interference subspace. We can combine these two images to firstly detect the target and to secondly reduce interference. This new SAR processor is applied to realistic simulated data for FoPen (Foliage Penetration) application. [C162]

"Random Forests for building detection in polarimetric SAR data"

Building detection from Synthetic Aperture Radar (SAR) images states a particular important as well as difficult problem. The high-resolution which is necessary to distinguish single buildings as well as the geometric and di-electric properties of dense urban areas cause most assumptions to fail, that are commonly made in SAR data analysis. This paper proposes the usage of Random Forests for building detection from high-resolution Polarimetric Synthetic Aperture Radar (PolSAR) imagery. Random Forests can handle high-dimensional input and therefore a large set of different features, they are known to lead to good classification performance in terms of robustness and accuracy, and are nevertheless seldomly applied to analysis of PolSAR images in general and building detection in particular. This paper presents first results of Random Forests when applied to a building detection task and shows their successful applicability. [C163]

"Characterization of volume scattering of dry sand at millimeter-wave frequencies"

Fully polarimetric measurements of volume scattering contribution from dry layer of fine sand with smooth air/sand interface were performed at millimeter-wave frequencies. The measured radar response was compared to predictions made by the numerical solution of the DMRT model. Sand particles were modeled as spherical particles. The simulated response was able to predict the angular dependence of the data but was not able to predict accurately the absolute level, especially for the cross-polarized return. Furthermore, a simpler model, which was developed earlier for asphalt surfaces and is based on 1storder solution of RT for semi-infinite medium, was tested against the measured data. The model was not able to predict the angular dependence demonstrated by the measured data. [C164]

"Statistical polarimetric radar detection of submerged obstacles via perturbed flows on the ocean surface"

The ability of microwave radar to detect and characterize obstacles below the sea surface is dependent on the extent to which perturbations of the surface geometry and dynamics resulting from either movement of the obstacle or disruption of waves and currents due to the presence of the obstacle can be discriminated from the natural state of the surface in the absence of such obstacles. In this paper we report recent results from a systematic investigation of the radar signatures of some classes of submerged obstacles and examine some of the practical issues which can arise in operational implementation of a sensing capability. [C165]

"An experiment for oil spill recognition using RADARSAT-2 image"

In this paper, an experiment that is oriented to discriminate between different oil slicks using polarimetric SAR image was introduced. Dark patches which often appear in SAR images such as biogenic slicks, atmospheric front, and crude oil with different chemical composition were identified according to the result of Eigenvector-Eigenvalue based Incoherent Target Decomposition. The experiment demonstrated that polarimetric SAR can be of great help in classifying of oil spills. [C166]

"Polarimetric and interferometric applications in a bistatic hybrid SAR mode using Terrasar-X"

A lot of bistatic experiments have recently been performed by different researchers to show the differences between monostatic and bistatic SAR. The acquired data was needed to verify the developed bistatic processing algorithms. To extend the conventional bistatic SAR experiments, we investigated whether bistatic systems can

be used in the field of bistatic interferometry and polarimetry, also shown by [3]. For this purpose we have used our stationary receiver system together with TerraSAR-X as transmitting satellite. This paper describes the experiments and shows some results we obtained using single and repeat pass SAR configurations. [C167]

"Forest parameter retrieval from SAR data using an estimation algorithm applied to regrowing forest stands in Queensland, Australia"

The use of a non-linear estimation algorithm for retrieving the biomass and structure of vegetation from polarimetric Synthetic Aperture Radar (SAR) data is demonstrated for woody regrowth in Queensland, Australia dominated by Acacia harpophylla (Brigalow). By varying the size and density of trees and associated woody components (branches and trunks), multiple simulations of the backscattering coefficient (σ0) were performed based on the SAR simulation model of. Functions relating σ0to these variables were subsequently used to generate spatial estimates from NASA JPL airborne SAR (AIRSAR) data. Above ground biomass was estimated from stem density and size measurements using available allometric relationships. The study demonstrates potential for retrieval of regrowth structure and biomass through nonlinear estimation. [C168]

"Unsupervised nonparametric classification of polarimetric SAR data using the K-nearest neighbor graph"

Polarimetric SAR classifications are often based on assumptions about the shape of clusters in the data space. Such a scheme will fail for nonlinear structures in the feature space, unless the classification algorithm has the capacity to describe cluster shapes in sufficient generality. Existing polarimetric SAR classification methods are faced by this exact problem: typically they initialize clusters in the Cloude-Pottier parameter space [1], further optimizing them in the coherency matrix space [2, 3]. Methods using K-means [2] or agglomeration [3] require clusters that are spherical, or compact and well separated, respectively. In the Cloude-Pottier space, these requirements are not met, so initialization in the Cloude-Pottier space cannot be consistent with optimization by K-means or agglomeration. This paper sets out to address this problem, by implementing a new data-driven clustering approach, for arbitrarily shaped clusters. It is applied to quad-polarisation data, demonstrating the new methodology's potential for forest land-cover type discrimination. [C169]

"Combined active and passive measurements of snow, bare and vegetated soils microwave reflective and emissive characteristics by Ka-band, combined scatterometer-radiometer system"

In this paper the results spatio-temporally collocated measurements of bare, dry vegetated and ash covered soils microwave reflective (radar backscattering coefficient) and emissive (brightness temperature) characteristics angular dependences at ~37GHz are presented. During the experiment with dry vegetated soil the observed area was set ablaze and microwave active and passive measurements at 300incidence angle were continued for smock, fire and ash situations. For these measurements Ka-band, polarimetric, combined scatterometric-radiometric system was used, set on a mobile buggy moving along the measuring platform. Structures, operational features and the main technical characteristics of the used system are presented too. The paper has an aim as well to attract attention of interested researchers and to invite them to perform their own or joint researches using available devices and facilities. [C170]

"An improvement for the unsupervised Wishart Freeman classification with fully polarimetric SAR data"

In this paper, we proposed an improvement for the Wishart Freeman classification, which is based on the Wishart distance measurement and the estimation algorithm of the number of clusters for fully polarimetric SAR data. Our experimental results show the effectiveness of the proposed method. [C171]

"Estimation of the degree of polarization in dual-polarized SAR imagery"

Analysis of dual-polarized SAR imagery has gained new importance with the recent launches of ALOS PALSAR, RADARSAT-2, and TerraSAR-X polarimetric SAR systems. Information contained in polarimetric images, collected by these SAR systems, can be characterized by a scalar parameter called the degree of polarization. This parameter has long been recognized as one of the most important parameters characterizing a partially polarized electromagnetic wave. In this paper, we provide maximum likelihood and moment-based estimators of the degree of polarization in dual-polarized SAR imagery. We evaluate and compare the performance of these estimators on RADARSAT-2 polarimetric data, over various terrain types such as urban, vegetation, and ocean. [C172]

"Rain effect on polarimetric SAR observation"

The purpose of this paper is to consider the radio wave propagation of Polarimetric SAR in rain and to verify the influence of rain quantitatively. We assume the Polarimetric SAR observation model in non-spherical rain drop environments and evaluate the influence of rain at 5.405, 9.65 and 13.9GHz by calculating the rain distortion matrix with parameters of rainfall rate and the rain drop canting angle. The results show that the rain attenuation, the attenuation difference between horizontal and vertical polarization, and the cross-polarization factor increase as the frequency and rainfall rate increase, and they depend on the rain drop canting angle and the incident angle. [C173]

"Potential of mapping soil moisture by combining radar backscatter modeling and PolSAR decomposition"

The purpose of this study is to evaluate the capability of the Oh backscattering model in combination with the Freeman Durden decomposition to estimate soil moisture over agricultural fields from fully polarimetric RADARSAT-2 C-band SAR responses. Initially, soil moisture multi-polarization retrieval was accomplished by using a look-up table (LUT) approach applied to the Oh model. Two methods were considered: the multi-polarization method and the one-unknown configuration. Of the two methods, results showed that the HH-HV inversion provided the best estimates. In the second phase, the Freeman Durden decomposition was applied to the polarimetric data. The conceptual approach for retrieving soil moisture using the surface scattering component of the total power was implemented in a LUT inversion. The algorithm attempts to minimize the difference between measured single scattering power obtained by applying the Freeman Durden decomposition and simulated total power using Oh model. When compared with the multi-polarization approach, this polarimetry-based method improves the accuracy of soil moisture estimates. [C174]

"Semantic segmentation of Polarimetric SAR imagery using Conditional Random Fields"

The paper proposes a fast and accurate semantic segmentation approach for a large Polarimetric SAR (PolSAR) image using Conditional Random Fields (CRFs). It efficiently incorporates the polarimetric signatures, texture and intensity features into a unite CRFs model, and employs a fast max-margin training method for parameters learning. Experiments on RadarSat-2 PolSAR data in Flevoland test site demonstrate that our approach achieves precise segmentation results with a few well-selected training samples. [C175]

"Electromagnetic characteristics of simple targets embedded in chiral multilayer structures"

The scattering properties of a chiral stratified multilayer structure having an printed planar electric dipole are addressed in this paper. In order to obtain the scattered fields the method of moments in spectral domain is applied. The dipole scattering is characterized by the radar cross section (RCS), the polarimetric response, the α-angle from Cloude-Pottier's target decomposition theorem and the directivity function. The results point out that all parameters are sensible to variations on the chiral layer admittance. The chiral layer impinges a rotation on the polarization plane of linearly incident wave for all frequency analyzed. [C176]

"Monitoring grasslands with radarsat 2 quad-pol imagery"

Radarsat 2 quad polarization imagery has been used to study the effectiveness of polarimetric radar to monitor the extent and health of prairie grasslands in southern Alberta, Canada. In this report of preliminary findings, the imagery is shown to be effective in the separation of cropped lands from rangelands, and in the separation of native grasslands and improved pastures. Classification was more accurate using Freeman-Durden decomposition parameters than using Cloude-Pottier parameters. Incidence angle differeces were noted and use of multiple angles in classification improved accuracy. In a second part of the study, it was shown that polarimetric imagery was capable of identifying weeds and brush growing in native rangland, and in separating different kinds of brush and weeds. Validated sample sets were too small to allow proper accuracy assessment, but a `performance metric' showed that accuracy would be improved by use of multiple incidence angles, and by the use of Freeman-Durden or coherency matrix parameters. [C177]

"Evaluation of system polarization quality for polarimetric SAR imagery and target decomposition"

The quality of polarimetric synthetic aperture radar (PolSAR) imagery and its polarimetric decompositions depends on the accuracy of polarimetric observations of the SAR system and its calibration. Polarization distortions on the polarimetric measurement can be incurred due to nonideal system polarization quality and propagation factors, such as channel imbalance, cross-talk, and Faraday rotation at lower frequencies. All these distortions have varying impacts on different target types as well as different decomposition methods. In this paper, we assess the polarization quality of the PolSAR system in the context of polarimetric imagery analysis and quantify the various effects of polarization distortions on polarization target decompositions. A generic metric

is defined to measure the polarization purity of the system. Considering the fact that target decomposition plays an important role in imagery analysis, we apply several widely used decomposition methods to showcase the polarimetric system requirement based on the defined metric. [C178]

"A modified wind vector retrieval algorithm for polarimetric scatterometer"

Experiments and theoretical analysis demonstrate that the polarimetric scatterometer has the potential in enhancing the accuracy of the wind vector retrieval. However, currently, there is no special wind vector retrieval algorithm for the polarimetric scatterometer. Based on the distribution characteristic of the objective function, a modified wind vector retrieval algorithm was designed for the conically scanning polarimetric scatterometer in this paper. Simulation experiments indicated that this algorithm could further improve the retrieval precision of the polarimetric scatterometer in comparison with the traditional algorithm, especially in the nadir- and outer-swath. By extending the wind direction range for the first and second ambiguity in the nadir- and outer-swath, the algorithm can effectively reduce the uncertainty of the wind direction solutions with error magnitude of 0° to 15°. Up to 2° improvement in wind direction retrieval can be achieved in the nadir track. [C179]

"A hybrid manmade-target detection algorithm for polarimetric sar images"

This paper proposes a hybrid target detection algorithm for polarimetric Synthetic Aperture Radar (SAR). The proposed algorithm includes three parts: Span Detector (SD), Polarimetric Whitening Filter Detector (PWF) and Optimal Polarimetric Detector (OPD). The detection output of SD is used to optimize the input of PWF, and the detection output of PWF is used to optimize the input of OPD. The iteration is also employed in the proposed method. A new criterion is presented to compare the performances of different polarimetric target detection algorithms. According to the new criterion, different detection algorithms will select the same number of pixels as their detection results. Experimental results demonstrate that the performance of the proposed algorithm is better than other algorithms, and the new criterion is more appropriate for the comparison of different polarimetric target-detection algorithms. [C180]

"Research on transition matrix between non-standard polarization base defined by a polarimetric radar and H/V polarization base"

Transition matrix between non-standard polarization base defined by a kind of variable-polarization radar and standard orthogonal polarization base is deduced. The electric field with expected polarization can be synthesized in space by multi-polarimetric millimetre wave array antenna. The transition matrix established the relation between amplitude and phase of feed of every subarray and the expected-polarization electric field in far zone. The transition matrix can be regarded as algorithmic support for variable-polarization radar to realize virtual polarization synthesis and polarization agility. Finally, the algorithm is proved right and useful by presenting simulation results of far zone electric field of 3-element and 5-element radar array antenna. [C181]

"Ultra wideband impulse radar calibration"

Sensing and locating with Ultra Wideband is a quickly evolving technology in automation and disaster monitoring. Features are the high resolution, extremely fast measurements and the moderate cost. For target and object classification these UWB impulse Radars require a full polarimetric calibration. Only by this, the correct target features can be assigned. A complete mathematical description by scattering and transfer matrices is derived. Proper calibration targets and procedures are discussed and evaluated. [C182]

"Instantaneous polarimetric radar PSM measurement for moving target"

This paper proposes the instantaneous polarization radar measurement method of the PSM (polarimetric scattering matrix) using the up and down chirps for the motive target with a uniform acceleration; it defines a new ambiguity function matrix considering Doppler frequency shift and acceleration in order to get the PSM of target. This paper also gives the signal processing and the expression of the PSM for a target moving at a uniform acceleration. The simulation results of missile-defence radar prove the feasibility of the presented method, which enhances the precision in measurement of the PSM compared to the traditional method. [C183]

"Interferometric phase compensation using coherence for vegetation areas in PolInSAR"

Acquiring accurately interferometric phase information of the polarimetric interferometry SAR (PolInSAR) is the key of precisely parameters inversion of ground features. However due to the scattering complexity and the attenuation of electromagnetic waves in the canopy of vegetation, measurement interferometric phase of vegetation layer is often lower than the true phase corresponding to vegetation height. And a large number of random phase errors are produced at the same time. Based on properties of PolInSAR coherent coefficient, we

present a method of phase compensation to the measurement interferometric phase in PolInSAR using coherent coefficient of polarization assortment which is corresponding to the most vegetation-sensitive scattering. The method succeeds reducing interferometric phase error which is brought by the vegetation layer attenuation. Finally, through experimental data, interferometric phase after compensation using the presented method is closer to true phase of the vegetation real height than the measurement phase, and the validity of the method is verified. [C184]

"The automatic judgment for SAR change detection"

An automatic judgment algorithm based on the autocorrelation coefficient is proposed to solve the problem of targets' arrival or departure after change detection. By building probability distribution model of the polarization vectors in the two SAR images, estimating the autocorrelation coefficient of the current and neighboring sliding window in the extent around change part respectively. Comparing the coherence property, we can distinguish the arrival or departure of the change. Comparing to current algorithm based on the covariance, the algorithm in this paper exploits the autocorrelation coefficient to indicate the coherence property. This algorithm improves the accuracy and robustness of distinguish the arrival or departure. At last, by simulating, we proved the validity of this algorithm. [C185]

"Unsupervised classification of PolSAR data using Freeman decomposition and fuzzy clustering"

An unsupervised classification method using Freeman decomposition and fuzzy clustering is proposed to solve the ambiguity problem among surface, volume and double-bounce scattering dominated region. A fuzzy clustering method of PolSAR data making use of scattering power entropy and anisotropy parameters is proposed to partition different scattering mechanisms dominated region. The proposed method is applied to full polarimetric synthetic aperture radar data of Oberpfaffenhofen acquired by ESAR. Experiment result confirms the validity of this method. [C186]

"A novel method for ship detection in polarimetric SAR images using gopce"

In this paper, a novel method for ship detection in fully polarimetric SAR images is developed. This method employs the Generalized Optimization of Polarimetric Contrast Enhancement (GOPCE) to maximize the target-to-clutter ratio in an image. For comparison, the traditional OPCE, Polarimetric Matched Filter (PMF) and Polarimetric Whitening Filter (PWF) are also used. Experiments results of the NASA/JPL AIRSAR C-Band image over Sydney Coast show that the proposed method has a considerably improvement as to enlarge the separation of ships and sea clutter, demonstrating a robust detection performance. [C187]

"A polarization reconfigureable microstrip antenna used in polarimetric radar"

A polarization reconfigurable antenna used in polarimetric radar was studied in this paper. The millimeter microstrip polarization reconfigurable antenna is based on multi-polarized subarrays which has relatively simple feed system. The polarization of far field electric field can be reconfigured by amplitudes and phases of the feeds. Far field electric field with P subarrays based on rectangular patch was first analyzed. Then the simulation results of the polarization reconfigurable antenna with four subarrays were presented. The measuring results were shown finally. The cross polarization in 4 degree beam width is less than −15dB. [C188]

"Study on Polarimetric measurement and radar target identification in instantaneous polarization radar system"

Instantaneous polarization radar can obtain radar target polarization scattering matrix (PSM) by taking advantage of single pulse echo signal. The Polarimetric measurement properties and weak target detection of this system is verified by external field experiment. The actual measured data is used to target classification by applying polarization statistical properties and transformation of target polarization scattering matrix or decomposition. Two different radar target identification subject to its polarization properties has been demonstrates the effectiveness of using Polarimetric data and motivates the use of polarimetry for target detection in clutter and interference environment. The back-scattering power and optimized transmission polarization of the system is also involved. [C189]

"Segmentation of dual polarized SAR imagery of the west of China based on evidence theory"

Most areas in the west of China are mountains covered by cloud and mist all the year. Therefore mapping by negative remote sensing could not satisfy the requirements of thematic map. SAR is an alternative approach. Among single, dual and quad polarized imagery, dual polarized one is a compromised choice taking cost and information into account. A new algorithm based on the theory of evidence for dual polarized SAR images of

west China is proposed in this paper. Firstly we get a single channel image from original dataset by PWF (Polarimetric whiten filter), and then over-segment the image. Secondly the borderlines of each segment are adjusted by fusing two evidences, pixels' values and the values of their neighbourhood by applying evidence theory. Finally initial segments are merged based on evidence combination. In this paper, not only each channel but also the mean of neighbour areas is considered as a piece of evidence. In order to eliminate the factor of hypsography, the ratio of different polarization was added as a new piece of evidence. The experimental results of dual-polarimetric SAR images in Hengduan Mountain of West China show that the proposed algorithm performs better than traditional algorithm when noise rich images are processed because it is less sensitive to speckle noise so edge information is better reserved and it reduce the influence of hypsography. [C190]

"Unsupervised segmentation of polarimetric synthetic aperture radar data by Markov random field"

An unsupervised segmentation method of polarimetric synthetic aperture radar (POLSAR) data is proposed in this paper. Firstly, this method performs initial classification of the POLSAR data based on polarimetric target decomposition. Then a model for the conditional distribution of the polarimetric coherency matrix is combined with a Markov random field (MRF) representation for the distribution of the region label to obtain the posterior distribution. Finally, iterated conditional modes (ICM) method is used to obtain the final segmentation results. A new MRF model with variable parameter is used in this method. Experiment results indicate that the proposed method achieves improvement over standard MRF method. [C191]

"Preliminary evaluation of Radarsat-2 polarimetric SAR data for forest applications"

Radarsat-2 polarimetric SAR data for Natural Resources Canada became available in May, 2008. In this paper we evaluate analysis methods and investigate potential forest applications with Radarsat-2 polarimetric SAR data. The Radarsat-2 Fine Quad-polarization data were studied and the Cloude H/A/Alpha and Freeman three-component decompositions were performed. We found that Radarsat-2 FQ data has a Faraday rotation angle estimated at less than 0.01 degree. The georeferencing information embedded in the FQ metadata file provided good pixel positioning accuracy. However, polarization orientation shifts introduced by terrain topography slopes in azimuth direction were difficult to be sensed. Various polarimetric parameterizations of Radarsat-2 FQ data are useful for identifying different landcover types and detecting changes in forested areas. The Cloude entropy, dominant scattering alpha and eigenvalues (λ2+λ3) were used to create a HSV coding image for better differentiation of water surface, vegetation and forest and to reduce topographic effects. Multitemporal time series of the Freeman decompositions showed that the volume and double bounce scattering were as expected. The surface scattering was seen to be stronger in winter than in summer. [C192]

"A new edge detection method of polarimetric SAR images using the curvelet transform and the Duda operator"

A new method for edge detection of polarimetric SAR images is proposed based on the curvelet transform and the Duda operator in this paper. The detection of edge features from SAR images is complicated by the presence of speckle. Firstly, a despeckled polarimetric SAR image is derived by the Polarimetric Whitening Filter (PWF), and then the image is filtered by Lee's method with eight edge-aligned windows to preserve the edge sharpness. The curvelet transform which is a multi-scale representation suited for edge enhancement is applied to estimate the area including edges approximately. Then the Duda operator, a contrast ratio edge detector to extract linear features, is used to give the positions of the edges precisely. The proposed method is applied to PISAR images to illustrate its effectiveness. [C193]

"Application of C-band polarimetric radar on rainfall-type classification"

The rainfall-type classification method which gives a judgment of the presence of the melting layer in addition to a conventional convective-stratiform classification was developed using a C-band polarimetric radar. The convective-stratiform separation was conducted based on the horizontal Zhhfield. The melting layer was detected using the vertical profile of rhohv. Four rainfall types are identified by a combination of these two classifications: 1) convective rainfall with melting layer, 2) convective rainfall with no melting layer, 3) stratiform rainfall with melting layer, and 4) stratiform rainfall with no melting layer. [C194]

"Polarimetric radar perforamnce test of signal processing for anti-active jamming"

A test system using Virtual Polarization Adaptation (VPA) technique to simulate the target return signals of variable-polarization radar is studied in this paper. This test system can be used to testify the performance of polarimetric radar signal processing and evaluate the effectiveness of polarization agile jammers. Several issues about typical polarization agile jammers are discussed along with their suppression methods. [C195]

"Limitations in the polarization orientation shift estimation using L band POLSAR data"

This paper considers the problems of topography polarization orientation angle (POA) shift estimation. The shift value accuracy is influenced heavily by both sparse and thick canopy for L band POLSAR data. Topography-POA shift model limitation makes the algorithm performance poor over forested area. The AIRSAR and ESAR L band polarimetric SAR images used in this paper are typical examples as non-vegetated and vegetated terrain. Otherwise, the polarimetric calibration accuracy requirements for this application are also discussed. This is an attempt at analyzing the impacts of miscalibration on topography POA shift estimation accuracy. [C196]

"Agricultural performance monitoring with dualpolarimetric TerraSAR-X imagery"

This paper presents an experiment for yield prediction using TerraSAR-X dual-polarimetric mode and precision agriculture machinery which records harvested amounts every few meters. The experimental field setup and data collection using TerraSAR-X are discussed and some preliminary results are shown. [C197]

"Analyzing the impact of polarisation angles on the PolInSAR coherence"

By setting the polarisation angles different values, we can obtain the coherence maps and interferometric phase maps in arbitrary polarisation states using the coherence synthesis techniques. We also analyze the different polarisation-angles-sensitivity of different scatters. According to the experimental results and analysis, the change of coherence maps indicates the change of polarisation angle. The difference of the change manifests the different sensitivity to the angles. Scatters with different sensitivity can be distinguished from surrounding areas. The experiment results show that the volume scattering area and the surface scattering area are similarly dark in HV-HV and XY-XY coherence maps. However, surface scatters are more sensitive to the change of the angles than the volume scattering. That is to say, the volume scattering and the surface scattering mechanism can be distinguished. It's promising to use the method in this paper for classification. [C198]

"Dual-polarized antenna based on MEMS technology for terahertz polarimetric radar"

Planar integrated antenna has special advantages in Terahertz application, but with disadvantage of low gain. In this paper, a novel Terahertz integrated dual-polarized horn antenna at 900 GHz is proposed which can be used in a Terahertz polarimetric radar system. The processing of this type horn antenna combine two kind MEMS techniques, DRIE etch and wet etch. The structure of the horn include two parts, pyramid horn back cavity and octagonal horn front cavity. There are many tunable parameters of the horn. FEM method is used to analyze it, this new type integrated horn antenna can improve the radiate performance of planar integrated dual-polarized antenna elements. [C199]

"Investigation of the scattering intensity parameters and the hue-saturation based color space models used in the Cloude-Pottier decomposition method"

In this paper, different scattering feature parameters anisotropy, span, I, λ1are investigated and compared. Besides, different colour space models HSI, HSV, HSL, and IHSL are compared in the visualization of the results of Cloude-Pottier target decomposition. The merits and demerits of each scattering feature parameter and each colour space model are discussed, which provides useful help to the improvement of the Cloude-Pottier decomposition method. [C200]

"Two-stage sequence classification of PolInSAR imagery"

In this paper, we present a two-stage scheme for supervised classification of polarimetric interferometric synthetic aperture radar (PolInSAR) imagery. In the first stage, a regularized logistic regression classifier is employed to generate probability vectors of object labels with polarimetric and interferometric features, respectively. The soft outputs (probability map) of previous logistic classifier with different features are concatenated as the input features of the second stage classifier-SVM classifier, which provides the final classification. We compare the two-stage methods against the baseline method and show its effectiveness. [C201]

"The Chaotic Neural Network is Used to Predict the Sea Clutter Signal"

The study includes the correlation dimension and the largest Lyapunov exponent of sea clutter based on real radar data obtained with IPIX X-band polarimetric coherent radar, which proved that sea clutter has chaotic characteristics. A method of prediction about sea clutter signal based on chaotic neural network and theory of phase-space reconstruction is established, which has a in-depth analysis of the chaotic neural network and modulates the network parameters to improve the convergence rate of the network. The numerical results of

prediction model demonstrate that chaotic neural network is better than traditional methods. [C202]

"An improved correlation method of phase difference detection between two signals in polarimetric radar signal processing system"

In this paper, an improved correlation method is proposed to detect the phase difference between two signals in high frequency in a polarimetric radar system. The mean value of the correlation of two sampled signals is calculated based on field programmable gate array (FPGA) to give a more accurate result of the detection. The method is simulated in SimulinkГ‚В®, and the blocks are then converted into a Quartus II project and compiled to show the occupied resources. The basic principle of the method is described in detail and the results of the simulation provide some evidences that the method can be applied in the radar system for real time processing. Some notes are also given to improve the performance in practical applications. [C203]

"C-Band multi-polarimetric SAR and the flight experiment of land and sea"

The C-Band multi-polarization SAR system has a wide range of applications in the earth observation field, and it can be applied to ocean observing, crop monitoring, mapping and other fields. The application flight experiment is introduced, and some SAR image, inversion results of land, sea are presented. [C204]

"Detection of ships using sub-aperture airborne PolSAR data"

The objective of this paper is to assess the sub-aperture analysis for ship detection using airborne polarimetric SAR data. Three optimal non-normalized coherences can be obtained by tuning the polarization status using the full polarimetric SAR data. These parameters are used to greatly improve the contrast between ships and ocean clutter, since it preserves the intensity and phase information of the coherent target. The airborne polarimetric SAR data is applied to evaluate the results of polarimetric sub-aperture detection for the ships over the ocean. In this way, the improvement in ship detection performance that is realized by using polarimetric information and coherence product is demonstrated in this paper. [C205]

"Design and simulation analysis of polarimetric interferometric synthetic aperture radar"

Polarimetric SAR interferometry (POLINSAR) is a very promising technique by combining polarimetric technique and interferometric technique. It can be applied to the area of remote sensing and measurement of structure over forest terrain. At present, many POLINSAR systems were developed, and the first POLINSAR prototype in China is also developed by 38thResearch Institute of CETC. Lots of data are acquired by these systems, so POLINSAR techniques have been studied as hot research topics in the area of SAR remote sensing in recent years. In this paper, we introduce design of the POLINSAR prototype and demonstration of system parameters, and we also study coherence and elevation precision by computer simulation. [C206]

"A polarimetric sea surface backscattering model"

An extended Bragg scattering model, for fully polarimetric SAR data, is here proposed for describing sea surface scattering. Moreover, the model is considered to examine the scattering contributions from sea surface and detected dark areas due to the presence of anthropogenic and biogenic slicks. Experiments are conducted on fully polarimetric C- and L-band SAR data. [C207]

"Hardware-accelerated edge detection for polarimetric synthetic aperture radar data"

From the literature review, there are two constant false alarm rate detectors for detecting edges in multi-look fully polarimetric synthetic aperture radar (POLSAR) imagery, namely the likelihood ratio edge detector and the Roy's largest eigenvalue-based edge detector. In the latter approach, one major restriction is the computation complexity, i.e. in the context of the chosen C language-based implementation. Thus, in this paper, a novel hardware-based architecture is presented to improve the processing time for the Roy's largest eigenvalue-based edge detection. The algorithm was implemented in a field-programmable gate array (FPGA) with an accelerated solution targeting data rates of up to 1 Gb/s. Its performance was examined using nine-look NASA/JPL C-band data and evaluated in terms of processing speed and accuracy as compared to the C language-based implementation on a personal computer (PC) with a CoreГ‚Вї 2 Duo processor clocked at 2.2 GHz. [C208]

"Golay complementary waveforms for sparse delay-Doppler radar imaging"

We present a new approach to radar imaging that exploits sparsity in the matched filter domain to enable high resolution imaging of targets in delay and Doppler. We show that the vector of radar cross-ambiguity values at any fixed test delay cell has a sparse representation in a Vandermonde frame that is obtained by discretizing the

Doppler axis. The expansion coefficients are given by the auto-correlation functions of the transmitted waveforms. We show that the orthogonal matching pursuit (OMP) algorithm can then be easily used to identify the locations of the radar targets in delay and Doppler. Unambiguous imaging in delay is enabled by alternating between a Golay pair of phase coded waveforms at the transmission to eliminate delay sidelobe effects. We then extend our work to multi-channel radar, by developing a sparse recovery approach for dually-polarimetric radar. We exploit sparsity in a bank of matched filters, each of which is matched to an entry of an Alamouti matrix of Golay waveforms to recover a co-polar or cross-polar polarization scattering component. [C209]

"Doppler-polarimetric radar system for recognition of distributed objects"

This paper considers Doppler-polarimetric radar methods in application to observing distributed targets. Examples of typical distributed targets are meteorological objects. For instance, among wide variety of meteorological objects, such targets as clouds with precipitation are considered. Developed mathematical models of Doppler-polarimetric reflections from distributed targets as rain and clouds are discussed. Phenomenological and mathematical aspects of the relationships between different Doppler-polarimetric measurable variables and parameters of the object under observation such as its microstructure and dynamic properties of scatterers inside the resolution volume are considered. Implementation of Doppler-polarimetric approach, which requires significant processing power, in reasonable devices is considered. [C210]

"Recent advances in fully polarimetric space-SAR sensor design and its applications"

With the un-abating global population increase our natural resources are stressed as never before, and the global day/night monitoring of the terrestrial covers from the mesosphere to the lithosphere becomes all the more urgent. Microwave radar sensors are ideally suited for space imaging because those are almost weather independent, and microwaves propagate through the atmosphere with little deteriorating effects due to clouds, storms, rain, fog and haze. Globally humidity, haze and cloudiness are increasing at a rather rapid pace, whereas only 20 years ago all of those covered only 48% of the globe, today those have increased to about 62% and within another 20 years may exceed 80% for irreversible reasons; thus optical remote sensing from space especially in the tropical and sub-tropical vegetated belts will become rather ineffective, and microwave remote sensing technology must now be advanced strongly and most rapidly because operationally it is more rapidly available especially for disaster mitigation assistance. [C211]

"Unsupervised polarimetric SAR image classification using fisher linear discriminant"

How to use the POLSAR data to classify and interpret the conditions of the earth is a very important research field of POLSAR. In this paper, we propose an improved algorithm on the basis of studying and analyzing some common algorithms. This technique introduces the fisher criterion in the feature selection and the hierarchical method in the classification of POLSAR image, which can improve Lee's combination method of the unsupervised classification based on polarimetric target decomposition and the maximum likelihood classifier based on the complex Wishart distribution. The effectiveness of this algorithm is demonstrated using a polerimetric SAR image. [C212]

"Plenary session"

The forest-land use carbon source is still the major area of uncertainty in determining the global carbon budget. Methods to map forest and non-forest areas with precision using optical remote sensing in the tropical world is extremely difficult due to cloud cover. Time series satellite derived radar data provide the opportunity to map forest change and forest degradation in a consistent and quantifiable manner for input into forest carbon assessment models. Recent work with GEOSAR an airborne radar dataset has resulted in biomass estimations being retrieved directly from multi-band X and P band interferometric (height) and polarimetric (class) information. While the methods still need verification using ground based estimates of biomass, the potential exists to map biomass and greatly assist in the estimation of carbon sequestration and carbon emissions in tropical regions. [C213]

"An approach for ionospheric effects reducing on SAR imaging"

For low-frequency (UHF/VHF and L band) spaceborne SAR imaging and applications, the ionospheric effects which lead to image defocusing and Faraday rotation can not be ignored. In this paper, a scheme combining Faraday rotation (FR) correction and image defocusing reduction together was presented. This scheme makes use of Faraday rotation estimated from SAR raw data to deduce the total electron content (TEC) disturbance. The soundness of this polarimetric information based technology is analysed and examined by simulations. The result shows that SAR focusing can be improved and the azimuth shift can be calibrated well. [C214]

"Polarimetric SAR image classification using Multiple-Component Scattering Model and Support Vector Machine"

The classification of polarimetric SAR image based on Multiple-Component Scattering Model (MCSM) and Support Vector Machine (SVM) is presented in this paper. MCSM is a potential decomposition method for a general condition. SVM is a popular tool for machine learning tasks involving classification, recognition or detection. The scattering powers of single-bounce, double-bounce, volume, helix, and wire scattering components are extracted from full polarimetric SAR images. Combined with the scattering power and the texture feature, SVM is used for the polarimetric classification. We generate a validity test for the method using EMISAR L-band full polarized data of Foulum Area (DK), Denmark. The preliminary result indicates that this method can classify most of the areas correctly. [C215]

"Comparison of ALOS PALSAR RVI and Landsat TM NDVI for forest area mapping"

The objective of this research is to investigate the effectiveness of the radar vegetation index (RVI) derived from ALOS PALSAR full polarimetric data for forest area mapping. Comparison was made between RVI and NDVI of Landsat TM data. After examining of the index maps and the corresponding histograms, forest/non-forest segmentation was performed by unsupervised classification and by threshold method. The results show that RVI is much better in this kind of application. Considering the data acquisition capability, full polarimetric SAR data are quite promising for forest monitoring. [C216]

"Analysis of the polarimetric parameters of representative targets and its application to land use classification"

Polarimetric SAR (POLSAR) data contains both phase and amplitude information from radar returns transmitted in four different polarizations. Thus it is necessary that we place strong emphasis upon extracting physical information from the observed scattering of microwaves. In this paper, we studied the Freeman decomposition method as well as some feature parameters that can represent targets' characteristics. Further more, we made an in-depth investigation on applying these parameters to discriminate several representative terrain cover types. [C217]

"A hybird vegetation height inversion method for dual frequency PolInSAR"

Polarimetric interferometric SAR (PolInSAR) is a new advanced technique based on measurement techniques of polarimetric SAR and interferometric SAR, and making use of it for retrieving the vegetation parameters becomes a hot research topic at present. In this paper, a high precise vegetation height estimation method is presented using dual frequency PolInSAR data. This method is based on fusion of dual frequency differencing and the coherence amplitude method. It can not only keep the accuracy of vegetation height estimation, but also it reduces the calculation of the algorithm greatly. Finally, the simulated PolInSAR data are used to validate the proposed method. [C218]

"A new method for polarimetric SAR image classification"

In this paper, the authors propose a new method for supervised target classification of polarimetric synthetic aperture radar (SAR) image, by using the optimization of polarimetric contrast enhancement (OPCE). First, using the idea of the generalized optimization of polarimetric contrast enhancement (GOPCE), the authors modify the model with three polarimetric parameters which are related to the physics of the scattering mechanisms. It leads to enlarge the difference between two categories and improve the classification results. A new classification approach is then proposed, it is similar to a single binary tree, which the misclassification between the classes with a big power difference is minimal. After the classified results are obtained by the combination of Fisher-OPCE and polarimetric parameters, the coefficients of the scattering parameters information of every two adjacent classes will be used as the last discrimination for final classification results. The effectiveness of the proposed algorithm is demonstrated by using a NASA/JPL AIRSAR L-band image over San Francisco. [C219]

"Unsupervised classification for compact polarimetric SAR data using m-δ decomposition, SPAN and the Wishart classifier"

This paper studies the polarimetric decomposition and unsupervised classification of compact polarimetric data. Compact polarimetric data have been synthesized from AirSAR L-band fully polarimetric data by matrix transformations. Polarimetric decomposition for compact polarimetric data have been introduced and analyzed. Decomposition result of relevant fully polarimetric data has been used for comparison. An unsupervised classification method is proposed for compact polarimetric data using polarimtric decomposition. Degree of

polarization m and relative H-V phase Г‚Вї combined with the total backscattering power SPAN have been used to initialize the compact polarimetric data into 15 classes. Then the Wishart classifier is applied. The result of this algorithm is illustrated and compared with the classification result of full polarimetric data. [C220]

"Polarimetric sscattering for information retrieval of SAR imagery"

This paper presents an overview of recent research progress in WSRS on theoretical modeling of the terrain surface for polarimetric scattering simulation and Mueller matrix solution, mono-static and bistatic SAR image simulation, new parameters for unsupervised surface classification based on de-orientation approach, DEM inversion, change detection from multi-temporal SAR images, and reconstructions of buildings from multi-aspect SAR images etc. [C221]

"ALOS-PALSAR Quad. Pol. images and their applications"

The four-component scattering power decomposition is applied to ALOS-PALSAR Quad. Pol. Data sets. PALSAR is Phased Array type L-band Synthetic Aperture Radar onboard ALOS (Advanced Land Observing Satellite) launched by JAXA, Japan, in 2006. It has acquired more than 10000 fully polarimetric scenes although the polarimetric mode is experimental one. This paper presents some of scenes in Sichuan earthquake area to see how polarimetric data works and to show the effectiveness and usefulness of fully polarimetric data. [C222]

"Simulation, measurement and validation of amplitude and phase matching performance between transmitter and receiver subsystems in dual-channel high-resolution polarimetric radar"

Stringent requirements for the matching performance between the channels of high-resolution multi-channel radar for superb target detection and classification capabilities have to be met. This paper focuses on the investigation on the amplitude and phase matching performance between two transmitters and two receivers in a dual-channel polarimetric agile radar system. The system will be used to estimate all elements of the polarization-dependent backscattering matrix simultaneously in 3 meters resolution cells. The paper presents breakthroughs in designing such complex radar systems based on very up to date methods used for system level simulations, for measurements and for cross-validation between simulations and measurements. The measurement results of the developed transmitters and receivers demonstrate the validity of our design approach for obtaining the needed matching performance between transmitters and receivers in such a dual-channel radar system. [C223]

"Full polarimetric GPR antenna system aboard the ExoMars rover"

A full polarimetric antenna system on board the ExoMars rover is part of the Experiment ldquoWater Ice and Subsurface Deposit Observations on Marsrdquo (WISDOM). The WISDOM-Experiment is a Ground Penetrating Radar (GPR) selected to be part of the Pasteur payload aboard the rover of the ExoMars mission. The Pasteur Panoramic Instruments (wide angle camera PANCAM, infrared spectrometer MIMA and WISDOM) will perform large-scale scientific investigations at the sites the Rover will visit. Among these instruments, WISDOM is the only that can provide a view of the subsurface structure prior to drilling. WISDOM has been designed to characterize the shallow subsurface structure of Mars. WISDOM will for the first time give access to the geological structure, electromagnetic nature, and, possibly, hydrological state of the shallow subsurface by retrieving the layering and properties of the buried reflectors. It will address important scientific questions regarding the planet's present state and past evolution. The measured data will also be used to determine the most promising locations to obtain underground samples with the drilling system mounted on board the rover. The instrument's objective is to get high-resolution measurements down to 2 m depth in the Martian crust. The radar is a gated step frequency system covering a frequency range from 500 MHz to 3 GHz. The radar is fully polarimetric and makes use of an ultra wideband antenna system based on Vivaldi antenna elements. The paper describes requirements, design and realization of the WISDOM antenna system accommodated on the ExoMars rover. Simulated and measured antenna performance is compared in this paper. Test measurements performed in permafrost regions on earth will be shown in the presentation. [C224]

"Design of multilayer stacked patch array with waveguide feeding network for high power SAR system"

This paper describes a novel synthetic aperture radar (SAR) antenna design in Ku Band. This antenna is an 8 times 2 array composed by a waveguide feeding network in order to support high-level input power, and multilayer stack patches which are exited by electromagnetic coupling from the waveguide through a resonant iris with dumbbell shape. Both polarizations (linear horizontal and vertical) have been designed to achieve a polarimetric and interferometric sensor. [C225]

"A scatterometer for XOVWM, the Extended Ocean Vector Winds Mission"

This paper presents a designs for a scatterometer satisfying the performance requirements set by the National Research Council Decadal Review in its description of the Extended Ocean Vector Winds Mission (XOVWM). Our design consists of a Ku and C-band pencil-beam scatterometer system coupled with an X-band polarimetric radiometer. Multiple frequencies allow us to achieve all winds and all-weather capabilities, and we achieve high spatial resolution thanks to an onboard SAR processor. We present examples of significant improvements in performance that can be achieved by this next-generation system compared with current ocean vector winds instruments. [C226]

"On the design of spaceborne polarimetric SARs"

To date, spaceborne polarimetric SARs have predominantly been implemented as experimental add-on modes to existing designs for single-pol or dual-pol systems. As a result, current and planned spaceborne SARs have polarimetric (or quad-pol) modes that are severely limited in swath width, are restricted in the range of look angles, suffer from low SNR and ambiguity problems, and are difficult to calibrate. The consequence of this is that the high potential science return expected from polarimetric SAR data has not and will not be realized. In this paper, the design of polarimetric SAR systems is revisited. Design principles are established, and recent advances will be described that allow wider swath polarimetry over a wide range of incidence angles, and simplified calibration of the final data product. [C227]

"Updating GeoSAR for full-pol interferometric capability"

GeoSAR is a single pass, dual frequency (X-band and P-band) interferometric mapping radar designed to map both top vegetation canopies and the terrain beneath the canopy. This system was developed from 1998-2003 as a joint effort of NASA JPL and EarthData under sponsorship of DARPA and NGA. The system is flown on a G-II aircraft and maps 10-12 km swaths simultaneously on both sides of the aircraft to generate high quality DEMs and imagery at both X-band and P-band. The system was later augmented with a nadir-pointing lidar profiler system to generate highly accurate control points that can be used in generating large area mosaics. Over the last 5 years the field of polarimetric interferometry has shown great utility in mapping the top of canopies and the underlying terrain with a great deal of accuracy at both L-band and P-band. This paper discusses an upgrade of the GeoSAR dual-pol (HH, HV) P-band interferometer to a fully polarimetric interferometer (HH, HV, VH, VV). We present both hardware and processor changes to the GeoSAR system needed for fully polarimetric interferometric operation. [C228]

"Information assessment for polarimetric SAR intensity images"

Polarimetric synthetic aperture radar (SAR) systems generate data, which have different information content in each polarimetric band. In analyzing the intensity information of multi-polarimetric SAR images (without taking into account phase information) two key issues were addressed. First, the mutual information and the entropy are used to assess the information difference between the polarimetric bands. Second, the image restoration method for full polarimetric SAR images can be evaluated with the information theory and a statistical method of minimum mean squared error estimation. This method was used to find the amount of information in an image as a function of spatial frequencies. A priori information about the power spectrum of an image and a point spread function of SAR system was applied. Statistical quality measures as well as the amount of information show good performances for polarimetric image restoration. [C229]

"Ultra light-weight antenna system for full polarimetric GPR applications"

The motivation to develop an ultra light-weight antenna system was driven by a space borne radar application. The experiment Г‚Вїwater ice and subsurface deposit observations on MarsГ‚Вї (WISDOM) is a ground penetrating radar (GPR) selected to be part of the Pasteur payload on board the rover of the ExoMars mission. Among the Pasteur panoramic instruments on the ExoMars rover, only WISDOM can provide a view of the subsurface structure. WISDOM is the first GPR on a planetary rover. It has been designed to characterize the shallow subsurface structure of Mars. WISDOM will for the first time give access to the geological structure, electromagnetic nature, and, possibly, hydrological state of the shallow subsurface by retrieving the layering and properties of the buried reflectors. It will address important scientific questions regarding the planet's present state and past evolution. The measured data will also be used to determine the most promising locations to obtain underground samples with the drilling system mounted on board the rover. The instrument's objective is to get high-resolution measurements down to 2 m depth in the Martian crust. The radar is a gated step frequency system covering a frequency range from 500 MHz to 3 GHz. The radar is fully polarimetric and makes use of an ultra wideband antenna system based on Vivaldi antenna elements. The paper describes antenna

requirements to fulfil for this very specific GPR application and it gives an overview about the light-weight design and its realization. Simulated and measured antenna performance is compared in this paper. Test measurements were performed in permafrost regions on earth. [C230]

"Simultaneous observations of X-band polarimetric SAR and ground-based weather radar during a tropical storm to characterize the propagation effects"

Synthetic aperture radar (SAR) is a well established surface imaging technology with recent launches of SAR systems at smaller wavelengths for increased resolution observations. However, these higher frequency systems have to deal with the impact of precipitation modifying the observations. In particular, the X-band, multi-polarization TerraSAR-X launched by German Aerospace Center (DLR) in 2007 has acquired data with distinct storm signatures in the resulting images. These signatures usually appear as dark cloud-like features and occasionally are brighter on the near range side if significant backscatter from the melting layer is received. The dark feature is due to attenuation as the electromagnetic wave passes through the heavy precipitation and can have a polarization dependent effect. Together with ground based weather radar, the attenuation due to the storm can be further studied and quantified. This paper presents results from a storm case over Florida, USA from dual-polarization TerraSAR-X with simultaneous observations from a National Weather Service WSR-88D radar during a cyclone. In addition, since the primary SAR data is from surface backscatter which can change for a variety of reasons, images acquired 11 days prior to and after the storm are used to provide additional insight into the propagation component. [C231]

"Design of tapered-slot antenna arrays for landmine detection"

Two compact ultra-wideband antenna arrays built of tapered-slot antennas and intended for landmine surveys are described. In one array, the antennas are arranged in two parallel lines differing by the antenna polarizations. Polarimetric data collected by the array are important for the detection of lengthy objects buried in the ground. The antennas in the second array form a zigzag line with reduced spacing between adjacent transmitting/receiving antenna pairs. Such a dense array is useful to detect small buried targets like landmines. Some experimental examples for the both arrays are presented. [C232]

"Shapes and orientations of raindrops from 2D-video disdrometer, polarimetric radar and a wind-tunnel study"

Measurements of shapes and orientations of raindrops using 2D video disdrometer have been compared with those derived from a recent wind-tunnel study as well as those inferred from an advanced polarimetric weather radar at S-band, respectively. Results are consistent with each other. This paper presents the quantitative comparisons. [C233]

"The tandem-L mission proposal: Monitoring earth's dynamics with high resolution SAR interferometry"

Tandem-L is a proposal for an innovative interferometric and polarimetric radar mission that enables the systematic monitoring of dynamic processes on the Earth surface. Important mission objectives are global forest height and biomass inventories, large scale measurements of millimetric displacements due to tectonic shifts, and systematic observations of glacier movements. The innovative mission concept and the high data acquisition capacity of Tandem-L provide a unique data source to observe, analyze and quantify the dynamics of a wide range of mutually interacting processes in the bio-, litho-, hydro- and cryosphere. By this, Tandem-L will be an essential step to advance our understanding of the Earth system and its intricate dynamics. This paper provides an overview of the Tandem-L mission concept and its main application areas. Performance predictions show the great potential of Tandem-L to acquire a wide range of bio- and geophysical parameters with high accuracy on a global scale. Innovative aspects like the employment of advanced digital beamforming techniques to improve performance and coverage are discussed in detail. [C234]

"On the impact of propagation disturbances on SAR Tomography: Analysis and compensation"

This paper is meant to discuss the role of propagation disturbances, such as those due to atmospheric disturbances or to residual platform motion, in SAR Tomography applications. It will be shown that phase stability requirements vary as a function of the number of targets within the system resolution cell, from which it follows that SAR Tomography applications require a higher phase stability, or a more accurate phase calibration, with respect to SAR Interferometry. Phase calibration will be discussed by comparing two approaches. The first is the traditional approach from Permanent Scatterers Interferometry, based on the assumption that it is possible to find stable targets in the imaged scene. The second is a new technique based on the Sum of Kronecker Products

Decomposition, recently introduced in literature, which allows to isolate ground and volume contributions within the data provided the availability of multi-polarimetric acquisitions. As such, the latter approach is suited to carry out phase calibration in presence of volume scattering, as it is the case of forested areas. Experimental results will be provided basing on the analysis of the P-Band data-set relative to the forest site of Remningstorp, Sweden. [C235]

"Correlation properties of UWB Radar target impulse responses"

In this paper the time domain responses of UWB radar signals from scattering targets are analyzed. In particular, the aim of this paper is to investigate the pulse distortion of UWB radar signals by a scattering object, i.e. how does the scattered signal vary with respect to the radar signal incident on the object itself. The investigation is performed analyzing the polarimetric responses of different targets (flat plate, sphere). The time domain description (impulse response and pulse preserving capability) of a generic scattering process is mathematically described. Then for verification and application, these prior defined quantities are experimentally measured for two particular targets, a flat plate and a sphere. [C236]

"Application of AdaBoost in polarimetric SAR image classification"

In this paper, a method of polarimetric SAR image classification based on polarimetric decomposition and AdaBoost algorithm is proposed. The proposed method improves classification accuracy and speed. AdaBoost algorithm, as a robust learner with high accuracy, can fully utilize the polarimetric features to achieve image classification. In simulated tests, the proposed method is observed to produce improved classification accuracy and speed, compared with H /alphamacr classification algorithm. [C237]

"Using complex-valued ICA to efficiently combine radar polarimetric data for target detection"

Target detection in sea clutter is a challenging problem in radar detection, specifically, when the Doppler return of the target and clutter are collocated. Polarization diverse radars provide additional information that enhances target detection. In this paper, we use an effective independent component analysis (ICA) approach, adaptive complex maximization of non-Gaussianity (A-CMN), to efficiently combine polarimetric radar data prior to detection. We show that A-CMN estimates the polarimetric scatter coefficients for the single target in clutter case, thereby providing matched-filter performance without the need for clutter or target models. The detection performance using ICA is evaluated with sea clutter collected with the McMaster IPIX radar off the coast of Canada. We also demonstrates the ability of this approach to adapt to the changing sea clutter conditions using simulation results. [C238]

"New polarimetric signal subspace detectors for SAR processors"

This paper deals with three new polarimetric SAR processors based on subspace detectors. These algorithms aim at using models with physical and polarimetric scattering properties not exploited by the isotropic point model. These processors are implemented by computing the corresponding target subspaces. Results on simulated data with realistic targets show the interest of these new processors. [C239]

"The conformity coefficient or how to explore the scattering behaviour from compact polarimetry mode"

In a previous paper, we have investigated the potential of the compact polarimetry mode at longer wavelengths in a space environment for soil moisture estimation. At longer wavelengths, one of the main challenges in dealing with compact polarimetry is the Faraday rotation estimation and correction. One proposed technique relies on bare surface scattering properties. Identifying the bare surfaces can be done using the conformity coefficient. This new coefficient can also be used to discriminate between surface, volume and double bounce scattering. It provides similar results to the Freeman-Durden classification in discriminating bare surfaces. In this paper, the study is pursued to include theoretical approach to the comparison. The potential of the conformity coefficient is benchmarked further against the well-known entropy-alpha-anisotropy classification. The comparison between these techniques is first performed theoretically and the effect of noise is investigated. These techniques are then applied to existing datasets coming from various sources, airborne sensors as RAMSES and AIRSAR and spaceborne sensors as PALSAR data and the results are cross-evaluated. The Faraday rotation can be estimated from full polarimetric data as was proposed by both Freeman and Bickel & Bates. These approaches are not applicable to compact polarimetry data. In a previous paper, it was shown how bare surface behavior can be used to perform this estimation. In this paper, the performance of this estimation is evaluated on PALSAR data and on airborne data where a constant ionosphere is simulated. The results are contrasted with estimates derived from full polarimetric data. [C240]

"Ground validation of satellite measurements of precipitation with C-band polarimetric radar"

Ground validation is an essential part of all satellite precipitation missions aiming to describe clouds and precipitation parameters. It helps to characterize errors, quantify measurement uncertainty, and provide insight into the physical and statistical basis of the retrieval algorithms. Dual-polarization weather radar is a very powerful tool for many important issues of the validation process. This paper presents various aspects considered to develop C-band dual-polarization weather radar products specifically tailored for ground validation of precipitation satellite measurements. Examples are provided by case studies observed with the CNR-ISAC Polar 55C radar operating in Rome (Italy). [C241]

"DESDynI adopts hybrid polarity SAR architecture"

DESDynI-Deformation, Ecosystem Structure, and Dynamics of Ice-is one of the first-tier missions recommended in The National Research Council's Earth Science 2007 Decadal Survey. DESDynI's L-band synthetic aperture radar (SAR) is designed to measure terrain surface deformation and forest biomass, hence its quadrature-polarimetric SAR mode. The objective to provide quantitative information on a global scale imposes severe requirements on the radar to maximize coverage and to sustain reliable operational calibration. These requirements are best served by the hybrid-polarity architecture, in which the radar transmits in circular polarization, and receives on two orthogonal linear polarizations, coherently, retaining their relative phase. This architecture offers many significant advantages over conventional all-linearly-polarized SARs. This paper reviews those advantages, summarizes key attributes of hybrid-polarity dual- and quadrature-polarized SARs including conditions under which the signal-to-noise ratio is conserved, and describes the evolution of this architecture from first principles. [C242]

"Topographic relief compensation on spaceborne polarimetric SAR for forest applications"

In order to use the advanced capabilities of polarimetric SAR data for forest applications, analysis methods must address topographic relief effects in mountainous regions. ALOS PALSAR L-band and Radarsat-2 C-band polarimetric SAR data over study sites in Hinton, Alberta, and the Greater Victoria Watershed District, BC, were collected and used to investigate the effectiveness of polarization orientation shifts correction, decomposition filtering techniques and local incident angle compensation. We found that the polarization orientation shifts estimated from PALSAR winter data corresponded to the topographic relief. The shifts from the PALSAR summer data were noisy. The polarization orientation shifts were not seen in the Radarsat-2 data. Various polarimetric parameterizations were useful for identifying terrain features and land cover types. The Cloude entropy, dominant scattering alpha and eigenvalues (lambda2+lambda3) were used to create HSV coding images for better differentiation of forest, vegetation and water surfaces with minimized topographic effects. The local incident angle compensation on single polarization backscatters was applied to Radarsat-2 data. Due to the high biomass volume in the study area and the higher radar frequency, the correlations between the polarization backscatter and the ground measured volumes at the plot level were poor. [C243]

"Reconfigurable digitally scanned polarimetric L-Band radar"

We present the design and initial results from a digitally steered, polarimetric, phased array L-band radar utilizing a novel, high performance architecture. The instrument leverages recent advances in radio frequency and digital signal processing components in order to enable collocated measurements of emission and backscatter in a compact aircraft instrument with no moving parts. The driving methodologies are the minimization of costly and inflexible analog circuitry, adoption of standardized manufacturing processes, and inclusion of reconfigurable firmware and software architectures to facilitate fulfillment of varied sensing requirements. [C244]

"A dual-polarized cylindrical array antenna for aerial vehicles"

An X-band conformal array antenna designed for the use of unmanned aerial vehicles with polarimetric radars/sensors is presented. The array antennas mounted on the cylinder with various curvature radii are experimentally studied. The array can be easily placed on the aircraft fuselage or payload due to its ultra-thin and ultra-lightweight characteristics. It should have potential applications in radar surveillance, remote sensing, and wireless communications. [C245]

"Analysing the elements of SAR polarimetry matrixes"

The various applications have been promised by the new generation of the spacecraft SAR data (i.e. Radarsat2 and TerraSAR-X), as the classification, the decomposition, and the modelling of the polarimetric synthetic aperture radar (SAR) data has been improved in recent years. This work is based on the fact that in order to extract the various patterns in distinctive field of studies, all the scattering matrix components are informative

source of data. Different cross products of the complex scattering matrix channels (HH, HV, VH, and VV) that are involved in the phase and amplitude information are joined together to build instructive features. In the vector space, Fisher class separability algorithm will be tested, and the features with the best class separability, large distance between classes, and small within-class variances will be selected. As we measured the classification effectiveness of the individual features, we needed to choose a subset of the informative features from the nine originally available features. Finally, we combined all the educational information contents in order to classify desired images with the best overall accuracy. [C246]

"The synergy of SAR polarimetry and interferometry for forest parameters retrieval"

In this paper we deal with the combination of SAR polarimetry and SAR interferometry to estimate bio-physical parameters, in particular the height of vegetated areas. We show a preliminary inversion approach that uses the polarimetric and interferometric (POLINSAR) coherence phase to estimate forest height. The POLINSAR degree of coherence is first optimized to identify the ground and top-canopy height, and then corrected for the wave penetration and terrain slope. We use a coherent POLINSAR scattering model to estimated the correction parameters. ALOS-PALSAR data are used to illustrate the results. [C247]

"Full polarimetric time domain calibration for UWB Radar systems"

In this paper a full polarimetric calibration for Ultra-Wideband Radar systems is presented. The proposed calibration method is completely performed in the time domain. Conducting the UWB Radar calibration in the time domain has several advantages compared to classical frequency domain calibration procedures. First of all, the possibility to perform a lower number of measurements than in the classical frequency domain calibration, and second that it is by far faster. A complete mathematical description by scattering and impulse response matrices is derived. Proper calibration targets and procedures are discussed and evaluated. [C248]

"Water Objects Extraction from Polarimetric SAR Imagery Based on Sequential Nonlinear Filtering and Independent Component Analysis"

A new method is proposed for speckle noise suppression and water objects extracting from synthetic aperture radar (SAR) imagery based on sequential nonlinear filtering and independent component analysis. The distribution of SAR image data with multiplicative speckle noise is non-Gaussian and its parameters are unknown. Logarithmic quantification is utilized to transform multiplicative speckle noise to independent additive noise. Speckle noise and image data are separated from multi-polarimetric imagery, and the components with the least speckle index are chosen as the object component automatically by means of ICA while the specific distribution of SAR imagery is unnecessary. Water objects are extracted from the separated object component imagery based on sequential nonlinear filtering according to their lightness and region shape features. The experimental results using ENVISAT ASAR polarimetric imagery show that the proposed method can extract water objects rapidly and accurately. [C249]

"DDV-novel Doppler-polarimetric technique for remote sensing of precipitation"

This paper presents results of Doppler-polarimetric radar signal modelling and real data processing that show correlation between Differential Doppler Velocity (DDV) and parameters of rain including rain microstructure and turbulence in rain. Reasonability to use DDV as one of informative parameters in recognition neural network system is checked. [C250]

"Quasi-simultaneous measurements of scattering matrix elements in polarimetric radar with continuous waveforms providing high-level isolation in radar channels"

This paper presents a new type of sounding signals for polarimetric FM-CW radar and corresponding de-ramping technique for processing, which provide the possibility for simultaneous measurement of all backscattering matrix elements and have high-level isolation between branches of the polarimetric receiver. The radar transmitter forms sounding signal, which has orthogonally-polarized components with orthogonal waveforms. The radar receiver is splitting orthogonally-polarized components of the scattered signals in two parallel receiver channels. Every such channel includes two parallel independent branches, which use wave-form orthogonality of the orthogonally-polarized components of sounding signal to split further signal components for simultaneous estimation of all four complex elements of the polarization backscattering matrix of radar object. The isolation between pairs of such branches in one receiver channel strongly depends on the time interval when scattered signals with orthogonal waveforms occupy the same frequency band. In this paper we propose to use a pair of LFM-signals as orthogonally-polarized components of the sounding radar signal. Both have the same form but are shifted in time relatively to each other. Our analysis shows that such time shift between the components of

sounding signal prevent the frequency overlap between polarimetric components of scattered signal. As result, standard de-ramping processing technique can be used in the receiver, providing high level isolation between receiver's branches that simultaneously estimate all elements of the radar target backscattering matrix. [C251]

"Basics and first experiments demonstrating isolation improvements in the agile polarimetric FM-CW radar-PARSAX"

The article describes the IRCTR PARSAX radar system, the fully polarimetric FM-CW radar with dualorthogonal sounding signals, which has the possibility to measure all elements of the radar targets polarization scattering matrix simultaneously, in one sweep. [C252]

"A statistical approach to assess randomly rough surfaces in imaging radars"

In this paper, a statistical approach to evaluate randomly rough surfaces (RRS) in an inverse scattering problem is presented. Whereas in these investigations the roughness criterions possess random variables, the use of deterministic techniques such as the target decomposition (TD) can not be useful by itself as a tool of analysis. In these conditions, a statistical approach is essentially required to evaluate the target parameters. The goal of this study is the estimation of the polarimetric signatures, such as the scattering mechanism a and the entropy H, via a novel approach including the combination of TD and a new statistical model. To validate our work, SAR data sets, provided by the European Space Agency (ESA), are analyzed and compared with the simulation results. [C253]

"SAPPHIRE: a novel building mapping radar"

Through-the-wall radar is available for single walls, providing range, direction, and motion information of moving subjects, often requiring a close position to the wall. No proven technology exists yet that allows mapping of building structures in a covert way. At TNO an innovative concept to synthesize a 3D map of a building with a stand-off, through-the-wall radar is being developed: SAPPHIRE. [C254]

"Statistical analysis of sea clutter spikes"

In this work a set of coherent and polarimetric sea clutter data is analyzed with a special interest for sea-spikes. Using three sea-spikes defining parameters, the spike amplitude, the minimum spike width and the minimum interval between spikes, it is possible to positively identify the spiking events from the background. This work shows a sample of results from a statistical and spectral analysis of a set of sea-spikes selected from the radar returns, focusing on their Doppler properties, the spike duration and the temporal interval between spikes. [C255]

"Polarimetric measurements of the extinction cross section"

A method based on broadband polarimetric measurements of the radar cross section in the forward direction and then using the optical theorem to calculate the extinction cross section is developed. The method is tested using a helix sample. Good agreement between experiments and calculations is found. [C256]

"Markov Chain CFAR detection for polarimetric data using data fusion"

The paper proposes a new Markov chain based CFAR detector for polarimetric data using low level data fusion and high level decision fusion. The Markov chain based CFAR detector extends traditional PDF based CFAR detection to first-order Markov chain model by considering both correlation between neighboring pixels and PDF information in CFAR detection. With the additional correlation information, the proposed approach results in advancing the performance of conventional CFAR detectors. Moreover, to take advantage of full polarizations of polarimetric data, various data fusion methods are considered to improve detection performance, including polarimetric transformation, principal component analysis, and decision fusion. Our experimental results both show the superiority of the new Markov chain polarimetric CFAR detector over conventional PDF-based CFAR detectors. [C257]

"SMOS image reconstruction algorithm: Extension of the band limited approach to the fully-polarimetric mode of MIRAS"

It is now well established that synthetic aperture imaging radiometers (SAIR) promise to be powerful sensors for high-resolution observations of the earth at low microwave frequencies. Within this context, the European Space Agency is currently developing the SMOS mission devoted to the monitoring of soil moisture and ocean salinity at global scale from Lband space borne radiometric observations obtained with a two-dimensional interferometer. This contribution is concerned with the reconstruction of radiometric brightness temperature maps from

interferometric measurements. It extends the concept of band-limited resolving matrix to the case of the processing of full-polarimetric data. [C258]

"Comparision of Two ICA Based Methods for Speckle Reduction of Polarimetric SAR Images"

In this paper, Two speckle reduction methods based on ICA are introduced. After speckle reduction experiments, the effect of two methods are compared in detail. The comparison shows that each method has its own advantage. It is not easy to say which method is better. [C259]

"Analysis of human backscattering in buildings for through-wall radar applications"

A hybrid simulation of wideband polarimetric radar backscatter of humans within a building is introduced. The model is composed of a full-wave simulation tool that can accurately predict the scattering from a realistic human model, and an accurate indoor wave propagation and scattering model, known as bricktracer. These two models are efficiently connected using a Huygen's interface box that encloses the entire human body. Sample backscattering results for a human walking in a small building were presented. It was shown that the backscatter response of human can be completely obscured by the building backscatter clutter. Time-sequenced subtraction of the backscattered responses using a stationary transceiver was proposed to detect a mover. This method can be used for the development and testing of highly sophisticated location and detection algorithms of humans inside building. [C260]

"Combining ICA with LSSVM for Speckle Reduction of SAR Image"

Speckles are inherent defects due to coherent imaging principles in synthetic aperture radar (SAR) systems. An improved polarimetric SAR image filtering method based on ICA (independent component analysis) -LSSVM (least squares support vector machine) was developed to get better results for terrain classification, target detection and other applications. The first step of this method is to apply ICA to LSSVM for feature extraction. By using ICA, the original higher dimensional inputs will be transformed into other lower dimensional features, the regularized parameter and feature subsets will be geted,These new features are then used as the inputs of LSSVM to process a regularized procedure which defines a cost function to estimate true SAR image.Experiment results using polarimetric SAR data of ERS-1 satellite show that this algorithm attains good despeckling effect and preserves more valuable image details than traditional algorithms. [C261]

"X-band phase-shifting dual-output balanced amplifier MMIC"

An X-band MMIC containing two 6 bit phase shifters and 1 Watt amplifiers in balanced configuration has been developed. The device has two output ports. The balance between the output powers of the two ports can be controlled via de phase shifter settings. This MMIC could be applied in systems where variable linear polarisation control is required, such as polarimetric radar or satellite communication systems. The MMIC has been developed in the 6-inch 0.5 mum power GaAs pHEMT process (PP50-11) of WIN Semiconductors. [C262]

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"Polarization decomposition with S and T matrix of a PolSAR image"

Polarization decomposition is an important approach for polarimetric SAR image classification. In this paper, decomposition methods with different data format are discussed. Especially, A new decomposition method which is Krogagger decomposition with T matrix is proposed. Simulation results show that decompositions with T matrix have less speckle. [C265]

"Azimuth, elevation, and polarization estimation for arbitrary polarimetric array configurations"

In this paper we propose an algorithm for high-resolution, joint azimuth, elevation and polarization estimation using polarimetric arrays of arbitrary geometry. The array elements may be placed on a planar or conformal surface and all the array imperfections are considered jointly. In particular, we focus on real-world arrays with imperfections. The Crameacuter-Rao Lower Bound (CRLB) for polarimetric arrays is established taking into account imperfections of the array. [C266]

"Investigation of Radarsat-2 and Terrasar-X data for river ice classification"

To date, monitoring of river ice using remote sensing has mainly focused on the use of mono-polarized and multi-polarized C-band radar data only. In this paper, Support Vector Machine (SVM) classifications using polarimetric parameters are tested to identify types of river ice. Classification algorithms are validated on the newly available C-band Radarsat-2 and X-band Terrasar-X data to investigate the potential of this new imagery, acquired in winter 2009. An electromagnetic model is improved to simulate the polarimet-ric response of a river ice cover to understand the interactions of the radar signal with the ice cover. At C-band, using dual-polarized data over mono-polarized data increases by 23.9% the final classification producer accuracy. Furthermore, the best producer accuracy is 91.6% when using dual-pol data at C-band, which stand for a gain of 2.2% compared to dual-pol data at X-band. [C267]

"Development of a simple scattering model for vegetation canopies and examination of its validity with scatterometer measurements of green-onion fields"

A simple scattering model for radar backscattering from vegetated surfaces is developed based on the radiative transfer technique. The number of input parameters of the model is minimized to simplify the scattering model. The validity of the model is examined by comparison between the computation outputs and scatterometer measurements for the backscattering coefficients of green-onion (scallion) fields. [C268]

"Exploitation of ALOS-PALSAR SAR full-polarimetry data to the mapping of an African region"

Due to their large scale of observation and their relatively high revisiting frequency, spaceborne SAR systems offer interesting possibilities for the systematic monitoring of land cover. Several techniques have been developed to analyze land cover areas from single-polarization spaceborne SAR data, based on the statistical properties of the reflectivity of such complex media and its spatial variations (texture). The reduced resolution of the data, compared to the airborne SAR case, is a particularly limiting factor. Polarization diversity offers an interesting and powerful alternative mean to characterize land cover areas. In this paper, we propose to use polarimetric SAR acquired by the ALOS sensor at L band, to monitor land cover of an African region. [C269]

"On the accuracy of scatterers LOS rotation estimation procedures in radar polarimetry"

The Line-of-Sight (LOS) rotation angle of scatterers can be estimated using polarimetric radar measurements. Exact estimation is unrealistic since noise and clutter are almost always present in the data. The paper presents the derivation of an approximated distribution, mean bias and variance analysis, of the scatterers LOS rotation angle using polarimetry, when estimated for the high-coherent (quasi-deterministic) scattering case. Example of scatterers fulfilling such condition are the so-called Coherent Scatterers (CSs). [C270]

"Validation of RADARSAT-2 Polarimetric SAR measurements of ocean waves"

Four C-band fully polarimetric synthetic aperture radar (POLSAR) images of ocean waves from the RADARSAT-2 SAR are used to measure ocean slopes and wave spectra. A new technique has been developed to measure wave slopes in the SAR azimuth and range directions. The POLSAR ocean wave parameter measurements were validated with in situ observations from an NOAA National Data buoy Center (NDBC) buoy. The results show that wave parameters measured using the new method are in good agreement with in situ NDBC measurement products. [C271]

"Investigation on the applications of decorrelation analysis in Polarimetric SAR Interferometry"

Interferometric coherence is a key quantity in Polarimetric SAR Interferometry (Pol-InSAR), but it is usually decreased (named decorrelation) by the decorrelation sources, such as polarization type, volume scatterers, instrument settings and processing errors. The analysis of decorrelation has been used to system performance assessment and vegetation parameter estimation. This paper presents two other applications of the decorrelation analysis. One is the derivation of Pol-InSAR system and processing requirements. It is based on quantitative expressions of the decorrelation as a function of system and processing parameters. The other is compensation

of the decorrelation that cannot be eliminated by optimizing system and processing parameters. It is implemented by using dual-baseline Pol-InSAR data. The Pol-InSAR requirement on noise equivalent backscattering coefficient and the compensation of temporal decorrelation are shown to demonstrate and validate these two applications respectively. [C272]

"A unified polarimetric approach for SAR sea oil slick observation"

In this study, a novel unified theoretical framework to describe the polarimetric sea surface scattering with and without surface slicks, entirely based on the Mueller scattering matrix, is proposed. Dealing with slick-free or weak-damping-slick-covered sea surface a Bragg scattering mechanism is expected, while, a non-Bragg scattering mechanism is expected in case of oil-covered sea surface. Following this rationale, the Mueller scattering matrix is physically read in terms of slick-free and slick-covered sea surface scattering mechanisms, through the analysis of some Mueller based polarimetric descriptors, i.e. the degree of polarization, the statistics of the phase difference and the pedestal height. Experiments accomplished on Level 1.1 full polarimetric L-band ALOS PalSAR data confirm the effectiveness of the proposed approach. [C273]

"Comparison of helicopter-borne thin sea ice thickness profiles with polarimetric signatures of dual-pol Terrasar-X data"

In this paper first results of a sensitivity study using dual polarimetric TerraSAR-X data for ice thickness estimation are presented. The sea ice thickness reference data set was measured, coincident to the SAR data take, by means of a helicopter-borne EM sounding device on April 28, 2008 in the Russian Arctic. For some of the signatures, namely the complex correlation coefficient, a relation to ice thickness could be found that is theoretically predicted for L-band SAR. The first results show, that the new generation of polarimetric space borne SAR sensors like TerraSAR-X may open a new opportunity for thin sea ice thickness monitoring from space. [C274]

"Contribution of the inter-channel polarimetric coherence for soil classification"

Fully polarimetric SAR (POL-SAR) images provide a large amount of information through the four channels HH, VV, HV and VH. They proved to be useful in many applications such as delimiting homogenous areas. Such large amounts of data require robust processing algorithms with minimal supervision and low complexity, especially for classification purposes. Most existing classification algorithms (H/A/alpha for instance) use combinations of some or all the channels as features for classification. In this paper, we present a new approach for polarimetric images classification. We are interested in the information of the inter-channel polarime-tric coherence as a feature element for the classification algorithm. The coherence information is known for being used in multi-temporal acquisitions for its advantage of detecting changes in the scenes during time. It is commonly used in in-terferometry. We want to profit from this information in the case of polarimetric images in order to take advantage of the multi-channel property of the data. This coherence classification approach (reading images, computing the coherence and the classification) will be implemented within the OTB (ORFEO ToolBox), the free software which is dedicated especially for remote sensing imagery processing. The approach is tested using images acquired by the CV-580 airborne near Ottawa, Ontario, Canada. [C275]

"Comparison with CLPX II airborne data using DMRT model"

In this paper, we considered a physical-based model which use numerical solution of Maxwell Equations in three-dimensional simulations and apply into Dense Media Radiative Theory (DMRT). The model is validated in two specific dataset from the second Cold Land Processes Experiment (CLPX II) at Alaska and Colorado. The data were all obtain by the Ku-band (13.95 GHz) observations using airborne imaging polarimetric scatterometer (POLSCAT). Snow is a densely packed media. To take into account the collective scattering and incoherent scattering, analytical Quasi-Crystalline Approximation (QCA) and Numerical Maxwell Equation Method of 3-D simulation (NMM3D) are used to calculate the extinction coefficient and phase matrix. DMRT equations were solved by iterative solution up to 2ndorder for the case of small optical thickness and full multiple scattering solution by decomposing the diffuse intensities into Fourier series was used when optical thickness exceed unity. It was shown that the model predictions agree with the field experiment not only co-polarization but also cross-polarization. For Alaska region, the input snow structure data was obtain by the in situ ground observations, while for Colorado region, we combined the VIC model to get the snow profile. [C276]

"Polarimetric analysis over African savanna woodland using ALOS/PALSAR"

This paper presents polarimetric analysis over African Savanna woodland using ALOS/PALSAR to investigate the trend between backscatter and biomass levels. An extensive field inventory was carried out combining Differential GPS and conventional topographic mapping techniques. Geographic position, basal diameter and

height of trees in sampled plots were measured. Plot level biomass quantities were obtained using established allometry for the region. Geocoded ALOS/PALSAR level 1.1 and 1.5 data is checked for accuracy against existing geospatial data for the case study area. Sigma nought, Freeman and Pauli component are extracted for the sampled plots to investigate the relationship between biomass, volume and double bounce scattering. Finally a comparison of sigma nought, Freeman and Pauli components is carried out to analyze trend against volume and double bounce scattering. [C277]

"Classification of polarimetric SAR data over wet and arid regions of India"

Polarimetric SAR data from ALOS PALSAR, SIR-C and ENVISAT ASAR over wet and arid regions were processed for classification and soil moisture estimation. HH and HV dual polarized ALOS PALSAR could classify wetlands of Mumbai coastal area with an accuracy of 96%, whereas fully polarized SIR-C data over Kolkata gave 92% accuracy. The accuracies are based on selected training areas and not based on test areas. ALOS PALSAR could clearly discriminate water, mangrove forest and ocean water. With Dual polarized data, discrimination between Ocean water and wetlands is not possible. Several features in arid data can also be classified using PALSAR data in addition to the estimation of soil moisture. [C278]

"Investigation of multiple frequency polarimetric SAR signal backscattering from tidal flats"

The tidal flats are largely developed along the western and southern coast of Korean peninsula. The simulation results of tidal flats through analytical scattering models could not be fully assessed by using only surface roughness (RMS height and correlation length) and soil moisture. The tidal flats are usually saturated with saline sea water and partially covered with remnant water in depressions. This may cause lower backscatters in SAR images due to the partial specular reflection. [C279]

"Polarimetric scattering feature estimation for accurate vegetation area classification"

This paper proposes an accuracy improvement of the vegetation area classification based on the POLSAR image analysis, when vegetation and man-made areas are both included in the radar target region. Here we introduce a simple compensate polarimetric marker, T13or T31, to accurately distinguish the unexpected scattering from the obliquely oriented man-made targets and the complex volume scattering generated from vegetation area. T13or T31is the (1, 3) or (3, 1) elements of the 3Γ́B—3 averaged coherency matrix ([T]), and has not been effectively utilized in the general scattering power decomposition scheme. By appropriately utilizing T13(T31), one can extract only the vegetation area from the mixed target region. It is verified from the detailed analysis that the proposed marker T13(T31) works well not only for Pi-SAR data but also for ALOS/PALSAR data. [C280]

"Multi-path correction model for multi-channel airborne SAR"

This paper analyzes the multi-path component effect in the airborne SAR context, proposing a model as an approach to correct the generated disturbances in the processed phase and amplitude images. The method assumes along-track interferometric or polarimetric data to estimate the unknowns of the model. Airborne data acquired by the F-SAR system of DLR are used to evaluate the performance of the proposed approach. [C281]

"Polarimetric analysis of the dependency of backscattering from ocean surface on wind direction"

The dependencies of the backscattering from the ocean surface on the wind direction are analyzed by using the Pi-SAR under weaker wind condition (5 m/s) than the former analysis under stronger wind as 14 m/s. In the X-band HH polarization, the dependency of the normalized cross section (NRCS) on wind direction depends on the incidence angle, differently from the former analysis. In the X-band VV polarization, the NRCS represents weak incidence angle dependency as same with the former analysis. As a result, the dependency of the polarization ratio (PR) in the X-band on the wind direction also depends on the incidence angle. In the L-band, the dependencies of the NRCS and the PR are also weak, same as the former analysis. [C282]

"Multi-baseline POL-inSAR statistical techniques for the characterization of distributed media"

This paper presents principles and robust techniques to estimate physical parameters of natural environments using Multi-Baseline Polarimetric and Interferometric SAR (MB-POL-inSAR) data. The first part of this paper concerns the abstract topic of MB-POL-inSAR coherence optimization The second part is dedicated to the general estimation of the coherence line model parameters [1]. It is demonstrated that the line parameters can be estimated in an analytical and robust way by using the whole available POL-inSAR information. [C283]

"Semi-supervised learning for classification of polarimetric SAR-data"

Supervised learning algorithms are important methods to automatically interpret image data in general as well as PolSAR data in particular. However, they suffer from the need of a training set, which has to contain manually labelled data. Un-supervised methods do not demand this kind of data, but cannot be directly used to assign user-defined class labels to image regions. This paper proposes a semi-supervised method to overcome both shortcomings. The data is analysed by an un-supervised clustering algorithm under the usage of all available information. Simultaneously each pixel is classified by a supervised method using the information available at the current phase of clustering. [C284]

"An algebraic approach to ground-volume decomposition from multi-baseline PolInSAR data"

In this paper, an algebraic methodology is described for the separation of ground and volume contributions basing on multi-baseline and multi-polarimetric acquisitions. As a result, a new general procedure is defined that encompasses single-baseline PolInSAR as a special case, and allows to proceed to ground/volume separation not only through model based approaches, but also through model free and hybrid approaches. Furthermore, it will be shown that such a methodology yields the best solution in the Least Square sense. [C285]

"Model-based statistical analysis of PolSAR data"

In this paper, we consider statistical analysis of PolSAR data in the framework of the multivariate product model. The complex scattering vector is here considered as a double stochastic circular Gaussian variable, in which the variance is linearly scaled by a common stochastic scaling factor z. The scaling factor is associated with texture. We discuss various parametric probability density functions for z, and indicate how model parameters can be estimated from data by a simple moment based method. Experimental analysis shows that for some surface covers, certain texture distributions fit better than others. Then, polarimetric covariance matrix data analysis is addressed in the framework of product models, and we propose a processing scheme which perform image segmentation using a stochastic EM approach. [C286]

"Estimation and segmentation in non-Gaussian POLSAR clutter by SIRV stochastic processes"

In the context of non-Gaussian polarimetric clutter models, this paper presents an application of the recent advances in the field of Spherically Invariant Random Vectors (SIRV) modelling for coherency matrix estimation in heterogeneous clutter. The complete description of the POLSAR data set is achieved by estimating the span and the normalized coherency independently. The normalized coherency describes the polarimetric diversity, while the span indicates the total received power. Based on the SIRV model, a new maximum likelihood distance measure is introduced for unsupervised POLSAR segmentation. The proposed method is tested with airborne POLSAR images provided by the RAMSES system. [C287]

"Potentials of RADARSAT-2 data to monitor freezing/thawing cycles over agricultural lands in Canada"

The target decompositions technique of Freeman-Durden is used to monitor freeze/thaw cycles, with fully polarimetric RADARSAT-2 images acquired over agricultural areas. In this paper is presented a preliminary analysis of the scattering mechanisms derived from three RADARSAT-2 acquisitions during the fall of 2008, over agricultural sites located in Saskatchewan, Ontario and Quebec. AMSR-E brightness temperatures data is also used in the analysis. Contrary to expectations, results indicate that surface scattering represents the main contribution to the signal over frozen soils. [C288]

"Sub-canopy ground characteristics retrieval of PolinSAR using spectral analysis technique"

The advances in Polarimetric SAR Interferometry (PolInSAR) techniques provide a promising way to recover ground characteristics such as sub-canopy soil moisture and roughness using SAR data. Spectral analysis techniques have been applied to extract the vegetation and building parameters. Yamada et al proposed the ESPRIT algorithm to estimate vegetation height; Sauer et al apply the spectral analysis techniques to estimate building heights and extract physical properties from Multi-baseline (MB) PolinSAR data. In these applications, the parameters are mainly estimated from the phase information or phase center, but the validity of the sub-canopy soil backscattering or reflectivity estimation from polarimetric spectral analysis technique is not investigated. In this paper, the ground scattering center is first located by po-larimetric MUSIC algorithm and then the ground reflectivity is recovered using a polarimetric least-square method. The validity of the polarimetric spectral analysis technique for the sub-canopy ground reflectivity estimation is demonstrated using simulated and real SAR data. [C289]

"Recent advances in SAR remote sensing: "Multimodal POLinSAR imaging with applications to remote sensing of the terrestrial covers and the monitoring of environmental stress changes""

Land cover monitoring is one of the most potential applications of Polarimetric Synthetic Aperture Radar (POLSAR) sensing and so is Repeat-Pass Polarimetric-Interferometric SAR (RP-DIFF-POL-IN-SAR) stress-change assessment by air/high-altitude/space-borne SAR sensor deployment. Provided fully polarimetric SAR information can be made available, a plethora of novel POLSAR matrix decomposition methods can be implemented for recovering rather precise scattering contributions from isolated and distributed scattering scenarios, and so can rather exact environmental changes from consecutive repeat-pass observations at 1 m resolution from air and from space. With the recent launches of the fully polarimetric satellites JAXA-ALOS (PAL-SAR-L-Band), the DLR TerraSAR-X (X-Band) and of RADASAT-2 (C-Band), a new era in space imaging of the terrestrial terrain and ocean surfaces has arrived providing unforeseen advantages. [C290]

"Selectable target detector using the polarization fork"

A new target detection methodology is described that makes novel use of the polarization fork of the target. The mathematical formulation is general and can be applied to any kind of single target as long as its expression in the target space is known. Aim of this paper is to present a standard procedure to set the detector parameters for any target of interest. The algorithm makes use of the Gram-Schmidt ortho-normalization in order to set the appropriate basis for the polarimetric space. Validation against real data shows significant agreement with the expected results based on the theoretical description. [C291]

"Case studies of frozen ground monitoring using PALSAR/ALOS data"

Frozen ground is a sensitive indicator of how our home planet is changing. In the meantime, new spaceborne SAR systems have been launched, such as the polarimetric PALSAR sensor onboard ALOS in January 2006. In this paper, the relevance of L-band polarimetric SAR data for extracting information on frozen ground is presented. Dealing with ground assessments, the necessity for a validated Electromagnetic (EM) model is of importance. The adequation between Oh's po-larimetric EM model and PALSAR data is first studied over agricultural bare fields in Hokkaido, Japan. The assessment of residual liquid water can be realized by means of bare soil EM backscattering model. Over natural wildland area, an approach is proposed in order to tackle the effect of the vegetation or other irrelevant effects. The monitoring of permafrost active layer is performed over the ANWR, Alaska. [C292]

"Polarimetric ice sounding at P-band: First results"

For polar ice sheets valuable stress and strain information can be deduced from the crystal orientation fabric (COF) and its prevailing c-axis alignment. Polarimetric radio echo sounding is a promising technique to measure the anisotropic electromagnetic propagation and reflection properties associated with the COF. In this paper, dual-polarized P-band data acquired with the airborne POLARIS system near the ice divide of the Greenland ice sheet are analyzed. The internal layers in the uppermost few hundred meters of the ice sheet look the same at HH and VV polarizations, whereas the layering differs further down. Accordingly, the magnitude of the complex HH-VV correlation coefficient decreases with depth and, interestingly, the phase gives evidence of polarization dependent reflection and birefringence effects. [C293]

"Compact polarimetry mode at low frequency for vegetation applications"

Global warning is now known to be the major environmental issue mankind will have to face in the next decade. Monitoring of vegetation and biomass is clearly an essential piece of information required at all levels ranging from the scientific studies to understand and forecast, to the political actors and government leaders responsible for drafting remediation policies and evaluating their impact. Microwave remote sensing with the low-frequency SAR technique can provide a useful characterization of forest (spatial coverage, species, density, height...) at a global scale, relying on the all-weather imaging capabilities of SAR linked with the significant penetration of the low-frequency EM wave in the canopy. The published techniques for forest characterization from low frequency SAR data include radiometry inversion, polarimetric inversion based on the anisotropy parameters and PolInSAR Random Volume Over Ground inversion . In this paper, we will more specifically concentrate on the PolSAR technique and the impact of ionospheric effect. [C294]

"Polarimetric MIMO radar with distributed antennas for target detection"

Distributed antenna radar systems provide spatial diversity gain by viewing the target from different angles. Polarimetric radar offers improved performance over conventional radar systems by exploiting polarization diversity. We propose a radar system that offers both spatial and polarimetric diversity gains for detecting

stationary point-like targets. The receive antennas of the proposed system use 2D vector sensors, each measuring the horizontal and vertical components of the received electric field separately. We design the Neyman-Pearson detector for this proposed system and analyze its performance. This analysis is used to select the optimal transmit polarizations for this system. Using simulations, we demonstrate the improvement offered by the optimal choice of polarizations. We also show the spatial diversity offered by MIMO radar. [C295]

"Analysis of the KK-distribution with X-band medium grazing angle sea-clutter"

Robust maritime surveillance with radar requires an accurate description of the backscatter from the sea. An estimated probability distribution of the backscatter is commonly used to determine the threshold for separating targets from clutter at a given false alarm rate. Data collected at medium to high grazing angles by the Defence Science Technology Organisation (DSTO) Ingara fully polarimetric X-band radar demonstrates that the commonly used K-distribution is not always adequate for modelling the probability distribution. This is especially the case for the horizontal polarisation and in regions of high backscatter where target detection can be a problem. An alternative proposed as a more accurate model in this region is known as the KK-distribution. The analysis presented in this paper describes this model with the addition of multiple looks and a thermal noise component to produce greater accuracy in the mean and underlying shape. The threshold required to achieve a constant false alarm rate is then studied and compared with that derived from the K-distribution model. [C296]

"The airborne SAR-system: SETHI airborne microwave remote sensing imaging system"

SETHI, the airborne SAR system developed by the ONERA, the French Aerospace Lab., integrates a new frequency band radar: the UHF-VHF component. Thanks to its new payload, SETHI can operate over a wide range of frequency bands from UHF-VHF, to X including L-Band and has polarimetric and interferometric capabilities. We describe in this paper the pod-based SAR-system SETHI and its associated numeric remote control. Then we describe the UHF-VHF validation campaign and as a conclusion the first polarimetric SAR results. [C297]

"New polarimetric SAR processors based on signal and interference subspace models"

We develop in this paper new polarimetric SAR processors based on signal and interference subspaces model. These processors aim at using models with physical and polarimetric scattering properties not exploited by the isotropic point model. Our goal is to increase the response of the target and decrease the response of the interferences. These processors are implemented by computing the corresponding target and interference subspaces. Results on FOPEN simulated data with realistic target show the interest and the limits of these new processors. [C298]

"Hierarchical segmentation of Polarimetric SAR images using heterogeneous clutter models"

In this paper, heterogeneous clutter models are introduced to describe Polarimetric Synthetic Aperture Radar (PolSAR) data. Based on the Spherically Invariant Random Vectors (SIRV) estimation scheme, the scalar texture parameter and the normalized covariance matrix are extracted. If the texture parameter is modeled by a Fisher PDF, the observed target scattering vector follows a KummerU PDF. Then, this PDF is implemented in a hierarchical segmentation algorithm. Segmentation results are shown on high resolution PolSAR data at L and X band. [C299]

"3-D characterization of buildings in a dense urban environment using L-band Pol-InSAR data with irregular baselines"

Diverse spectral estimations methods, i.e. MUSIC, Maximum Likelihood (ML), Weighted Subspace fitting (WSF), are proposed and applied to the estimation of building height dense urban environments and to the retrieval of scatterers' physical properties. Compared to other estimators, the polarimetric WSF estimator is optimally model adaptive and results in reduced sidelobes induced by irregularly sampled baselines. [C300]

"3D topography and forest recovery from an L-BAND single-pass airborne PolInSAR system"

Polarimetric InSAR (PolInSAR) using repeat-pass L-Band has generated interest in recent years because of its potential for extraction of forest height and of bare-earth topography beneath the canopy. However temporal de-correlation remains a problem. In previous papers a single-pass system has been demonstrated which removes the temporal issue. In this paper we extend the single-pass PolInSAR work previously described and show results for forests in which tree height maps and corresponding DTMs have been generated and compared to lidar truth. [C301]

"Microwave scattering behaviour analysis of typical targets with SAR image"

As the high resolution radar satellite's has been successfully launched, its ability of the typical target's recognition monitor enhances a lot. This article mainly does analysis based on the RADARSAT2 quad-polarimetric data, compared scattering properties of typical target feature with two temporal full polarized data, and used the measured data to drive MIMICS (Michigan Microwave Canopy Scattering model) model and carry on the multi-wave band full polarization backscattering simulation about the farmland and forest. Then we carried on the comparison between X, C band SAR image gain's actual scattering value and simulation value in order to infer the typical target feature' scattering properties rule of S band. With anticipation of HJ-1-C satellite soon launched by China and then we can carrry on the comparison with the fact. Along with the full polarized data's development, the typical target feature's scattering properties analysis will be more perfect. [C302]

"Snow density estimation using Polarimitric ASAR data"

Remote sensing of radar polarimety has great potential to determine the extent and properties of snow cover. Availability of spaceborne sensor dual polarimetric C-band data of ENVISAT-ASAR can enhance the accuracy in measurement of snow physical parameters as compared to single fixed polarization data measurement. This study shows that the capability of C-band SAR data for estimating dry snow density over snow coverer rugged terrain in Himalayan region. The study area lies in Beas, Chandra and Bhaga catchments of Himachal state (India). For this investigation, the main assumptions are that the snow is dry and at C-band, total backscattering coefficient comes from snowpack and snow ground interface. An algorithm for estimating snow density has been developed based on snow volume scattering and snow-ground scattering components. Snow density estimation algorithm requires HH and VV polarization combination data. The radar backscattering coefficients of both HH and VV polarization and incidence angle are given as input to the developed algorithm. Finally, the algorithm gives the snow dielectric constant which can further be related to snow density using Looyenga's semi empirical formula. Comparison was done between algorithm estimated snow density and field value of snow density in the study region. The mean absolute error between estimated and measured snow density was 21.3 kg/m3. [C303]

"Polarization plane rotation effects on SAR polarimetric attributes"

The polarization plane rotation effects on SAR polarimetric attributes are analyzed. This analysis is carried out by simulating a polarimetric SAR image containing four regions with different electric characteristic. The simulation process is based on an electromagnetic scattering model. Employing a rotation model is generated a image set having 361 images, where each image has it polarization plane rotated by a different angle. From all images of the set are computed the covariance matrix and six polarimetric attributes of each image region and compared with their correspondent parameter in the image without rotation. From this evaluation it could be seen that the rotation angle influences differently all polarimetric attributes. The effects of rotation angle can lead to a misunderstanding of the target scattering mechanism. [C304]

"Extrapolation of airborne polarimetric and interferometric SAR data for validation of bio-geo-retrieval algorithms for future spaceborne SAR missions"

This paper describes a methodology to extrapolate spaceborne quality SAR image products from long wavelength airborne polarimetric and interferometric SAR data. The methodology is applied to E-SAR data of DLR, partially acquired under ESA contract especially for the development and validation of bio/geo-retrieval algorithms in forested regions. For this purpose not only system (sensor) related parameters are altered, but also those relating to the propagation path (ionosphere) and to temporal decorrelation. Examples for future spaceborne products are presented and the potential of Pol-InSAR methods for the retrieval of forest heights from these data is discussed. [C305]

"Differential Reflectivity (ZDR) calibration for CASA radar network using properties of the observed medium"

The Center for Collaborative and Adaptive Sensing of the Atmosphere (CASA) has deployed a Distributive, Adaptive and Collaborative Sensing (DCAS) network of four radars in central Oklahoma working as a closed-loop system since 2006. The radars operate at the X-band frequency and are capable of polarimetric and Doppler measurements. The radar network is being evaluated for Quantitative Precipitation Estimation (QPE). QPE algorithms based on radar power measurements (e.g. ZHand ZDR) require bias correction. ZDRcalibration is required prior to any application of the self-consistency principle. Two different methods were evaluated for ZDRbias correction. The intrinsic properties of dry aggregated snow present above the melting layer and light rain measurements close to the ground are used for the study. Results show a ZDRcalibration accuracy of 0.2 dB or less for both analyzed events when both methods are compared. [C306]

"Development of X-band airborne polarimetric and interferometric SAR with sub-meter spatial resolution"

These days, the space-borne SAR becomes one of the powerful instruments to observe the earth surface. On the other hand, a airborne SAR is also important for development of SAR system and analysis technique. Moreover, airborne SAR is able to make immediate observation of disaster area. The National Institute of Information and Communications Technology (NICT) has been developing the new airborne synthetic aperture radar: Pi-SAR2 since 2006. The Pi-SAR2 is an airborne X-band polarimetric and cross-track inter-ferometric SAR with sub-meter spatial resolution. The spatial resolution is measured less than 0.5m using some corner reflectors. The Pi-SAR2 system were completed and began the operation in autumn 2008. [C307]

"F-SAR-DLR's new multifrequency polarimetric airborne SAR"

The Microwaves and Radar Institute of the German Aerospace Center (DLR) is known for consistent work on the field of airborne synthetic aperture radar and its application. In April 2008 the 20th anniversary of the maiden flight of the well-known E-SAR system was celebrated. E-SAR has been maintained well over the time. It provided valuable knowledge to the science community, especially in the past 10 years. However, it became more and more obvious that a technological renewal was inevitable. Consequently the development of a new SAR system was put on line under the name `F-SAR'. [C308]

"RBX: The new X-band radar from INTA"

This paper describes the architecture and main characteristics of the new synthetic aperture radar system which is being developed at Spanish National Institute of Aerospace Technology. The new prototype will support submetric resolution and interferometric and polarimetric capabilities, similar to other research SAR systems. The system architecture was designed taking into account an easy upgrade procedure and a continuous mount and dismount requisite. Hence, the system has just a few units and external interconnections. In addition, a feature which focused a significant design effort was data quality, thus the system supports calibration procedures like calibration loops or the acquisition of a replica from the transmitted signal. [C309]

"Analysis of ASAR/Envisat polarimetric backscattering characteristics of Docana national park wetlands"

DoГґB±ana National Park wetlands, in southwest Spain, undergo yearly cycles of inundation and drying out. These cycles, together with great extensions of annual helophytes, make of DoГґB±ana a rapidly changing environment. 43 ASAR/Envisat images of DoГґB±ana in HH, VV and HV polarizations were acquired throughout the hydrological year 2006/07 with the aim to monitor in detail an entire flooding cycle. The images were ordered in the seven ASAR swaths to achieve high observation frequency. Backscattering temporal signatures of two main land cover types were obtained in the three polarization configurations and six ASAR swaths. Polarimetric behavior of the signatures is analyzed with the aid of extensive site data, such as a precise digital elevation model and continuous records of water level and meteorological parameters. Conclusions on the feasibility to discriminate emerged versus flooded land are derived for the different incidence angles, land cover types and phenological stages. [C310]

"ALOS-PALSAR polarimetric SAR data to observe sea oil slicks"

In this study an electromagnetic approach is proposed for exploiting polarimetric information for sea oil slick observation in L-band ALOS PALSAR full polarimetric SAR data. The problem is tackled form an electromagnetic viewpoint by describing the sea surface scattering mechanism with and without oil slicks. Following this rationale, a filtering technique, based on the Mueller scattering matrix, is applied to detect oil slicks in full polarimetric SAR data. Successively, the filtering results are verified by the analysis of the slick-free and slick-covered pedestal height and polarimetric entropy (H). Experiments, accomplished on a meaningful set of Level 1.1 L-Band ALOS PALSAR full polarimetric data, demonstrate the effectiveness of the proposed approach. [C311]

"A study of forest vertical structure estimation using coherence tomography coupled to a macro-ecological scattering model"

In this paper we combine a macro-ecology forest model with a numerical scattering code to estimate the vertical scattering profile of L-band penetration into forests. We use these simulations to show that structure has an important impact on interferometric coherence and hence on height retrievals based on single baseline polarimetric interferometry. We conclude with some suggestions for dual baseline extensions to allow for better height and structure estimation in future sensors. [C312]

"Transpolarizing trihedral measurement using UPC X-band GB-SAR"

The use of a transpolarizing surface placed on one side of a trihedral corner reflector (TCR) as polarimetric calibrator is presented in this paper. The transpolarizing-TCR presents a high back-scattered cross-polar response. This structure has been tested at 9.65 GHz (X-band) with the help of the UPC GB-SAR system. [C313]

"An internal calibration scheme for polarimetric Synthetic Aperture Radar system"

Two important aspects of internal calibration of polarimetric Synthetic Aperture Radar (SAR) are discussed, that is, system gain calibration and individual Transmit/Receive Module (TRM) calibration. System gain variation is measured utilizing the internal calibration loop. Dualchannel TRM gain and phase calibration is carried out using Orthogonal Phase Coding (OPC), in which signal of individual TRM is phase-encoded according to a set of orthogonal codes in order to be separated from the composite calibration signal of all TRMs. Calibration results are developed both theoretically and through simulation in the case of TRM failure. A crosstalk model is used to investigate the effect of imperfect isolation between the two polarization channels of each TRM on the calibration error. [C314]

"Calibration of the high performance airborne SAR system (Pi-SAR2)"

NICT (National Institute of Information and Communications Technology, Japan) have developed a high performance airborne SAR system (Pi-SAR2) since 2006, as a successor to the Pi-SAR (X-band). Pi-SAR2 has polarimetric and interferometric functions with high spatial resolution of 0.3-0.6 m in along track (azimuth) direction and 0.3-0.5 m in cross track (slant-range) direction at X-band. In this paper we report the ground based calibration experiment using active radar calibrators (ARC) and corner reflectors (CR) in conjunction with the Pi-SAR2 test flight. [C315]

"Multi-resolution target scattering decomposition for urban feature characterization using polarimetric SARs"

Urban areas include features (buildings) of coherent scattering as well as areas such as parks that manifest partially coherent scattering due to the significant natural variability in the scattering properties. While high-resolution coherent target decomposition(CTD) can be used for characterization of buildings, incoherent target scattering decomposition (ICTD) is more suitable for analysis of partially coherent targets [11]. In contrast to CTD, ICTD preserves the polarimetric information of the latter at the expanse of the requirement for use of coarse-resolution for unbiased estimation of ICTD parameters [9]. The Touzi decomposition [10], [15] permits a unified roll invariant decomposition of both coherent and partially coherent scattering. In this paper, a multi-resolution technique is introduced to adapt the Touzi decomposition to the coherence nature of target scattering. The multi- resolution mixture CTD-ICTD decomposition is validated using polarimetric Convair 580 SAR data collected over Ottawa city. Implications on the use of the new multi-resolution decomposition for the unified analysis of coherent and partially coherent target scattering are discussed. [C316]

"Overview of the PolSARpro V4.0 software. the open source toolbox for polarimetric and interferometric polarimetric SAR data processing"

The objective of this paper is to make a review of the current status of the PolSARpro v4.0 Software (Polarimetric SAR Data Processing and Educational Toolbox), developed under contract to ESA by a consortium comprising I.E.T.R at the University of Rennes 1, AELc, DLR-HR and Dr mark Williams from Adelaide. The objective of this current project is to provide Educational Software that offers a tool for self-education in the field of Polarimetric SAR data analysis at University level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. The PolSARpro v4.0 Software establishes a foundation for the exploitation of Polarimetric techniques for scientific developments and stimulates research and applications developments using PolSAR and PolInSAR data. [C317]

"Analysis and observation of polarimetric scattering behavior in wetland area"

This paper proposes a simple monitoring technique for water area change in wetland environment based on POLSAR image analysis. From the results of the image analysis by utilizing fully or quad. polarimetric SAR data set, it is found that strong double-bounce scattering can be observed at the vicinity of the boundary region between water area and the surrounding emerged-plants area. This peculiar scattering feature is utilized as a useful marker for estimating the water area change. To verify the generating mechanism of the double-bounce

scattering, the Finite-Difference Time-Domain (FDTD) polarimetric scattering analysis is also carried out for a simplified water-emergent boundary model. The dependency of the polarimetric scattering feature on the variation of the radar incident angle, the change of the biomass and material parameters of the surrounding emerged-plants is investigated. Resultantly, it is confirmed from the detailed FDTD analysis that by using the proposed technique, one can estimate the true water area change in wetland and its surrounding area in all seasons. [C318]

"An evaluation of PolSAR speckle filters"

Speckle suppression in PolSAR images is an important step for the extraction of meaningful information from PolSAR images, especially for homogeneous extended targets. It has been shown that insufficient noise filtering resulting in low equivalent number of look (ENL) values will increase bias on incoherent polarimetric parameters such as the Cloude-Pottier parameters. In addition, meaningful high-frequency information, such as edges and point targets must be preserved. Adaptive filters have been the most successful in reaching a good compromise between noise suppression and detail preservation. A large set of artificial PolSAR images, which ground truth are realizations of Markov random fields, has been generated. Performance metrics are focusing on speckle suppression (ENL), edge preservation, relative errors on polarimetric parameters and point target preservation. [C319]

"The effect of orientation angle compensation on polarimetric target decompositions"

The orientation angle of scattering media affects the polarimetric radar signatures. This paper investigates the effect of orientation compensation on polarimetric target decompositions including Pauli decomposition, Freeman and Durden decomposition and Yamaguchi decomposition. The Cloude and Pottier decomposition is excluded, because entropy, anisotropy and alpha angle are rotational invariant. We will show that after the orientation compensation, the volume scattering power is consistently decreased, while the double bounce power has increased. The surface scattering power is relatively unchanged, and the helicity power is rotational invariant. All these characteristics can be explained by the compensation effect on the nine elements of the coherency matrix. This analysis reveals that, contrary to the general perception, the 4-component component decomposition by Yamaguichi et al. does not use complete information of the coherency matrix. Only six quantities are included-one more than the Freeman/Durden decomposition under the assumption of refection symmetry. [C320]

"A preliminary study of target contour extraction based on scattering mechanism using polarimetric SAR images"

Finding the target contour information from a remote sensing image is one of the fundamental steps for image analysis. Conventional target contour extraction methods are usually based on the statistics information of the image. In this paper, using the maximum return value of the normalized scattering matrix derived from full-polarized Synthetic Aperture Radar (PolSAR), the relationship between the contour of targets and their corresponding dominate scattering type is preliminary researched. Then a novel target contour information extraction method based on the physical scattering mechanism of terrain targets is proposed, which is more effective and adaptable due to the scattering mechanism of terrain targets do not depend on the radar backscattering intensity, but its proportion among different polarizations. After applying to E-SAR airborne data, the results show that this method has a good capability to extract the target contour information. [C321]

"Forest parameters inversion using Polarimetric and Interferometric SAR data"

In this paper we discuss some aspects of the forest height estimation using Polarimetric and Interferometric (POLINSAR) SAR data. Three main issues limit the inversion of the POLINSAR coherence from repeat-pass POLINSAR systems: temporal decorrelation, terrain slope distortions and effects of wave penetration. We show that, if temporal decorrelation is not severe, the distortions due to terrain slope can be removed and the wave penetration can be compensated using the predictions of the scattering simulator PolSARProSIM. A detailed procedure that applies to any POLINSAR data is presented and illustrated using ALOS/PALSAR data and the SRTM digital elevation model (DEM). [C322]

"Independent component analysis of polarimetric SAR data for separating ground and vegetation components"

In this study, the use of independent component analysis (ICA) to separate the ground and vegetation scattering components from polarimetric, synthetic aperture radar (SAR) data is presented. In vegetation covered terrain, the backscattered signal is a composite of both a ground scattering component and a vegetation scattering component. The FastICA algorithm is customized and applied to both simulated and field data. The improved

customized algorithm is found to work better than the standard FastICA algorithm. It is also shown that noise and depolarization limit the ability of ICA to separate the different scattering components. The technique is applied to field data from the Glen Afric region in Scotland and produces results consistent with other radar metrics obtained from that region. [C323]

"Forest parameter retrieval using a general repeat-pass polarimetric interferometric vegetation model"

This paper concerns forest parameter retrieval from multi-temporal polarimetric interferometric SAR data. A two-component polarimetric interferometric model, designed for geophysical parameter retrieval, is presented for volumetric media over the ground. It is founded on a scattering model based polarimetric decomposition and the random volume over ground (RVoG) PolInSAR inversion technique. For forest vegetation observed at L-band, this model accounts for the ground topography, canopy layer and total tree heights, mean wave attenuation in the canopy, tree morphology in the form of orientation distribution and effective shapes of the branches, surface scattering contribution, and double-bounce ground-trunk interactions. A parameter retrieval framework is developed for repeat-pass acquisitions which aims to estimate and to compensate temporal decorrelation. The parameter estimation performance is evaluated on real airborne L-band SAR data in the repeat pass mode. [C324]

"SETHI, the ONERA airborne SAR sensor, and his low frequency capability"

SETHI is the airborne SAR system developed by the ONERA, the French Aerospace Lab dedicated to civilian application. This new SAR system was designed to explore the science applications of radar remote sensing; it can operate over a wide range of frequency bands (X, L and UHF/VHF) and it has polarimetric and interferometric capabilities. In this paper, we will more specifically illustrate the low frequency capability of this new airborne SAR system and provide some results obtained with the system. [C325]

"A polarimetric vegetation model to retrieve particle and orientation distribution characteristics"

A simple vegetation model for polarimetric covariance and coherency matrix elements is presented. The model aims to represent vegetation characteristics which are observable by radar polarimetry, including the average particle scattering anisotropy, the main orientation of the volume, the degree of orientation randomness in the volume, and the terrain slopes. The goal of this approach is to quantify these parameters and to enable their estimation in a remote sensing parameter inversion framework. The retrieval of parameters related to effective particle shapes in the polarization plane and the orientation distribution characteristics is evaluated on real SAR data acquired by DLR's E-SAR system at L-band. [C326]

"Bayesian building extraction from high resolution polarimetric SAR data"

Building extraction from high resolution Synthetic Aperture Radar (SAR) images can benefit from modelling the interaction of several elements in urban scene. This paper proposes a Bayesian approach to exploit the interplay. The appearances of buildings in SAR images are dependent on their orientation angles. We estimate the orientation angles of buildings by supervised learning. The knowledge of other object classes could contribute to the building detection. We extract surface evidence of major object classes. The integration of angle estimation, building detection and surface classes provides promising results. [C327]

"Supervised classification by neural networks using polarimetric time-frequency signatures"

In radar imaging, the assumption is made that scatterers are white in the emitted frequency band and isotropic for all direction of observation. Nevertheless, new capacities in radar imaging, using a wideband and a large angular excursion, make these hypotheses not valid. Time-frequency analysis highlight this point of view and show some scatterers are anisotropic and/or dispersive. This information source can be completed by radar polarimetry. This paper suggests a supervised classification of scatterers using neural networks based on polarimetric time-frequency signatures. This method is applied here on anechoic chamber data, however can be generalized to SAR or circular SAR imaging. [C328]

"Urban areas characterization from polarimetric SAR images using Hidden Markov Model"

Scatterers in synthetic aperture radar (SAR) images exhibit high dependence on scatterer-sensor orientations. This phenomenon is prevalent in urban areas. This paper applies hidden Markov model (HMM) to characterize the dependence and model the variations with respect to orientation. Buildings in high resolution SAR images of urban areas are studied. Buildings regions are divided into several discrete classes according to their orientation angles. We model the variations of scatterers characteristics throughout the subapertures using HMM.

Subapertures are generated using wavelet packet decomposition. The experimental results show that HMM is efficient in building detection and orientation angle identification. HMMs trained using different feature sets are investigated. The evolution of scatterer states in subapertures are obtained from the HMM inference. [C329]

"Parametrization of integrated hydrological model of Nam Co lake catchment on Tibetan Plateau using synergy of SAR and optical data"

Understanding of exchange processes over Tibetan Plateau including hydrological cycle is becoming increasingly important since their influence on the formation of the Asian monsoon system is known. Tibetan Plateau is source area for main Asian rivers that are of crucial importance for downstream communities of China, India, Bangladesh, Pakistan and SE Asia. Accurate and up-to date information of the characteristics and the current trend of these changes, provided by modern satellite systems like TerraSAR-X, are thus needed. The study area is delimited by the watershed of Nam Co basin on Tibetan Plateau in Tibet Autonomous Region of China approximately 100 km NNW from Lhasa. The no-outlet basin of the lake offers an excellent example of landscape unit characteristic for Tibetan Plateau where all exchange processes between land and atmosphere can be studied. Hydrologic modeling of Nam Co basin will be supported by complex interpretation of TerraSAR-X data that will provide whole set of hydrologic parameters. The TerraSAR data will be processed in synergy with other available microwave and optical remote sensing data sets. Basic extracted variables will be thus transformed into meaningful hydrological parameters. Data evaluation will take into account various aspects of landscape qualities with respect to water cycle. Variability of lake level, seasonal changes of soil moisture, influence of wetlands, lake icing and snow melt will be estimated. The synergetic approach to interpretation of TerraSAR-X data will benefit from major advantages of the high spatial resolution, the fast repetition cycle and the full-polarimetric capabilities in combination with high resolution optical data (RapidEye, QuickBird, Kompsat-2, ASTER. Landsat etc.) and digital elevation models. [C330]

"Measurement and analysis of paddy field by polarimetric GB-SAR"

Polarimetric ground-based synthetic aperture radar (GB-SAR) measurements in a paddy field and its analysis results are presented. The measurements were carried out three times before and after an ear emergence of rice, and SAR images of full polarimetric components are reconstructed from the acquired dataset. By using those images, a sensitivity of a polarimetric component and a frequency range due to the ear emergence is discussed. Then, we could confirm that HH component of C-band is the most sensitive parameter although HV and VV components do not give significant changes. Especially, HH component of 5-6 GHz and 6-7 GHz show 10 dB increases after the ear emergence. Moreover, Freemen decomposition is applied to the SAR images. And, increases of a surface scattering component and a double bounce component in a same frequency range with the increase of HH component can be observed. [C331]

"Ship detection from polarimetric sar images"

SAR image from sea can constantly contain ships and their ambiguities in azimuth and range directions. For maritime applications, the ambiguities are visible due to their strong intensities in a low backscattering background of sea environment. Thus, the ambiguities can be often mistaken as ships and cause false alarms. Many approaches have been proposed for reducing the azimuth ambiguities in single channel SAR image. This paper analyzed scattering mechanisms of the azimuth ambiguities for PolSAR images and proposed a method for detecting ships from PolSAR images. By using eigenvector-eigenvalue decomposition, three eigenvalues can be used to differentiate ship targets, azimuth ambiguities and sea clutter. One C-band JPL AIRSAR polarimetric data have been chosen to evaluate the method. The experimental results show that the proposed method can effectively reduce false alarms caused by the azimuth ambiguities. [C332]

"Polarimetric analysis from compact-pol measurements: Potential and limitation"

Global warming is now known to be the major environmental issue mankind will have to face in the next decade. Monitoring of vegetation and biomass is clearly an essential piece of information required at all levels ranging from the scientific studies to understand and forecast, to the political actors and government leaders responsible for drafting remediation policies and evaluating their impact. Microwave remote sensing with the low-frequency SAR technique can provide a useful characterization of forest (spatial coverage, species, density, height...) at a global scale, relying on the all-weather imaging capabilities of SAR linked with the significant penetration of the low-frequency EM wave in the canopy. The published techniques for forest characterization from low frequency SAR data include radiometry inversion, polarimetric inversion based on the anisotropy parameters and PolInSAR Random Volume Over Ground inversion. In this paper, we will more specifically concentrate on the PolSAR technique and the impact of ionospheric effect. [C333]

"Soil moisture estimation using a multi-angular modified three component polarimetric decomposition"

In this paper a modified three component polarimetric decomposition incorporating multi-angular acquisitions is developed to estimate soil moisture under vegetation cover over agricultural areas. The approach is applied on fully-polarimetric L-band data acquired by DLR's airborne E-SAR sensor in the frame of the OPAQUE campaign conducted in May 2008 in the WeiГґBцeritz catchment area, near Dresden, Germany. The results for the estimated soil moisture from the overlapping area of the flight strips demonstrate a significant increase of the inversion rate, if more than one acquisition is used. The inverted soil moisture values are validated against in situ measurements for five test fields with different crop types resulting in an RMSE of approximately 7vol.% for different incidence angle constellations. Finally the results show how topographic effects in the soil moisture retrieval can be compensated by multi-angular constellations. [C334]

"Calibration of radargrammetric DEMs from RADARSAT-2 high-resolution and fine-quad modes"

The new high-resolution and full polarimetric modes of RADARSAT-2 are evaluated for digital elevation model (DEM) generation using stereo-radargrammetry with Toutin's 3D physical model. The stereo-radargrammetric DEMs were evaluated with accurate Lidar data. Results on a test site north of QueГ‚bec City, Canada showed good accuracy: (2 m 1Г‚Bï horizontal and vertical) for Ultra-Fine mode (better than the resolution), and 5 m and 11 m (1Г‚Bï horizontal and vertical, respectively) for the Fine-Quad polarimetric mode (about the resolution). [C335]

"Polarimetric signatures and classification of tropical land covers"

Polarimetric signatures for different tropical land covers were extracted from RADARSAT-2 data. Subsequently, the data were classified. The objective of this work was to assess the potential of RADARSAT-2 polarimetric C band data on land cover mapping. RADARSAT-2 data were acquired over Tapajos National Forest, a tropical forest reserve in Brazil, and surroundings, in September 2008. A field campaign was conducted during the same week of the SAR data recording. Polarimetric signatures for the different land covers were extracted for co- and cross-polarised bands and results indicated the variety of scattering mechanisms in the study area. Following that, the coherence and covariance matrices were used for the Freeman-Durden target decomposition, which decomposed the image targets in new bands representing the main scattering mechanism in the resolution cells-corner reflection, volumetric and superficial. Data were later classified by a k-means-Wishart classifier. The bands representing volumetric and superficial scattering helped discriminating vegetated and non-vegetated areas. Classification accuracy reached around 80% for forest and pasture/bare soil classes. For the remaining classes, the classification accuracy results did not reach 50%. [C336]

"Karst forest type discrimination in southwest China using spaceborne polarimetric SAR data"

Karst forest physiognomy occupy a large area of Guizhou, southwest China. It is a rare forest resource in the earth and urgently needed to carry out protection. Due to synthetic aperture radar (SAR) data's ability to acquire images through clouds, it was tested as an alternative to optical data to map changes of land use/land cover, to estimate biophysical parameters of vegetation types, and to detect deforestation. The main goal of this paper is to analyze the potential of the spaceborne full polarimetric data in distinguishing the different types of forest in southwest China. Different polarimetric target decompositions, such as eigenvetor-based decomposition (Cloude-Pottier's decomposition and Touzi Decomposition) and scattering model-based decomposition (Freeman decomposition), were used in this paper to extract forested areas from the scene. To further divide the extracted forested area into deciduous and coniferous forest., Supervised polarimetric classification procedures based on Freeman decomposition is presented in this paper. [C337]

"Multiple Crop Yield prediction using dual-polarimetric TerraSAR-X stripmap imagery"

This paper presents the results of an experiment carried out to relate the yield from various crops to TerraSAR-X dual polarimetric imagery. X-band wavelength has higher sensitivity to smaller crop structures, especially stem and head density making it suitable for relating yield to backscatter. The coherent dual-polarimetric mode of TerraSAR-X was also used to emphasize the volume scattering through dual-polarimetric entropy/alpha decomposition. Good correlations to yield data as gathered by harvester telemetry were obtained. [C338]

"Three-component decomposition for polarimetric SAR"

An improved three-component decomposition for polarimetric SAR data is proposed in this paper. The reasons of the emergence of negative powers in the Freeman decomposition have been analyzed, and two improvements are included. Firstly, the deorientation process is applied to the coherency matrix before it is

decomposed into three scattering components. Then, the coherency matrix with the maximal polarimetric entropy, i.e, the unit matrix is used as the new volume scattering model instead of the original one adopted in the Freeman decomposition. The E-SAR polarimetric data acquired over the Oberpfaffenhofen area in Germany are applied for experiment to demonstrate the effectiveness of the new model. [C339]

"Statistical characterization of the Sinclair matrix: Application to polarimetric image segmentation"

This paper focuses on the flexibility of a multidimensional model of probability density function (pdf) to describe distribution of complex data in polarimetric SAR images. This model is based on Copulas Theory for characterizing the dependence between the polarimetric channels (HH, VV, HV, VH). This corresponds to finding a model based on multidimensional copulas to describe the behavior of the target vector. The advantage in using copulas theory is to extend correlation concept to a wider dependence one, which may be non-linear, especially when processing high-resolution data. So, from this point of view, the model is more flexible than the classical Wishart distribution since no speckle filtering is required as preprocessing step to model accurately the pdfs. The other advantage of copulas is to split dependence concept and marginal distributions. Then, this multidimensional characterization may be linked to pdf which are not necessary of circular Gaussian law. So, specific parametric distribution may be choosen to fit each component (modulus and phase) of the Sinclair matrix. It yields a flexible model, for characterizing statistical behavior of the polarimetric SAR data, that may be derived to produce a segmentation algorithm. [C340]

"Accuracy improvement of maximum likelihood inversion of forest height with PolInSAR"

Polarimetric synthetic aperture radar interferometry (PolInSAR) technique has been intensively used for extracting forest heights. Among the forest height inversion algorithms, maximum-likelihood estimate computes the maximum-likelihood estimate of the vegetation parameters based directly on the sample coherency matrix. The estimation of the sample coherency matrix is of great importance in this inversion process. A coherency matrix estimation method with adaptive averaging window derived from coherence region shape parameters is presented. Then the estimated coherency matrices are applied in the maximum likelihood inversion algorithm. In order to confirm the validity of the proposed method, simulated L-band PolInSAR data provided by ESA is used. Experiment results suggest that this method can help improve the accuracy of maximum likelihood inversion of forest heights. [C341]

"Detection subsurface hyper-saline soil in Lop Nur using full-polarimetric SAR data"

This paper presents the research results about Lop Nur using full-polarimetric technology. Lop Nur Lake is one of the driest places in the world and finally lost its last drop of water in 1972. It is well known for its Г‚ВїEarth EarГ‚Вї feature in optical remote sensing images. Likewise, Г‚ВїEarГ‚Вї feature is shown in Synthetic Aperture Radar (SAR) images, and even larger because of penetration effect. With the penetration capability SAR is capable of detecting the subsurface targets and materials, especially in arid environment. As for SAR images, both C-band and L-band, there are two key features about Lop Nur area. One is the whole Lop Nur area is high-bright that means the backscattering is much stronger than other sites, such as Gobi, desert and so on. The other feature is the Г‚ВїEarГ‚Вї pattern formation. polarimetric analysis about these two questions will be conducted based on past research results and field investigations. [C342]

"Forest type discrimination using polarimetric Radarsat 2 data"

In the south of China, synthetic aperture radar (SAR) provides a powerful tool for forestry inventory because of its all-weather and all-day capabilities. Nevertheless previous single or dual polarization SAR data cannot meet the requirements of forest type classification. Polarimetric SAR data contained more information of targets and in this paper we investigated the capability of polarimetric Radarsat 2 data for forest type discrimination. Taking Zhazuo forest farm of Guizhou Province as study area, an 8-temporal field experiment was designed and used for polarimetric backscattering signatures analysis based on MIMICS model. Then two-temporal polarimetric Radarsat 2 data was analyzed to extract polarimetric variables for forest species discrimination, and then polarimetric decomposition and classification were carried out. Experiments prove that forest type can be discriminated using polarimetric Radarsat 2 data, but it is not very effective for forest species identification mainly due to the spatial resolution limitation. Polarimetric SAR data with higher resolution and more complicated classification methods are needed in the future. [C343]

"Determination of scattering mechanisms inside rice plants by means of PCT and high resolution radar imaging"

3-D high-resolution radar images have been produced for a mature rice crop sample by using wide-band fully polari-metric data collected at the EMSL, JRC-Ispra (Italy). These images have been compared with the 1D

vertical density profiles produced by the Polarization Coherence Tomography technique on the same rice sample. In order to obtain a 1D vertical reflectivity profile from the 3D SAR images, several slices at certain ground-range positions have been selected and then all the horizontal cross-range contributions have been summed up. As expected, very similar qualitative results are obtained when comparing these profiles with the PCT ones. The ground exhibits the highest response for all three polarization channels up to C-band, and also for the HH channel at X-band. In addition, at X-band the VV channel decreases significantly at ground level but the HV channel remains high. Finally, an important contribution from the upper layers is observed at C-band and more notably at X-band for all three polarization channels. [C344]

"Dependence of P-band interferometric height on forest parameters from simulation and observation"

GeoSAR is a unique dual-band, interferometric SAR (DBInSAR) sensor capable of collecting single-pass, X-band (VV) and P-band (HH) interferometric data simultaneously. In this paper we examine the dependence of the P-band HH interferometric phase centre height upon forest and terrain parameters. We develop a simple model for P-band GeoSAR observations, and use the model to show how the elevation in P-band HH phase centre height above true ground height is related to the volume-to-ground scattering ratio. GeoSAR is not fully-polarimetric, but records cross-polar (HV) returns at P-band (although not interferometrically). We conjecture that these returns are dominated by direct-volume scattering and related to the direct-volume HH backscatter. We use this relationship to model the dependence of the P-band HH DTM height upon the HV/HH ratio, and the difference in X-band DEM with P-band DTM heights. The relationships are examined using simulated forest InSAR data, and a model is proposed for ground-height and tree-height estimation using DBInSAR that does not require full polarimetry. [C345]

"Time series of polarimetric and interferometric observations of TerraSAR-X data over rice fields in Spain"

The objective of this work is to investigate the coherent co-polarized behavior of rice plants during the growing stages and to explore their information content for rice monitoring at high frequencies recently available through new SAR satellite missions. Time series of dual-pol TerraSAR-X images have been acquired during the whole cultivation period over a rice site in Spain. Among different observations, the backscattering coefficients at HH and VV channels and the HH/VV ratio have confirmed to show a temporal variation that has a significant correlation with the development of the plants during the vegetative and reproductive phenological phases. In addition, the information content of the HHVV complex coherence and a dual polarimetric target decomposition is investigated and discussed. All the information layers investigated are contributing to the discrimination of rice fields from other crop types. Finally, interferograms computed with pairs of successive images (11 days separation) have been preliminary tested. [C346]

"Polarimetric SAR interferometry for forest application at P-band: Potentials and challenges"

This paper presents the impact of simulation parameters according to the potential future space-borne mission BIOMASS (P-band) in polarimetric and interferometric SAR (Pol-InSAR) inverison performance. Forest height inversion is obtained from the simulated data sets (bandwidth, NESZ and ambiguities) generated from DLR E-SAR (Experimental Synthetic Aperture Radar) airborne SAR data. For this study two campaign data sets (BioSAR 2007 / INDREX-II) have been selected and investigated. The several comparative results of Pol-InSAR between airborne data and the simulated data (incl. bandwidth, NESZ and range/azimuth ambiguities) will be shown and discussed. [C347]

"Mapping aurora activity with SAR-a case study"

Auroral physics is an exceedingly rich and complex subject. However, due to a lack of high resolution data of ionospheric activity during auroral events, not all phenomena in the high latitude ionosphere are fully understood. Recent research has proven that L-band SAR data is significantly affected by the ionosphere and can be used for mapping its activity. With this paper we will prove and unambiguously verify the potential of L-band SAR to capture auroral activity. We will present examples of aurora signatures mapped from ALOS PALSAR data and will verify the results from SAR with observations provided from ground based measurements. [C348]

"Boreal forest height estimation with SAR interferometry and laser measurements"

In this paper we summarize the results of FINSAR campaign, which was arranged to evaluate X- and L-band SAR interferometric and polarimetric SAR techniques for Boreal forest. The main emphasis of the work was on L-band polarimetric interferometry and forest height estimation. Also X-band interferometry and coherence

tomography for X- and L-band, phase center height, extinction coefficient of forest and several other aspects of polarimetric interferometry were studied with help of ancillary measurements. Our results show that L-band polarimetric SAR interferometry can estimate well Boreal forest height. Also X-band interferometry shows good potential in height estimation. When accurate ground model is available, tree height can be estimated even by using one polarization interferometry. SAR appears to be more accurate in forest height measurement than forest inventory database, but not as accurate as laser measurement. [C349]

"Detection and analysis of urban areas using ALOS PALSAR polarimetric data"

Due to their large scale of observation and their relatively high revisiting frequency, spaceborne SAR systems offer interesting possibilities for the systematic monitoring of urban areas. Several techniques have been developed to analyze urban areas from single-polarization spaceborne SAR data, based on the statistical properties of the reflectivity of such complex media and its spatial variations (texture). The reduced resolution of the data, compared to the airborne SAR case, is a particularly limiting factor. Polarization diversity offers an interesting and powerful alternative mean to detect and characterize urban areas. In this paper, we propose to use po-larimetric SAR acquired by the ALOS sensor at L band, to monitor urban areas. The proposed technique uses three complementary approaches to discriminate urban structures using detectors adapted to the complex polarimetric features of this medium, to isolate specific coherent responses from a Time-Frequency analysis of the coherent SAR signal, and finally to characterize built-up areas from the coherence properties of their Polarimetric and Interferometric SAR (POL-inSAR) response. [C350]

"Polarimetric coherence optimization for interferometric differential applications"

In this paper, the potentials of polarimetric coherence-optimization techniques for differential interferometric SAR (DInSAR) applications are examined. For this purpose, the cutting-edge approaches available in the literature are considered. First, synthetic PolSAR data simulating homogeneous distributed scatterers are employed to demonstrate the convergence of the optimized differential phase to the deformation phase information. Then, real X-band ground-based PolSAR acquisitions concerning an urban environment are analyzed. The relation between optimum coherences and corresponding optimum phase in terms of deformation on retrieval is carefully analyzed using two zero-baseline fully-polarimetric data sets. In the end, general conclusions about the advantages and drawbacks of the alternative maximization approaches are drawn. [C351]

"Calibration of spaceborne polarimetric SAR data using a genetic alogrithm"

Calibration method for spaceborne polarimetric SAR data using a genetic algorithm is discussed in this paper. Recently some satellites which have polarimetric synthetic aperture radar were launched, and the polarimetric data analysis techniques are being developed for terrain classification, forest biomass and soil moisture estimations, etc. Thus, polarimetric calibration becomes an important issue for accurate polarimetric analysis. However, typical polarimetric calibration methods have some restrictions. For example, Freeman method requires the polarimetric data which satisfy reflection symmetry and does not estimate cross-talks. Thus, it is desired that a polarimetric calibration method is needed to estimate all polarimetric calibration parameters by using polarimetric data without considering reflection symmetry. In this report, a polarimetric calibration technique based on a genetic algorithm (GA) is proposed. This proposed method can estimate cross-talks, channel imbalances and Faraday rotation angle using one trihedral corner reflector and the measured polarimetric SAR data with non-reflection symmetry. [C352]

"Scattering component decomposition for POL-InSAR dataset and its applications"

The three-component scattering model decomposition based on the scattering mechanisms corresponding to single-bounce, double-bounce, and volume scattering, is one of the powerful tools to classify terrain for fully polarimetric SAR data. However, the conventional scattering component decomposition technique with POLSAR image requires several assumptions to obtain a unique solution. This paper presents scattering component decomposition technique with Pol-InSAR image pair. The proposed technique based on the ESPRIT can decompose without any assumptions when a suitable set of candidates for volume scattering covariance matrix is prepared. In this report, we show the concept of the proposed method with the POL-InSAR image pair and the role of the ESPRIT in the volume scattering estimation. Experimental results of SIR-C/X-SAR are also provided as an example. [C353]

"A comparison of clustering fully polarimetric SAR images using SEM algorithm and G0 P mixture modelwith different initializations"

This paper presents a comparison between two types of initializations for multilook polarimetric SAR image segmentation: a random partition and a sample quantile partition. These are the inputs of a stochastic

expectation-maximization algorithm that uses a mixture of G0Pdistributions to describe the data. The parameters are unknown, and estimated by the moments method. The G0Plaw is able to describe different type of targets, like urban areas, vegetation and pasture. The experimental results on real PolSAR data are reported, showing that the use of G0Pmodel with quantile partition inicialization provide good segmentation results with few iterations. [C354]

"Critical analysis of polarimetric PALSAR data for landcover classification"

Polarimetric SAR provides a substantial source of information over conventional imaging radars. Fully polarimetric PALSAR data has been used for land cover classification. Co and Cross Polarization signatures for different classes are obtained in linear (h,v) and circular (l.r) basis. Different combinations from both basis have been extracted for the (principal component analysis) PCA. Supervised minimum distance classifier is used on principal components of various bases combinations for classification. HH-HV-VV feature set gives a better estimate of urban and vegetation class but water bodies are estimated with higher accuracy from LL-LR-RR feature set. [C355]

"Recent advances of POL-SAR, POL-IN-SAR & RP-POL-IN-SAR imagery for remotely sensing natural habitats: Desert and wetlands remote sensing"

Land cover monitoring is one of the most potential applications of Polarimetric Synthetic Aperture Radar (POLSAR) sensing and so is Repeat-Pass Polarimetric-Interferometric SAR (RP-DIFF-POL-IN-SAR) stress-change assessment for air/high-altitude/spaceborne SAR sensor deployment. Provided fully polarimetric SAR information can be made available, a plethora of novel POLSAR matrix decomposition methods can be implemented for recovering rather precise scattering contributions from isolated and distributed scattering scenarios, and so can rather exact environmental changes from consecutive repeat-pass observations. With the recent launches of the fully polarimetric satellites JAXA-ALOS (PAL-SAR-L), the DLR TerraSAR-X and RADASAT-2 (C), a new era in space imaging of the terrestrial terrain and ocean surfaces has arrived providing unforeseen advantages. Whereas in the past, POLSAR applications were focused mainly on information product gathering for agriculture, forestry and the fisheries, little emphasis was placed on demonstrating its full capacity also for the assessment of natural habitats and especially wetlands. Therefore, it is essential to demonstrate how seasonal changes and features of vegetation in natural habitats, shallow vegetated lakes and wetlands can be recovered, provided fully polarimetric SAR image data takes can be made available for full polarimetric scattering matrix acquisition for which the standard symmetry condition HV=VH may not necessarily be sufficient. [C356]

"Wideband ambiguity matrix of LFM-signals used in polarimetric radar allowing simultaneous measurement of scattering matrix elements"

A pair of concurrent up- and down-going Linear Frequency Modulated (LFM) wideband signals is used in a polarimetric radar allowing simultaneous measurement of all scattering matrix elements. In wideband LFM radar the ambiguity function for a selected polarization at transmit and receive and presented in the delay time versus Doppler frequency coordinate system shows a skewness. This skewness affects the accuracies in object range and velocity. The ambiguity matrix in wideband multi-polarization LFM radar can be used to study for the different orthogonal polarization states the impact of this shortcoming connected to this skewness. In this paper the wideband ambiguity matrix is generalized. We define the time scaling so that in the ambiguity matrix the consequences of skewness are minimized. We show simulation results to demonstrate the improved potentials of this newly-defined wideband ambiguity matrix approach. The error in range (time delay) measurements for fast moving radar target becomes minimal. [C357]

"Robustness of polarimetric detection algorithms against steering mismatches"

We analyze robustness of several multichannel radar detection algorithms to mismatches in the steering vector. In particular, we address the scenario of a staged detection, where a history of measurements provides the region of interest and a-priori polarimetric target signatures for a target. The four second stage detection approaches-optimally weighed span, Kellypsilas and Robeypsilas detectors, and Gerlachpsilas secondary data free detector-are considered using these polarimetric features. The evaluation based on recordings of real natural scenes and both real and artificially inserted extended objects concerns robustness of these algorithms to mismatches in the steering vector. It has been observed-for different ground clutter environments into which extended target is placed-that Kellypsilas detector provides the best detection but may suffer severely from the mismatch, Gerlachpsilas detector while allowing higher probability of false alarms, produces the most stable performance and Robeypsilas matched filter gives a suitable trade-off. [C358]

"Optimizing two-tone spurious-free dynamic range for polarimetric agile radar receivers"

Polarimetric agile radar is able to transmit and receive two dual-orthogonal signals simultaneously. Some special requirements for the receivers of such radar should be seriously taken into account. This paper focuses on the simulation, verification and validation of the RF receiverpsilas two-tone Spurious-Free Dynamic Range (SFDR) for an S-band radar with an IF sampling digital receiver. The models of every component and the non-linear components in the receiver chain in particular, are investigated in detail by using Agilent Advanced Design System (ADS) software. The measurement results of the components are used in this study to verify our initial models and they allow us to build up realistic models at component level. Furthermore simulation results of the receiver by using such realistic models are presented. Finally, the measurement results of the developed receiver are given to demonstrate the validity of our design approach for the two-tone SFDR optimization. [C359]

"Recent advances in microwave multi-modal SAR remote sensing of the terrestrial covers"

Land cover monitoring is one of the most potential applications of Polarimetric Synthetic Aperture Radar (POLSAR) sensing and so is Repeat-Pass Polarimetric-Interferometric SAR (RP-DIFF-POL-INSAR) stress-change assessment by air/high-altitude/space-borne SAR sensor deployment. Provided fully polarimetric SAR information can be made available, a plethora of novel POLSAR matrix decomposition methods can be implemented for recovering rather precise scattering contributions from isolated and distributed scattering scenarios, and so can rather exact environmental changes from consecutive repeat-pass observations at 1 m resolution from air and from space. With the recent launches of the fully polarimetric satellites JAXA-ALOS (PAL-SAR-L-Band), the DLR TerraSAR-X (X-Band) and of RADASAT-2 (C-Band), a new era in space imaging of the terrestrial terrain and ocean surfaces has arrived providing unforeseen advantages. Whereas in the past, POLSAR applications were focused mainly on information product gathering for agriculture, forestry and the fisheries, little emphasis was placed on demonstrating its full capacity also for the assessment of natural habitats and especially wetlands and desert regions. Specifically, we are now able to demonstrate how seasonal changes and features of vegetation in natural habitats, shallow vegetated lakes and wetlands & deserts can be recovered under worst weather conditions and at day and during night at most distant and often inaccessible hidden sites, where for example migrant birds rest. Land cover monitoring is one of the most potential applications of Polarimetric Synthetic Aperture Radar (POLSAR) sensing and so is Repeat-Pass Polarimetric-Interferometric SAR (RP-DIFF-POL-IN-SAR) stress-change assessment by air/high-altitude/space-borne SAR sensor deployment. Provided fully polarimetric SAR information can be made available, a plethora of novel POLSAR matrix decomposition methods can be implemented for recovering rather precise scatte--ring contributions from isolated and distributed scattering scenarios, and so can rather exact environmental changes from consecutive repeat-pass observations at 1 m resolution from air and from space. It is essential to emphasize that fully polarimetric SAR image data sets are strictly required for optimal information extraction and compacted or hybrid quasi-polarimetric SAR imaging will fail to discover intricate detailed feature characteristics and parameters. [C360]

"Basics of microwave radar & SAR polarimetry and its applications"

The development of radar polarimetry and radar interferometry is advancing rapidly, and these novel radar technologies are revamping "synthetic aperture radar imaging" decisively. In this exposition the successive advancements are sketched; beginning with the fundamental formulations and high-lighting the salient points of these diverse remote sensing techniques. Whereas with radar polarimetry the textural fine-structure, target-orientation and shape, symmetries and material constituents can be recovered with considerable improvements above that of standard 'amplitude-only polarization radar'; with radar interferometry the spatial (in depth) structure can be explored. In 'polarimetric-interferometric synthetic aperture radar (POL-IN-SAR) imaging' it is possible to recover such co-registered textural plus spatial properties simultaneously. This includes the extraction of 'digital elevation maps (DEM)" from either 'fully polarimetric (scattering matrix)' or interferometric (dual antenna) SAR image data takes' with the additional benefit of obtaining co-registered threedimensional 'POL-IN-DEM' information. Extra-wide-band POL-IN-SAR imaging-when applied to 'repeat-pass image overlay interferometry'-provides differential background validation and measurement, stress assessment, and environmental stress-change monitoring capabilities with hitherto unattained accuracy, which are essential tools for improved global biomass estimation. More recently, by applying multiple parallel repeat-pass EWB-POL-D(RP)- IN-SAR imaging along stacked (altitudinal) or displaced (horizontal) flight-lines will result in 'tomographic (multi-interferometric) polarimetric SAR stereo- imaging', including foliage and ground penetrating capabilities. It is shown that the accelerated advancement of these modern 'EWB-POL-D(RP)-IN- SAR' imaging techniques is of direct relevance and of paramount priority to wide-area dynamic homeland security surveillance and local-to-global envi--ronmental groundtruth measurement and validation, stress assessment, and stress-change monitoring of the terrestrial and planetary covers. [C361]

"Synthetic Digital Correlation for Combined Polarimetric Microwave Remote Sensing"

Combined passive and active microwave remote sensing can provide complementary information and enhance performance of the retrieval of parameters. In consideration of the combination of passive and active microwave polarimeters in an identical system, an active polarimetric matrix consisting of six parameters is combined with the format of the passive polarimetric parameters matrix which is known as the Stokes vector. A synthetic digital correlation method is designed to perform combined measurements of the two types of parameter matrixes, and to achieve cost saving using shared subsystems and hardware. Performances of the design are analyzed including measurement sensitivities, relative errors, and dynamic range. [C362]

"LOS PALSAR data analysis of snow cover area in Himalayan region using four component scattering decomposition technique"

Snow cover is the important parameter for hydrological modeling and climate change modeling. Land use/cover classification is one of the most important applications of polarimetric synthetic aperture radar (POLSAR) sensing. Hence, the application of radar polarimetry is one of the best remote sensing techniques to classify snow cover terrain. In this paper, PALSAR data have been analyzed of snow cover area in Himalayan region based on three and four component scattering mechanism model. This study shows the implementation problem of four-component decomposition model in Himalayan terrain. Finally, supervised Wishart classifier has been used for snow cover and other land feature classification. The over all accuracy was measured to be 74.12 % without speckle noise reduction. [C363]

"Snow density estimation using polarimetric ASAR data"

Remote sensing of radar polarimetry has great potential to determine the extent and properties of snow cover. Availability of spaceborne sensor dual polarimetric C-band data of ENVISAT-ASAR can enhance the accuracy in measurement of snow physical parameters as compared to single fixed polarization data measurement. This study shows that the capability of C-band SAR data for estimating dry snow density over snow coverer rugged terrain in Himalayan region. The study area lies in Beas, Chandra and Bhaga catchments of Himachal state (India). For this investigation, the main assumptions are that the snow is dry and at C-band, total backscattering coefficient comes from snowpack and snow ground interface. An algorithm for estimating snow density has been developed based on snow volume scattering and snow-ground scattering components. Snow density estimation algorithm requires HH and VV polarization combination data. The radar backscattering coefficients of both HH and VV polarization and incidence angle are given as input to the developed algorithm. Finally, the algorithm gives the snow dielectric constant which can further be related to snow density using Looyengapsilas semi empirical formula. Comparison was done between algorithm estimated snow density and field value of snow density in the study region. The mean absolute error between estimated and measured snow density was 21.3 kg/m3. [C364]

"Classification of polarimetric synthetic aperture radar images from SIR-C and ALOS PALSAR"

SIR-C quad-pol MLC data and ALOS PALSAR quad-pol and dual pol SLC data over Indian sites have been processed using PolSARpro software for classification of various land features. The land features include ocean, clear water, settlements, agriculture fields, arid lands, grown and young forest, hilly terrain, mangrove forest, etc. The test sites used are SIR-C L-band and C-band Kolkata city and its surroundings, ALOS PALSAR data over West Bengal, Haryana, Rajasthan, Uttar Pradesh, and Mumbai. For Kolkata city we observed that classification results for L- and C-bands are slightly different. For Mumbai dual pol data classification accuracy is poor due to overlap of backscattering values for bare ground and mangrove vegetation with ocean backscattering values. [C365]

"Target recognition and polarimetric SAR"

This tutorial presents a state-of-the-art survey of advanced applications of Synthetic Aperture Radar (SAR). Applications include: the detection and recognition of targets in SAR imagery, and the detection of targets under trees (and in the open) using change detection (coherent change detection, full-polarization change detection, etc). A fully polarimetric SAR sensor is described. Models of clutter and targets are developed from analysis of full-polarization SAR imagery. Algorithms for optimum (GLRT) processing of full-polarization data are derived, including the polarimetric whitening filter (PWF) and the polarimetric matched filter (PMF). Polarization-based discrimination features (polarization entropy, anisotropy, etc.) are developed and applied to SAR image terrain classification. Model-based and template-based target recognition systems are described and classifier performance results versus resolution and polarization are summarized for 10-and 20-target classifiers. Super-resolution algorithms are applied to SAR imagery and target recognition performance improvements demonstrated. Multi-polarization and multi-pass change detection algorithms are developed and demonstrated using UHF SAR imagery of targets under trees; fusion of multi-polarization coherent and non-coherent change

detection algorithms is demonstrated. The effect of SAR image compression on change detection performance is quantified. Change detection performance using multi-pass VHF SAR imagery of targets under trees is demonstrated using data gathered by the Swedish CARABAS SAR system. [C366]

"Speckle Reduction of Polarimetric SAR Image Based on ICA-SCS Algorithm"

In this paper, a new method of sparse coding shrinkage based on independent component analysis is proposed to reduce speckle in polarimetric SAR Images. With soft-thresholding operator on polarimetric SAR Image, this method reduces speckle effectively and preserved polarimetric properties. The experiment shows that the image edges are retained with the proposed method and the speckle is removed effectively. [C367]

"Classification for polarimetric SAR images based on subaperture decomposition"

In this paper, a novel method, which combines subaperture decomposition with H/alpha/Wishart classifier, is introduced to classify polarimetric synthetic radar (SAR) images. We use H/alpha plane to initially classify the full-resolution polarimetric SAR image. The initial classification map defines training sets for classification based on coherency matrices of subapertures and wishart distribution. The classified results are then used to define training sets for the next iteration. The convergence of this kind of iteration is much faster than using full-resolution images. And the interpretation of this method is more easily. Results show that the method provides a significant performance improvement with respect to the approaches based on full-resolution images. [C368]

"Model-oriented hydrometeor classification and water content estimate using dual-polarized weather radars"

Dual-polarized weather radars are capable to detect and identify different classes of hydrometeors, within stratiform and convective storms exploiting polarimetric diversity. A model-supervised Bayesian method for hydrometeor classification (BRAHC), tuned for S- and X- band, is described in this study. The critical issue of X-band radar data processing is the path attenuation correction, usually negligible at S-band. During the IHOP experiment (Oklahoma, 2002) two dualpolarized radars, at S- and X- bands, were deployed and jointly operated with closely matched scanning strategies, giving the opportunity to perform experimental comparisons between coincident measurements at different frequencies. Results of hydrometeor classification and water content estimates at S- and X- bands are discussed and the impact of path attenuation correction is quantitatively analyzed. [C369]

"An integrated procedure for rainfall estimation using C-band dual-polarization weather radars"

Weather radar polarimetric techniques have been widely studied due to their potential to improve radar rainfall estimation and to infer on the microphysical characteristics of clouds and precipitation. Nowadays, polarimetric techniques are receiving an increasing attention from meteorological services. In fact, programs aiming at upgrading national weather radar networks with polarimetry are ongoing in both in Europe and in USA. Therefore, there is growing a demand for properly designed products that capitalizes research results in order to obtain improved and reliable meteorological products, such as rainfall estimates, based on polarimetric measurements. This paper presents an integrated methodology which, starting from C-band polarimetric radar measurements, allows to obtain the best rainfall estimation. The procedure takes into account radar meteorology key issues such as: real time calibration check, ground clutter identification, and C-band attenuation correction. The methodology takes advantage of the synergy among radar measurements of reflectivity factor, differential reflectivity, and specific differential phase, as expressed by the self-consistency principle of polarimetric radar measurements in rain. The procedure is evaluated with a case study observed by the ISAC-CNR Polar 55C radar during an intense rainfall event which occurred on 25 September 2006 over the Lazio region (central Italy). A comparison analysis of the method is also performed using rainfall data collected by the hydrographic regional office telemetered network. [C370]

"Radar interferometry"

Since its inception 30 years ago perhaps no innovation in radar technology has made such a tremendous impact on the field as that of radar interferometry. Radar interferometry uses two or more observations separated in either time or space to measure fraction of a wavelength scale range differences between the two observations. Radar interferometry is used by scientific, commercial and government institutions for numerous applications including topographic map generation, surface deformation mapping, landslide monitoring, current velocity measurement, vegetation structure determination and change detection. Radar interferometers can be flown on either spaceborne or airborne platforms or be fixed observing systems. This course is designed to provide an overview of the basic concepts of radar interferometry and an introduction to some of its applications. The course will cover basic radar imaging principles, a geometric and imaging signal perspective of the

interferometric phase, interferometric correlation, basic sensitivity equations, phase unwrapping, topographic mapping and repeat pass interferometry for deformation measurements. The principles will be illustrated with examples from both spaceborne and airborne interferometric data sets. An overview of some of the major applications of radar interferometry will be presented with an emphasis on topographic and deformation mapping. The course will also briefly touch upon permanent scatter methods and polarimetric interferometry. [C371]

"The PARSAX-full polarimetric FMCW radar with dual-orthogonal signals"

The article describes the IRCTR PARSAX radar system-fully polarimetric FMCW radar with dual-orthogonal sounding signals, which has the possibility to measure all elements of the radar targets polarization scattering matrix simultaneously, in one sweep. [C372]

"Hydrometeor type and turbulence intensity recognition with Doppler-polarimetric radar"

This paper presents some new results on Doppler-polarimetric radar application to recognition both hydrometeor type and turbulence intensity level. The results are obtained by using the integrated approach proposed earlier and application of fuzzy logic-neural network recognition technique. Measurable variables are described. Based on physical considerations, calculations, and modelling, the parameterization for different situations is done and fuzzy logic procedures are developed and applied to real data processing. Finally, fuzzy logic recognition results are used for neural network procedure training. [C373]

"Polarimetric synthetic range profile autofocusing via contrast optimization"

One of the main benefits brought by the use of fully polarimetric radars is the ability to identify the scattering mechanism, which is related to target physical properties. One of the most critical problems in synthetic range profile reconstruction is the distortion induced by the target motion. Radial target velocity and acceleration generate second and third order phase terms in the received signal, which produce range shift and point spread function (PSF) smearing. The distortions induced by the target motion produce, as a consequence, a SNR loss. Recently, a method based on contrast maximisation has been proposed to compensate target radial motions in single polarisation radar. In this paper, an extension of such an algorithm is proposed that exploits full polarisation. [C374]

"Anomaly detection in multi-polarimetric radar images"

An anomaly detection algorithm for SAR (synthetic aperture radar) images, making use of multi-polarized data, is developed. The processing contains several stages including: calibration of the images, information parameters extraction and speckle filtering, suspect pixels detection and morphology operator application. The developed algorithm is independent of the anomaly radar cross section; it depends only on the physical structure. The proposed processing is non-iterative, adaptive and automatic. Performance evaluation shows improved performance of the algorithm over the common alternatives. [C375]

"Transpolarizing Surfaces and Potential Applications"

Transpolarizing surfaces are characterized for their property of rotating by 90deg the reflected electric field with respect to the incident one. Several transpolarizing surface designs are presented, and their potential applications and limitations, mostly for oblique incidence, are discussed. [C376]

"Incoherent Polarimetric ISAR Decomposition for target classification"

The incoherent target decomposition theorem (ICTD) has been largely used when dealing with the problem of classifying distributed targets by using polarimetric synthetic aperture radar (PolSAR) images. In this paper, a method based on the use of the ICTD and the nearest neighbour classifier is proposed and applied to man made point-like targets in an ISAR-like scenario. the algorithm is tested by using real data in several signal to noise ratio (SNR) scenarios. [C377]

"The Impact of the Ionosphere on Interferometric SAR Processing"

The impact of ionospheric propagation effects on the signal properties of SAR systems is significant and increases with decreasing carrier frequency. Besides polarimetric applications, also interferometric SAR processing can be significantly affected. Relative range shifts, internal image deformations, range and azimuth blurring, and interferometric phase errors are the most significant effects to be considered. In this paper we provide the theoretical background for ionospheric effects on InSAR. We quantify expected magnitudes of the respective effects for various existing SAR sensors and discuss methods for their detection and correction. Real

data examples, mainly stemming from the ALOS PALSAR mission, are presented to verify the derived theory. [C378]

"Inversion Algorithm for Soil Moisture Retrieval from Polarimetric Backscattering Coefficients of Vegetation Canopies"

This paper presents soil moisture retrieval from measured polarimetric backscattering coefficients of a vegetated surface. Based on the analysis of the quite complicate first-order radiative transfer scattering model for vegetated surfaces, a simplified scattering model is proposed for an inversion algorithm. Extraction of the surface-scatter component from the total scattering of a vegetation canopy is addressed using the simplified model, and also using the three-component decomposition technique. The back-scattering coefficients are measured with a polarimetric L-band scatterometer during two months as well as the biomasses, leaf moisture contents, and soil moisture contents. Then the measurement data are used to estimate the model parameters for vv-, hh-, and vh-polarizations. The scattering model for tall-grass-covered surfaces is inverted to retrieve the soil moisture content from the measurements using a genetic algorithm. The retrieved soil moisture contents agree quite well with the in-situ measured soil moisture data. [C379]

"Surface Parameter Estimation Over Periodic Surfaces Using a Time-Frequency Approach"

The aim of this paper is to analyze the feasibility of soil moisture retrieval over rough periodic surfaces. For this kind of fields, the Bragg phenomenon effect appears and the inversion algorithms are shown to be no more valid. Using a time-frequency approach and a new random periodic surface scattering model, a polarimetric analysis allows to show that the use of alpha1polarimetric parameter is important for the inversion since it is quasi insensible to this phenomenon. Thus, the alpha1inversion method is proposed that provides some encouraging results. [C380]

"Scattering type phase for wetland classification using C-band polarimetric SAR"

The Touzi decomposition is investigated for wetland characterization. Like the Cloude alpha scattering type, the magnitude alphasof the symmetric scattering is not effective for vegetation type discrimination. The phase Phialphasof the symmetric scattering type has to be used for enhanced characterization of wetland vegetation species. A new tool is introduced for assessment of the scattering type phase coherence, and the phase of the dominant scattering type is shown to be very promising for wetland target classification. The unique information provided by Phialphasfor enhanced wetland class discrimination is demonstrated using Convair-580 polarimetric C-band SAR data collected over the Mer Bleue wetland in the East of Ottawa, Canada. The use of Phialphasmakes possible the discrimination of shrub bog from sedges fen, and permits even the discrimination between conifer dominated treed bog from upland deciduous forest under leafy conditions. [C381]

"Seasonal Change Monitoring of Wetlands by Using Airborne and Satellite Polsar Sensing"

This paper presents a simple water area classification technique based on POLSAR image analysis and investigates the seasonal change of the true water area in wetland by making use of the satellite ALOS/PALSAR data, in addition to the air-borne Pi-SAR data. We here utilize the scattering power decomposition method in the image analysis, and verify that the double-bounce scattering, which can be considered as a true water area classification marker, is observed from the wetland and the surrounding emerged plants for both the airborne and satellite POLSAR data sets, even though the resolution and the incident angle are quite different. The dependency of the polarimetric scattering feature on the variation of the incident angle is also investigated by the polarimetric scattering analysis for a simplified emergent-water boundary model by using the finite-difference time-domain (FDTD) method. It is resultantly confirmed that the double-bounce scattering is utilized as a useful marker for the distinction of the true water area of the wetland even for small incident angle case. [C382]

"Recent Advances in POL-SAR & POL-IN-SAR Imaging of Natural Habitats and Wetland Remote Sensing"

Land cover monitoring is one of the most potential applications of Polarimetric Synthetic Aperture Radar (POLSAR) sensing and so is Repeat-Pass Polarimetric-Interferometric SAR (RP-DIFF-POL-IN-SAR) stress-change assessment for air/high-altitude/space-borne SAR sensor deployment. Provided fully polarimetric SAR information can be made available, a plethora of novel POLSAR matrixde composition methods can be implemented for recovering rather precise scattering contributions from isolated and distributed scattering scenarios, and so can rather exact environmental changes from consecutive repeat-pass observations. With the recent launches of the fully polarimetric satellites JAXA-ALOS (PAL-SAR-L), the DLR TerraSAR-X and RADASAT-2 (C), a new era in space imaging of the terrestrial terrain and ocean surfaces has arrived providing

unforeseen advantages. Whereas in the past, POLSAR applications were focused mainly on information product gathering for agriculture, forestry and the fisheries, little emphasis was placed on demonstrating its full capacity also for the assessment of natural habitats and especially wetlands. Therefore, it is essential to demonstrate how seasonal changes and features of vegetation in natural habitats, shallow vegetated lakes and wetlands can be recovered, provided fully polarimetric SAR image data takes can be made available for full polarimetric scattering matrix acquisition for which the standard symmetry condition HV=VH may not necessarily be sufficient. [C383]

"Mapping the Ionosphere Using L-Band SAR Data"

The influence of the ionosphere on spaceborne SAR signals can be significant, especially approaching wavelengths at L-band or larger. By measuring these effects and inverting the underlying physical model, these effects can be used to measure and map aspects of the ionosphere. ALOS PALSAR data is employed to demonstrate this capability. Single-pol data is used to determine second-order gradients of the ionosperic Total Electron Content (TEC) (the second derivative of intensity). Dual-pol can yield lateral TEC variations in homogeneous areas. Finally, Faraday rotation measurements from full-pol data can be used to create 2-D maps of the absolute TEC. [C384]

"Quantifying and Correcting Ionospheric Effects on P-Band SAR Images"

Faraday rotation and scintillation will seriously affect P-band SAR images if methods are not used to deal with them. There are published methods for correcting Faraday rotation when polarimetric data are available, but less is known about scintillation. Scintillation is unlikely to present a problem if data acquisitions at low and mid latitudes avoid the post-sunset equatorial region, but correction procedures are likely to be needed in the auroral zones. Such correction is possible using autofocus methods; this is demonstrated using the Phase Gradient Algorithm applied to SAR imagery seriously affected by simulated scintillation. [C385]

"Polinsar at Low Frequency and Ionospheric Effects"

Global warming is now known to be the major environmental issue mankind will have to face in the next decade. Monitoring of vegetation and biomass is clearly an essential piece of information required at all levels ranging from the scientific studies to understand and forecast, to the political actors and government leaders responsible for drafting remediation policies and evaluating their impact. Microwave remote sensing with the low-frequency SAR technique can provide a useful characterization of forest (spatial coverage, species, density, height...) at a global scale, relying on the all-weather imaging capabilities of SAR linked with the significant penetration of the low-frequency EM wave in the canopy. The published techniques for forest characterization from low frequency SAR data include radiometry inversion, polarimetric inversion based on the anisotropy parameters and PolInSAR Random Volume Over Ground inversion. In this paper, we will more specifically concentrate on the PolInSAR technique and the impact of ionospheric effect on this inversion. PolInSAR at low frequency can be envisioned with two radar platforms flying in formation or as a repeat pass mission. The second alternative is more plausible given the cost and the size of a low frequency SAR instrument. However the two cases will be discussed in the paper. [C386]

"SAR Coherence Tomography for Boreal Forest with Aid of Laser Measurements"

In this paper we evaluate X- and L-band SAR coherence tomography in boreal forest with the help of detailed digital terrain and canopy height models, produced by laser scanning. Polarimetric coherence tomography (PCT) needs accurate estimates of ground phase and tree height. Supplemental accurate elevation models allow us to evaluate the performance of PCT in normal case when initial values are derived from RVoG model inversion and provides opportunity to use PCT for nonpolarimetric data. The work is based on E-SAR L-band and X-band measurements in Finland. Our results show that with accurate elevation and tree height information single polarization X-band coherence tomography is feasible and works well. Accurate ground elevation information improves also the performance of fully polarimetric repeat pass L-band PCT. The laser DEM provides better ground phase estimate than RVoG model inversion in the presence of temporal decorrelation. Our results show that accurate ground phase estimation is more critical for successful coherence tomography than other parameters. [C387]

"Analysis of Temporal Decorrelation in Dual-Baseline Polinsar Vegetation Parameter Estimation"

Vegetation parameters can be estimated using the single-baseline polarimetric synthetic aperture radar interferometry (POLinSAR) data based on the random volume over ground (RVoG) model. Temporal decorrelation, which is the coherence loss due to scene changes within the time between radar data acquisitions, will decrease the estimation accuracy and needs to be compensated. The RVoG+VTD model is a simple model incorporating a temporal decorrelation term into the RVoG model. The inversion of RVoG+VTD

model can not perform due to the limited number of single-baseline POLinSAR observables. Dual-baseline POLinSAR approach provides more observables and hence can be used to invert the model. This paper introduces and analyzes the dual-baseline inversion procedure of RVoG+VTD model and validates them using simulated data. [C388]

"Modeling and Interpretation of the Multitemporal and Multibaseline Polinsar Coherence"

This paper focuses on the physical understanding of the polarimetric interferometric SAR (PolInSAR) coherence, and on the accurate utilization of this coherence for vegetation parameter inversion. A polarimetric interferometric vegetation model presented here provides the possibility to estimate parameters related to ground topography, vegetation, and surface scattering. In particular, one can estimate such vegetation characteristics as the main orientation, the degree of orientation randomness and the effective shape of the particles, together with structural parameters like the ground height and the depths of vegetation layers. The polarimetric model is based on the Freeman's three component decomposition, which is extended to consider vegetation orientation. To enhance polarimetry, a complimentary interferometric coherence model is presented. The model and the parameter inversion method are tested on accurate electromagnetic simulations of real forests. Parameter inversion performance is evaluated for single-baseline and multibaseline data. [C389]

"Preliminary Polarimetric Measurements of Ruffled Water Surface Radar Backscattering Coefficients and Brightness Temperatures Angular Dependences at 15GHz"

In this paper preliminary results of smooth and waved water surface radar backscattering coefficient and brightness temperature angular dependences at 15 GHz are represented. The results were obtained by combined radar-radiometer system moving along a quarter circle shaped measuring platform of 7 m of radius. [C390]

"Polarimetric Scattering Mechanizms of Ocean Surface from Wave Breaking or at Large Incident Angles"

Polarimetric scattering mechanisms of ocean surface are important for improving ocean surface scattering model and detecting objects on the ocean surface, especially at large incidence angles and wave breaking. We proposed polarimetric parameters technique to analyze the scattering mechanisms of ocean surface. Lacks of the related data, we only analyzed the variances of polarimereic parameters with incidence angles for C, L and P-band at low ocean state. The results show the polarimetric parameters are different at different incidence angles and different radar work bands. It further indicates that the same ocean surface will present different scattering mechanisms at different radar work conditions. [C391]

"Ocean Surface Observation by C-Band Polarimetric Weather Radar in Okinawa Island"

We apply a C-band multi-parameter weather radar in the Okinawa Island to non-weather measurements. Its full-polarimetric and Doppler velocity measurement capability would be very powerful tool for observing land and ocean surface properties, if the target area is located appropriately to the radar. Located at the top of a mountain in the middle of the island, the radar has good view of its surrounding ocean. We make the radar observe ocean surfaces, in different wind conditions. The results show that the radar cross-section is larger when the wind speed is larger, and relatively smaller in the downwind side of the island, as expected. Cross-polarization components HV show similar dependency on wind conditions to HH and VV components. Measured Doppler velocities also show azimuth variation depending on the wind speed and direction. [C392]

"Polarimetric PALSAR System Model Assessment and Calibration"

Polarimetric PALSAR system parameters are assessed using data sets collected over various calibration sites. The data collected over the Amazonian forest permits validating the zero Faraday rotation hypotheses near the equator. The analysis of the Amazonian forest data and the response of the corner reflectors deployed during the PALSAR acquisitions lead to the conclusion that the antenna is highly isolated (better than -35 dB). Theses results are confirmed using data collected over the Sweden and Ottawa calibration sites. The 5-m height trihedrals deployed in the Sweden calibration site by the Chalmers University of technology permits accurate measurement of antenna parameters, and detection of 2-3 degree Faraday rotation during day acquisition, whereas no Faraday rotation was noted during night acquisition. Small Faraday rotation angles (2-3 degree) have been measured using acquisitions over the DLR Oberpfaffenhofen and the Ottawa calibration sites. The presence of small but still significant Faraday rotation (2-3 degree) induces a CR return at the cross-polarization HV and VH that should not be interpreted as the actual antenna cross-talk. PALSAR antenna is highly isolated (better than -35 dB), and diagonal antenna distortion matrices (with zero cross-talk terms) can be used for

accurate calibration of PALSAR polarimetric data. [C393]

"Normalized Coherency Matrix Estimation Under the SIRV Model. Alpine Glacier Polsar Data Analysis"

This paper presents an application of the recent advances in the field of Spherically Invariant Random Vectors modelling. We propose the use of the Fixed Point (FP) estimator for deriving normalized polarimetric coherency matrices in compound Gaussian clutter. The main advantages of the FP estimator are that it does not require any "a priori" information about the probability density function of the texture and it can be directly applied on adaptive neighborhoods. Interesting results are obtained when coupling this FP estimator with an adaptive spatial support driven on the scalar span information. The proposed method is tested with both simulated POLSAR data and high resolution POLSAR data acquired over the French Alps. [C394]

"Dependency of NRCS of Ocean Surface on Wind Direction Using an Airborne Dual-Frequency Polarimetric SAR Observation"

The normalized radar cross section (NRCS) of ocean surface is measured from three directions of illumination by an air-borne dual-frequency synthetic aperture radar (SAR) in the L- and X-bands, and the dependency of the NRCS and the polarization ratio on the relative wind direction is analyzed. In the X-band, the dependencies of the NRCSs in the parallel polarizations are different each other. The NRCS in the X-band HH polarization has difference between the up-and down-wind conditions, though that in the VV polarization the NRCSs for the up- and down-wind conditions are almost same. The dependency of the NRCS in the L-band is smaller than that of the X-band. The polarization ratio in the X-band shows the dependency on the wind direction with difference between the up- and down-wind conditions, though that in the L-band is not apparent. The results suggests the possibility of ocean wind measurement by the polarimetric SAR in the X-band. [C395]

"Investigation of a New Multifunctional High Performance SAR System Concept Exploiting MIMO Technology"

In this paper, we introduce an innovative system concept for synthetic aperture radar (SAR) and investigate the performance. Based on multiple-input multiple-output (MIMO) configuration, a versatile SAR operation can be feasible, for instance interferometric and full polarimetric SAR operation over a wide area simultaneously. For this purpose the space-time coding (STC) and digital beamforming (DBF) are key elements of the proposed MIMO SAR concept. A waveform diversity gain is obtained from the STC scheme, applied on transmit and DBF on receive provides array gain and improved noise performance for each multiple SAR images. In this paper, using a simple transmit diversity technique, well known as Alamouti scheme, the complete processing topology is introduced. The performance is investigated from a system point of view. [C396]

"On the Use of Dual-Polarized SAR Data for Oil Spill Observation"

In this paper a novel approach for oil spill observation, based on partially polarimetric Synthetic Aperture Radar (SAR) data, is proposed. A model which relates the co-polarized phase difference (CPD) to the sea surface scattering mechanism with and without slicks is developed. Experiments accomplished over multi-look complex (MLC) C-Band SAR data, show that the CPD approach is useful both to observe oil spills and to distinguish between oil spills and biogenic slicks. [C397]

"Data Fusion Study Between Polarimetric SAR, Hyperspectral and Lidar Data for Forest Information"

ALOS PALSAR L-band quad-pol data were acquired over our study area on Vancouver Island in British Columbia in the summer of 2007. The site has significant topographic relief and high biomass in this temperate coastal rainforest. Our emphasis was on integration and fusion techniques of polarimetric SAR, hyperspectral and LIDAR data for useful forest information extraction. The polarimetric SAR techniques and analysis methods studied in this project drew on the work of other researchers. The Jong-Sen Lee algorithm for polarization compensation for terrain azimuth slope variations was implemented and tested. The Shane Cloude decomposition method, with basic types of scattering analysis for reducing sensitivity to topography effects was examined and applied. In this study, the hyperspectral data was used for providing high spectral resolution information, such as major forest species and land-cover characterization, and the LIDAR data were utilized to generate information related to vertical structure of both the underlying topography and the forest structure. The combination of these data sources and techniques provided an opportunity to examine the potential capabilities of polarimetric SAR and the synergy of the fused data for forest classification. [C398]

"Comparison of Ship Detectability Using SAR Polarization Data: Envisat ASAR AP Mode"

Preliminary results are reported on ship detection using coherence images computed from cross-correlating images of multi-look-processed dual-polarization data of ENVISAT ASAR. The traditional techniques of ship detection by radars such as CFAR (Constant False Alarm Rate) rely on the amplitude data, and therefore the detection tends to become difficult when the amplitudes of ships images are at similar level as the mean amplitude of surrounding sea clutter. The proposed method utilizes the property that the multi-look images of ships are correlated with each other. Because the inter-look images of sea surface are covered by uncorrelated speckle, cross-correlation of multi-look images yields the different degrees of coherence between the images and water. The polarimetric information of ships, land and intertidal zone are first compared based on the cross-correlation between HH and HV. In the next step, we examine the technique when the dual-polarization data are split into two multi-look images. [C399]

"Compensation of Faraday Rotation in Multi-Polarization Scatterometry"

The effects of Faraday rotation on spaceborne polarimetric scatterometers are discussed. A method of exploiting an estimate of the Faraday rotation angle to retrieve co-cross polarization is outlined. [C400]

"Volume Coherence Estimation for Random Forest Height Retrieval Based on Polinsar Data"

The volume coherence is an important parameter in the two-layer model for random forest height retrieval. Though it is "invisible" from the observation, it can be estimated from the data. Considering the argument range of the coherences for all the possible polarizations, six polarizations can be obtained for each scattering cell. The volume coherence can be estimated more reasonably and the ground phase center can be determined more accurately. It benefits to improve the height retrieval accuracy by this model. The proposed method is validated by using L-band single-baseline polarimetric interferometric SAR data collected with the DLR Experimental SAR system. [C401]

"Simplified and fast iterative physical optics algorithm for human body analysis at W-band"

The millimeter-wave (MMW) region of electromagnetic spectrum presents a unique opportunity in detection of pedestrians in heavy clutter environment and hidden objects carried by individuals. In our previous studies [1], [2], we presented polarimetric radar Doppler signature of walking human and dog at 95 GHz. We utilized physical optics (PO) method to model the body with equivalent PO surface and geometrical optics (GO) method to determine the shadowed areas for a given orientation of human body with respect to the direction of the incident wave. The first order PO approach does not actually account for interactions between different body parts. As a result, an accurate cross-polarized response cannot be expected. To alleviate this problem, we employed Iterative PO model in which the interactions between body parts are fully accommodated. In this analysis, human body is descretized into a number of flat facets for each of which the induced currents resulted from other facetspsila scattered field is also taken into account. In this case, if the number of constituent facets is N, the operation of calculating all the interactions is on the order of N2since each facet has N operations (interactions). This is unlike the first order PO in which we had one operation for each facet and analysis was on the order of N. This massive number of operations for higher order PO brings up some difficulties regarding the exorbitant computation time needed for analysis of a walking individual. This challenge forced us to revise the scheme and take advantage of some features in human body to make the IPO analysis computationally tracktable. [C402]

"Object-oriented classification of polarimetric SAR imagery based on Statistical Region Merging and Support Vector Machine"

This paper presents a new object-oriented classification method based on statistical region merging (SRM) for segmentation and support vector machine (SVM) for classification where polarimetric synthetic aperture radar (PolSAR) data are used. The proposed approach makes use of polarimetric information of PolSAR data, and takes advantage of SRM and SVM. The SRM segmentation method not only considers spectral, shape, scale information, but also has the ability to cope with significant noise corruption, handle occlusions. The SVM used for classification takes its advantages of solving sparse sampling, non-linear, high-dimensional, and global optimum problems comparing with other classifiers. It is thus expected that the input vectors of SVM will include fully polarimetric information for image classification. A test image, acquired by the Jet Propulsion Laboratory Airborne SAR (AIRSAR) system, is used to demonstrate the advantages of the proposed method. It is shown that the proposed approach outperforms the traditional pixel-based SVM classification method for land cover classification with PolSAR data, and the integration of SRM and SVM makes the proposed algorithm an attractive and alternative method for polarimetric SAR classification. [C403]

"Polarimetric signature for oil spill observation"

Synthetic aperture radar (SAR) oil spill observation is not at all an easy task since the presence of many natural phenomena and surfactants call for complex and time-consuming classification techniques, generally based on the use of ancillary external data. In this study, polarization diversity is employed to assist oil spill observation techniques. The polarization signature, commonly used for land application, is firstly read in terms of a sea surface scattering mechanism with and without surface slicks. Experiments, accomplished over multilook complex (MLC) C-band SIR-C/X-SAR data, show that the polarization signature can be useful both for observing oil spills and for distinguishing between oil spills and biogenic look-alikes. [C404]

"Extended object detection and extraction in a high resolution polarimetric surveillance radar"

Detection in most surveillance radars is based on assumptions on point targets against a more or less homogeneous background. Currently, the resolution of many new types of radar is increasing, at least in the range dimension. Therefore many objects no longer can be considered as points. Also, the background is getting more diverse, in statistical terms, since many individual objects in the background are no longer mixed coherently. The current paper proposes as staged approach to detection and parameter assessment of extended objects and adds classification based on the polarimetric features. The evaluation of the approach is based on recordings with a polarimetric radar of real natural scenes and both real and artificially inserted extended objects. It has been observed that a multi-stage detection outperforms a classical method, in terms of the ratio between wanted and unwanted alarms. [C405]

"Clustering of fully polarimetric SAR data using finite Gp 0 mixture model and SEM Algorithm"

This paper presents a novel method for clustering multilook polarimetric SAR images by combining the stochastic expectation-maximization (SEM) algorithm with the mixture of Gp0distributions, using the method of moments for parameter estimation. The pixel values of multilook SAR data are complex covariance matrices, and they are described by mixtures of gp0laws. This distribution can describe different type of targets; like urban areas, forest and pasture. The proposed clustering technique can be applied to unsupervised classification and segmentation process. Experiments with real image data provide good results. [C406]

"Unsupervised classification of PolSAR images using eigenvector analysis, Krogager decomposition and the Wishart classifier"

In this paper, a new scheme for unsupervised classification of polarimetric synthetic aperture radar (PolSAR) images is presented. The method mainly consists of four parts: eigenvector analysis of the coherency (or covariance) matrix, Krogager decomposition, unsupervised classification using Krogager coefficients and scattering entropy, and iterative classification based on the Wishart distance measure. The method can classify the pixels into nine classes, and its effectiveness is demonstrated using the Jet Propulsion Laboratorypsilas AIRSAR and SIR-C/X-SAR L-band PolSAR data. [C407]

"Automatic Target Recognition by means of polarimetric ISAR images: a model matching based algorithm"

Automatic target recognition (ATR) is generally the reason why ISAR imaging systems are employed. Moreover, the use of fully polarimetric radar systems in radar imaging applications such as SAR and ISAR has enhanced both image quality and classification capabilities. In this paper, the authors propose a novel technique for ATR by using Polarimetric ISAR (Pol-ISAR) images. The proposed method is based on a model matching approach. Results are obtained by using real data that show the effectiveness of such technique. [C408]

"Automatic Target Recognition of terrestrial vehicles based on polarimetric ISAR image and model matching"

An Automatic Target Recognition (ATR) algorithm has recently been proposed that makes use of Polarimetric ISAR images and a Model Matching approach. In this paper, the authors propose a variation of such an approach that is suitable for ATR of terrestrial vehicles. The effectiveness of the proposed implementation is tested by means of real data acquired during a controlled turn-table experiment. [C409]

"Aspect dependence of the polarimetric characteristics of sea clutter: I. Variation with elevation angle"

The polarisation dependence of radar scattering from the sea at low to moderate angles of incidence has been studied extensively and has shown Bragg scatter to be the dominant mechanism for these geometries. At high

angles of incidence the polarimetric scattering behaviour is rather more complicated, with numerous mechanisms active. The transition region where the characteristics of the radar scattering from the sea changes, is not so well understood, due partly to the scarcity of experimental data from the open sea. Wave tank measurements have addressed some aspects, but it is not always easy to extrapolate these results to the natural environment. In this paper we examine the transition from Bragg scattering at low incidence angles to the more complicated scattering which occurs at high incidence angles by examining the changes that occur to the distribution of points in the partitioned H-alphamacr space. [C410]

"Multi-frequency polarimetric radar earth observations"

The air-borne multi-frequency polarimetric SAR ldquoIMARCrdquo allows radar earth observation measurements at 4 frequency bands (X,L,P and VHF) and utilizes a complete set of different linear polarizations: VV, HH, VH and HV. Theoretical and experimental feasibilities have been carried out in recent years. System capabilities and potential applications have been demonstrated. Operational usage in a wide range of applications is expected. However, from our research it became obvious that despite interesting data can be collected the major limitation of full and reliable utilization in various applications comes from the mismatch between available electro-magnetic models and the description of the actual earth surface and sub-surface during the SAR measurement campaigns. Applications are foreseen in hydrology and in classifying vegetation, snow, ice and frozen soils, and in sub-surface sensing for locating artificial and natural objects, as well as different natural anomalies. New and more advanced electro-magnetic modeling is needed in order to exploit all IMARC potentials. In the framework of a large multi-national activity an integrated software package will be developed in which new and more-advanced vegetation surface and sub-surface scattering models are included. [C411]

"Wideband correlation processing in polarimetric radar with compound signals and simultaneous measurement of scattering matrix elements"

In this paper wideband correlation processing is proposed for use in polarimetric radar with compound signals and simultaneous capabilities for measuring the scattering matrix elements. The processing technique does not affect the range and velocity characteristics of radar objects. [C412]

"Evaluation of some features for extended target extraction in polarimetric radar"

Detection in most surveillance radars is based on the condition of point targets against a more or less homogeneous background. Currently, the resolution of many new types of radar is increasing, at least in the range dimension. Therefore many objects no longer can be considered as points. Also as a consequence, the background is getting more diverse, in statistical terms. The scene addressed in this paper concerns a ground clutter environment, and extended objects observed with a polarimetric radar with modestly high resolution (i.e. 6m resolving power in range). A staged approach is proposed to detection and parameter assessment of extended objects and adding classification based on polarimetric features. The evaluation of this approach is based on recordings of real natural scenes and artificially inserted extended objects. It has been observed that in the multi-stage detection the object classification benefits from several features, amongst which polarimetric ones. It is proposed that the quality of the contour circumscribing the object is the prime factor for quality of the features next to the polarimetric features. Clutter is affecting the edges of the contours, and therefore may have a major impact on features that are dependent on these contours. [C413]

"A polarimetric scattering research of ocean surface based on the matrix of scattering facet"

A. new method of simulating polarimetric scatter coefficient of sea rough surface is given. Based on normal line matrix of scattering facets which is derived from a three dimensional sea model, an expression of scattered field with elliptic polarized incidence wave is deduced in Cartesian coordinate system. Finally fully polarized RCS are numerically calculated and compared in different conditions. [C414]

"Detection of buried objects using GPR change detection in polarimetric Huynen spaces"

Change detection is a useful method for detecting new events in a scene such as the placement of mines, and/or the movement of people, vehicles and structures. The basis of the approach is to examine an area via radar several times. Once, before there were targets planted there, and the other (or others) after. The change detection algorithm will notice if there are any changes after the first view was made. False alarm, that is a critical issue in this approach, can be reduced in a number of ways: exploiting additional information such as phase and polarization, and 2) exploiting critical attributes by computing changes in focused sub-spaces. In this paper we present anew approach for polarimetric change detection, whereby the target is represented not in terms of the complex scattering elements but in terms of phenomenologically-based Huynen parameters. Each element of the Huynen parameter set conveys useful physical and geometrical attributes about the scatterers

thus augmenting the potential for significant false alarm mitigation. Results of the application of this approach on fully polarimetric signatures of simulated buried targets are provided. These results indicate that Huynen parameters are more effective for change detection than the scattering matrix elements in generating higher unambiguous autocorrelation peaks and less prominent cross-correlation peaks. [C415]

"Colorization for Polarimetric SAR Image Based on Scattering Mechanisms"

Polarimetric synthetic aperture radar (POLSAR) images are widely used for aerial and spatial image applications, such as terrain classification, target detection, etc. However, only monochrome gray images can be derived from SAR data due to the imaging mechanisms of SAR, which limits image presentation and visual appeal. In this paper, we proposed a new approach to colorization for POLSAR images. The basic principle is that pixels with the same scattering characteristics should have similar colors. To achieve this, the algorithm first utilizes the Cloude and Pottier's decomposition to separate pixels into eight scattering categories, and then unsupervised classification is applied for further iteration. Colorization is performed in Lab color space using the classification result, which assigns a color to each class according to the self-defined entropy-alpha color map. In this semiautomatic method, an operator only needs to define a color map, and then the indicated colors are automatically transferred to produce a fully colorized image. The effectiveness of this algorithm is demonstrated by a JPL/AIRSAR POLSAR image. [C416]

"Enhancements of an Adaptive Neighborhood Speckle Filtering Algorithm to Improve Analysis of Polarimetric SAR Imagery"

Image noise often hinders the analysis and understanding of most remote sensing imagery. Synthetic aperture radar (SAR) images, in particular, suffer from a phenomenon known as speckle. Speckle is the result of the coherent sum of scattering mechanisms within a resolution cell and is typically modeled as multiplicative noise. Numerous approaches have been taken to reduce speckle, the most promising of which are adaptive and statistically based. These algorithms typically take advantage of the statistics of speckle or the multi-scale image structure to detect regions of similarity. Several of these algorithms also take advantage of the multi-channel nature of polarimetric SAR to improve the region detection. This work presents two enhancements to such an algorithm with an application toward polarimetric parameter estimation and change detection and presents results using the Japanese satellite-based Phased Array L-band Synthetic Aperture Radar (PALSAR) system. [C417]

"The UAVSAR Transmit / Receive Module"

This paper describes the L-band transmit/receive (T/R) modules of the UAVSAR phased array antenna. UAVSAR (uninhabited aerial vehicle synthetic aperture radar) is an airborne, repeat-pass, polarimetric radar interferometer instrument that is being developed at JPL and NASA Dryden. The instrument has demanding requirements for phase stability over temperature and the antenna components, particularly the T/R modules, are key to meeting these requirements. The UAVSAR T/R modules have a bandwidth of more than 80 MHz centered at 1257.5 MHz and support dual receivers for full quad polarization measurements. Phase and amplitude are controlled by a 7- bit phase shifter and a 5-bit attenuator, respectively. Custom microwave integrated circuits were developed and fabricated for the low noise amplifier (LNA) and phase shifter circuits. The receiver noise figure is 2.25 dB at OC including all front-end losses. The transmitter power amplifiers use silicon bipolar junction transistors that typically generate 162 W peak into a nominal 50 ohm load. The modules have an overall efficiency of 32% at the peak operating duty cycle of 5%. Module mass and dimensions are 567 g and 16 cm times 12 cm times 3 cm, respectively. Fifty four of these T/R modules were fabricated for integration into two antennas. System architecture and performance data for this ensemble of modules are discussed. [C418]

"A Comparative Study of Speckle Filtering In Polarimetric Radar SAR Images"

Speckle appearing in polarimetric synthetic aperture radar (SAR) images is generated by coherent processing of radar signals. It hampers perception and extraction of fine details in the image. That is why speckle reducing is necessary before images analysis because Speckle filtering of polarimetric synthetic aperture radar (POLSAR) image has a great impact on the accuracy of terrain and land-use classification and scene interpretation. In this communication, we studied and tested several linear and non linear methods (Boxcar, Lee, Novak, Russell and Saad filters) to remove speckle in polarimetric SAR images. The single look complex (SLC) images to be filtered were acquired on the P band in airborne polarimetric mode. The evaluation of each filter is based on the following principal criteria: i) Its capacity to smooth the homogeneous areas, ii) Its aptitude to preserve contours, and iii) its capacity to preserve polarimetric information [C419]

"On the correlation of area-extensive measurement of fractional area whitecap coverage with

microwave brightness temperatures"

On August 21, 2007, while mounted in a U.S. Navy P3 aircraft, the Naval Research Laboratorypsilas Airborne Polarimetric Microwave Imaging Radiometer (APMIR) and the University of Washingtonpsilas FoamCam recorded microwave and video images of the sea surface in the Gulf of Mexico as a function of distance from the eye of Hurricane Dean. From a working altitude of 6.1 km, the FoamCam sea surface optical imagery determined sea state, including presence of whitecaps, while APMIR measured the ocean surface brightness temperature at bands from 6.6 GHz to 37 GHz. The specific brightness temperatures measured were 6.6 VH, 6.8 VH, 7.2 VH, 10.7 V and full polarimetric data at 19.35 and 37 GHz. Collocated nearly cotemporaneous data from both SSM/I and WindSat satellite radiometer overpasses were available, as were oceanographic and meteorological data from National Buoy Data Center buoys. As an initial result from the analysis of these datasets, this paper provides a comparison of the APMIR-measured brightness temperatures with those measured by SSM/I and WindSat. The APMIR data and the surface video imagery is also used to investigate the relationship between linearly polarized microwave brightness temperatures and whitecap coverage. Future analysis directions for this data are discussed at the end of the paper. [C420]

"Poincarй sphere method for improvement of the terrain height measuring accuracy"

The problem of parameterization of scattering mechanisms being met in the literature [1] [2] will be reconsidered from fundamental points of view when applying the Poincare sphere (PS) presentation of the voltage equation and the polarimetric two-port approach to the interferometry transmission equations. [C421]

"Polarimetric calibration-a comparison of different approaches"

Polarimetric calibration is performed by applying distortion matrices acting on transmit and receive. Two different approaches to determine these distortion matrices are compared to each other, a statistical one, and an approach that uses radar reflectors. The effect of polarimetric calibration is demonstrated by means of two examples pertaining to polarimetric detection, and to feature based target recognition. [C422]

"Combined airborne radio-instruments for ocean and land studies (CAROLS)"

The CAROLS, L band radiometer, is built and designed as a copy of EMIRAD II radiometer of DTU team. It is a Correlation radiometer with direct sampling and fully polarimetric (i.e 4 Stockes). It will be used in conjunction with other airborne instruments (in particular the C-Band scatterometer (STORM) and IEEC GPS system, Infrared CIMEL radiometer, one visible camera), in coordination with in situ field campaigns for SMOS CAL/VAL. The instruments are implemented on board the French research airplane ATR42. A validation campaign with four flights was made over south west of France, Hourtin Lake and Bay of Biscay (Atlantic Ocean) in September 2007. In order to qualify the radiometer data, different types of aircraft movements were realized: circle flights, wing and nose wags. Simultaneously to flights, different ground measurements were made over continental surfaces and ocean. First results show a good quality of data over ocean surfaces. For continental surfaces, important Radio-Frequency Interferences (RFI) were observed over a large part of the studied region. [C423]

"Perturbative solution for the scattering from multilayered structure with rough boundaries"

The objective of this paper is to investigate analytically the fully polarimetric electromagnetic wave scattering and emission from a three-dimensional layered structure with N-rough interfaces in the framework of SPM method. Assuming that deviations and slopes-with respect to the reference mean plane-exhibited by rough interfaces are small enough, we firstly perform a perturbative expansion of the fields in the rough-interfaces layered structure, following the classical scheme employed to deal with a rough surface. Subsequently, by using effectively the concept of generalized reflection/transmission coefficients, the unknown expansion coefficients of scattered wave propagating upward in the upper half-space are derived via a recursive method. This approach can be also applied to the evaluation of the second-order contribution, opening the way to the accurate calculation of thermal emission from complex layered structure. [C424]

"An anisotropic ocean surface emissivity model based on WindSat polarimetric brightness observations"

{no data available} [C425]

"A wide swath, full polarimetric, L band spaceborne SAR"

The design of a space-borne synthetic aperture radar (SAR) with large swath coverage in full polarimetric mode is a challenging task in L band. The requirement for full-polarimetry involves a doubling of the PRF, reducing the

available swath and making range ambiguities a serious problem, particularly for the cross polarization. This is the case of the next Argentinean constellation, SAOCOM, made of two identical L band SAR. In the paper it is proposed a design based on two innovative techniques, namely TOPSAR and split-band pulse coding (SBPC). TOPSAR allows for wide swath by revisiting different beams in a time-division approach. In this, TOPSAR is similar to ScanSAR mode, but with no artifacts like scalloping and azimuth varying clutter-to-noise ratio. The joint use of SBPC coding and TOPSAR allows for reduction of the range ambiguities that are particularly strong at the shallow incidence angles. The paper presents a full example of the overall SAR acquisition design fulfilling the demanding tasks. [C426]

"Fully polarimetric analysis of weather radar signatures"

In this work the concept of depolarization response, namely the degree of polarization as a function of transmit polarization state, is investigated. Application examples are shown in the field of radar meteorology, namely for hydrometeor identification with fully polarimetric weather radar signatures. Data are from POLDIRAD, DLR research weather radar. [C427]

"Recent advances in Polarimetric SAR Interferometry for forest parameter estimation"

Polarimetric SAR Interferometry (Pol-InSAR) is a radar remote sensing technique that, based on the coherent combination of SAR interferometry and radar polarimetry, provides sensitivity to the vertical distribution of different scattering processes and makes the inversion of forest structure parameters possible. In this paper we present the main scientific results achieved in actual airborne campaigns, discuss the potential and limitations of the different inversion scenarios (based on different frequencies, temporal and spatial baselines) and draw the conclusions. [C428]

"Airborne Ku-band polarimetric radar remote sensing of terrestrial snow cover"

Preliminary analyses of the POLSCAT data acquired from the CLPX-II in winter 2006-2007 are described in this paper. The data showed the response of the Ku-band radar echoes to snowpack changes for various types of background vegetation. We observed about 0.2 to 0.4 dB increases in backscatter for every 1 cm SWE accumulation for sage brush and agricultural fields. The co-polarized VV and HH radar responses are similar, while the cross-polarized (VH or HV) echoes showed greater response to the change of SWE. The data also showed the impact of surface hoar growth and freeze/thaw cycles, which created large snow grain sizes and ice lenses, respectively, and consequently increased the radar signals by a few dBs. [C429]

"Observations and mitigation of RFI in ALOS PALSAR SAR data: Implications for the DESDynI mission"

Initial examination of ALOS PALSAR synthetic aperture radar (SAR) data has indicated significant radio frequency interference (RFI) in several geographic locations around the world. RFI causes significant reduction in image contrast, introduces periodic and quasi-periodic image artifacts, and introduces significant phase noise in repeat-pass interferometric data reduction. The US National Research Council Decadal Survey of Earth Science has recommended DESDynI, a Deformation, Ecosystem Structure, and Dynamics of Ice satellite mission comprising an L-band polarimetric radar configured for repeat-pass interferometry. There is considerable interest internationally in other future L-band and lower frequency systems, as well. Therefore, the issues of prevalence and possibilities of mitigation of RFI in these crowded frequency bands are of considerable interest. RFI is observed in ALOS PALSAR in California and Hawaii, USA, and in southern Egypt in data examined to date. Application of several techniques for removing it from the data prior to SAR image formation, ranging from straight-forward spectral normalization to time-domain, multi-phase filtering techniques, are considered. Considerable experience has been gained from the removal of RFI from P-band acquired by the GeoSAR system. These techniques applied to the PALSAR data are most successful when the bandwidth of any particular spectral component of the RFI is narrow. Performance impacts for SAR imagery and interferograms are considered in the context of DESDynI measurement requirements. [C430]

"Real-time autonomous disturbance detection and monitoring system with L-band UAVSAR"

We developed an autonomous disturbance detection and monitoring system with imaging radar that combines the unique capabilities of imaging radar with high throughput onboard processing technology and onboard automated response capability based on specific science algorithms. This smart sensor development leverages off recently developed technologies in real-time onboard synthetic aperture radar (SAR) processor and onboard automated response software as well as science algorithms previously developed for radar remote sensing applications. In this project, we use a high rate data interface to ingest NASApsilas UAVSAR data and compute SAR imagery in real-time complete with motion compensation and antenna beam steering capabilities.

NASApsilas UAVSAR is a compact, L-band 80 MHz bandwidth, fully polarimetric radar. It is designed for repeat-pass InSAR and has had engineering flights in 2007 and successful science data collections in 2008. The fidelity of the onboard SAR processor is tuned by implementing polarimetric calibration capabilities. Science algorithms are implemented for detecting and monitoring fire disturbances over the US forests. We additionally developed artificial intelligence for decision-making, and adapted existing onboard activity re-planning and execution software to interface with the UAVSAR radar controller. The product of this development is a prototype closed loop smart sensor. [C431]

"CFAR ship detection system using polarimetric data"

The objective of this work is to develop optimal polarimetric Constant False Alarm Rate (CFAR) ship detection system. Polarimetric transformation/decompositions, clutter analysis, modeling, Principal Component Analysis (PCA), and multi-CFAR detection are the necessary components of optimal polarimetric CFAR ship detectors. The resulting CFAR detector outperforms the conventional polarimetric CFAR detector by providing higher probability of detection without introducing much more computations. Optimal polarimetric CFAR detection procedures are proposed in this report. Given the simulated polarimetric RADARSAT-2 data, different polarimetric transformations and decompositions are applied. The resulting images will be transmitted to an adaptive Principal Component Analysis (PCA) block. Through the adaptive PCA block, the image of the first principal component which has the highest SNR among all the images (including the original, transformed/decomposed images, and the images after the adaptive PCA) will be used for ship detection. Optimal multi-CFAR detection will be applied to this image and then the final decision will be made. [C432]

"Development of a polarimetric CFAR detector using Markov Chains"

The paper proposes a novel constant false alarm rate (CFAR) detector using Markov chain models, an innovative new technique that will utilize the finer resolution of RADARSAT-2 to yield improved detection performance for higher-resolution objects. The Markov chain based CFAR detector extends traditional PDF based CFAR detection to first-order Markov chain model by considering both correlation between neighboring pixels and PDF information in CFAR detection. With the additional correlation information, the proposed approach results in advancing the performance of conventional CFAR detectors. Our both analytical and experimental results both show that the new Markov chain CFAR detector can improve the conventional PDF CFAR detector about 30% in terms of detection probability gain and about 2.84 dB in terms of signal-to-clutter ratio gain. [C433]

"Forest SAR tomography: A covariance matching approach"

In this paper a technique to conduct tomographic analyses of forested areas through multiple, coherent SAR images is presented. This technique differs from other methods existing in literature in that it may be regarded as a natural extension of SAR interferometry to the case where several distributed targets are present within the system resolution cell. In this way, it is possible to estimate the position of each target in the resolution cell with virtually the same accuracy obtainable by a single target interferometric analysis. Furthermore, this approach is suited to both single and multi polarimetric channel data. As a validation, this paper reports the results of a tomographic analysis of the forest site of Remningstorp, Sweden, basing on a data-set of 9 P-band SAR images acquired by DLRpsilas E-SAR. [C434]

"Advances in SAR Polarimetry applications exploiting polarimetric spaceborne sensors"

The SAR Polarimetry represents an active area of research in Radar Remote Sensing. This interest is clearly supported by the fact that nowadays there exists a non negligible quantity of launched Polarimetric SAR Spaceborne sensors. The aim of this communication is to present the current state of the art in SAR Polarimetry ranging from theory to applications, with special emphasis in the analysis of data provided by the new Polarimetric Spaceborne SAR sensors. A review of the current status of the PolSARpro v3.0 Software (Polarimetric SAR Data Processing and Educational Toolbox), developed under contract to ESA by a consortium comprising I.E.T.R at the University of Rennes 1, AELc, DLR-HR and Dr mark Williams from Adelaide is also made. The objective of this toolbox is to provide Educational Software that offers a tool for self-education in the field of Polarimetric SAR data analysis at University level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. [C435]

"Using second order residue in PolInSAR phase unwrapping"

In this paper, the residue is extended to the second order, which is called second order residue. Second order residue is researched and applied in the interferometric synthetic aperture radar (SAR) phase unwrapping.

Similar to the residue, the second order residue reflects the discontinuity in the wrapped phase. In phase unwrapping, the traditional residue is normally used to form the branch cut according to some criterions. The second order residue can be directly or indirectly used as quality map. The second order residue is used as quality map in the polarimetric interferometric SAR (PolInSAR) phase unwrapping. The experiments using real PolInSAR data show that the second order residue is a promising quality map in SAR phase unwrapping. [C436]

"H/α polarimetric features for man-made target classification"

Entropy (H)/ Alpha (alpha)/ Anisotropy (A) polarimetric features are largely employed in polarimetric SAR for supervised and/or unsupervised land classification. Can these features be exploited for classifying man-made targets? This paper answers this question by proposing: 1) A technique for extracting H/alpha/A parameters from High Resolution Range Profiles (HRRP) of the target 2) A MAP classifier based on such parameters 3) A performance analysis of such classifier based on simulated polarimetric radar data of ships. [C437]

"Weather radar-recent developments and trends"

Recent developments in weather radar technology are discussed and results obtained with the NOAA/NSSL polarimetric Doppler research radar are shown. These include mitigation of range velocity ambiguities via systematic phase coding of transmitted signal and staggered PRT technique. Reduction of errors and faster volume scans is possible by decorrelation transformation (whitening) of oversampled signals in range. Spectral processing of polarimetric variables brings a new dimension whereby it is possible to adaptively recognize ground clutter and filter it as well as to estimated winds by separating passive wind tracers (such as insects) from migrating birds. [C438]

"The estimate of instantaneous power of polarization spectrum components in polarmetric weather radar"

New approach to use polarimetry for turbulence intensity estimate is proposed. It is based on estimation of the energetic characteristics of turbulent polarization spectrum. Such approach can increase the informativity of weather radar systems relatively to obtaining information about factors that are the origin of changing polarization of reflected signal. [C439]

"Use of spectral differential reflectivity at remote sensing of precipitation"

Recent advances in the radar system design allow to perform Doppler and polarimetric measurements simultaneously. This paper considers behavior of a Doppler-polarimetric parameter-spectral differential reflectivity and its characteristics. Slope of differential reflectivity which is connected with turbulence intensity in rain zone is considered using real data processing. [C440]

"The Ingara Bistatic SAR Upgrade: First Results"

An upgrade programme to add a bistatic collection capability to the Ingara airborne X-band fully-polarimetric imaging radar has recently been completed, and the first field trials of the new bistatic SAR system were conducted in December 2007. This involved a set of experimental SAR data collections in a bistatic geometry, in which the airborne radar was operated in a fine-resolution (600 MHz bandwidth) circular spotlight-SAR mode, in conjunction with a newly-developed fully-polarimetric stationary ground-based bistatic receiver. These data collections were largely successful, and produced a set of fully-polarimetric bistatic SAR data, collected over a wide range of bistatic angles. In this paper, we give an overview of the Ingara bistatic SAR system, describe the recent bistatic SAR experiment, discuss the techniques employed for processing the data, and present preliminary experimental results. [C441]

"Aspect dependence of the polarimetric characteristics of sea clutter: II. Variation with azimuth angle"

The dependence of the spatial, temporal, Doppler and polarization characteristics of monostatic microwave radar sea clutter on the direction of observation relative to the prevailing sea direction has been the subject of many investigations. In most instances, though, the data and interpretation have focussed on the upwind/downwind and cross-wind directions, rather than exploring the detailed azimuthal variation. Such a policy certainly establishes the key qualitative differences in radar signature which reflect the influence of scattering geometry on scattering characteristics, but is not adequate to guide the optimization of viewing geometry for specific missions. For example, it may be that the scattering properties are simplest over some range of intermediate angles, with benefits to echo interpretation as well as providing a means to validation of modeling techniques. To address this issue, we conducted an experiment at Ardrossan, in Gulf St Vincent, near Adelaide South Australia,

where X-band sea clutter was measured over 270deg of azimuth with 4deg beams at ~ 22.5deg spacing. This paper presents the initial results of an investigation of the azimuthal variation of the polarimetric structure of the dominant clutter returns. A companion paper explores the variation with the angle of incidence in the vertical plane. [C442]

"Analysis of generalized polarimetric measurement equations for Stokes polarimetry techniques"

We study the errors variances for some popular strategies of Stokes vector measurement. It was shown that the errors of the Stokes parameters measurement are non-uniformly distributed for different measurement strategies. This fact can be used in optimization of the polarization parameters measurement. [C443]

"A novel supervised classification scheme based on Adaboost for Polarimetric SAR"

In this paper, a novel scheme for supervised classification problem of Polarimetric SAR images is proposed, which is based on Adaboost. Compared to traditional classifiers such as complex Wishart distribution based maximum likelihood classifier or Neural Network based classifier, the proposed method is more robust and flexible. Different features or parameters extracted from Polarimetric SAR data could be adopted into the scheme and a quantitative analysis on the significance of each parameter for classification could be achieved. Experiment results demonstrated the effectiveness of the proposed scheme. [C444]

"Interferometric phase improvement in multi-look case"

In this paper, an intensity optimization based method is proposed to improve the interferometric phase in the multi-look case by polarimetric information fusion. In general, the lower the intensity is, the less reliable is the phase. The reliability of phases can be improved by maximizing the intensity for the multi-look case. For each pixel, an optimal unitary complex vector is found to maximize the lesser intensity of the interferometric pair. The Cloudepsilas coherence optimization method is used for comparison. Using the data collected by SIR-C/X-SAR, the authors demonstrate the effectiveness and the robustness of the proposed approach. [C445]

"Forest height inversion based on polarimetric SAR interferometry"

To extract the forest height accurately and quickly based on polarimetric SAR interferometry, a forest height inversion method is proposed, based on the polarimetric interferometric model (PolIn-model). A credit (linearity measurement) of height inversion is introduced. For each pixel with high credit, the complex volume coherence gammavis estimated by the ESPRIT algorithm, and then the forest height is estimated by a pre-calculated look-up table according to the PolIn-model. Otherwise, the forest height is estimated by the ESPRIT algorithm directly. The experimental results demonstrate that the proposed linearity measurement is more effective compared to the traditional way and the location of the volume coherence is in accordance with the PolIn-model. The time consumption by the proposed method is decreased to 25% of that by the PolIn-model based method. [C446]

"Remote sensing of urban areas from polarimetric SAR data using Time-Frequency and spectral analysis methods"

This article presents two complementary approaches for the study of urban areas using polarimetric and interferometric SAR (POL-inSAR) data. A multidimensional linear Time-Frequency (TF) decomposition is used to analyze the intrinsic polarimetric behavior of different components of an urban area. A TF signal model, adapted to the case of urban areas, is proposed and studied using relevant statistical descriptors. A TF classification procedure is introduced to retrieve building location and characterize their polarimetric response, and applied to fully polarimetric SAR data acquired by the E-SAR sensor at L-band. Multiple POL-inSAR signals, acquired from different positions, are used to estimate the height of buildings using the interferometry principle. High-performance array signal processing techniques are adapted to the case multi-baseline POL-InSAR (MBPI) observations, in order to enhance the height estimation of scatterers by calculating optimal polarization combinations and determining their scattering characteristics. These multidimensional spectral estimation methods are shown to resolve the building layover problem by extracting and analyzing two components within one azimuth-range resolution cell. [C447]

"Study on change detection for multi-temporal polarimetric SAR images"

Multi-temporal single polarimetric synthetic aperture radar (SAR) images are performed change detection and it doesnpsilat wholly reflect the change information of ground objects. Through analyzing the features of multi-polarimetric SAR images, the results show that the multi-polarimetric SAR image change detection ought to choose different polarimetric data, polarimetric total power data or echo polarimetric power ratio data in terms of

different purpose and the effect of the former two states is better. Finally, the difference value two-threshold method is performed the change detection experiments with the multi-polarimetric data of Convair-580 C/X-SAR of Canada, and the experimental results obtain the expectant effect. [C448]

"Polarimetric smoothing revisited: Applicability to randomly polarized sources and to incomplete electromagnetic vector-sensors"

Randomly or partially polarized sources occur frequently in practical applications such as radar and modern communications. In this paper, we revisit the polarimetric smoothing technique, which is previously customized for decorrelating completely polarized coherent signals with identically oriented complete electromagnetic (EM) vector-sensors, on its applicability to randomly polarized signals and to incomplete EM vector-sensors instead. It is shown here that polarimetric smoothing can be extended in a rather straightforward way for decorrelating randomly polarized source signals, using either complete or incomplete EM vector-sensors. However, when utilizing incomplete EM vector-sensors for completely polarized signals, polarimetric smoothing may fail to decorrelate signals that have distinct directions of arrival (DOAs) and/or polarizations. Some typical numerical results are also presented to confirm the main points made in the paper. [C449]

"Model Based SAR Tomography of Forested Areas"

In this paper a technique is described for the tomographic characterization of forested areas through multiple SAR observations. This technique is based on a model of the second order statistics of the multi baseline, multi polarimetric, data which accounts for the presence of multiple distributed targets within the system resolution cell. The results of an experiment performed on a real P-band, multi-baseline, fully polarimetric data set relative to the forested site of Remningstorp, Sweden, are reported. Such results show the feasibility of performing a model based tomographic analysis of forests, resulting in a characterization of both the ground and the canopy in terms of elevation, spatial structure, and scattered power. [C450]

"Change Detection with Multi-Polarization SAR Imagery"

In this paper, change detection with multi-polarization SAR imagery is focused. Based on the polarimetric statistic distribution, a polarimetric test statistic is applied to evaluate the equality of two areas in two pass polarimetric SAR images. And then, in order to find out the `real' changed area, a constant false alarms rate (Pfa) is given to determine a threshold for change detection. Moreover, a majority processing considering the context information of a given target is preferred to improving the final accuracy of the change detection. Finally, the proposed method was tested with the multitemporal Envisat-ASAR's alternative polarization SAR data. Experiments are performed to validate efficiency of the method presented in the paper. [C451]

"Integration of RADARSAT-2 Dual and Quad Polarization Data into Pipeline Third Party Encroachment Monitoring"

Mechanical damage incurred from unauthorized third-party activities remains a leading cause of oil and gas pipeline failure, indicating the need for effective strategies to monitor encroachment over extensive sections of pipeline right-of-ways (ROWs). The purposes of the work discussed in this paper are to evaluate the use of polarimetric spaceborne synthetic aperture radar (SAR) for detecting vehicle targets and discriminating them from false alarms and to lay the foundation for integrating RADARSAT-2 products into the existing encroachment management system (EMS). RADARSAT-2 simulated products were created from Convair-580 imagery collected over Calgary, Canada. Results show that target detection is better for higher resolution data, but discrimination of targets from false alarms is better for dual and quad polarization data due to the increased feature set available that captures more of the scattering behavior. Overall, the Ultra Fine HH and dualpolarization Fine HH/HV or quad-polarization Fine are the recommended modes for an EMS using RADARSAT-2. [C452]

"Integration of Spatial Chaotic Model and Type-2 Fuzzy Sets for SAR Images Change Detection"

It is very difficult to perform change detection in SAR images, because speckle noise contaminates the images in nature. Speckle, which results from coherent energy imaging, is indeed a chaotic phenomenon. As a result, an SAR signal can be modeled by a spatial chaotic system and characterized by its fractal dimension. The differential box-counting (DBC) technique is adopted to estimate fractal dimension in this paper. Based on the spatial chaotic model (SCM), a simplified SAR image change detection procedure is proposed. Observations provided by SAR sensors are uncertain due to changing illumination conditions at different acquiring time. Besides, the selection of window size M and grid size s in DBC provides an additional degree of uncertainty. Both the uncertainty involved in the measurements and the uncertainty involved in the selection of M and s motivate us of integrating type-2 fuzzy sets with the SCM to achieve a better performance. The proposed

approach is applied to multitemporal polarimetric SAR images for change detections as demonstrations. The change detection results of using the original SCM method and the proposed approach are compared. The effects of misregistration for different change detection approaches are also presented. Simulation results suggest that the proposed approach is more tolerant to misregistration and offers better results of detecting changes when speckle noise is present. [C453]

"The Impact of Adaptive Speckle Filtering on Multi-Channel SAR Change Detection"

One of the most promising applications of synthetic aperture radar (SAR) imagery is change detection. However, the success of change detection algorithms is highly dependent on the type of change being detected. With the advent of multi-channel SAR systems (multi-frequency and/or polarimetric) new algorithms to improve change detection are being developed to take advantage of the additional information. However, these algorithms are still hindered by the speckle phenomena of radar imaging. Adaptive neighborhood filtering techniques have been shown to be effective to reduce speckle, but the impact on change detection has not been explored. The research presented explores the impact of an adaptive filtering algorithm on the probability of detection for synthesized changes. [C454]

"A BPM Two-Scale Contrast Model"

This paper describes a new two-scale polarimetric contrast model based on the Boundary Perturbation Model (BPM). The damping of the short gravity-capillary surface waves by small slicks is modelled by the Marangoni damping coefficient. The surface slick is supposed to modify both the short wave part of the sea surface spectrum intensity and the wind input. The model has been validated over SIR-C/X-SAR Multi Look Complex (MLC) L- and C-band Synthetic Aperture Radar (SAR) data. [C455]

"Land Cover Segmentation of ALOS Polarimetric SAR Data"

Image segmentation is a basic step of any segment-based classification method. Various segmentation approaches of polarimetric SAR data, such as region growing and splitmerge to name a few, have been proposed recently. This paper describes the development of a new segmentation approach that improves the polarimetric SAR data analysis by including information from the backscattering behavior of objects in the Freeman-Durden analysis images. This method is based on the main scattering mechanism that appears in each image pixel and the second most important scattering mechanism that might have been contributed significantly in the scattering process. Further segmentation is performed based on the calculated histograms of sub-regions. The state-of-art ALOS polarimetric SAR data are used in this study. The study area is located in the south of the United Kingdom and includes the city of Minehead. [C456]

"The H/A/Alpha Polarimetric Decomposition Theorem and Complex Wishart Distribution for Snow Cover Monitoring"

This study discusses the capability of full polarimetric L-band ALOS PALSAR data for snow classification. In this study, Polarimetric decomposition and the complex Wishart classifier are applied on ALOS-PALSAR data. Optical (ALOS-AVNIR) data within six days difference was used for visual interpretation of snow and non-snow classes. Application of Entropy-Anistropy-Alpha-Wishart classifier for training samples gives better classification results. To reduce speckle effects and to improve classification results, the refined Lee filter was applied on the covariance matrix several times, each time increasing the size of the moving window. Over all classification accuracy were observed 75.61%, 91.46%, 94.91%, 96.19%, 97.16% and 98.37% using different window sizes 1times1 (without filtered image), 3times3, 5times5, 7times7, 9times9 and 11times11 respectively for refined lee speckle filter. It is observed that classification accuracy increases as size of the filter window increases for speckle reduction. Polarization signatures of various features have also been generated using polarization synthesis techniques and signatures are represented in 3-D plot. [C457]

"A Study on Sea Ice Observation in the Sea Okhotsk by Polarimetric SAR"

Since polarimetric SAR data are powerful tools to derive scattering mechanism of the observation target, it is expected to give us more detailed information in sea ice monitoring. Electro-Magnetic (EM) measurement for sea ice was conducted during the Soya cruise period in February, 2004. Pi-SAR/L-band polarimetric data simultaneously acquired during the ship cruise were compared with the sea ice thickness and the surface roughness derived by EM measurement. RR-LL coherence is related to sea ice surface roughness in lower incidence angle, while VV to HH backscattering ratio in higher incidence angle is also related to sea ice thickness. [C458]

"The Glacier Identification using SAR Interfermetric and Polarimetric Information in Qinghai-Tibetan Plateau"

For climatological and hydrological investigations, the areas covered by glacier and their spatial variability are important parameters, particularly in Qinghai-Tibetan Plateau. A interferometric SAR technique not only can produce a high-resolution digital elevation models but also can identify the surface object with coherence coefficients. This property of SAR polarimetry is particularly useful in classification. In this paper we analyze to demonstrate the method and result for the glacier identification integrated intensity of backscattering from Envisat/ASAR images, coherence coefficients of repeat pass interferometry from ASAR and ALOS/PalSAR, and full polarimetric SAR from PalSAR. [C459]

"Comparison of Surface Roughness Parameters of Tidal Flat Estimated from AIRSAR and ALOS Observations"

Tidal flats form a unique ecosystem, playing important roles in the environmental assessment of coastal zones. This study aims to derive surface characteristics of tidal flats from fully polarimetric SAR data sets. The microwave surface scattering models were employed to measure the surface roughness on tidal flats from air-borne and space-borne polarimetric SAR data, such as NASA/JPL AIRSAR and ALOS PALSAR. Surface roughness parameters were estimated from the circular polarization coherence and co-polarized scattering elements. Recent changes in costal wetlands will be continually monitored by using the PALSAR data sets together with other newly developed space-borne SAR systems, such as RADARSAT-2 and TerraSAR-X. [C460]

"Capabilities of Full-Polarimetric PALSAR/ALOS for Snow Extent Mapping"

Snow classification using full-polarimetric PALSAR data is investigated in this paper. It is first demonstrated that dry snowpack over frozen ground slightly affects polarimetric signature at L-band. Given the fact that PALSAR data do not permit the use of a simplistic threshold-based method, a refined method for Snow Covered Area mapping is outlined. A supervised Support Vector Machine approach is used showing fairly good results within the framework of a three-classes classification (dry snow over frozen ground, wet snow and no snow). [C461]

"Agricultural Vegetation Parameter Estimation using Pol-SAR: Retrieval of Soil Moisture"

In this paper the focus is given to the soil moisture retrieval under a vegetation cover, exemplarily for two crop types winter wheat and rape. For this Pol-SAR data over a whole vegetation period were used acquired in the frame of the AGRISAR campaign in 2006 at L-band. The potentials and limitations over time are investigated by modifications of the model based Freeman decomposition in order to decompose the scattering contributions and to invert the surface and dihedral scattering component for soil moisture estimation. The applied decomposition approaches for agricultural land surfaces are suitable, but exhibit deficiencies in modeling the volume component, even though some improvements due to the modifications could be presented. In the end the soil moisture estimation does not perform constantly well over the whole acquisition period due to the complexity of the crop vegetation. [C462]

"Polarimetric Deformation Maps Retrieval of Urban Areas using Ground-Based SAR Acquisitions"

A one-year subsidence monitoring activity has been carried out by the Remote Sensing Laboratory (RSLab) of the Universitat Politecnica de Catalunya (UPC) using an X-band ground-based SAR sensor. The project aimed at studying the subsidence phenomenon induced by salt mining extraction of the past years in the village of Sallent (Spain). The polarimetric capability of the system allowed to gather zero-baseline POL-SAR data in the single-pass mode in 9 different days, from June 2006 to April 2007. The estimation of the linear component of deformation process obtained using each polarization channel separately is here compared with the result of a new approach exploiting the full knowledge of the scattering matrix at once. For this purpose, a coherence-based approach is employed. The higher amount information carried by polarimetric data is finally pointed out both in terms of number of reliable pixels selected within the scene and higher quality of the retrieved subsidence map. [C463]

"Review of Polarimetric Indicators for Forest Characterisation over Several Sites"

Global warning is now known to be the major environmental issue mankind will have to face in the next decade. Monitoring of vegetation and biomass is clearly an essential piece of information required at all levels ranging from the scientific studies to understand and forecast, to the political world responsible for drafting remediation policies and evaluating their impact. Microwave remote sensing with the low-frequency SAR technique can provide a useful characterization of forest (spatial coverage, species, density, height...) at a global scale, relying on the all-weather imaging capabilities of SAR linked with the significant penetration of the low-frequency EM

wave in the canopy. In this paper, we will review the potential polarimetric indicators and evaluate their performance over several types of forest. We will particularly focus on the impact of the topography and the influence of the weather conditions. [C464]

"Analysis and Classification of high Arctic Glaciers with ASAR Data"

We apply a polarimetric classification scheme to Envisat Alternating Polarisation mode ASAR images and compare to ground truth data. By analysing images with a range of acquisition conditions and comparing the classification accuracy with the ground truth data, we investigate the influence of the acquisition conditions for glacier facies discrimination. We find that the main influence is the image swath angle, which affects the image pixel geometry. There was no obvious preference for the different polarisation channels, although the dual polarisation classifications were consistently better than single polarisation classifications. [C465]

"An Experiment of GB-SAR Interperometric Measurement of Target Displacement and Atmospheric Correction"

We made a ground-based synthetic aperture radar (GB-SAR) system and tested its interferometric SAR (InSAR) measurement on the displacement of a trihedral corner reflector with atmospheric correction in terms of humidity and range. The GB-SAR worked at C-band with the synthetic aperture length of 5 m. Fully-polarimetric images were obtained with resolutions of 25 cm in range and 0.32 degree in azimuth direction. Located 160 m away from the system, the reflector was moved from 1 mm to 40 mm toward the system during each acquisition. An atmospheric correction function was obtained in terms of humidity and range by analyzing the phase of several stationary targets. The result showed an atmospheric delay of 3 mm at 160 m range when humidity changed from 47% to 58%. After atmospheric correction, DInSAR error was less than 1 mm with the correlation coefficient of 0.9999 when compared with the actual displacements. We concluded that atmospheric correction should be reinforced somehow for most spaceborne InSAR applications. [C466]

"Polarimetric Scattering Model Decomposition for Pol-InSAR Data"

This paper presents scattering model decomposition technique with Pol-InSAR datasets. The target model decomposition based on the scattering mechanisms corresponding to surface, double, and volume scattering, is one of the powerful tools to analyze and classify the ground surface conditions with fully polarimetric SAR data. However, we sometimes meet difficulty that the power of the decomposed component(s) becomes negative. This is caused by assumptions in the decomposition technique. When a Pol-InSAR dataset is available, additional observables can be obtained. These new observables will be available to resolve the difficulty of negative power in the conventional decomposition technique. In this paper, we consider the scattering model decomposition technique with Pol-InSAR data, and propose some modifications for the decomposition. [C467]

"P-band Polarimetric Ice Sounder: Concept and First Results"

ESA has assigned the Technical University of Denmark to develop an airborne P-band ice sounding radar demonstrator. The intention is to obtain a better understanding of the electromagnetic properties of the Antarctic ice sheet at P-band and to test novel ice sounding techniques in preparation for a potential spaceborne ice sounding radar. The airborne system is a coherent, high-resolution and fully polarimetric radar. Aperture synthesis is applied in the along track direction and an experimental surface clutter suppression technique based on a multi-aperture antenna can be applied in the across track direction. In May 2008, a proof-of-concept campaign was organized in Greenland, where data were acquired over the ice sheet. The system proved capable of detecting the bedrock under 3 km thick ice and of mapping the internal ice layers down to a depth of at least 1.3 km. In this paper, the system concept is outlined and first results are presented. [C468]

"Radar Backscattering Measurement of a Paddy Rice Field using Multi-frequency(L, C and X) and Full-polarization"

The objective of this study is to measure backscattering coefficients of paddy rice using L, C, X-bands scatterometer system with full polarization and various angles during a rice growth variables. The measurement was conducted at an experimental field located in National Institute of Agricultural Science and Technology (NIAST), Suwon, Korea. The rice cultivar was Japonica type, called Chuchung. The scatterometer system consists of dual-polarimetric square horn antennas, HP8720D vector netword analyzer (20 MHz ~ 20 GHz), RF cables, and a personal computer that controls frequency, polarization and data storage. The backscattering coefficients were calculated by applying a radar equation for the measured at incidence angles between 20deg and 60deg for full polarization (HH, VV, HV, VH), respectively, and compared with rice growth data such as plant height, stem number, fresh and dry weight and LAI that were collected at time of each scatterometer

measurement simultaneously. [C469]

"Estimation of the Equivalent Number of Looks in Polarimetric SAR Imagery"

We present two new estimators for the equivalent number number of looks (ENL) designed for polarimetric synthetic aperture radar data. These are the first known estimators to utilise the full multilook polarimetric covariance matrix, and both are derived from moments of the Wishart distribution. The first estimator is obtained from the second-order trace moment, which provides a multivariate generalisation of the conventional ENL definition. The second estimator is found from the log-determinant moment, and is also shown to be the maximum likelihood estimator. The latter estimator proves to have superior statistical properties to any other known ENL estimator. These properties are decisive for the good performance obtained with a proposed procedure for unsupervised estimation. We demonstrate on airborne AIRSAR data how a robust ENL estimate can be extracted from the distribution of small sample estimates collected over the whole scene. [C470]

"Radar Polar Decomposition for Natural Surfaces Cartography"

Illustrations of parameters obtained from polar decomposition derived from fully polarimetric data acquired by ALOS-PALSAR over the Mai-Ndombo lake, in the Democratic Republic of Congo are presented. Results show their complementarity to usual polarimetric indices, such as the entropy or the alpha parameters [C471]

"Polarimetric Scattering Analysis for Simplified Man-Made Structure Model on Rough and/or Inclined Ground Plane"

This paper analytically examines polarimetric scattering for a simplified man-made structure model, by utilizing the finite-difference time-domain (FDTD) method. The model considered here simulates a building in mountainous environment and is composed of a dielectric rectangular parallelepiped on finite rough and/or inclined plate. The statistical FDTD analysis on two polarimetric indices, the scattered power decomposition and the polarimetric correlation coefficient, with respect to squint angle change is carried out. It is found from the detailed analysis that the considered polarimetric indices are valid even when the surface of the ground plate has small roughness and gentle slope. This result contributes to the development of Polarimetric Synthetic Aperture Radar (POL-SAR) image analysis for detecting or classifying man-made residential houses in mountainous region. [C472]

"Comparison of Polarimetric Change Detection Methods on ALOS PALSAR Images over Finland"

Six polarimetric change detection indices were tested on L band ALOS PALSAR data over Kuortane, Finland. Tests included quantitative evaluation of change indices compared to reference change maps, and qualitative evaluation by visual inspection. Results suggest an additional accuracy using fully polarimetric data in change detection. Contrast Ratio and the Wishart test gave the best results among the tested indices. [C473]

"Requirements for Model-based Polarimetric Decompositions"

Several authors have proposed decompositions of measured polarimetric covariance matrices into the weighted sums of individual covariance matrices that represent known scattering models. In this paper we critically examine some minimum requirements that these model-based polarimetric scattering decompositions must satisfy. Starting with the definition of the covariance matrix, we show that a necessary requirement for these decompositions is that the eigenvalues of the individual covariance matrices must be non-negative. We then show with examples that this is not guaranteed for some of the proposed decompositions. Finally, we propose a method of decomposition that would ensure that the eigenvalues of the individual covariance matrices would be non-negative. [C474]

"Analysis of WindSat Data over Arctic Sea Ice"

The radiation of the 3rdand 4thStokes components emitted by Arctic sea ice and observed by the spaceborne fully polarimetric radiometer WindSat is investigated. Two types of analysis are carried out, spatial (maps of different quadrants of azimuth look angles) and temporal (time series of daily averages over small selected ranges of azimuth angles). The 3rdStokes component at 37 GHz has shown the highest signal during early summer (Gt2 K). The next highest signals were observed at the 10.7 GHz 3rdand 4thStokes components during the summer months (Gt1 K). The 37 GHz 4thStokes component has shown the least variability (Lt1 K). The 10.7 GHz 4thStokes component has higher signal at the ice edge, confirmed from the sea ice concentration maps derived from Advanced Microwave Scanning Radiometer (AMSR-E) data, and similar to signals observed over global coastlines. From the comparison with near surface air temperature of the European Center for Medium-Range Weather Forecasts (ECMWF) model data and Scanning Multichannel Microwave/Imager (SSM/I) NASA

Team ice concentrations it was concluded that the microphysical processes during early melting in the topmost sea ice layers are responsible for the high 37 GHz 3rdStokes signal. [C475]

"A Markov Chain CFAR Detector for Polarimetric Data using Adaptive Linear Discriminant Analysis"

The paper proposes a new Markov chain based CFAR detector for polarimetric data using adaptive linear discriminant analysis. The Markov Chain based CFAR detector extends traditional PDF based CFAR detection to first-order Markov chain model by considering both correlation between neighboring pixels and PDF information in CFAR detection. With the additional correlation information, the proposed approach results in advancing the performance of conventional CFAR detectors. Moreover, to take advantage of full polarizations of polarimetric data, the new polarimetric detector utilizes complementary features from full polarizations for target detection using adaptive Fisher linear discriminant analysis. Our experimental results both show the superiority of the new Markov chain polarimetric CFAR detector over conventional CFAR detectors. [C476]

"Classification of Polarimetric SAR Images using the Degree of Polarization and the Co-Polarized Phase Difference"

A new polarimetric SAR image classification technique based on the degree of polarization (DoP) and the co-polarized phase-difference (CPD) is presented in this paper. Since the DoP and the CPD of a scattered wave provide information on the randomness of the scattering and the type of scattering mechanisms, at first, the statistics of the DoP and CPD are examined with measured polarimetric SAR image data. Then, a DoP-CPD diagram with appropriate boundaries between six different classes is developed based on the SAR image. The classification results are compared with the existing Entropy-alpha diagram as well as the JPL-AirSAR polarimetric data. The technique may have capability to classify an SAR image into six major classes; a bare surface, a village, a crown-layer short vegetation canopy, a trunk-layer short vegetation canopy, a crown-layer forest, and a trunk-dominated forest. [C477]

"Effect of Forest Structure on Scattering Center Height from Model and SAR Data"

Modeling vegetation using coherent approaches has attained prominence over the past two decades. The distorted Born approximation has been known as one of the basic approaches used for coherent modeling of vegetation, in which each scatterer is illuminated by a mean field and the backscattered fields are added coherently. In some papers, Lindenmayer Systems (L-systems) were employed to generate accurate 3D tree structures. Although this method is found to be useful, it needs too many input parameters. Thus it is not suitable to retrieve forest parameters by model inversion. In this study the three-dimensional radar backscatter model of forest canopy constructed by Sun and Ranson in 1995 was modified to be a coherent model for simulation of InSAR signals. It provides a balance between the accuracy and feasibility of parameters' retrieval. The effects of incident wave length and forest stand structure on phase center heights were analyzed. The phase center heights were also compared with the phase center heights from PALSAR LHH InSAR data. It shows that the simpler coherent model described in this study gives acceptable results. [C478]

"Improving PWF Method of Despeckle in Polarimetric SAR Image by Fusion Based on Nonsubsampled Contourlet Transform"

A novel and efficient improving PWF method of speckle reduction in polarimetric SAR image by fusion based on nonsubsampled contourlet transform is proposed. First, the three complex elements (HH, HV, and VV) of the polarimetric scattering matrix were decorrelated to form a new elements matrix. Then we show that the sub-band decompositions of the three elements using nonsubsampled contourlet transform, and fusion factor is applied to the decomposed directional high-frequency coefficients to create new sub-band coefficients. Finally, we process and reconstruct multi-resolution contourlet coefficients according to the PWF method. Experimental results show that compared with PWF de-speckling algorithm, the proposed algorithm can achieve an excellent balance between suppresses speckle effectively and preserves image details, and the significant information of original image like textures and contour details is well maintained. [C479]

"Quad Polarimetry SAR Target Recognition Based on Parametric Statistics and Multidimensional Analysis"

Diverse parameters decomposed from quad-polarimetric SAR could become the important basis in target recognition, classification and other applications.During the target recognition, due to the sidedness of single parameter or two parameters decomposed by same algorithm, obvious differences exist among the results extracted by different parameters. In this paper, a parametric statistics and multidimensional analysis algorithm will be applied in target recognition from quad-polarimetric SAR image. The proposed algorithm looked the

backscattering characters of land cover targets as the basis of analysis. Through parametric statistics, the dominant scattering mechanisms of every decomposing algorithm would be picked out such as volume scattering and sphere scattering of paddy. They become the data of multi dimensional analysis. In the multi-dimensional analysis, the targetpsilas location of parametric space will be the basis of target recognition. The application on land cover and land use by the proposed algorithm improved the monitoring capability of quad polarimetric SAR. [C480]

"Investigation on Tree Height Retrieval with Polarimetric SAR Interferometry"

Polarimetric SAR interferometry (POLInSAR) has been widely applied in tree height retrieval. A refined algorithm of three-stage inversion process for polarimetric SAR interferometry is proposed in this paper. The refined algorithm focuses on resolving the ambiguity estimation of the volume coherence. The coherence region extraction algorithm is combined with the three stage inversion algorithm to obtain accurate estimate of volume decorrelation. According to the physical explanation of the scattering model of the forest area, we can conclude that the proposed algorithm can get more accurate inversion results. The proposed algorithm is applied to simulated coherent L-Band SAR data provided by ESA, and the validity of the modified algorithm is confirmed. [C481]

"Reflectivity and Differential Reflectivity Rainfall Algorithm Performance at X-band"

X-band weather radar systems present several advantages mainly related to their lower cost and smaller size relative to their S and C band counterparts. The main drawback of X-band is the attenuation suffered by the electromagnetic wave propagating through precipitation that reduces the reliability of rainfall estimates based on power measurements. Developments in dual-polarization techniques have provided solutions to mitigate this problem and have revived the interest on X-band radar systems for operational applications. Because of this growing interest, there is a need to evaluate the performance of X-band polarimetric radars for quantitative rainfall estimation. At X-band, attenuation affects any radar parameter based on backscatter power measurements such as Zh, while differential attenuation affects parameters based on differential power measurement such as Zdr. Consequently, Zhand Zdrmust be corrected prior to use in quantitative applications such as rainfall estimation. However, correction procedures can introduce additional errors that impact on rain estimation and therefore must be applied with caution. When using the X-band rain algorithm based on Zhand Zdr, the biases due to attenuation and differential attenuation nearly cancel each other and result in a small bias of the estimated rainfall rate, so that correction of Zhand Zdrmay not be needed. This paper investigates this property of rain rainfall estimation based on X-band dual-polarization measurements. [C482]

"The Potential of Combined Lidar and SAR Data in Retrieving Forest Parameters using Model Analysis"

3D Lidar waveform and 3D radar backscatter models based on Radiative Transfer theory were used to simulate waveform and backscattering of various plots with different stand ages and structures, which were generated using forest growth model. The inversion models for estimating forest Above Ground Biomass (AGB) and Average Stand Height (ASH) were derived from the combined simulated database of large footprint Lidar waveforms and L-band polarimetric SAR backscattering using stepwise analysis method. The inversion procedures were then applied to NASA LVIS and ALOS PALSAR data to retrieve forest parameters for the study area. The study area is a 10km by 10km area located at International Paper's Northern Experiments Forest, Maine, USA, where field measurements that include stem coordinate, DBH, species and canopy position were recorded within a 200m by 150 m stand. Heights and AGB of total 7956 trees were estimated by applying species-specific allometric equations to stand measurements. AGB and height were then scaled up to the area according to the LVIS footprint size and location at 149 20m*20m plots, which were used to verify the inversion model developed using simulated database. The study concludes that Lidar waveform indices and SAR backscattering are complementary for forest parameters retrieving, which improved the limitation of signature saturation for regional biomass mapping using SAR data only. The comparison between inversed forest parameters and field measurements shows good consistency. [C483]

"Extraction of Area Averaged Urban Parameters from POLSAR Measurement"

By using data analysis using full-polarimetric measurement results, we can estimate area-averaged urban parameters which can not be observed from simple HH, HV and VV pseudo-color map due to insufficiency of spatial resolution of POLSAR. For example, estimation of urban buildings density or building orientation is reported. In the above estimation, we analyzed air-borne Pi-SAR and satellite-borne PALSAR data as POLSAR observations measured over Tokyo area. For evaluation of the estimated results, we adopt high-resolution optical observation data from QuickBird and 1/2500 POLYGON map surveyed by Tokyo Metropolitan Office. [C484]

"Analysis of Simulated Polarimetric SAR Images Generated by a Multilayer Electromagnetic Scattering Model"

The evaluation of a polarimetric SAR image, which is generated by means of computation of far electric field scattered by multilayer structure, is carried out. The image analysis consists on the study of statistical properties of amplitude data and the investigation of the information gathered by alpha and szlig angles derived from the standard Cloude-Pottier's target decomposition and the orientation angle induced by azimuthal terrain slope. The discriminatory power capability of these three angle features is assessed through a simple threshold polarimetric classification procedure. The results show that the simulation process is working properly and that the SAR return is extremely sensitive to scatter local orientation. [C485]

"An Ocean Wave Spectrum Derived from Polarimetric Microwave Radiometer Data"

This paper presents a detailed analysis of a simplified Two-Scale Model for ocean surface polarimetric microwave emission, and investigates the extent to which varying ocean surface length scales contribute to brightness temperature zeroth and second azimuth harmonics. The Two-Scale Model can be expressed as a weighting function M0,2multiply ocean surface curvature spectrum C0,2. This implies a simple way to investigate the effect of curvature spectrum on ocean emission. It is found that ocean waves with wavelengths both comparable to and much greater than the electromagnetic wavelength can contribute to these harmonics, depending on the value of the ocean surface spectrum in these length scales. An ocean wave spectrum was derived from polarimetric microwave radiometer data according to constrained linear least-squares method. [C486]

"Decomposition of Polarimetirc Scattering of Paddy Rice"

This paper reports the effects of the probability distribution of the target shape to the results of four-component decomposition. The four-component decomposition method decomposes polarimetric microwave data into four components, i.e. surface scattering, double bounce scattering, volume scattering and helix scattering. Prior to the present research, three dimensional structure of the rice was measured and modeled. The model was used to calculate the probability density function of the rice leaves at a viewpoint of arbitrary zenith and azimuth angles. With this probability density function, a covariance matrix of volume scattering for the rice was developed. This covariance matrix was embedded in the four-component decomposition, and it was applied for the polarimetric X-band scattering data of rice, measured in an anechoic radio wave chamber in Niigata Univ. during September 25 to 26, 2007. It was found that the proposed four-component decomposition produced more volume scattering and less surface scattering than the results produced by the standard four-component analysis. As a result, it is concluded that the probability distribution to the target shape should be considered. [C487]

"Polarimetric Characterization of Magnetic Flat Dipole Embedded in Multilayer Structures"

The scattering properties of an embedded planar magnetic dipole are addressed in this paper. In order to obtain the scattered fields the method of moments in spectral domain is applied. The dipole scattering is characterized by the radar cross section (RCS), the polarimetric response and the alpha-angle from Cloude-Pottier's target decomposition theorem. The results point out that alpha-angle is the most sensible parameter to variations on incident angles. The RCS is influenced by the incident angles and by the geometrical dipole area. The incident angles have also influence over polarimetric response, showing its use and interpretation must be done with extremely care. [C488]

"Automatic Target Recognition by Means of Polarimetric ISAR Images and Neural Networks"

Inverse Synthetic Aperture Radar (ISAR) images are often used for classifying and recognising targets. Moreover the use of a fully polarimentric ISAR image enhances classiication capabilities. In this paper, the authors propose a novel ATR technique based on the use of fully polarimetric ISAR images and Neural Networks. In order to reduce the amount of data processed by the classifier, the brightest scattering centres are first extracted by means of the Pol-CLEAN technique and then their scattering matrices are decomposed using Cameron's decomposition. The proposed ATR algorithm is finally tested on real data. [C489]

"Segmentation of Polarimetric SAR Data based on the Fisher Distribution for Texture Modeling"

The Polarimetric Synthetic Aperture Radar (PolSAR) covariance matrix is generally modeled by a complex Wishart distribution. For textured scenes, the product model is used and the texture component is often modeled by a Gamma distribution. In this paper, authors propose to use the Fisher distribution for texture modeling. From a Fisher distributed texture component, we derive the distribution of the complex covariance matrix and we

propose to implement the KummerU distribution in a hierarchical segmentation and a hierarchical clustering algorithm. Segmentation and classification results are shown on synthetic images and on ESAR L-band PolSAR data over the Oberpfaffenhofen test-site. [C490]

"Enhanced Military Target Discrimination using Active and Passive Polarimetric Imagery"

Surveillance operations often make use of electro-optic (EO) imaging systems to detect civilian and military targets. To increase the overall target detection performance, such active/passive EO sensors could exploit the polarization of light as additional information to discriminate man made objects against different backgrounds. The target contrast enhancement obtained by analyzing the polarization of the reflected light from either a direct polarized laser source as encountered in active imagers, or from natural ambient illumination, can be used for such target discrimination scheme. This paper reports results from field experiments exploiting polarization-based imaging sensors to enhance the detection of man made objects. Active and passive polarimetric signatures of objects have been acquired at wavelengths in the near and long-wave infrared bands. Results demonstrate to what extent and under which illumination and environmental conditions the exploitation of active/passive polarimetric images is suitable to enable target discrimination. [C491]

"Amplitude and Phase Statistics for Bistatic Scattering from Rough Surfaces"

In this paper we study the statistical characteristics of scattering from rough surfaces. By assuming normal-distributed and correlated real and imaginary scattering components, we derive analytical probability density functions (pdfs) for the amplitude and phase. The amplitude pdf is in the form of an infinite sum of modified Bessel functions while the phase pdf is expressed in terms of the error function. The analytical amplitude and phase distributions are verified by comparing with both the empirical distributions of simulated data and experimental measurements. Simulated data sets are derived from Monte Carlo simulations of bistatic scattering from ocean-like rough surfaces. Experimental data were collected from monostatic measurements conducted at a wind-roughened reservoir with an S-band polarimetric radar. These simulated and experimental results show that the amplitude and phase pdfs vary with wind speed, observation angle, and polarization. The TM wave is observed to have a wider amplitude distribution than a TE wave. The phase of the scattered field is not uniformly distributed, especially under the low wind condition. The analytical amplitude and phase distributions are in good agreement with the empirical distributions of both simulated and experimental data sets. [C492]

"Land Cover Characterization and Classification using Polarimetric ALOS PALSAR"

In this study, the Touzi and Cloude-Pottier decompositions are compared for land cover characterization using ALOS/PALSAR polarimetric data collected at September, 4, 2006, over the Weinan region of Shanxi Province in China, the most useful parameters are combined for land cover classification. The classification results are assessed and validated using Landsat TM image of Weinan area acquired at August, 9, 2006. [C493]

"Analysis of C-band Polarimetric Signatures of Arctic Lead Ice using Data from AIRSAR and RADARSAT-1"

In December 2004 the JPL airborne synthetic aperture radar (AIRSAR) flown on the NASA DC-8 acquired fully polarimetric data in the Beaufort Sea at C, L and P-band. This work presents the backscatter coefficients (sigmaHH, sigmaVV, sigmaHV), copolarized ratios (sigmaHH/sigmaVV) and copolarized phase differences (phiHH-VV) at C-band from different young sea-ice types formed in recently frozen leads. Two weeks of RADARSAT-1 imagery from the same region as the AIRSAR data were used in order to identify when and where leads were formed and to estimate the age of the newly formed ice contained within the leads. A known empirical relationship based on freezing degree days was used to estimate the sea-ice thickness. The results indicate that some of the identified thin ice types have characteristic signatures. [C494]

"Performance Analysis of Multivariate Super-resolution Processing of Polarimetric Synthetic Aperture Radar Tomography"

In a previous paper, the authors developed a technique known as Vector Linear Prediction (VLP) which achieved super-resolution processing for polarimetric SAR tomography. In this paper, the performance of this multivariate super-resolution processing technique is investigated. Both simulations and field data are used to assess the limitations of this technique due to the loss of spatial and polarimetric coherence. The model assumes two scattering centers in each image pixel. The study shows that if one component remains linearly polarized, while the other is fully depolarized, then meaningful interferometric information can still be retrieved for the linearly polarized scattering center. However, if the depolarized component is also spatially decorrelated (loss of spatial coherence), then the interferometric phase estimates of both components are prone to significant errors. The

field data is used to verify and validate the observations obtained with the simulations. [C495]

"Combined Airborne Radio-instruments for Ocean and Land Studies (CAROLS)"

The CAROLS, L band radiometer, is built and designed as a copy of EMIRAD II radiometer of DTU team. It is a Correlation radiometer with direct sampling and fully polarimetric (i.e 4 Stockes). It will be used in conjunction with other airborne instruments (in particular the C-Band scatterometer (STORM) and IEEC GPS system, Infrared CIMEL radiometer, one visible camera), in coordination with in situ field campaigns for SMOS CAL/VAL. The instruments are implemented on board the French research airplane ATR42. A validation campaign with four flights was made over south west of France, Hourtin Lake and Bay of Biscay (Atlantic Ocean) in September 2007. In order to qualify the radiometer data, different types of aircraft movements were realized: circle flights, wing and nose wags. Simultaneously to flights, different ground measurements were made over continental surfaces and ocean. First results show a good quality of data over ocean surfaces. For continental surfaces, important Radio-Frequency Interferences (RFI) were observed over a large part of the studied region. [C496]

"Estimation of Terrain Slope Using a Compensation-Lambertian Method from Single-Pass Polsar Data"

In this paper, we introduce a new method of terrain slope estimation in the azimuth direction and the ground range direction using only one pass POLSAR data. This method is derived from the polarimetric SAR data compensation for terrain azimuth slopes variation [1] and the Lambertian backscattering model used in the radarclinometry [2]. The AIRSAR L-band POLSAR data are used to show the preliminary results of this method. The comparison of the proposed method and the digital elevation model (DEM) are given to show the effectiveness. The preconditions and limitation of this method are also discussed in this paper. [C497]

"Super-Resolution of Polarimetric SAR Images Based on Target Decomposition and Polarimetric Spatial Correlation"

Polarimetric SAR (PolSAR) is becoming more and more popular in remote sensing research area. Super-resolution processing of PolSAR image is usually desired for PolSAR image applications, such as image interpretation and target detection. Usually in a PolSAR image, each resolution contains several different scattering mechanisms. If these mechanisms can be allocated to different parts in one resolution cell, the details of the images can be enhanced, which means the resolution of the images is improved. In this paper, a new super-resolution algorithm for PolSAR image processing is proposed, in which target decomposition and polarimetric spatial correlation are both taken into consideration. Results of ESAR L-band full polarized images have validated the effectiveness of the proposed method. [C498]

"Analysis of Valid Ranges in Soil Inversion Models Based on the Cloude-Pottier Decomposition"

In this paper we improve the valid range analysis method in soil inversion models, using entropy/alpha space in the Cloude-Pottier decomposition theory. The ranges in data where inversion models can be applied are called the valid ranges of the inversion models. The improved valid ranges are considered more accurate through the Integral Equation Method (IEM) simulations. General method used to find out valid ranges of inversion models is the Normalized Difference Vegetation Index (NDVI), which shows the areas where the vegetation over soil is not too heavy for inversion models to apply. The proposed method introduces entropy/alpha parameters to the analysis of valid ranges, because these two parameters are closely related to target scattering mechanisms. Experiment results with fully polarimetric AIRSAR data show that the effectiveness of inversion models is increased by adding entropy/alpha space analysis. [C499]

"Non-Parameter Correlation Analysis in Polarimetric Signature and its Application to Change Detection in Polarimetric SAR"

Gonradsen et al. developed a change detection method with multilook fully polarimetric Synthetic Aperture Radar (SAR) data. The method is based on complex Wishart distribution supposition limits the applicable scope of test statistic, especially when only polarimetric diversity (the texture and speckle statistics depend on polarization) and not radiometric diversity. On the other hand, the polarization signature has the capability of representation of the polarimetric diversity. A new test statistic for equality of two polarization signature is proposed in this paper. Without statistical distribution hypothesis, it can give the associated asymptotic probability measure as the Conradsen's method just by non-parameter correlation analysis. Some experiments have been done in this paper with ALOS-PALSAR data by two different algorithms. It has been shown that the new method is effective. [C500]

"POLSCAT Ku-band Radar Remote Sensing of Terrestrial Snow Cover"

Characteristics of the POLSCAT data acquired from five sets of aircraft flights in the winter months of 2006-2008 for the second Cold Land Processes Experiment (CLPX-II) in Colorado are described in this paper. The data showed the response of the Ku-band radar echoes to snowpack changes for various types of background vegetation in the study site in north central Colorado. We observed about 0.15 to 0.5 dB increases in backscatter for every 1 cm of snow water equivalent (SWE) accumulation for areas with short vegetation. Based on a simplified radiative transfer model, the change detection technique is used to convert the temporal change of radar backscatter into SWE accumulation for dry snow conditions. The resulting SWE accumulation estimates are consistent with the in-situ SWE measurements, with about 2 to 3 cm Root-Mean-Square (RMS) difference for regions with sagebrush or pasture. [C501]

"An Approach for Mapping Frozen Soil of Agricultural Land under Snow Cover using RADARSAT-1 and RADARSAT-2"

A frozen soil map is a key tool to assess environmental impacts of agricultural practices on water quality, because the frost penetration in the ground has a direct impact on runoff and nutrient losses at spring melt in Eastern Canada. SAR images data have a great potential to provide this information due to there sensibility to the soil dielectric properties. The goal of this study is to develop a classification model by analyzing interactions between the different parameters resulting from insitufield data and SAR images under snow cover and to produce frozen soil maps at watershed scale. Two issues will be tackled, the mapping of frozen soil using RADARSAT-1 images and the polarimetric scattering mechanisms generated by frozen/unfrozen soil status. In this paper we present some initial results of polarimetric radar measurements using the C-band Convair-580 SAR. The analysis is addressing polarimetric signatures and entropy-alpha space distributions. [C502]

"Analysis of Polarimetric Surface Scattering in High Resolution SAR"

Statistical properties of rough surfaces can be affected by the spatial resolution of the radar sensor. This study aims to understand effects of the spatial resolution on the statistical description of surface roughness properties and on the surface scattering characteristics of polarimetric radar signal. A new expression for the surface autocovariance function and its corresponding roughness spectrum is proposed in order to characterize surface scattering. Results represent increases in the backscattering coefficients in accordance with decreases in the resolution cell size. Conventional continuous spectrum in the theoretical scattering model could underestimate the radar response in case of the surface defined by high correlation length. [C503]

"PolInSAR for Forest Biomass Retrieval: PALSAR Observations and Model Analysis"

This paper presents a new approach to the exploitation of polarimetric and interferometric (POLINSAR) data for the quantitative estimation of the forest height and, in general, of forest parameters. Our procedure aims to match simulations from the coherent scattering model PolSARProSim and real measurables. First, a parametric model analysis is used to study the dependence of the interferometric coherence versus forest height, canopy density and terrain slope. Secondly, we show the separation of scattering phase centers on PALSAR data acquired over the Amazon forest. Finally, we perform a preliminary forest height inversion based on the sensitivity of coherence versus forest height. The same procedure can be applied to a compact polarimetric (CP) data-set. In this case, we introduce a full POLINSAR (FP) reconstruction algorithm based on symmetry properties of geophysical media. [C504]

"Modeling Active Microwave Remote Sensing of Multilayer Dry Snow using Dense Media Radiative Transfer Theory"

In this paper, we model the backscattering coefficients of multi-layer dry snowpacks, based on Dense Media Radiative Transfer theory (DMRT) with the Quasicrystalline Approximation (QCA). The DMRT model accounts for adhesive aggregate effects, which leads to dense media Mie scattering by using a Sticky particle model. The same set of DMRT equations are used for modeling both active and passive remote sensing. The model is validated by using the Cold-Land Processes Field Experiment CLPX ground based polarimetric scatterometry observation at local-scale observation site (LSOS) and airborne polarimetric Ku-band scatterometer (POLSCAT) data at Fool-Creek, Fraser. The snow density profiles are from ground observation and grain sizes are fitting parameters. It shows that the co-polarization simulations are in good agreement with the data, the cross-polarization simulations are around 2 dB lower than ground based observation and 5 dB lower than airborne observation. With the same set of multi-layer snowpack profile, the QCA/DMRT model matched co-polarization backscattering coefficients and all 4 channels of brightness temperature observations simultaneously at LSOS. The cross-polarization simulation can be improved by 3-dimensional numerical solutions of Maxwell equations

(NMM3D). Study at Fool-Creek shows that NMM3D/DMRT simulations can match both co-polarization and cross-polarization observations simultaneously. [C505]

"Dual Polarization Detection of Ships and Icebergs-Recent Results with ENVISAT ASAR and Data Simulations of RADARSAT-2"

The RADARSAT-2 satellite is an advanced C-band synthetic aperture radar (SAR) with a variety of new modes including options for polarization combinations, resolution, and swath width. This paper examines the potential of multi polarization data for detecting and discriminating ship and iceberg targets Data used in this study consist of well validated airborne Convair-580 SAR and spaceborne ASAR HH/HV and HH/VV. In total, the data set used for evaluating detection and discrimination consists of 901 validated iceberg and ship targets. Optimizing target detection is accomplished using receiver operator curves (ROC) as proposed by [6] and discrimination is conducted using a quadratic discriminant (QD) with feature selection based on sequential forward selection (SFS). In general it was found that detection and discrimination improve with more polarimetric information; however, HH/HV and VV/VH only had nominally less discrimination performance than the quad polarization modes evaluated. [C506]

"Analysis and Correction of Speckle Noise Effects on Polinsar Data Based on Coherent Modeling"

PolInSAR data is a good example of a high dimensional SAR data. A blind filtering of these data does not make use of possible constraints imposed by the scattering process. In this paper it is shown that the scattering over forested areas induces some constrains on the data that can be fruitfully exploited to improve the final filtering, with que consequent improved of the quantitative estimation process. [C507]

"Robust vegetation height Extraction using maximum likelihood estimation for Dual-baseline PolInSAR"

Polarimetric SAR interferometry technique has been widely used for parameters extraction of the earth's surface vegetation. In this paper, based on the two layers Random Volume over Ground model, we present a vegetation height inversion algorithm for dual-baseline PolInSAR data. The method obtained the ground and volume scattering component respectively by using the theory of Freeman polarimetric decomposition. Then the maximum likelihood estimation of the covariance matrix was used to construct the vegetation height for dual-baseline PolInSAR. The proposed algorithm overcomes the restriction of traditional maximum likelihood estimation method which required the parameters of ground scattering to be known. Finally, the experimental results of L-band PolInSAR simulated data show that the algorithm improves the effect of height estimation compare to the coherence method. [C508]

"Extraction of Forest Biophysical Parameters Using Polarimetric SAR"

There is a continual pressing need for the ability to produce accurate, quick and cost-effective forest inventories to assist with forest management and the development of ecological models. Canada Space Agency's recently launched Radarsat-2 offers the ability to significantly advance this field with its multi-temporal and fully polarimetric C-band SAR capabilities. To explore the usefulness of C-band fully polarimetric data for modeling forest biophysical parameters, Convair-580 polarimetric C-band SAR data have been acquired over the Petawawa Research Forest in Ontario, Canada. An inventory of more than 1600 forest stands with information on species, age, canopy closure, height, stocking, basal area and volume have been obtained in order to determine which SAR parameters are most related to each of these biophysical parameters. The VV polarization, target anisotropy, ratios of the radar cross-section measurements and the order parameter of the K-distributed SAR clutter were found to consistently produce the strongest relationships. [C509]

"Multi-baseline coherence optimisation in partial and compact polarimetric modes"

Modern space-borne SAR sensors, like ALOS-PALSAR, TerraSAR-X and Radarsat-2 all provide at least a "partial polarimetric mode", acquiring only 2 of the 4 elements of the Sinclair matrix, like for example HH and HV or VV and VH. In addition, it has been demonstrated that with certain so-called "compact PolSAR" single-transmit dual-receive techniques one can obtain an estimation of the fully polarimetric information. Such systems are attractive in terms of reduction of pulse repetition frequency, data rate, and complexity and are currently very popular. However, they do not acquire complete information pertaining to the full polarisation state of the target and, as a consequence also coherence optimisation suffers from the reduced configuration space. In this paper, the potential of the different partial polarimetric setups for coherence optimisation is evaluated both theoretically and experimentally and compared to the capabilities of a fully polarimetric system. It will be analysed to which extent partial polarimetric system can improve the derivation of interferometric information from partly

decorrelated surfaces, in particular of vegetated or even forested areas. Special attention is paid to the constrained coherence optimisation of multi-baseline setups, important for modern DInSAR techniques like PS analysis and continuous DInSAR monitoring in general. All experimental analyses will be performed using fully polarimetric multi-baseline data sets. For proper comparison, partial polarimetric information is derived from these by matrix transformations according to the respective transmit / receive configuration. [C510]

"A Public Database of Simulated Multidimensional SAR Data for Techniques Validation"

This paper presents a new benchmark for techniques validation based on a multidimensional database of simulated data. By exploiting a SAR simulator of complex targets, series of numerical simulations may be run for specific sets of observation conditions and the results made public. Targets are in principle focused on urban structures, despite any other type of man-made targets may be considered. User interaction has allowed to fix the range of values for some design parameters according to the experience gained with real data. Multi-baseline polarimetric SAR interferometry and SAR tomography are the techniques for which this benchmark has been initially conceived, despite other research areas may also benefit, as multi-temporal or multi-frequency analysis. With the resulting amount of images, an adequate testing set can become available for multidimensional methods, which validation with real imagery is difficult. [C511]

"Forest Spatial Structure Enhancing Non-Gaussian Texture in Airborne L-Band Polsar Images"

In this paper, results of texture analyses over coniferous forests using airborne L-band POLSAR data are shown. Interestingly, field experiments have disclosed existence of patch-like sparse areas in a forest division where low order parameters of the K-distribution are calculated in the texture analyses. In order to validate that the observed non-Gaussian texture is related to existence of the patch-like sparse forests, the two-component decomposition method is applied. It is successfully revealed that there is spotted high contribution of ground (double-bounce or direct) scattering in the highly textured forest division. Furthermore, difference of the ground contribution between polarization channels could encourage our understanding of polarimetric variation of the forest texture. [C512]

"Preliminary Polarimetric Measurements of Bare and Vegetated Soils Radar Backscattering Coefficients and Brightness Temperatures Angular Dependences at 15GHz"

In this paper preliminary results of bare soil and soil vegetation radar backscattering coefficient and brightness temperature angular dependences at 15 GHz are represented. The results were obtained by combined radar-radiometer system moving along a quarter circle shaped measuring platform of 7 m of radius. [C513]

"KU-Band Sensitivity to Soil Moisture. An Evaluation Study for Monitoring Temporal Soil Moisture Change Detection Over the NAFE06 Study Area"

The combination of radiometer and radar observations is a very promising technique for spatial disaggregation of soil moisture. The enhanced QuikSCAT sigma-0 product (2.225 km) offers a possibility for overcoming the temporal and spatial limitations of the available radar systems. The current study investigates QuikSCAT sensitivity to soil moisture and its capability to accurately monitor and capture change in soil moisture. The research was undertaken for the National Airborne Field Experiment area located in the Murrumbidgee catchment, SE Australia. Validation of the temporal change detection analysis was undertaken using an airborne soil moisture product derived from the Polarimetric L-band Multibeam Radiometer (PLMR). The main propose of the PLMR use was to assess accuracy in terms of spatial patterns distribution. The results reveal expected temporal variability and adequate response of the active sensor to change in meteorological conditions. The presence of irrigation and standing water (rice fields) in the region challenges the spatial agreement throughout the study area. [C514]

"Potential of C-Band Multipolarized and Polarimetric SAR for Soil Drainage Classification and Mapping"

Among the various soil properties, drainage is the most important one for land productivity as well as the environmental management. Classification and mapping of regional and local soil drainage conditions and hydrologic soil groups are often required as input in many hydrological models used for assessing soil degradation processes and soil vulnerability to environmental losses under intensive agricultural production. The objective of this study was to evaluate the capability of high resolution SAR remote sensing data for mapping soil drainage. Backscattering coefficients (HH, VH, VV, RR, LL, psi45deg and psi135deg) extracted from CV-580 SAR were analyzed as function of drainage classes according to the land use (bare soil, annual crops). The multipolarization data showed a maximum of difference of 2 dB between drainage classes. Discriminant analysis

performed after applying principal component analysis (PCA) showed overall classification accuracy of 60% for drainage classes. Only the poorly drained class was clearly discriminated (73-97%) under agricultural fields. Introducing the polarimetric parameters (mean alpha_ angle, entropy (H), and anisotropy (A)) in the general disciminant classification, the soil drainage classification accuracy was improved particularly by the anisotropy parameter. The study demonstrated the potential of C-band multipolarized and polarimetric SAR for soil drainage classification and mapping. However, the high spatial resolution of the CV-580 showed high variability of scattering mechanisms associated to the fall acquisition period, where many crop fields were harvested but some corn fields being not. Spring acquisition near seeding of RADARSAT-2 (launched on December 14, 2007) imagery, should give better classification results. [C515]

"Towards Complex-Valued Neural Algorithms for Forest Parameters Estimation from Polinsar Data"

We discuss the development and application of a Complex-Valued Neural Network (CVNN) algorithm for retrieving forest biomass from polarimetric interferometric SAR data. After discussing some features of the net and of the training procedures, we analyze the performance of the algorithm in inverting combinations of simulated radar backscattering at different polarization states. The CVNN performance is compared with that of other retrieval algorithms. [C516]

"W-band 2-D Scanning Fully Polarimetric Radiometer System for Remote Sensing Applications"

In this paper, we present the design and calibration of the fully polarimetric radiometer at 94 GHz. For stable and high sensible Stokes parameters measurements, we applied a wideband analog correlator and a total power type receiver with a periodic calibration. To perform the fully polarimetric calibration, a calibration standard was designed and tested. Using the calibration standard, the calibration gain-offset was estimated and evaluated. The measured sensitivities with the integration time of 10 ms are approximately 1.26 K and 1.27 K in the horizontal and vertical channels, respectively. Other performances of the developed system and the calibration are also described and discussed. [C517]

"Turbo Speckle Filtering applied to PolSAR Data"

A new approach for speckle reduction in polarimetric synthetic aperture radar (PolSAR) images based on the turbo iterative principle is proposed. The turbo iterative algorithm shows high performances due to the propagation of the information between two complementary filters. One filter can boost up the results of the other by processing its residue image and retrieving valuable information in the noise subspace. [C518]

"Classification of Polarimetric SAR Images using Radiometric and Texture Information"

Image segmentation and unsupervised classification are difficult problems. We propose to combine both. A clustering process is applied over segment mean values. Only large segments are considered. The clustering is composed of a mean-shift step and a hierarchical clustering step. The approach is applied on a 9-look polarimetric SAR image. Textured and non-textured image regions are considered. The K and Wishart distributions are used respectively. The obtained region groups constitute an important simplification of the image and a good initial classification map. Multiplying the class map by the image of scalar texture component produces an image almost identical to the original where speckle 'color' noise variation is filtered out. [C519]

"Speckle Filtering of Dual-Polarization and Polarimetric SAR Data based on Improved Sigma Filter"

The advancement of SAR technology with high resolution and multiple polarization data demands better and efficient speckle filtering algorithms. In this paper, we developed an effective speckle filtering algorithm for dual-pol and fully polarimetric high resolution data. The proposed algorithm is effective and computational efficient based on the improved sigma filter ALOS/PALSAR and JPL AIRSAR data were used for demonstration. [C520]

"Sahelian-Grassland Parameter Estimation from Backscattered Radar Response"

In recent years a special emphasis has been placed on the retrieval of physical parameters from polarimetric radar at microwave frequencies in many research programs. In this paper, we adapted a technique based on an empirical model and a genetic algorithm, and verify its applicability for a complex class of vegetation within a wide temporal interval. This complex class of vegetation is Sahelian grassland which is mainly composed of annual grass and shrubs. The proposed retrieval algorithm is conformed of 3 main steps: (1) Identification of sensitive parameters, (2) Development of the empirical model, and (3) Implementation of a genetic algorithm for the inverse process. For this class of vegetation the sensitive parameters are: the soil moisture content ms, the grass density D, and the grass moisture content mv. When applying the retrieval algorithm to simulated radar responses, a great agreement (an error of 6% when estimating the soil moisture content, 13% for the grass

density, and 18% for the grass moisture content in the adult-plant stage) is observed between input parameters and estimated ones. [C521]

"Moving Targets Detection and Analysis on Multi-Look Polarimetric SAR Images using PWF Method"

The motion of moving targets causes distortions in SAR image, which present a challenge on image interpretation. Comparing to stationary targets' signatures, signatures of moving target are distorted from azimuth displacement to smearing beyond detectability. In this paper, a moving target detection algorithm is proposed based on polarimetric whitening filter (PWF) as well as time-frequency (TF) analysis. An experiment is implemented using multi-look X-band PolSAR image acquired by PiSAR. Both moving target and stationary target are included in the image. Results shows PWF method and time-frequency analysis could be used detect moving targets as respected. [C522]

"Analysis of Natural Scenes using Polarimetric and Interferometric SAR Data Statistics in Particular Configurations"

This paper introduces statistical tools for the analysis of POL-inSAR data acquired over natural environments. Maximum likelihood procedures are provided to test particular structures of POL-inSAR data presentations an to estimate relevant parameters. These particular configurations concern the stationarity of the separate POLSAR information between, the equality of the optimal POL-inSAR projection vectors and the presence of reflection symmetry. [C523]

"Coherent Decomposition of Fully Polarimetric Radar Data"

This paper presents a coherent decomposition scheme for a few scattering matrix data. A simple model-fitting decomposition method is applied to retrieve scattering mechanism or identify scatterers based on the coherency matrix. The decomposition results are compared with some experimental data obtained by fully polarimetric FM-CW radar. It is shown the scattering mechanisms are well recovered and the orientation angles of wire scatterer are precisely measured. [C524]

"Building Detection from High Resolution PolSAR Data by combining Region and Edge Information"

We propose a three step method to extract buildings from the high-resolution PolSAR data, using both the region-based and edge-based information. Firstly, low-level detectors are employed to provide raw region and edge information of the scene. In the second step, improved region-based building detection results are achieved by fusion of label fields, meanwhile the building profile line segments are extracted under a line Markov random field framework. The last step gives the final building footprint estimates: initial rectangle buildings are defined from the building line segments; by optimizing a surface criterion, the final rectangles are retrieved to fit the region-based building detection results. The effectiveness of this method is demonstrated using the real full PolSAR data. [C525]

"3D Urban Remote Sensing using Dual-baseline POL-InSAR Images at L-Band"

This paper generalizes a multibaseline interferometric SAR signal model to the polarimetric configuration. Based on this formulation, two high-performance array signal processing techniques are adapted to analyze multibaseline POL-InSAR observations. These new methods enhance the height estimation of scatterers by calculating optimal polarization combinations and allow the determination of their physical characteristics. Applying the algorithms to urban environments, the building layover problem is resolved by means of polarimetric dual-baseline InSAR measurements: Up to two components within one azimuth-range resolution cell are separated. The techniques are tested using dual-baseline Pol-InSAR data acquired by DLR's E-SAR system over Dresden city. [C526]

"Bistatic Pol-InSAR Scenario and Evaluation by Forest Scattering Simulations"

This paper comes within the context of exploring the potential of bistatic Pol-InSAR. Numerical simulations are carried out by means of MIPERS, multistatic interferometric polarimetric electromagnetic model for remote sensing which has already proved many abilities. The latter involves a electro-magnetic coherent approach of a discrete natural media description and enables us to model Pol-InSAR observables over forests in the bistatic configuration. Taking into account bistatic SAR constrains in terms of resolution, critical base-line, SNR, range and height ambiguities, new configurations for Pol-InSAR applications are envisioned. [C527]

"Extraction of Building Heights from VHR SAR Imagery using an Iterative Simulation and Match Procedure"

The new spaceborne very high resolution (VHR) SAR sensors onboard the TerraSAR-X and COSMO-SkyMED satellites have a spatial resolution of up to 1 meter. In VHR SAR data, features from individual urban structures (like buildings) can be identified in their characteristic settings in urban settlement patterns. In this paper, we present a novel methodology for the height estimation for generic man made structures from single power SAR data. The proposed approach is based on the definition of a hypothesis on the height of the building and on the simulation of a SAR image for that hypothesis. Then a matching procedure is applied between the estimated and the actual SAR images in order to validate the height assumption. The process is iterated for different initial height assumptions until the matching function is satisfied and thus the building height is estimated. The efficiency and the properties of the proposed method are demonstrated for the height estimation of flat- and gable roof buildings from a VHR airborne SAR scene and for a pyramid in Giza (Egypt) from VHR TerraSAR-X SPOT beam data. [C528]

"Comparison between Multitemporal and Polarimetric SAR Data for Land Cover Classification"

The investigation focuses on the determination of the land cover type using SAR data, including single polarisation, dual polarisation and fully polarimetric data, at L-band. The analysed data set was acquired during the AgriSAR 2006 campaign by the airborne ESAR system over the Gormin agricultural site (Northeast Germany). The multitemporal acquisitions significantly improve the classification results for single and dual polarization configurations. The best results for the single and dual polarization configurations are better than for the polarimetric mode. Overall, the cross-polarisation configuration provides the best results. [C529]

"Polarimetric BISAR Image Simulation and Analysis"

Employing three-dimensional mapping and projection algorithm (MPA), imaging simulation of bistatic SAR (BISAR) observation over complex scenario is developed. Based on the explicit expression of point target response of stripmap BISAR imaging, raw data is efficiently generated from the scattering map pre-calculated by MPA. Some examples of BISAR image simulation are studied. Polarimetric characteristics of BISAR image are then discussed. A transform of unified bistatic polar bases for BISAR image is proposed. Analysis of simulated images shows that the redefined parameters by the unified bistatic polar bases transform well describe different scattering mechanisms in BISAR imaging. It provides a primary tool for BISAR image interpretation and terrain classification. [C530]

"Microwave Scattering Profiles of a Rice Sample by Means of Polarization Coherence Tomography"

In this work we have applied the polarization coherence tomography (PCT) to indoor data acquired on a rice sample. Different baselines, frequency bands and polarimetric channels have been used in order to analyze the potential of this technique for retrieving information about the vertical structure of such a specific crop and, additionally, these observations have been also used for studying the validity of the RVoG and OVoG models. Results obtained show that the PCT profiles exhibit no dependence on polarization, which is in agreement with the clustering effect observed on PolInSAR observables, i.e. coherences for different polarimetric channels are located very close one to another. In the dual-baseline case, the best profile reconstruction is obtained for the highest baseline ratio available (0.25deg and 1deg baselines) when the condition number of the inversion problem is improved by filtering out the fifth coefficient of the Legendre-Fourier expansion. Differences on the reconstructed profiles between linear and Pauli basis are negligible. The application of the triple-and four-baseline approaches without filtering out the last terms of the expansion leads to unstable results, whereas the filtered cases reveal that the contribution of a fourth baseline is null. [C531]

"PolSARpro v3.3: The Educational Toolbox for Polarimetric and Interferometric Polarimetric SAR Data Processing"

The objective of this paper is to make a review of the current status of the PolSARpro v3.3 Software (Polarimetric SAR Data Processing and Educational Toolbox), developed under contract to ESA by a consortium comprising I.E.T.R at the University of Rennes 1, AELc, DLR-HR and Dr mark Williams from Adelaide. The objective of this current project is to provide Educational Software that offers a tool for selfeducation in the field of Polarimetric SAR data analysis at University level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. The PolSARpro v3.3 Software establishes a foundation for the exploitation of Polarimetric techniques for scientific developments and stimulates research and applications developments using PolSAR and PolInSAR data. [C532]

"Soil Moisture Estimation in time with D-InSAR"

This paper explores the potential to estimate soil moisture in the presence of vegetation using differential SAR interferometry and polarimetry. It is well known that a change in soil moisture changes the penetration depth of the electromagnetic wave, hence inducing an "artificial" change in the observed phase center. The presence of vegetation, or the vegetation vitality itself, can also affect the location of the observed phase center. Finally, a change in the polarimetric signature of the scatterer can also induce a phase center change. The purpose of this paper is to make a first study concerning the possibility to separate those contributions using differential SAR interferometry together with SAR polarimetry. Exemplary results are shown with data acquired by the airborne E-SAR system of DLR in the frame of the AGRISAR campaign. [C533]

"Polarimetric Classification of Vegetation in Prairie Landscapes"

The successful launch and commissioning of several fully polarimetric synthetic aperture radar satellites has made possible the routine use of polarimetric imagery for the classification of and detection of change in the vegetated cover of our planet. In a precursor study for Radarsat 2 application development, three lines of airborne quad-pol SAR data were collected over Canadian Forces Base Shilo in southwestern Manitoba, Canada. Analysis of these data in comparison to classified Landsat imagery shows that a classification based purely on radar data can successfully reproduce the basic sense of the visible/infrared classification although detailed, arbitrary sub-classes are not well replicated. A critical dependency on incidence angle in the classification implies that it will be important to collect comparative imagery from space-borne radars at a constant incidence angle. [C534]

"Fusion of High Resolution Polarimetric SAR and Multi-Spectral Optical Data for Precision Viticulure"

In the follow-up of the BACCHUS project, aimed at establishing a reference high quality geographic information system for vineyards, an airborne SAR survey has been carried out in fall 2005 in the Frascati area, near Rome (Italy) to investigate on the potential of radar remote sensing in vineyard monitoring. This contribution reports the joint use of high resolution polarimetric SAR data and QuickBird optical data in order to evaluate the potential of remote sensing in vineyard detection and bio-physical parameters retrieval. [C535]

"Retrieval of Aerosol from Space-Borne Polarimetric Data in Beijing"

It is difficult to determinate the aerosol model when retrieving the aerosol over land surfaces. In this paper, from the products of AErosol RObotic NETwork (AERONET), the aerosol model in city area of Beijing was analyzed. Then, the aerosol properties was retrieved from polarized data of the Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a LIDAR (PARASOL), and validated by the AOD products of AERONET. The results show: (1) the aerosol model based on ground based observations in Beijing is different from standard aerosol model of POLDER; (2) the particular aerosol model over Beijing can improve the retrieval accuracy over Beijing. [C536]

"Monitoring Fuel Moisture and Improving the Prediction of Wildfire Potential in Boreal Alaska with Satellite C-Band Imaging Radar"

Alaska currently relies on the Canadian Fire Weather Index (FWI) System for the assessment of the potential for wildfire and although it provides invaluable information it is designed as a single system which does not account for the varied fuel types and drying conditions (day length, permafrost, decomposition rate, and soil type) that occur across the North American boreal forest. Since 1999 research has been conducted to develop techniques for using Synthetic Aperture Radar to assess ground fuel moisture to improve the current fire danger prediction system in boreal Alaska. Research has been focused on recently burned forests using C-band satellite data. Analysis of the single channel SAR data resulted in two methods that can be used operationally, and a third time-series analysis method that is in need of further development but shows great promise in reducing the time-invariant confounding factors of surface roughness and aboveground biomass. Current and future research is focused on L-band PALSAR to expand to unburned areas, and the recently launched fully polarimetric Radarsat-II instrument. [C537]

"Pasture Monitoring from Polarimetric TerraSAR-X Data"

Good pasture management and optimal feed use are key drivers of profitability for New Zealand's pastoral dairy and meat industries. Preliminary results are reported on a study to evaluate TerraSAR-X dual-polarisation radar imagery for estimation of pasture biomass. At the time of writing, 4 out of 36 images have been acquired and

processed. Several linear models have been tested for field-measured pasture biomass in terms of co- and cross-polarisation backscatter. The best model is a linear regression using the HH and HV sum and difference, resulting in a residual standard error of 191.4 (kg/ha), with no evidence of a date effect. [C538]

"Polarimetric SAR Data for Forest and Deforestation Mapping in Guizhou Province, Southwest of China"

Forestry inventory in southwest of China often suffers from the cloudy cover, and Synthetic Aperture Radar (SAR) can play an important role because of its all-weather and all-day capabilities. In this paper, we studied the potential of polarimetric SAR data for forest mapping in heavy cloud prone and rainy areas with polarimetric TerraSAR-X, Radarsat 2 data and how to improve the forestry classification accuracy through integration of SPOT 5 image and polarimetric SAR data. Field works were carried out in late August of 2007, and parameters were collected using a ground based Lidar and field measurements. For the high relief condition at the test site, a geometric correction strategy using two side looking direction SAR images and high resolution digital elevation model was proposed to overcome the geometric distortion of SAR image such as foreshortening, layover and shadow in hilly areas. Neural net method was suggested for classification of the SAR and SPOT images. [C539]

"A new high-altitude airborne millimeter-wave radar for atmospheric research"

A high-altitude airborne millimeter-wave radar for atmospheric research is being developed by the National Center for Atmospheric Research. The radar will be mounted on the High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER). We present simulations of the minimum detectable signal, the reflectivity accuracy, the polarimetric purity, and the expected accuracy of cloud liquid water retrievals to describe the expected performance of the radar. We also describe the phased approach to implementing the system which starts with a W-band Doppler radar, and through phases, adds pulse compression, polarimetric capability, and a second wavelength (Ka-band) radar. [C540]

"Evaluation of X-band polarimetric radar estimates of drop size distributions from coincident S-band polarimetric estimates and measured raindrop spectra"

Recent research has demonstrated the value of polarimetric measurements for the correction of rain-path attenuation at X-band radar frequency and the estimation of rain parameters including drop size distributions (DSD). The issue this study is concerned with is to what degree uncertainties in attenuation correction can affect the estimation of DSD. Since attenuation correction uncertainty enhances with rain path our hypothesis is that DSD retrieval uncertainty at X-band may deteriorate with range. In this study we evaluate the relative accuracy of X-band DSD retrieval against DSD estimates from S- band radar observations and in-situ disdrometer spectra. We present comparisons of various techniques for estimating DSD model parameters from attenuation-corrected X-band dual- polarization radar data. Coincident X-band (XPOL) and S-band (S-Pol) dual-polarized radar measurements from the International H2O experiment (IHOP) as well as coincident X-band polarimetric radar (MP-X) measurements over disdrometer during a Typhoon storm case in Japan are used to assess the accuracy of the different DSD retrieval algorithms applied to X-band radar. [C541]

"Waveform coding for dual polarization weather radars"

Polarimetric variables are an essential part of algorithms for improved rainfall rate estimation, attenuation correction and hydrometeor identification. In such systems the transmit polarization state changes according to some fixed pattern that is repeated. The simultaneous mode and alternating mode waveforms are commonly used in weather radars. In the simultaneous mode of operation the horizontal and vertical polarization states are transmitted simultaneously and samples of both horizontal and vertical co-polar return are obtained A drawback of the current implementation of simultaneous mode is its inability to measure cross-polar parameters such as linear depolarization ratio. In this paper a technique to estimate cross- polar signals with a simultaneous mode waveform is presented. In this method, the horizontally and vertically polarized transmit waveforms are coded with orthogonal phase sequences. The performance of the phase coded waveform is determined by the properties of the phase codes. This paper presents the performance of the cross-polar and co-polar parameter estimation based on the simulation as well as data collected from CSU- CHILL radar. [C542]

"Adaptive bayesian algorithm for vegetated field parameters extraction by using multi-frequency and multi-polarimetric SAR images"

This paper proposes an alternative inversion algorithm for extracting soil and vegetation parameters from multi-frequency, multi-polarimetric SAR data. The alternative approaches aim at identifying a useful modelization of the soil and vegetation response to radar signal and then indicate a possible solution to the extraction of soil

moisture and vegetation water content. The core of the algorithm is based on the determination of probability density functions (pdfs) through a Bayesian methodology and has been initially developed for bare soils and tested on numerous data sets. The purpose is to apply this inversion algorithm to fields that have different levels of vegetation cover and considering different theoretical and empirical approaches. In fact, as already stated, a single approach, theoretical or empirical model, cannot be often applied on a wide number of cases. This paper addresses a possible solution based on two alternative different modelizations. [C543]

"Rainfall estimation and rain gauge comparison for x-band polarimetric CASA radars"

The Center for Collaborative and Adaptive Sensing of the Atmosphere (CASA) developed and deployed four polarimetric and Doppler-capable distributed, collaborative and adaptive X-band radars in Oklahoma with the capability to detect and track tornadoes and storms in the lower troposphere with high spatial and temporal resolution. This paper presents an analysis of the performance of X-band rainfall estimation composite algorithms and the conventional reflectivity-rainfall relationship. The polarimetric estimators are developed by different combinations of radar products including horizontal equivalent reflectivity (Zh), differential reflectivity (Zdr) and specific differential phase (Kdp)- The Micronet Little Washita rain gauge network is used for validating rainfall estimates of the KCYR CASA radar. In addition, NEXRAD WSR-88D KFDR radar data are analyzed and compared with the rain gauge network and the CASA radar estimates. Fourteen hours of data collected during August 2006 from three different storms are analyzed. Both convective and stratiform events are represented in the radar data analysis. An accuracy of point radar measurement is assessed for different rain intensities. Results demonstrate an improvement in hourly rainfall accumulation estimation for average rainfall intensities beyond 5 mm/hr with the use of polarimetric estimators. An increase in absolute difference standard error with distance by the use of absolute difference in radar and rain gauges estimates is also evaluated. [C544]

"PolSAR image filtering based on feature detection using the wavelet transform"

This paper elucidates a new approach for speckle reduction in polarimetric synthetic aperture radar ("PolSAR") images based on the stationary wavelet transform. Noisy wavelet coefficients are thresholded using an entropic thresholding technique. Principal Component Analysis and Sum of Squared Coefficients methods are used to detect significant coefficients based on the entire polarimetric covariance matrix. [C545]

"Dual-polarization spectral decompositions: Application to radar parameter estimation and quality control"

Spectral decompositions of dual polarization observation allows for extending of analysis of polarimetric radar data to the new dimension, namely Doppler frequency domain. In this paper it is shown how this new paradigm can be used for improving quality of radar data. On an example of the CSU- CHILL observations it is demonstrated that this analysis can be used to design a spectral filter that allows for both ground clutter mitigation and radar sensitivity improvement. [C546]

"IDRA: A new instrument for drizzle monitoring"

IRCTR is currently developing a high resolution radar aimed at the observation of rainfall and drizzle parameters for use in hydrological studies and in studies of the effect of the increase in anthropogenic aerosols in the radiation budget. Much effort has been done at obtaining a high sensitivity to be able to detect low reflectivity phenomena like drizzle. The radar is placed in the Cabauw meteorological super-site, allowing synergy with other instruments to further improve its capabilities. [C547]

"PALSAR CALVAL summary and update 2007"

This paper summarizes the geometric and radiometric calibration results of the PALSAR achieved during the ALOS initial calibration phase, which covers five months between May 16 2006 and October 23, 2006, and the half-year of the operational phase. All the PALSAR modes, FBS (fine beam single), FBD (Fine beam dual), SCANSAR, DSN (band limited SAR), and POL (Full polarimetry) were calibrated and validated using in-total 500 calibration points collected world widely and distributed target data from the Amazon. Through the characterization of the PALSAR, antenna pattern determination, and polarimetric calibration, we performed the adjustments of the PALSAR radiometric and geometric model installed on the SAR processor (SIGMA-SAR). Using the reference points, we finally confirmed that the geometric accuracy of the FBS, FBD, DSN, and POL modes is 9.3 m, that of SCANSAR is 70 m, and radiometric accuracy is 0.64 dB. Polarimetric calibration was successful that amplitude balance of VV/HH is 0.025 dB and the phase balance is 0.32 degrees. [C548]

"Multi-look polar decomposition of polarimetric SAR images"

This paper focuses an the multi-look polar decomposition of SAR images. Standard polar decomposition is generally used in single look polarimetry to decompose a bi-static or mono-static polarimetric scattering matrix into a product of an Hermitian matrix (boost) and a unitary matrix (rotation). An extension of this use in the framework of multi-looked polarimetry is proposed here. This new approach consists in decomposing the scattering matrix into boost and rotation components before vectorisation, then in averaging to generate boost and rotation coherency matrices separately, with new inferred parameters; the boost and rotation entropies, and concurrent dominant scattering mechanisms (alpha boost and alpha rotation). Tins multi-look extension of polar decomposition may allow for the definition of a new classification strategy for remote sensing data. [C549]

"Retrieval of ice thickness distribution in the seasonal ice zone from L-band SAR"

Airborne polarimetric and interferometric synthetic aperture radar (Pi-SAR) observation, conducted in the southern Sea of Okhotsk in February 2005, provided the opportunity to validate the retrieval of ice thickness distribution. In conjunction with the airborne SAR observation, in-situ ice thickness and ice- surface roughness measurements were carried out in the same area with ship-borne electromagnetic (EM) inductive sounding and supersonic profiling, respectively. Based on the analyzed results of data acquired in this experiment, this paper examine the possibility of ice thickness retrieval from the L-band SAR backscattering data in the seasonal ice zone (SIZ). [C550]

"The dependence of polarimetric decomposition parameters on biophysical forest parameters, frequency and methodology"

The increasing availability of fully polarimetric SAR data provides a large potential for the assessment of biophysical forest parameters. Aiming at an inversion of polarimetric parameters into forest parameters, this study shows the sensitivity of polarimetric decomposition theorems (Pauli- and H-Ialpha decompositions) to biophysical forest parameters, especially forest density. Effects of non-biophysical parameters on the estimation of decomposition parameters are also shown. The investigations were carried out on fully polarimetric data at L-band (1.3 GHz) and P-band (350 MHz) acquired in 2003 in a preAlpine region in Switzerland with the German E-SAR (Experimental SAR) platform. [C551]

"Bayesian classification of hydrometeors from polarimetric radars at S- and X- bands: algorithm design and experimental comparisons"

Dual-polarized weather radars are capable to detect and identify different classes of hydrometeors, within stratiform and convective storms exploiting polarimetric diversity. A model- supervised Bayesian method for hydrometeor classification (BRAHC), tuned for S- and X- band, is described in this study. The critical issue of X-band radar data processing is the path attenuation correction, usually negligible at S-band. During the IHOP experiment (Oklahoma, 2002) two dual-polarized radars, at S- and X- bands, were deployed and jointly operated with closely matched scanning strategies, giving the opportunity to perform experimental comparisons between coincident measurements at different frequencies. Results of hydrometeor classification and water content estimates at S- and X- bands are discussed and the impact of path attenuation correction is quantitatively analyzed. [C552]

"Properties of polarimetric sea clutter at 35 GHz"

The FGAN operated MEMPHIS radar was used to measure the backscatter behaviour of sea clutter at 35 GHz. The resulting fully polarimetric, carefully calibrated reflectivity data were analysed with respect to their temporal and spatial characteristics. Temporal decorrelation is fast, accordingly the polarimetric persistence is very low. As to spatial statistics, several well-known probability density functions like redistribution or log-normal are compared to each other. It is found that none of them is ideal. There is always a number of outliers that statistically behave differently. By eliminating them the goodness of the fit can be improved. [C553]

"Sensitivity of multi-temporal high resolution polarimetric C and L-band SAR to grapes in vineyards"

In the follow-up of the BACCHUS project, aimed at establishing a reference high quality geographic information system for vineyards, an airborne SAR survey has been carried out in fall 2005 in the Frascati area, near Rome (Italy) to investigate on the potential of radar remote sensing in vineyard monitoring. This contribution reports on the polarimetric very- high resolution C and L-band SAR data acquisition campaign supported by ESA and carried out by the DLR E-SAR on two dates in October 2005. The possible relation between the observed variations of backscattering at different polarizations and the harvest of the grapes is discussed. [C554]

"Pol-InSAR Results from ALOS-PalSAR"

The launch of JAXA's ALOS in January 2006 provides-for the fist time since the SIR-C/X-SAR mission's in the 80's-the opportunity to acquire Pol-InSAR data from space. Indeed, PalSAR (i.e. the SAR instrument onboard of ALOS) is able to operate in a quad-pol mode-declared by JAXA as an "experimental mode"-that allows the acquisition of Pol-InSAR data in a repeat- pass mode. In this sense, ALOS-PalSAR allows the application, validation and development of Pol-InSAR inversion techniques on a much wider range of sites distributed world-wide and accessible to a much wider scientific user community than possible with airborne sensors. In this paper we present the analysis of fully- and/or dual-polarimetric and interferometric data sets acquired by ALOS/PalSAR during its CAL-VAL and operational data acquisition phase and discuss the potential and the limitations for different polarimetric interferometric applications. More developed applications as forest height estimation from single- and multi-baseline Pol-InSAR ALOS-PalSAR data inversion-addressed in the frame of JAXA's Karbon & Kyoto initiative-as well as novel applications regarding soherent scatterer's detection and interpretation in urban environments are discussed. The impact of critical mission and operation design parameters as spatial coverage, repeat-pass time, observation scenario, and orbit control are evaluated and discussed. [C555]

"Polarimetric measurements of radar backscatters of a wet-land rice field throughout a growth period at L- and C-bands"

Backscattering coefficients and phase-difference statistics of a wet-land rice field in Suwon, Korea are measured using a ground-based polarimetric scatterometer at 1.9 and 5.3 GHz throughout a growth year from transplanting period to harvest period (May to October in 2006). The ground truth data including bio-mass, plant height, and leaf-area index (LAI) are also collected for each measurement. The measured backscattering coefficients and phase difference statistics are analyzed based on the growth age for each polarization, frequency, and incidence angle. It is found that the hh-polarized backscattering coefficients have wider sensitivity region than the w-polarized backscattering coefficients with respect to the rice growth age. [C556]

"Stochastic models of SLC HR SAR images"

The paper presents two algorithms for texture primitive feature extraction on Single Look Complex (SLC) and Polarimetric Synthetic Aperture Radar (PolSAR) SLC data. We assume the data to be modeled by a Gauss-Markov Random Field (GMRF): a complex GMRF model for characterizing the spatial correlation in SLC data and an extension of the model for inter-band correlation characterization. The complex GMRF characterizes the spatial relationship of a two-dimensional complex signal, i.e. SLC SAR data. The extended model characterizes the spatial interaction and the inter-band pixels correlation between the polarimetric complex channels. The Bayesian approach permits to deal with model fitting and selection in a direct way. The results are presented on a polarimetric E-SAR L band scene of Mannheim, Germany. [C557]

"Polarimetric analysis of maritime SAR data collected with the DSTO ingara X-Band radar"

Fine resolution spotlight synthetic aperture radar (SAR) imagery collected on a circular flight path is used to investigate the variation in ship detection performance with respect to three fundamental radar parameters: the transmit/receive polarisation combination, the incidence angle and the azimuth angle. The polarisation combinations examined are HH, HV, VV, RR and cross-slant 45deg. Three different incidence angles are considered-50deg, 60deg and 70deg-corresponding to collection geometries for high altitude maritime surveillance systems. Performance is assessed using a simple target-to-background contrast measure. Results are compared with preliminary results from a four component decomposition of the Mueller matrix. While the latter and cross-slant 45deg show promise, in general HH is shown to have the best performance. [C558]

"Snow wetness monitoring using multi-temporal polarimetric ASAR data and multi-layer hybrid model"

This paper presents a method to characterize snow cover using multi-temporal dual polarization ASAR/ENVISAT data. At first, variations of electromagnetic backscattering of snowpack depending on melting are explained and validated by a multi-layer model. It is demonstrated that it is crucial to exactly model the distribution of Liquid Water Content inside snow pack in C-band. Consequently, a new mapping algorithm based on the French weather model CROCUS is proposed in order to estimate the spatial variability of layered snowpack profile. [C559]

"Bistatic border effects modelling in forest scattering"

Simulating forest scattering by electromagnetic waves has been proposed with both coherent and incoherent models. However, to our best knowledge, most models consider a description of the forest as infinite in the horizontal plane and layered vertically. Such description is relevant in most cases, but fail when border effects

are present near the boundaries: the shadowing effects as well as the reinforcement ones, which are present in true SAR images, are absent in the synthetic images. The purpose of this study is to present a coherent scattering model taking into account forest regions of finite extent and benefit from its polarimetric, interferometric and bistatic capabilities to bring out interesting outlooks about border effect in the bistatic case. [C560]

"backscatter and interferometry for estimating above- ground biomass intropical savanna woodland"

Tropical savannas cover 15% of the Earth's land surface and are important ecosystems in the global Carbon cycle due to their high productivity. SAR interferometry and backscatter are investigated for estimating biomass in a tropical savanna in Belize, Central America. Single-pass InSAR data used are C-band (AIRSAR) and X-band (Intermap); SAR backscatter data used are fully polarimetric L and P band (AIRSAR). Results show that both C-band and X-band InSAR show a clear trend in vegetation patterns although both underestimate vegetation heights due to the heterogeneity of the vegetation cover. The scattering phase centre is lowered more for the X-band due to larger ground- level contribution. High P and L-band backscatter values are observed for areas containing high biomass vegetation, but also for leafy palmetto that have relatively low biomass. [C561]

"Detecting changes in polarimetric SAR data with content-based image retrieval"

In this study, we extended the potential of a Content- Based Image Retrieval (CBIR) system based on Self-Organizing Maps (SOMs), for the analysis of remote sensing data. A database was artificially created by splitting each image to be analyzed into small images (or imagelets). Content-based image retrieval was applied to fully polarimetric airborne SAR data, using a selection of polarimetric features. After training the system on this imagelet database, automatic queries could detect changes. Results were encouraging on airborne SAR data and may be more useful for spaceborne polarimetric data. [C562]

"Comparison and evaluation of polarimetric change detection techniques in aerial SAR data"

This article aims at providing a comparison of polarimetric change detection indices from a practical point of view. Six polarimetric change detection indices were tested on L band EMISAR data over Norway. Tests included quantitative evaluation of change maps compared to a ground truth of changes, and qualitative evaluation by visual inspection. Contrast ratio and the Wishart test gave the best results among the tested indices. [C563]

"Segmentation of polarimetric SAR data using contour information via spectral graph partitioning"

A new method for segmenting polarimetric Synthetic Aperture Radar (POLSAR) data is proposed. Image segmentation is formulated as a graph partitioning problem. Spectral graph partitioning-known to provide perceptually plausible image segmentation results using one or more cues (e.g., similarity, proximity, contour continuity)-is applied on POLSAR image data. The degree of similarities between pairs of pixels are calculated based on contour information. Graph partitioning is performed using the Multiclass Spectral Clustering method that minimizes the normalized cut cost function to ensure minimal similarity between partitions. The resulting segmentation is an approximation to the global optimal solution. C-band POLSAR data acquired by CV-580 are used for testing the performance. The results are found to closely agree with manual segmentations. [C564]

"Comments on hybrid-polarity SAR architecture"

Recent work on compact polarimetry is reviewed in the context of the fifty-year history of polarimetric diversity. One promising form of this genre is hybrid-polarity (CL-pol), in which a synthetic aperture radar (SAR) transmits circular polarization and receives on two orthogonal mutually-coherent linear polarizations. The CL-pol technique is compared and contrasted to alternative compact polarimetric schemes. Useful characteristics that are unique to the hybrid-polarity architecture are described, especially rotational invariance and polarimetric calibration. [C565]

"Urban land cover classification: potential of high and very-high resolution SAR imagery"

A comparative study on the complexity of the urban environments in SAR imagery at different spatial resolutions is presented. Two datasets have been considered, including the city of Rome, Italy imaged in decametric resolution and the Frascati area (Rome, Italy) acquired in very high spatial resolution (~2 m) at L-band in a fully polarimetric mode. The different characteristics of the radar sensors require careful managing of the corresponding product capabilities to maximize the various pieces of information contained in the variety of scattering mechanisms. [C566]

"The use of multidimensional copulas to describe amplitude distribution of polarimetric SAR data"

The paper focuses on a flexible model of multidimensional probability density function (pdf) dedicated to describe amplitude distribution of polarimetric SAR data. The model is based on the copula theory for characterizing the dependency between polarimetric channels (HH, VV, HV/VH or the target vector components). The benefit in using copula theory is to extend correlation concept to a wider dependence one, which may not be linear. From this point of view, the model is more flexible than the classical Wishart distribution. But it may include it. The other benefit in using the copula model is to separate the dependence concept from the shape of the marginal pdfs. Hence, this multidimensional characterization may be linked to classical 1D gamma pdf, or to a more flexible Pearson system of distributions. In the case of high resolution data, pdf shapes are becoming of heavy tailed and the Fisher system of distributions seems to be an interesting alternative for such a model. Any parametric 1D model may be used. The paper mainly focuses on the model itself and more precisely on the technique required to construct such multidimensional dependence function. The difficulties arise for copula on 3D in which the dependency is not homogeneous between the components (the link between HH and VV may not be of the same behavior as the one between HH and HV). Illustrations are given on classification and despeckling. Classification will be performed by a stochastic estimation maximisation (SEM). Despeckling will be achieved by a maximum A posteriori technique. [C567]

"Unsupervised classification of polarimetric SAR data using graph cut optimization"

The paper presents a new framework for the classification of polarimetric SAR data. The underlying model introduces cyclic conditional dependencies among the class labels assigned to neighboring observations as a mechanism to regulate the spatial homogeneity of classification results. Classification is posed as an inference problem, and is solved by coherently integrating expectation maximization and graph cut optimization. Results based on real SAR data are presented. [C568]

"Inversion algorithms comparison using L-band simulated polarimetric interferometric data for forest parameters estimation"

Polarimetric SAR interferometric data can provide estimates of forest biomass density. There are different approaches to deal with the inversion problem, such as neural networks and the traditional optimal estimation approach. This paper presents a study to evaluate their performance by means of quantitative indexes addressing both the computation time and the retrieval accuracy. Better forest parameters estimates have been obtained when neural networks algorithms were used. [C569]

"Multi-baseline polarimetrically optimised phases and scattering mechanisms for InSAR applications"

An interesting, but rarely used technique in polarimetric SAR interferometry is the enhancement of interferometric coherence by projection into an optimal polarimetric state. In particular, newly developed methods for polarimetric optimisation of multi-baseline coherences provide the possibility of simultaneous constrained coherence optimisation for more than one baseline. This technique can significantly improve the usefulness of long-term interferometric pairs and time-series, and appears, therefore, of interest to various fields of application. The aim of this paper is to discuss the correct derivation of multi-baseline differential interferograms with polarimetrically optimised coherence and to outline several possible areas of application, particularly in the field of differential interferometry and permanent scatterers. [C570]

"Quad-polarimetry and interferometry from repeat-pass dual-polarimetric SAR imagery"

New space-borne polarimetric SAR systems employ, or will employ, dual-pol imaging modes as well as full quad-pol imaging, e.g. PALSAR, RADARSAT-2, TERRASAR-X. Therefore questions arise as to the capabilities (and limitations) of these various dual-pol SAR imaging modes. One novel offshoot of our work on dual-pol SAR image analysis and polarimetric decompositions of dual-pol data was the idea to collect two dual-pol images employing geometry appropriate for parallel repeat-pass interferometry. The polarizations of the dual-pol collections differ, e.g. one is (HH, HV) and the other (VV, VH). Using the example of transmitting either horizontal (H) or vertical (V) polarizations, one collects all four polarimetric channels, but only two per pass. Except for the interferometric repeat-pass nature of the SAR image collections the polarimetric information should be identical to standard quad-pol SAR imagery. The relevant open questions concern the interferometric baseline and temporal decorrelations between the repeat-pass dual-pol images. [C571]

"Application of Polarimetric SAR images acquired in square-loop flights"

We acquired several data sets of polarimetrc SAR data in Sendai, Japan by airborne Pi-SAR system for fundamental research of radar polarimetry and interfereometry. Among these data acquisitions, two data sets were acquired in multiple flight paths in a short time period, and polarimetric SAR image acquired from different angles are available. We found very clear azimuth incident angle dependency of the polarimetric SAR images. In addition, a square-loop fight was carried out in the same location in January 2004. The incident angle dependency of the SAR image in polarimetry in X-band is very clear in these SAR images. We found that the phase difference in orthogonal circular polarization has significant dependency on the azimuth incident angle. The data sets also has a very good potential for SAR radargrammetry. We discussed the possibility of application of polarimetric SAR data acquired from multiple directions. [C572]

"Disaster monitoring and environmental alert in taiwan by repeat-pass spaceborne SAR"

The prevailing complex geological and ecological conditions of Taiwan have drawn considerable attention from various geo-ecological communities because of their vulnerability to produce various natural hazards at different scales. Located in the tropical/subtropical zone of the Pacific Rim, its ecological and rugged mountainous properties are environmentally sensitive making monitoring and observations especially difficult because of the high population density. For example, in terms of natural hazard mitigation tectonically active regions are used for analyzing the cause of abundant risk events, such as earthquakes, landslides and land subsidence. In fact Taiwan is well suited as a test site for studying those geologically disastrous processes. Implementing novel techniques of space remote sensing has proved to be an effective means in recent years for greatly improving our understanding of these phenomena. In this paper we report on the monitoring of such events using multi-modal polarimetric and/or interferometric SAR images at C and L band from ERS, JERS-1, RADARSAT-1, ENVISAT, and from the recent ALOS satellite. For crustal and surface deformation, we used radar image pairs with long temporal baselines and large areas of coverage for investigating deformation over Western Taiwan. Pre-seismic and co-seismic deformation patterns are spatial-temporally analyzed. The other topic deals with the coastline changes observed from a sequence of ERS-1/2 SAR images within the years of 1996 to 2005. Waterlines were extracted using multi-scale procedures of edge detection and were corrected with tidal motion data. Substantial analyses were carried out in conjunction with ground surveys and lidar mapping. The topographic feature changes due to large scale landslides triggered by torrential rains were also monitored. In addition, the SAR interferograms were used to analyze the deposition changes along the riverbeds and riverbanks for short-intervals using optimal baselines. Su- mmary and remarks on the implementation of such multi-modal polarimetric and/or interferometric SAR imagery for environmental monitoring are provided. [C573]

"Need for developing repeat-pass differential POLSAR interferometry"

Radar Polarimetry, Radar Interferometry and Polarimetric SAR Interferometry represent the current culmination in active 'Microwave Remote Sensing' technology, but we still need to progress very considerably in order to reach the limits of physical realizability. Whereas with radar polarimetry the textural fine-structure, target orientation, symmetries and material constituents can be recovered with considerable improvement above that of standard 'amplitude-only' radar; by implementing 'radar interferometry' the spatial (in depth) structure can be explored. With Polarimetric Interferometric Synthetic Aperture Radar (POL-IN-SAR) imaging, it is possible to recover such co-registered textural and spatial information from POL-IN-SAR digital image data sets simultaneously, including the extraction of Digital Elevation Maps (DEM) from either Polarimetric (scattering matrix) or Interferometric (dual antenna) SAR systems. Simultaneous Polarimetric-plus- Interferometric SAR Imaging offers the additional benefit of obtaining co-registered textural-plus-spatial three-dimensional POL-IN-DEM information, which when applied to Repeat-Pass Image-Overlay Interferometry provides differential background validation and environmental stress-change information with highly improved accuracy. However, hitherto only single-polarization-channel repeat-pass IN-SAR was developed and considered; and therefore the aim of this paper is to scrutinize and determine why and for what specific problems fully polarimetric differential RP-POL-IN-SAR imaging is required. [C574]

"Detection of foliage-obscured vehicle using a multiwavelength polarimetric lidar"

Foliage obscured man-made targets detection and identification is of great interest to many applications. In this paper, the backscattered laser signals from a multiwavelength polarimetric lidar were used to detect a vehicle hidden inside a vegetated area. The polarimetric reflectance data from the lidar at two separate laser wavelengths at 1064 nm and 532 nm revealed distinct target characteristics from both the vehicle and the vegetation. The results from this case study demonstrated the validity of the proposed lidar detection technique. Furthermore, the results could potentially lead to a lidar detection and identification technique for a wide variety of foliage-obscured man-made targets under various application scenarios. [C575]

"The Comparison of the V-Fold and the Monte-Carlo cross validation to estimate the number of

clusters for the fully polarimetric sar data segmentation"

In this paper, the cross validation algorithm is used to estimate the number of clusters for the unsupervised classification of fully polarimetric SAR data. Three different cross validation algorithms are applied for comparison, which are the dispersion measure method, the V-fold cross validation (VFCV) and the Monte-Carlo cross validation (MCCV). Our current experiments show that the dispersion measure method appears generally unable to provide a reliable estimation. The VFCV and the MCCV algorithms seem to be more effective than the dispersion measure method. Moreover, the VFCV is much faster than the MCCV, but the MCCV may be able to provide better estimation than the VFCV. [C576]

"Dependency analysis of normalized radar cross section of ocean surface on ocean winds using an airborne dual-frequency polarimetric SAR"

The normalized radar cross section (NRCS) of ocean surface is measured from three directions of illumination by an airborne dual-frequency synthetic aperture radar(SAR) with L- and X-band, and the dependency of the NRCS and the polarimetric ratio on the relative wind direction is analyzed. In X-band, the NRCSs in parallel polarizations represent the dependency on the relative wind direction. The NRCS in HH polarization of X-band has difference between upwind and downwind condition, though that in VV polarization the NRCSs for upwind and down wind condition are almost same. The wind dependency of the NRCS in L-band is smaller than that of X-band. The polarimetric rate in X-band shows the wind dependency with small difference between upwind and downwind conditions, though that in L-band is not apparent. The results suggests the possibility of measurement of ocean winds only using the polarimetric SAR in X-band. Moreover, the small dependency of the NRCS in L-band suggests the possibility of the wind speed measurement over the ocean. [C577]

"A geophysical model function for windsat polarimetric radiometer wind retrievals using linear polarizations"

In this paper, we develop a novel geophysical model function (GMF) for the WindSat radiometer relating the vertically (V-pol) and horizontally (H-pol) polarized brightness temperature (TB) to the ocean surface wind field. The brightness temperature data from the 10,18 and 37 GHz channels were used in this analysis. The brightness temperature combination of the form (AV-H) is found to be mostly independent of the atmospheric variations, where A is a constant number for each frequency. The GMF was developed empirically using the collocated wind vectors from the QuikSCAT scatterometer retrieval as truth and the WindSat's (AV-H) TB's. We examined the characteristic of the GMF and explored the opportunity to improve our current WindSat wind direction retrieval that utilizes only 3rdand 4thStokes measurements, by integrating this GMF. The strength of the wind directional signals is encouraging for moderate wind speed at 8 m/s and higher. [C578]

"Grecosar, a SAR simulator for complex targets: Application to urban environments."

This paper presents a preliminary study about the scattering properties of urban-like scatters based on simulated SAR images. A simple target performed by a box of gypsum located over a perfectly conducting flat plane is analyzed for different views in both ISAR and SAR fully-polarimetric modes. The results are analyzed with the Pauli decomposition theorem and they show that the scattering response of such a target is dominated by a strong scatter, which polarimetric behavior depends on the relative orientation of the target with respect to the radar. Tests with interferometry shows that the height of the box can be reasonably retrieved despite of model simplicity. [C579]

"Verification of Surface Scattering Models and Inversion Algorithms with the Polarimetric Backscatter Measurements of a Bare Soil Surface"

The backscattering coefficients of a bare soil surface were measured using an L-band polarimetric scatterometer, which were used to verify the validities of scattering models and inversion algorithms. The soil moisture contents and surface roughness parameters (the RMS height and correlation length) were also measured from the soil surface. The backscattering coefficients of scattering models with these surface parameters were compared with the measured backscattering coefficients. The soil moisture contents of the soil surface were retrieved from the measured backscattering coefficients, and compared with the measured surface parameters. This paper shows that the scattering models agree with the measurements, and also shows the inversion results. [C580]

"Retrieval of Soil Moisture and Surface Roughness from Backscatter Measurements of Vegetation Canopy"

This paper presents an inversion algorithm for retrieving the volumetric soil moisture content and surface rms

height from the measured backscattering coefficients of a vegetation canopy. The polarimetric backscattering coefficients of a tall-grass field are measured using a scatterometer at L-band. The water-cloud scattering model for the vegetation canopy are obtained by data-fitting with the measurements. Then, the soil moisture content and surface roughness of the tall-grass field are retrieved using a genetic algorithm. The retrieved soil moisture content and rms surface height of the tall-grass-covered soil surface are compared with the in-situ measured ground truth data, and good agreements between those values are shown. [C581]

"An Unsupervised Segmentation Using SPAN/H/γ/A initialization for Fully Polarimetric SAR Data Analysis"

In this paper, an unsupervised segmentation method is proposed for fully polarimetric SAR data. We use the parameter SPAN combined with the H/γ/A to perform the initialization, and the Wishart test statistic is used reduce the number of clusters. The output number of clusters is determined by the data log-likelihood algorithm. We try to keep the definition of SPAN as long as possible during the segmentation procedure. The experimental results show that the proposed segmentation algorithm is very fast, but the performance of the segmentation still need further investigation. [C582]

"Polarimetric SAR Image Classification Based on the Degree of Polarization and Co-polarized Phase-Difference Statistics"

This paper proposes a polarimetric SAR image classification technique based on the degree of polarization (DoP) and co-polarized phase-difference (CPD) statistics. At first, the formulation for the DoP and CPD is derived. Then, the classification technique is verified with the JPL-AirSAR full polarimetric L-band data acquired in 2000, Korea. The technique has capability of classifying an SAR data into four major classes, such as bare surface, short vegetation canopy, tall vegetation canopy, and village. [C583]

"Polarisation filtering for small target discrimination in ground clutter"

The Electronic Warfare and Radar Division (EWRD) of the Defence Science and Technology Organisation (DSTO) has initiated a number of studies investigating the exploitation of polarimetric analysis for the detection of small targets in strong ground clutter. This paper presents the results of experimental trials and associated signal processing research where an understanding of the scattering mechanisms present is used to design discrimination filters in the polarisation domain. It is shown that these physics-based filters provide highly efficient detection and identification of a variety of manmade targets immersed in strong clutter environments. [C584]

"Analysis and improvement of polarimetric calibration techniques"

This work presents an analytical study of the Quegan's PolSAR data calibration algorithm. As it shall be demonstrated, the solution proposed by Quegan based on certain approximations, gives in certain situations, biased crosstalk ratios u, v, w and z. An improved Quegan's calibration algorithm is proposed and tested. [C585]

"ALOS PALSAR products verification"

ALOS, an enhanced successor of the Japanese Earth Resources Satellite 1 (JERS-1), was launched from JAXA's Tanegashima Space Center in January 2006. An important contribution to the ALOS mission is the verification of PALSAR products to be distributed by the European ADEN node using the PALSAR processor developed by JAXA. A total of 28 ALOS PALSAR products have been analysed with respect to radiometric, geometric and polarimetric quality (including effects of Faraday rotation caused by the ionosphere) and a summary of the results is shown in this paper. [C586]

"High grazing angle X-band sea clutter distributions"

This paper investigates the statistical properties of sea clutter at grazing angles higher than traditionally used for airborne maritime radar surveillance, i.e. 10°-45°. Specifically, we study the spatial distribution of X-band, high resolution and high grazing angle polarimetric sea clutter data. We found that among the VV, HV, and HH polarisations, the VV data is least spiky and the K distribution usually provides a good fit. The HH data is spikiest and its distribution exhibits a sudden departure from the K distribution in the upper tail region, which usually requires the KA or similar distributions to achieve a better fit. Due to drawbacks of the KA distribution, this paper proposes a combination of two K distributions to fit the distribution of sea clutter with spikes. Referred to as the KK distribution model, it is found to provide the best overall fit. [C587]

"A Shaped-Beam Hybrid Coupling Microstrip Planar Array Antenna for X-band Dual Polarization Airport Surveillance Radars"

A novel dual-polarized microstrip patch array with a low-loss hybrid feed network suitable for X-band polarimetric airport surveillance radars (ASRs) is presented. A waveguide feed is used to excite a number of linear subarrays consisting of aperture-coupled microstrip cross-patch elements connected in series. The microstrip radiating part implements the dual polarization capability with low cross polarization, while the very reduced microstrip transmission line runs implied in the series-type feeding keep ohmic losses at a minimum. As a further major advantage of this antenna, the radiation pattern can be independently shaped in the two principal planes. In particular, the microstrip subarray is designed to produce a cosecant-squared pattern in the vertical plane, whereas the waveguide provides a Taylor-like illumination distribution to have low side lobes in the horizontal plane. As a result, the proposed array antenna is expected to stand out for high efficiency, polarization purity, simplicity of fabrication, light weight and compactness. [C588]

"Recent Advancements of Radar Remote Sensing; Air- and Space-borne Multimodal SAR Remote Sensing in Forestry & Agriculture, Geology, Geophysics (Volcanology and Tectonology): Advances in P0L-SAR, IN-SAR, POLinSAR and POL-DIFF-IN-SAR Sensing and Imaging with Applications to Environmental and Geodynamic Stress-change Monitoring"

Radar Polarimetry Radar Interferometry and Polarimetric SAR Interferometry represent the current culmination in "Microwave Remote Sensing' technology, but we still need to progress very considerably in order to reach the limits of physical realizability. Whereas with radar polarimetry the textural fine-structure, target orientation, symmetries and material constituents can be recovered with considerable improvement above that of standard 'amplitude-only' radar; by implementing "radar interferometry' the spatial (in depth) structure can be explored. With Polarimetric Interferometric Synthetic Aperture Radar (POL-IN-SAR) imaging, it is possible to recover such co-registered textural and spatial information from POL-IN-SAR digital image data sets simultaneously, including the extraction of Digital Elevation Maps (DEM) from either Polarimetric (scattering matrix) or Interferometric (dual antenna) SAR systems. Simultaneous Polarimetric plus Interferometric SAR Imaging offers the additional benefit of obtaining co-registered textural-plus-spatial three-dimensional POL-IN-DEM information, which when applied to Repeat-Pass Image-Overlay Interferometry provides differential background validation and environmental stress-change information with highly improved accuracy. Then, by either designing multiple dual polarization antenna POL-IN-SAR systems or by applying advanced POL-IN-SAR image compression techniques, will result in 'POLarimetric TOMOgraphic' (Multi-Interferometric) SAR or POL-TOMO-SAR imaging. By advancing these EWB-D-POL-IN/TOMO-SAR Imaging modes, we are slowly but steadily approaching the ultimate goal of eventually realizing air-borne and space-borne 'Geo-Environmental Background Validation, Stress Assessment, and Stress-Change Monitoring and Wide-area Military Surveillance of the Terrestrial and Planetary Covers'. [C589]

"Polarimetric hot spot processing for ISAR image autofocusing"

In recent studies the possibility of extending autofocusing techniques to fully polarimetric ISAR systems has been proposed. One of the first techniques for ISAR image autofocusing still in use is the Hot Spot processing. In this paper, the Hot Spot technique is extended and applied to fully polarimetric ISAR data. A performance analysis is then provided and compared to single polarisation Hot Spot by using real data. [C590]

"Polarimetric frequency agile FMCW RCS measurement radar"

Assessment of the frequencies and polarizations behaviour of the Radar Cross Section (RCS) of moveable targets with an unpredictable trajectory and/or targets with unrepeatable behaviour is difficult using single frequency/polarisation measurements. The variations of the RCS require a large number of measurements in order to acquire a representative RCS of the target over the spectrum of frequencies and different polarisations. The paper presents a RCS measurement radar system developed to measure RCS at different frequencies and polarizations, the relevant meteorological and oceanographic data and target movement simultaneously thus making it easy to assess RCS results and measurement quality. The system was developed for the Royal Norwegian Navy. [C591]

"Multidimensional waveform encoding for synthetic aperture radar remote sensing"

This paper introduces and analyses the innovative concept of multidimensional waveform encoding for spaceborne synthetic aperture radar (SAR). The combination of this technique with digital beamforming on receive enables a new class of highly performant SAR systems employing novel and highly flexible radar imaging modes. Examples are adaptive high-resolution wide-swath SAR imaging with compact antennas, enhanced parameter estimation sensitivity for applications like along-track interferometry and moving object indication, and

the implementation of hybrid SAR imaging modes that are well suited to satisfy the hitherto incompatible user requirements for frequent monitoring and detailed mapping. Further advantages arise for fully polarimetric operation where it becomes possible to reduce the PRF by a factor of two. Implementation specific issues will be discussed and examples demonstrate the potential of the new technique for different remote sensing applications. [C592]

"Diffusive CFAR & its extension for Doppler and Polarimetric data"

A new CFAR is introduced based on non-linear PDE (Partial Differential Equation) operators & geometric flows (Laplace-Beltrami & Mean Curvature Flows). This "Diffusive CFAR" smoothes Radar noisy data but preserves discontinuities. This kind of CFAR is well adapted for Radar detection in Littoral Area, where probability of detection in sea/ground clutter transitions and crest line (most threatening areas) could be non optimal by use of classical CFAR. We introduced these new CFAR in the framework of Information Geometry by taking into account radar signal statistics. We propose diffusive CFAR extension for Doppler & Polarimetric data. Finally, real time implementation is described based on "short-kernel" methods. [C593]

"Radar target-ground interaction"

An investigation of the X-band (10GHz) Electro-Magnetic (EM) scattering of a complex vehicle in-situ is reported. The aim of this work is to characterise radar multi-path effects in Synthetic Aperture Radar (SAR) imagery, and further to demonstrate how an appropriate choice of polarimetric basis can allow its mitigation. Ground-target multi-path effects reduce the interpretability of imagery by adding artefacts. Additionally, multi-path impacts on Automatic Target Recognition (ATR), because for any given situation it will not be clear what kind of ground should be employed for the training database. [C594]

"Forest monitoring by using L-band coherence"

Two ALOS/PALSAR polarimetry data taken in 2006 were used and examined the deforestation stage by using coherence value. Many trees were fallen by a typhoon hit on September 8, 2004 at a test site in Japan. Reforestation has started for the deforestation sites and several kinds of deforestation stages are appeared there. We classified the stands into four groups. 1) Only small stumps and branches are left. 2) Tree trunks have been carried out, but branches and stumps have been left. 3) The fallen trees have been left. 4) No trees were fallen by the typhoon (normal forest). Coherence values of HH-HH and VV-VV become ~0.39 for group 1 and ~0.30 for group 4, and show a significant difference. But the coherence values of group 2, and group 3 are ~0.3 and show almost same value as group 1. The coherence value of HH-VV and VV-HH are 0.1 lower than the one of the HH-HH and W-VV. The coherence values, which include cross polarization, such as HV-HV and HV-VV, show no difference for all groups and the value is 0.2 to 0.3. While coherence values show the difference between group 1 and group 4, sigma0HVshows wider dynamic range and is preferable to distinguish the deforested stands from forest stands. [C595]

"Polarimetric SAR observation by ALOS"

The Japanese microwave remote sensing satellite ALOS/PALSAR was launched successfully in January 2006. We are carrying out polarimetric calibration of the PALSAR sensor, which has the full-polarimetric function of L-band SAR. We set corner reflectors in Ulaanbaatar in May and August 2006, and the acquired data was used to confirm the polarimetric calibration coefficients, which will be used for the data sets delivered from October 2006. In addition, the acquired polarimetric SAR data will provide new possibility in remote sensing. Since this is the world first satellite borne full-polarimetric SAR system, we cannot show many examples in this moment, but from airborne SAR data, which we have studied, we show some examples of polarimetric SAR, which include tree type classification, and estimation of the orientation angle of scattering targets. [C596]

"ALOS-Indonesia POLinSAR Experiment (AIPEX): A Preliminary Result"

The successful launched recently of TerraSAR-X (X-Band) on 15 June 2007 marked the start of 'the golden era' for space-borne SAR in 2007, especially for SAR Polarimetry (PolSAR) and Polarimetric SAR Interferometry (POLinSAR). The first full polarization satellite mission SAR was ALOS/PALSAR (L-Band) which launched on 2006. In addition to these two SAR missions, Radarsat-2 (C-Band) is expected to be launched as scheduled in late 2007, which eventually will complete the availability of three bands (X, C and L) full polarization in separate space-borne SAR missions. This paper update the progress of AIPEX which was selected under JAXA/EORC's Second Research Announcement. The Experiment applies ALOS/PALSAR imageries which is the first available full polarization SAR in satellite mission. JAXA's systematic acquisition plan allows Indonesia to apply first L-Band spaceborne polarimetric SAR interferometry (POLinSAR) analysis, from April-May 2007 acquisition. It becomes an important milestone, as the country already had a monumental experience from its first L- and P-

Band airborne POLinSAR application in 2004, available through Indonesia Radar Experiment (INDREX)-II, funded by ESA. The recent study of Envisat-Indonesia Radar Biomass Experiment (EIRBEX), under ESA/Envisat AOE-869, has demonstrated the leading role of SAR for a cloudy tropical country such as Indonesia. The availability of Envisat/ASAR dual polarization allowed the first time implementation of a successful SAR polarimetry (PolSAR) analysis in tropical timber plantation forest. This promising result is parallel to the positive result of the previous airborne PolSAR vegetation analysis implemented on NASA's AirSAR full polarization, multi-frequencies imagery in Indonesia (JPL AirSAR/PacRim-2000). Based on the above milestone results, this Experiment concentrates in the basic studies on scattering and interferometric characteristics, by applying first attempt of space-borne POLinSAR analysis in a consolid- ated four different test sites. These sites are all related to the previous prominent SAR airborne and space-borne campaigns/exercises (Envisat AOE-869, AirSAR PacRIM 2000, and INDREX-II) in Indonesia. The objectives of the study, therefore, will be: (1) to do further studies on scattering and interferometric characteristics by applying first space-borne L-Band POLinSAR analysis; (2) to apply POLinSAR results into CDM/AR, LULUCF sector of the Kyoto Protocol; and (3) to provide feed back to JAXA in relation to suitable EO information product which relevant for Regional Observation mission. [C597]

"Polarimetric Analysis of Radar Signature of a Manmade Structure"

Identification of manmade structures from radar images has always been a difficult task, especially for single-polarization radar. Fully polarimetric radar, however, can provide detailed information on scattering mechanisms that could enable the target or the structure to be identified. Complexity remains stemming from overlaps of single bounce scattering, double bounce scattering and triple and higher order bounce scattering from various components of manmade structure that makes physical interpretation a challenge. In this paper, we will present an interesting example using polarimetric SAR data of the Great Belt Bridge, Denmark, to illustrate the capability of polarimetric SAR in analyzing radar signatures. Polarimetric target decomposition is used to differentiate the multiple bounce scattering contributions contained in the polarimetric SAR images. Two C-band Danish EMI SAR data takes, the first obtained during the bridge's construction and the second after its completion, are used to extract the scattering characteristics of the bridge deck, bridge cables and supporting structures. [C598]

"Prediction and detection of Faraday rotation in ALOS PALSAR data"

Faraday rotation can degrade the quality of low- frequency spaceborne SAR data, making an estimation and correction of these effects a prerequisite for data quality continuity. In this paper, methods for predicting and estimating Faraday rotation are presented and tested on ALOS/PALSAR data. A first example for unambiguous detection of Faraday rotation in SAR is shown. In addition, the improvement after correcting for FR is proven using a real data example. [C599]

"Signatures of polarimetric parameters and their implications on land cover classification"

Knowledge-based or rule-based classification schemes provide robust classification of normally a few major classes. In order to determine optimum polarimetric parameters for such classification schemes, a study has been performed, where the separability between different sets of major classes using many different polarimetric parameters has been investigated using airborne,C- and L-band polarimetric SAR data. [C600]

"Polarimetric optical tools and decompositions applied to SAR images"

Radar polarimetry aims to determine the scattering properties of a target or scatterer. For this purpose, the scattering matrix can be analyzed and represented in several ways using various techniques to extract information about the scattering mechanisms. Polarimetry and ellipsometry are techniques which both study the properties of the polarization of the scattered waves but traditionally refer to different wavelengths: optical wavelengths for ellipsometry, and high-frequencies radio waves for radar polarimetry. This paper deals with natural targets in the general bistatic case, for which the 16 parameters of the Mueller matrix are independent. We try to answer the following questions: how to deduce the radar polarimetric parameters from the optical measurements of a Mueller ellipsometer? What are the polarimetric parameters traditionally devoted to optical images, and in which extent is it possible to apply and interpret them in the case of SAR images? [C601]

"Estimation of forest stem volume using ALOS PALSAR satellite images"

A first evaluation of ALOS PALSAR data for forest stem volume estimation has been performed at a coniferous dominated test site in Sweden. In total, 7 Fine Beam Single polarization (FBS, look angle 34.3deg, HH-polarization) and 7 Polarimetric (PLR, look angle 21.5deg, HH-, HV-, VH-, and W- polarization) SAR images were used. In total, 56 forest stands with stem volume in the range of 45-650 m3 ha"1 (average 325 m3 ha"1) were analyzed by relating backscatter intensity to field data. The estimation accuracy of stem volume at stand

level was calculated in terms of root mean square error (RMSE). For the best case investigated an RMSE of 30% was obtained using one of the FBS images acquired in the winter season. The corresponding RMSEs for the PLR images with HH-, HV-, VH-, and W-polarization were 65%, 65%, 62%, and 81%, respectively. The better results for FBS compared to PLR mode could be explained by particularly favorable weather conditions at image acquisition, or by the higher ground resolution in the FBS images, which makes small stands less sensitive to errors in geocoding. [C602]

"An approach to classify polarimetric P-band SAR images for land use and land cover mapping in the"

In this paper the potentiality of polarimetric P-band SAR data for Amazon tropical forest land cover mapping is assessed. The classifying approach is based on the Iterative Conditional Mode (ICM) algorithm, taking into account several specific distributions to SAR data. Distinct land cover classes are modeled considering different distributions. The results show that the P-band data is not capable to discriminate the nine classes initially used. However this capability improves significantly when classes having similar vegetation structure are grouped. The HV image is effective in differentiating primary and very old regeneration forest areas from other land cover classes, while W image increases the classification of bare soil and crop/pasture areas. The results show the importance of polarimetric information for the classification of several land use classes. [C603]

"Degree of polarization for weather radars"

Future operational weather radars are likely to implement hybrid polarization, an operating mode that involves transmitting 45deg slant polarization and receiving the horizontal and vertical components of the backscattered field. In this work, the degree of polarization at slant send is theoretically considered and experimentally evaluated from fully polarimetric signatures in order to assess its potential for use in next generation operational weather radars. [C604]

"Retrieval of fully polarimetric mueller matrix under Faraday rotation effect at P band in space-borne polarimetric SAR observation"

Spaceborne microwave observation of subcanopy and subsurface requires the SAR (polarimetric synthetic aperture radar) technology at lower microwave frequencies, such as P band. However, SAR observation at P band is remarkably influenced by Faraday rotation (FR) effect through ionosphere. An example in this paper illustrates why the measured polarimetric data with FR at P band cannot be directly applied to terrain surface classification. We further present that the parameters u, v, H, a, A for terrain surface classification derived from the polarimetric data without FR, which are recovered from the data with FR, can be applied to the surface classification, even there is a plusmn pi/2 ambiguity error unresolved. Based on gradual change of FR degree along geographical location, a method to eliminate the plusmn pi/2 ambiguity error is designed. Thus, the polarimetric scattering vector and Mueller matrix without FR and plusmn pi/2 ambiguity can be fully inverted from the measured polarimetric data with FR. [C605]

"A neural approach to unsupervised classification of very-high resolution polarimetric SAR data"

Analysis of L-band polarimetric SAR data has not been extensively carried out for undulating, heterogeneous and fragmented landscapes, where classification can become quite challenging. This paper reports results of a study on the pixel-by- pixel unsupervised classification of very-high resolution polarimetric images by self-organizing neural networks. [C606]

"The problem of parameter estimation for spatially correlated polarimetric ground clutter at millimeterwave frequencies"

Most mathematical methods commonly used to estimate the parameters of a probability density function are based on the assumption of independent identically distributed (iid) data. However, the analysis of the reflectivity values of polarimetric ground clutter has shown that there may be a considerable amount of correlation depending on the type of clutter. For this analysis the estimated autocorrelation function, the Bartels test, and the runs up and down test for randomness are used. [C607]

"Comparison of parameter estimation accuracy of distributed-target polarimetric calibration techniques"

The accuracy with which distributed-target polarimetric calibration algorithms estimate crosstalk and the ratio of Tx-to-Rx channel imbalance is compared. The algorithms investigated are minor variants of previously-published

algorithms but rederived for notational and definitional consistency. Numerical simulations were used to assess the algorithms' performance in the absence of noise. Results indicate that the imbalance parameter is generally accurately-estimated but that crosstalk estimation accuracy varies greatly. [C608]

"Forest inventory applications using optical and RADARSAT-2 images in mexico"

There is a need in Mexico for accurate and up to date forest inventories due to concerns related with sustainable development programs. Forest inventories in the past have been incomplete and are not useful at regional levels. The national forest inventory is scheduled to be updated soon -optical remote sensing techniques and traditional field surveying are envisaged. There are no operational applications of radar remote sensing for forest management within government agencies or academic institutions in the country. Forest land cover is dynamical due to urban area growth, illegal logging and forest clearing for agricultural purposes in many regions. A previous land cover project combined Landsat-ETM and RADARSAT-1 imagery in Central Mexico, where forest areas are frequently foggy. A current project involves testing the potential benefits of combining polarimetric radar and optical data for forest applications. RADARSAT-2 imagery will be used as part of the Science and Operational Applications Research Program. The project aims to evaluate combined optical/radar approaches to improve forest inventory at regional scales. As a first step the total forested area is determined from optical SPOT 5 images. We show preliminary results from the optical data which are being validated on the field. As RADARSAT-2 imagery become available, polarization signatures for forest parameters will be obtained. Further work will evaluate the complementarities with optical signatures in determining forest species. [C609]

"Characterization of scatterers by their anisotropic and dispersive behavior"

Synthetic Aperture Radar (SAR) images built from received signals are high-resolution maps of the spatial distribution of the reflectivity function of targets. Conventional radar imaging assumes that all the scatterers are considered as bright points (isotropic for all observation angles and white in the frequency band) [1]. Recent studies based on multidimensional Time-Frequency Analysis describe the angular and frequency behavior of scatterers and show that they are anisotropic and dispersive [2]. Another useful information source in radar imaging is the polarimetry Studies based on multidimensional wavelet and coherent decompositions allow to represent the angular and frequency polarimetric behavior and show the non-stationarity of this behavior. The aim is to characterize scatterers by time-frequency analysis and polarimetry. [C610]

"Complex scene analysis from Time-Frequency statistics of POLSAR data"

This article presents a statistical approach for the study of PolSAR images using Time-Frequency (TF) correlation properties. PolSAR information is analyzed using a linear time- frequency (TF) decomposition which permits to describe a scene polarimetric behavior for different azimuth angles of observation and frequencies of illumination. A TF signal model is proposed and studied using two statistical descriptors related to the signal stationary aspect and coherence in the time-frequency domain. These indicators are shown to provide complementary information for an enhanced description of the scene. [C611]

"Inversion of soil moisture content from L- and P-band AIRSAR polarimetric SAR data"

Improvements of polarimetric inversion algorithms is presented in this paper. The confounding influence of roughness and vegetation cover on the estimation of the soil moisture contents is considered in the inversion algorithm that estimates volumetric moisture contents and roughness parameters simultaneously from the pertinent combination of polarization measurements. The estimation of the soil moisture contents from polarimetric SAR data is investigated using L- and P-band AIRSAR polarimetric SAR data collected over the Jeju Island, Korea. Results indicate that the estimation of the soil moisture contents can be expanded to a wider range of terrain types by using both L- and P-band polarimetric SAR data. [C612]

"Subaperture analysis of polarimetric SAR imagery"

In this paper we investigate the nonstationary behavior of individual polarimetric parameters, e.g. entropy, anisotropy, alpha angle, orientation angle, helicity, etc. We distinguish between parameters that depend solely on the eigenvalues of the standard Cloude-Pottier polarimetric decomposition (span, entropy and anisotropy) and the others that depend on the scattering mechanisms, i.e. the Cloude-Pottier eigenvectors. After producing a series of azimuth subaperture polarimetric images, we apply the polarimetric decomposition to each subaperture frame and identify subaperture frames that show nonstationary scattering. Comparison of several specific targets, both discrete and distributed, will highlight aspects of polarimetric variability with respect to the SAR view angle. We illustrate our results using EMISAR L-band polarimetric SAR data. [C613]

"The repeat-pass interferometric SAR by Pi-SAR(L)"

This paper describes the system and experiment of Pi- SAR(L) repeat pass interferometric SAR To obtain a high- quality interferometric image, it is necessary to make two flights on the same pass and observe in the same direction. We built a flight control system utilizing the preinstalled autopilot. This system measures position and altitude precisely with using a differential GPS, and controls the flight pass to be within virtual tube of 10 m diameter. The antenna rotation mechanism was also installed to control the observation direction. The repeat-pass flight has been conducted many times. The flights were stable and the deviation was within a few meters for both horizontal and vertical even in the gusty condition. The SAR data were processed in time domain based on range Doppler algorism to make the complete motion compensation. The interferometric image processed after precise phase compensation is shown. [C614]

"Some polarimetric aspects of processing sea surface M-ATI SAR data"

A brief review is presented of published work on detection and imaging techniques based on matrix group theory for the scalar non-polarimetric two channel along track interferometer and the vector polarimetric two channel across track interferometer. The relevance to ATI of the vector theory for the across track interferometer is discussed as is the problem of extending the theory to the case of the ATI with N beams. Difficulties in developing detection and imaging methods for the general case of N beams have lead to attempts to develop an alternative approach based on linear filtering. It is assumed that image modulations are a result of local fluctuations in mean intensity which can be described by a spherically invariant statistical process with a compound distribution. The unmodulated background consists of Gaussian scatterers. These scatterers and the modulated ones have different Doppler spectra and maximising the normalised standard deviation of the filtered image maximises the visibility of the image modulations. Polarimetric aspects of this approach are discussed and experimental results obtained with an airborne four beam M-ATI are presented illustrating aspects of the discussion. [C615]

"Polarimetric, combined, short pulse scatterometer-radiometer system at 5.6GHz"

In this paper a C-band (~5.6 GHz), dual polarization, combined scatterometer-radiometer system is described. The system allows carry out polarimetric (vv, vh, hh, hv), simultaneous and coincident microwave active-passive measurements of the observed surface (soil, vegetation, snow and water surface) parameters. The originality of the developed system is in the spatial-temporal combination of microwave active and passive channels of observation and its possible application for short distance sensing (the minimum operational range for the scatterometer is ~6 m) from low altitude platforms under far field conditions for both radar and radiometric observations. [C616]

"Physical parameter extraction over urban areas using L-band POLSAR data and interferometric baseline diversity"

Estimating the number of backscattering sources is an important issue in analyzing multibaseline interferometric SAR data. This paper extends model order selection algorithms to process polarimetric multibaseline InSAR observations. These methods are applied to urban environments using fully polarimetiric dual-baseline InSAR data of Dresden city acquired by DLR's E-SAR system. Experimental results for single polarization and polarimetric set-ups are presented and discussed. [C617]

"A novel optimization approach to forest height reconstruction from multi-baseline data"

The paper deals with the problem of reconstructing the height of forests from polarimetric/multi-baseline SAR data. The approach consists of optimizing an objective functional defined as the distance between the measured data and the data predicted by the model at the actual estimate of the unknowns. We indicate the role of global optimization on the performance of the forest height reconstruction algorithm. As global optimizer, a multilevel single-linkage method, which incorporates a local optimization into the global search, is exploited, thus offering computational efficiency and reliability. The performance of the method are illustrated against numerically simulated data. [C618]

"Radar Polarimetry for Target Discrimination"

Discrimination of targets vs. clutter is critical to many radar identification problems. For the purpose of Improvised Explosive Device (IED) detection, radar range profiles and images are valuable to capture the target of interest; it remains a big challenge to differentiate the target from the surrounding man-made clutter. The goal is to reduce the clutter. It is well-known that vector wave scattering is sensitive to both wave polarization and target orientation. This work makes use of ultra-wide-band (UWB) radar technology and polarization diversity to

characterize targets with polarimetric signatures. The results were based on both radar measurement and electromagnetic simulation. This research demonstrated the effectiveness of radar polarimetry for improved target identification. [C619]

"Polarimetric Azimuthal Spectral Histogram Exposes Types of Mixed Scatterers and the Cause for Unexpected Polarimetric Averages"

Echoes detected by polarimetric weather radar in clear air contain signals from air and biological scatterers. Discriminating the various scatterer types from a composite echo is challenging due to variability in scatterres' quantity, azimuthal dependences of their polarimetric properties, and uneven mixing in resolution volumes. We use polarimetric spectral densities to estimate the volume content by constructing two dimensional (2D) histograms. The dimensions used to form image are Doppler velocity and polarimetric variable. The assimilation of these histograms in azimuth results in a 3D-azimuthal-spectral-histogram (3DASH). This representation allows us to use transparency for small occurrences to visualize the 3D-signatures of dominant content. The scatterer types have distinguishable signatures in 3DASH due to their diverse physical shapes, scattering properties, different headings, and speeds. 3DASH can help to understand what constitutes the polarimetric averages of the resolution volume. 3DASH can help provide resources for establishing intrinsic polarimetric values/functions for different types of biological scatterers, which are necessary for scatterer classification algorithms. [C620]

"Information Compression and Speckle Reduction for Multifrequency Polarimetric SAR Imagery using KPCA"

Multifrequency polarimetric SAR imagery provides a very convenient approach for signal processing and acquisition of radar image. However, the amount of information is scattered in many images, and redundancies exist between different bands and polarizations. Similar to signal-polarimetric SAR image, multifrequency polarimetric SAR image is corrupted with speckle noise at the same time. This paper presents a method of information compression and speckle reduction for multifrequency polarimetric SAR imagery based on kernel principal component analysis (KPCA). KPCA is a nonlinear generalization of linear principal component analysis using kernel trick. The NASA/JPL polarimetric SAR imagery of P, L, and C bands quadpolarizations is used for illustration. Experimental results show that KPCA has better capability in information compression and speckle reduction compared with linear PCA. [C621]

"Super-Resolution of Polarimetric SAR Images for Ship Detection"

Polarimetric SAR images are used for aerial and space imagery applications, such as target detection, tracking, and resource exploration. However, spatial resolution is limited due to the signal bandwidth and the antenna dimension. Super-resolution reconstruction is the process to reconstruct a high-resolution image from multiple low-resolution images. Polarimetric SAR provides multiple images of the same scene at the different channels (HH, VV, HV and VH). In this paper, the POCS method is applied to extract the information from LR images in different channels to generate the HR image. The multiplicative characteristics of noises in SAR images are utilized to construct the convex sets in POCS method. Ship targets are selected as detection object for super-resolution. Results from simulated and real data have validated the effectiveness of proposed method. [C622]

"Recent Advancements of Multi-modal Radar & SAR Imaging"

Radar polarimetry radar interferometry and polarimetric SAR interferometry represent the current culmination in 'microwave remote sensing' technology. Whereas with radar polarimetry, the textural fine-structure, target orientation, symmetries and material constituents can be recovered with considerable improvement above that of standard 'amplitude-only' radar, by implementing 'radar interferometry', the spatial (in depth) structure can be explored. With polarimetric interferometric synthetic aperture, radar (POL-IN-SAR) imaging it is possible to recover such co-registered textural and spatial information from POL-IN-SAR digital image data sets simultaneously, including the extraction of digital elevation maps (DEM) from either polarimetric (scattering matrix) or interferometric (dual antenna) SAR systems. [C623]

"Image Processing in Polarimetric SAR Images Using a Hybrid Entropy Decomposition and Maximum Likelihood (EDML)"

This paper presents a hybrid entropy decomposition and maximum likelihood (EDML) for synthetic aperture radar (SAR) image analysis and classification with the application of land use management. Entropy decomposition is an effective technique to obtain valuable decomposed parameters for image interpretation with analysis of the underlying scattering mechanisms. However, the main disadvantage of entropy decomposition is that the decision boundaries of the analysis plane are arbitrary. To overcome this problem, maximum likelihood technique

is taken into consideration to help to determine the decision boundaries based upon Gaussian probability model. Hence, the hybrid EDML is developed to provide alternative way to improve the classification accuracy. The objective of this paper is to assess the use of polarimetric data for the image analysis and classification of land use management. It is illustrated using a well-known polarimetric AIRSAR data of San Francisco. In this paper, EDML technique is shown to have a superior result compared to other techniques. [C624]

"Evaluation of a fully self-consistent methodology to correct attenuation and differential attenuation at C-band"

A methodology to correct reflectivity factor and differential reflectivity at C-band for rain attenuation is presented and evaluated. The methodology is based on a full self-consistency condition describing the interrelation between polarimetric measurements and attenuation or differential attenuation along the rain medium. Evaluation is performed both using C-band profiles generated from S-band radar measurements collected by the NCAR S-Pol radar as well as data collected at C-band by the Polar 55 C radar in Italy. Evaluation shows improvement in performance with respect to the available techniques. In particular, it shows the capability to remove any systematic bias that could arise from drop size distribution variability from attenuation and differential attenuation estimates. [C625]

"Polarimetric ISAR autofocussing techniques: Comparison of results"

This paper briefly describes a number of scalar, partially polarimetric, and fully polarimetric ISAR image autofocusing approaches that are based upon the PPP and ICBA autofocusing techniques. All approaches are then compared and contrasted using real world data provided by the Defence Science and Technology Organisation of Australia. From this analysis the ICBA approach results in an improved image focus as defined by the image contrast, image entropy and image peak measures, whereas the performance of the PPP based approaches are mixed at best. [C626]

"Image contrast and entropy based autofocusing for polarimetric ISAR"

In recent studies the possibility of extending autofocusing techniques to fully polarimetric ISAR systems has been proposed. The image contrast and entropy based autofocusing techniques have been proposed in the last decade as some of the most common techniques for obtaining well focused single polarisation ISAR images. In this paper, the two techniques are extended and applied to fully polarimetric ISAR data. A performance analysis is then provided and compared to single polarisation ISAR using real data. [C627]

"Polarimetric Radar for Non-Destructive Testing of Building Structures"

Mobile polarimetric step-frequency radar for nondestructive visualization of building structures has been designed. Its main feature is polarimetric antenna array that radiates and collects both two co-and two cross-polarized signals, in order to obtain high resolution images. [C628]

"Unsupervised Classification of Polarimetric SAR Images Based on ICA"

Polarimetric SAR image classification is an important research area. Various classification methods continue to be developed for specific applications. In this paper, A new unsupervised classification method for polarimetric SAR images is proposed. It is based on independent component analysis (ICA). By ICA processing, several independent components are extracted from the channels of the SAR images. One of the independents is regarded as speckle noise and thrown away. By taking each remained independent as a kind of target, a classified SAR image with higher classification accuracy can be obtained. [C629]

"Polarization diversity for detecting targets in inhomogeneous clutter"

Polarization diversity has proved to be a useful tool for radar detection, especially when discrimination by Doppler effect is not possible. In this paper, we address the problem of improving the performance of polarimetric detectors for targets in heavy inhomogeneous clutter. First, we develop a polarimetric detection test that is robust to inhomogeneous clutter. We run this polarimetric test against synthetic and real data to assess its performance in comparison with existing polarimetric detectors. Then, we propose a polarimetric waveform-design algorithm to further improve the target-detection performance. A numerical analysis is presented to demonstrate the potential performance improvement that can be achieved with this algorithm. [C630]

"Unsupervised Classification of Polarimetric SAR Images by Gamma-Correction of Features using Self Organizing Map"

Unsupervised classification algorithms have tendency to form more clusters in the upper range of tin- features used for classification. In case of polarimetric SAR.. this means that, different areas having low polarimetric response will be merged into a single cluster and an area with large polarimetric response will be segmented into many clusters. This, for example, occurs in the areas like water, grass, roads and ot her flat surfaces which, owing to t heir low polarimetric response, are often assigned to the same cluster. Urban areas and other man-made objects, on the other hand, generally have large polarimetric response, and have tendency to form more clusters than required. To avoid this, we scale the features by applying gamma-correct ion or a power law transformation to nonlinearly reduce the dynamic range of features. A gamma-corrected feature has a more evenly distributed histogram as compared to the untransformed feature. In the transformed feature space thus obtained, the areas with low polarimetric response are mapped to a larger range of the total range as compared to the input feature space. This transformation of the feature space may provide a chance to the clustering algorithm to separate the low polarimetric response areas from each other. A neural network based on self organizing map (SOM) is used to classify I lie polarimetric SAR image into different clusters. A variety of features have been utilized to form the feature vectors. Elements of the polarimetric coherency matrix, derived features like Freeman decompositions. Alpha, Entropy. Anisotropy, and Eigen values of the coherency matrix may be used. The results show the comparison of the images classified by using both transformed and untransformed features. [C631]

"Optimal polarimetric interferometry coherence analysis in detection and location of moving target with SAR"

This paper mainly deals with the problem of the optimal polarimetric interferometry coherence in detection and location of moving target with SAR. The coherence is closely related with the estimated accuracy of the interferometric phase between the residual images which are obtained from clutter cancellation. A novel method for improving the estimated accuracy of the interferometric phase is presented. Using the echo model of moving target, the procedure of clutter cancellation in frequency domain is derived. The optimal polarimetric interferometry processing for residual images is proposed with detailed analysis. Finally, the interferometric coherences of the residual images with different polarization are analyzed by simulation to validate the theory. [C632]

"Circular SAR experiment for human body imaging"

In this paper, the CSAR (circular synthetic aperture radar) technique is introduced firstly. The principle of CSAR 3D (three dimensional) imaging and the spatial wavenumber support are analyzed and the 3D resolution is discussed secondly. Secondly, Ku band fully-polarimetric CSAR human body imaging experiments are performed, and the experimental data is processed by a fast 3D backprojection algorithm, the corresponding amplitude images are shown. Finally, the future experiments for human body imaging are discussed. [C633]

"Statistical distribution for scattering mechanism of targets based on eigenvector decomposition in Polarimetric Radars"

In this paper a decomposition scheme for analysis and classification of statistical radar targets is presented. For this purpose eigenvector target decomposition (ETD) analysis method is used for calculating coherency eigenvalues. Also a simulation scheme is developed for calculating entropy, scattering mechanism for discrimination of several surface scattering objects within distributed targets. As results, radar image data set have been used for compare. [C634]

"An X band polarimetric ARC prototype"

Polarimetric SAR can provide amplitude and phase information of targets, thus is widely used. For high image data quality, accurate ground calibration targets are needed. This paper describes a prototype multifunctional Polarimetric Active Radar Calibrator (PARC). An experiment was made in microwave darkroom to prove the applicability of PARC in polarimetric SAR calibration. [C635]

"A validation method for bare soil surface parameters inverted by Oh empirical model using integral equation method"

A new method is developed to validate the parameter inversion results of the empirical models proposed by Oh et al. for bare soil surface. Oh et al. developed a series of empirical models for retrieving bare soil moisture and root mean square (rms) height, while Fung et al. proposed integral equation method (IEM) to provide the relationship between backscattering coefficient and surface parameters in a rather wide range of roughness and moisture conditions. The proposed validation method combines the empirical scattering model Oh and the

theoretical scattering model IEM, which provides a method to show the accuracy of the inversion results. This method needs no ground truth measurement of surface in situ. [C636]

"Baseline analysis of Polarimetric SAR Interferometry"

Polarimetric SAR interferometry (Pol-InSAR) combines SAR interferometry (InSAR) and SAR polarimetry (PolSAR), and it helps to the generation of digital elevation models (DEMs) as well as the parameter estimation of natural volume scatters. Baseline is an important concept in conventional InSAR applications. With the introduction of polarization into InSAR, the baseline requirements of Pol-InSAR are different from those of InSAR. In this paper baseline decorrelation, which includes surface decorrelation and volume decorrelation, is firstly analyzed with the random volume over ground (RVoG) model. Then some different considerations in choosing baseline between Pol-InSAR and InSAR are presented. Finally methods of determining Pol-InSAR baseline are given and discussed. [C637]

"Comparison of bistatic signatures of octahedral and icosahedral reflectors in high-frequency domain"

In this paper, the bistatic polarimetric signatures of perfectly conducting octahedral and icosahedral reflectors with high dimensions with respect to the wavelength, are considered. A closed form solution for their fast computation is developed and results are compared. These particular faceted polyhedra, both composed by several identical elementary reflectors, should exhibit a large bistatic and monostatic radar cross section (RCS) over a wide angular range. The proposed method is based on coherent summations of the asymptotic solution of the trihedral corner reflector (TCR): the elementary reflector, evaluated for any incidence and observation angles. This can be done with the help of geometrical optics (GO) to take into account shadowing effects. physical optics (PO) and GO are used to derive the contribution of the TCRs in single, double and triple reflections. First order diffractions are also included in the analysis with the help of method of equivalent currents/incremental length diffraction coefficients (MEC/ILDC). [C638]

"Polarimetric approach to detection of probable aircraft Icing zones. icing detection algorithms"

Aircraft icing is a dangerous meteorological phenomenon. Most important conditions for growing of ice coating on aircraft body or wings are presence of supercooled liquid water (SLW) drops, high humidity and negative temperature of air. Remote sensing of the clouds with the help of polarimetric radar can detect the SLW in cloud. It can be used to avoid dangerous situations during the flight. Mathematical simulation of microwave backscattering from ice crystals of different forms and water drops in rain and clouds have been done. Different icing detection algorithms are described and analyzed. [C639]

"Millimeter wave RCS and Doppler spectrum of walking human and dog"

This paper presents a polarimetric model for backscatter and its Doppler spectrum of a walking human and a dog subject at W-band using GO-PO method. Polarimetric measurements of human target with and without a firearm are also presented to demonstrate the increase in the level of cross-polarized backscatter. Furthermore, we present a time-frequency analysis to separate polarimetric response of the human torso. [C640]

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"Clustering Polarimetric SAR Image Under Deorientation Theory"

In natural complex terrain surfaces, scattering targets with random orientations produce random fluctuating echoes which lead to confused classifications by directly using target decomposition on polarimetric SAR (PolSAR) image. In order to reduce the influence, the target vector is transformed into the state with minimization of cross-polarization. Then a set of new parameters u/v/w are used to characterize scattering mechanisms under the deorientation theory, and the fuzzy membership is adopted instead of "hard" division of parameter plan. Characterizing the sample coherency matrices as complex Wishart distribution, the PolSAR image is clustered based on Bayes maximum likelihood (ML) criteria. Experiment is carried out on an L-band NASA/JPL SIR-C PolSAR image over Danshui town, Guangdong, China. Comparison results with the popular used methods show that the proposed method provides a significant improvement in classification and the associated scattering mechanism of class is more accurate and beneficial for automatic terrain recognition. [C644]

"Spectral Analysis of Polarimetric Weather Radar Data with Multiple Processes in a Resolution Volume"

A new approach for the clear air velocity estimation in weather radar is presented. A combination of nonparametric with parametric spectral analysis allows us to identify and extract multiple processes caused by different scatterer types within a single radar resolution volume. An example of clear air observed using an S-band dual polarization radar is presented. Heretofore, migrating birds and wind-blown insects that are mixed within each resolution volume caused such data to be unusable for meteorological interpretation. In this paper, we construct power spectral densities of polarimetric variables. We use the polarimetric spectral densities to differentiate the scatterer types within the observed radar resolution volume. We demonstrate how our combination of non-parametric and parametric spectral analysis can be used to retrieve the true wind velocity in situations with severe contamination by biological scatterers [C645]

"Adaptive Polarized Waveform Design for Target Tracking using Electromagnetic Vector Sensors"

We develop an adaptive waveform design method for target tracking. In our method, at each time step, we optimally select the parameters, including the polarization of the transmitted signal waveform to improve the tracking accuracy. An array of electromagnetic vector sensors is employed to fully recover the polarimetric information from the reflected signals. We derive our approach under a framework of sequential Bayesian filtering. We apply a sequential Monte Carlo method to manipulate the nonlinear and non-Gaussian state and measurement models. We design a criterion for the waveform optimization based on a posterior Cramer-Rao bound [C646]

"Automatic Detection of Power Transmission Series in Full Polarimetric SAR Imagery"

An automatic extraction scheme of power transmission tower series in full polarimetric synthetic aperture radar is presented. Through analyzing the amplitude of four scattering powers in terms of scattering matrix elements based on four-component decomposition model, point-like targets including the power transmission towers are detected in the helix scattering component using the multi-resolution statistic energy level method. Due to the geometrical properties of power transmission tower series, radon transform is used for extraction by applying it to the graph structure which constructed by linking all the isolated power transmission towers. Using L-band Pi-SAR images, the effectiveness of the extraction method is validated. [C647]

"Model-based Correction of Through-wall SAR Imagery via Raytracing"

This paper develops a polarimetric model for through-wall propagation effects at RF frequencies and

incorporates this model in a backprojection imaging framework that corrects for defocusing observed with standard methods. This model accounts for refractive phase delay as well as multiple internal reflections within the wall, and the image-reconstruction correction refocuses the entire scene behind the wall at once. The proposed algorithm that implements this correction leverages CAD raytracing and forward prediction capabilities from widely-used shooting-bouncing-rays (SBR) electromagnetic scattering tools, enabling efficient implementation on complex wall geometry (e.g., windows, doors, and multiple walls). The development in this paper suggests that fully-polarimetric data is required in general to recover the focused reflectivity of the scene behind the wall for any arbitrary transmit and receive polarizations; however, for scenes without significant vertical extent the proposed algorithm can refocus a single-polarization measurement. This paper presents a benchmark scene comprising a homogeneous dielectric wall and four trihedral reflectors, two of which are obstructed by the wall. This paper uses synthetic data of the scene, generated using a nearfield SBR implementation, to demonstrate the effectiveness of the proposed algorithm. [C648]

"Super-Resolution Processing for Polarimetric Synthetic Aperture Radar Tomography"

In polarimetric SAR interferometry, fully-polarimetric measurements are obtained along multiple interferometric tracks and used to generate three-dimensional tomographic images of a scene of interest. The objective is to utilize the polarimetric diversity of the targets to separate multiple targets within a single pixel. In this study, a new technique known as Vector Linear Prediction (VLP) is developed and used to perform polarimetric aperture extrapolation with measurements from a single baseline SAR interferometer. The VLP method extends scalar, linear prediction-based extrapolation to coherent, multi-channel data such as polarimetric SAR interferometric measurements. The interferometric phase estimates, which reflect the elevation of the scattering centers, are obtained for both the ground and vegetation components. The phase difference between the two components is shown to be consistent with the vegetation cover in the region under study. In the future, this technique will be applied to multi-baseline SAR measurements to produce tomographic images of the scenes being imaged. [C649]

"Detection and classification of urban structures based on high-resolution SAR imagery"

In this paper, several advanced methods for detecting and classifying urban structures in high-resolution SAR imagery are presented. The detection of man-made structures resp. the suppression of clutter, for example natural surfaces, can be accomplished by a coherent time-frequency analysis. These techniques can detect targets in the scene that behave like point-scatterers (such as edges, poles, etc.) by their high degree of correlation across sub-apertures of the scene. If polarimetric data are available, this approach can be extended by taking into account the frequently anisotropic polarimetric backscattering of man-made targets. As a third approach, a simple but powerful operator for detecting urban structures by analysing texture inhomogeneity in SAR images is developed. A second objective of this paper is the segmentation and classification of the detected urban structures. Based on the detected man-made structures, the characteristic structure size is investigated, using several approaches, to distinguishing between residential areas, industrial areas and dense city centres. The methods are evaluated using several real airborne SAR datasets. [C650]

"Multisource Data Processing for Semi-Automated Radiometrically-Correct Scene Simulation"

The digital imaging and remote sensing image generation (DIRSIG) model is an established, first-principles based scene simulation tool that produces synthetic multi-spectral and hyperspectral images from the visible to long wave infrared (0.4 to 20 microns). Significant enhancements such as spectral polarimetric and active light detection and ranging (lidar) models have also been incorporated into the software, providing an extremely powerful tool for algorithm testing and sensor evaluation. However, the extensive time required to create large-scale scenes has limited DIRSIG's ability to generate scenes "on demand." To date, scene generation has been a laborious, time-intensive process, as the terrain model, CAD objects and background maps have to be created and attributed manually. To shorten the time required for this process, we have initiated a research effort that aims to reduce the man-in-the-loop requirements for several aspects of synthetic hyperspectral scene construction. Through a fusion of 3D lidar data with passive imagery, we are working to semi-automate several of the required tasks in the creation of high-resolution urban DIRSIG scenes. This paper reports on the progress made thus far in achieving these objectives. [C651]

"Mining Induced Subsidence Monitoring in Urban Areas with a Ground-Based SAR"

Since June 2006 the Remote Sensing Laboratory (RSLab) of the Technical University of Catalonia is carrying on a subsidence monitoring activity in Salient, a village in the central Catalonia. The project, in collaboration with the Cartographic Institute of Catalonia (ICC), aims at studying the deformation phenomenon induced by salt mining extraction of the past years using a ground-based SAR sensor. Polarimetric data are being monthly

acquired at X-Band in a perfect zero-baseline configuration. A detailed description of the on-going measuring campaign is here given. The advantages and drawbacks of using a terrestrial sensor are also stressed. Finally, first results carried out using a coherence approach are shown. [C652]

"3D Visualisation and Physical Feature Extraction of Urban Areas using Multibaseline POL-InSAR Data at L-Band"

This paper extends two single polarization multi-baseline interferometric SAR spectral analysis techniques to the fully polarimetric configuration. These new algorithms enhance the height estimation of scatterers by calculating optimal polarization combinations and allow to determine their physical characteristics. First experimental results show the retrieval of building height and their polarimetric properties by means of single-baseline polarimetric datasets. Dual-baseline observations permit the solution of the layover problem by separating two contributions within one resolution cell. The algorithms are tested using multibaseline Pol-InSAR data acquired by DLR's E-SAR system. [C653]

"Urban area remote sensing from L-band PolSAR data using Time-Frequency techniques"

This article presents a new approach for the study of urban areas using polarimetric SAR (PolSAR) data. The PolSAR multidimensional information is analyzed using a linear time-frequency (TF) decomposition which permits to describe an urban area polarimetric behavior for different azimuth angles of observation and frequencies of illumination. A TF signal model, adapted to the case of urban areas is proposed and studied using two statistical descriptors related to the signal stationary aspect and coherence in the time-frequency domain. These indicators are shown to provide complementary information, adapted to the case of man made environments. A TF based classification is proposed and applied to fully polarimetric SAR data acquired by the ESAR sensor at L-band. Results demonstrate the efficiency of this method in terms of buildings location retrieval and response characterization. [C654]

"Reconstruction of the 3D Stereo Buildings from Polarimetric SAR Images in Two Converse Flights"

The height and location of the three dimensional (3D) objects can be retrieved from polarimetric SAR images in multidirectional flights, and the 3D stereo objects can then be reconstructed. Polarimetric SAR image describes the objects via polarization synthesis, and presents much richer information than mono-polarized SAR image. Furthermore, multi-aspect flights of polarimetric SAR can see the 3D stereo objects in different angles and become feasible to invert the height and location of the objects. This paper presents an attractable approach for reconstruction of the 3D stereo buildings from two converse flights of airborne PI-SAR images (at X band with spatial resolution 1.5 m). [C655]

"Fisher Ratio Optimization under Volterra Filtering Model for Identification of Polarimetric Air/Air Range Profiles of Aircrafts"

This paper introduces an original supervised classification method based on the optimization of the Fisher ratio under the Volterra filtering model. Optimum Volterra filters are derived for the problem of discriminating 2 classes. They have properties yielding some decision strategy that aims to reject (i.e. take no decision) data corresponding to unlearned classes. An original extension of this solution is then proposed for the problem of discriminating more than 2 classes. Performances of our method are evaluated by classifying real data of jet fighters range profiles. Influence of the filtering model order is investigated. Interest of the waveform polarization states is also analyzed. Results obtained show that our method outperforms the nearest neighbor classification method in term of error probability, while yielding equivalent performances in term of correct identification probability. Moreover, it is shown that good rejection probability of unlearned classes can be obtained, particularly with fully-polarized data. [C656]

"On the Phase Centers of the Scattering of Compound Shape Bodies in SHF and Short-Wave Ranges"

In this paper the results of the experimental study of the polarization features of the backscattering from the compound shape bodies are presented that could be used for their recognition and their course determination as well. The investigations were carried out using the polarimetric coherent systems of the pulse as well as CW transmitting modes of the millimeter wave band. For the study of the phase parity between the elements of the scattering polarization matrix for the polarimeters utilizing the CW mode transmitting the polarization selectors were developed that provides not only orthogonally polarized component expansion of the received signal and the heterodyne signal injection to the working channel having equal phases as well. In the pulse radar

polarimeters we used the pulse-by-pulse switching of the receiving signal polarization and alignment of the electrical length of the signal injection and heterodyne ducts in the channels having orthogonally polarized components. [C657]

"Doppler-Polarimetric Approach to Microwave Remote Sensing of Precipitation"

This study has shown that considered Doppler and polarization parameters of radar signal contain information on rain microstructure and turbulence intensity in weather object. The differential Doppler velocity of raindrops carries the important information on microstructure of rain and can be used in order to measure the rain intensity. However turbulence decreases this effect and should be taken into consideration as well. Application of independent turbulence-related variables can improve the reliability and accuracy of radar measurements in rain. Measurements of weather objects by Doppler-polarimetric radar can be very useful to solve wave propagation problems for the tasks of microwave remote sensing, communications and the radar's ability to detect targets embedded in high clutter background. [C658]

"Derivation of Soil Surface Roughness Dynamics from Multi-temporal and Multi-parametric Air-borne PolSAR-data"

The dynamics of soil surface roughness is important to a number of land surface processes. The potential of multi-temporal and multi-parametric PolSAR-data for soil surface roughness estimation is investigated to determine its temporal development. The study is based on weekly quadpol L-Band E-SAR backscatter data, which was collected over the agri-phenological cycle in the course of the AgriSAR 2006 campaign. For ground truthing, the soil surface roughness was measured using photogrammetric imaging techniques. Two ground truth roughness inidces (rms-height s, tortuosity index TB) and three polarimetric roughness estimators (anisotropy A, circular polarization coherence gammaRRLLand the real part of the circular polarization coherence Re[RRLL]) were compared. While most of the comparison outlined weak correlations, best and sufficient results were obtained between s and Re[RRLL]. Multi-temporal roughness maps were derived from this relationship, which are further affected by the presence and development of particular plants. [C659]

"Anti-Full Polarization Active Jamming"

For anti-full polarization active jamming, a new polarization signal processing technology is proposed in this paper. The single polarization active jamming can be identified by polarimetric radar, but the full polarization active jamming is effective to deceive polarimetric radar. Therefore, the new detection technology is necessary to be adopted against full polarization active jamming. The purpose of the paper is to present a new method for anti-full polarization active jamming. The polarization coding technology, as a new method used in polarimetric radar, is proposed and a new polarization demodulation method by included angle of polarization state between transmitter signal and echo signal on the Poincare polarization sphere is given in the paper. [C660]

"Polarimetric Monopulse Radar Intelligent Emulator"

For debugging polarimetric monopulse radar and testing polarization algorithms, a new polarimetric monopulse radar intelligent emulator is proposed and designed in this paper. The polarization information, as a basic character of the target echo, plays an important role in modern radar detection nowadays. The polarization algorithms are developed with rapid speed. It is not realistic to test all algorithms on real radar in research stage. Therefore, the polarimetric radar emulator is required. The functions of radar emulator are as follows: recording the valuable experiment data for researching, playing the experiment data as a radar receiver for radar signal processor debugging, running some polarization programs with real experiment data to test the programs. In the paper, the polarimetric monopulse radar intelligent emulator is introduced in detail. Firstly, the index of emulator is given; secondly, the emulator is divided into 3 modules to be introduced; thirdly, the system architecture and key techniques are analyzed; finally, the performance of emulator is given. [C661]

"Polarization Diversity for Detecting Targets in Heavy Inhomogeneous Clutter"

Polarization diversity has proved to be a useful tool for radar detection, especially when discrimination by Doppler effect is not possible. In this paper, we address the problem of improving the performance of polarimetric detectors for targets in heavy inhomogeneous clutter. First, we develop a polarimetric detection test that is robust to inhomogeneous clutter. We run this polarimetric test against synthetic and real data to assess its performance in comparison with existing polarimetric detectors. Then, we propose a polarimetric waveform-design algorithm to further improve the target-detection performance. A numerical analysis is presented to demonstrate the potential performance improvement that can be achieved with this algorithm. [C662]

"Anti-Millimeter Wave Polarization Agile Active Jamming"

For anti-millimeter wave polarization agile active jamming, interpulse polarization coding technique, as a new polarization signal processing method, is proposed in this paper. The active jamming, as an effective technique to interfere traditional radar, is popular used nowadays. It often works with a single polarization antenna, so it can be identified by polarimetric radar. But a millimeter wave polarization agile active jamming is effective to deceit millimeter wave polarimetric radar. Therefore, a new recognition technique is necessary to be researched for anti-millimeter wave polarization agile active jamming. The purpose of the paper is to present an effective method for countermeasure to millimeter wave polarization agile active jamming. The interpulse polarization coding technology, as a new method using in millimeter wave polarimetric radar, is proposed and a new polarization demodulation method is given in the paper. The results of simulation prove the new method is effective to suppress millimeter wave polarization agile active jamming. [C663]

"Millimeter Wave Polarimetric Monopulse Radar Debugging System"

For testing millimeter wave polarimetric monopulse radar and testing algorithms for polarimetric radar, millimeter wave polarimetric monopulse radar debugging system is proposed in this paper. Polarimetric radar, as a kind of radar with strong counter-countermeasure capability, is more and more popular used nowadays. The cost of polarimetric radar is more expensive than traditional single-polarimetric radar. Millimeter wave polarimetric monopulse radar debugging system is a kind of assistant instrument. With it, the research cost and period both can be reduced. In the paper, the millimeter wave polarimetric monopulse radar debugging system is introduced in detail. Firstly, the conception of millimeter wave polarimetric monopulse radar debugging system is given; secondly, according to different functions, the debugging system is divided into three modules to be introduced; thirdly, the system key techniques and the performance are given. [C664]

"Polarimetric Scattering Properties of Chaff Clouds for Non-coherent Radars"

Non-coherent radar backscattering from chaff clouds is studied, employing a polarimetric radar cross section. Two orthogonally polarimetric scattering cross sections are derived. Both mathematical analysis and measurements show that the depolarization phenomenon is remarkable in radar echo of chaff clouds. [C665]

"Complex Wishart Distribution Based Analysis of Polarimetric Synthetic Aperture Radar Data"

Multi-look, polarimetric synthetic aperture radar (SAR) data are often worked with in the so-called covariance matrix representation. For each pixel this representation gives a 3 times 3 Hermitian, positive definite matrix which follows a complex Wishart distribution. Based on this distribution a test statistic for equality of two such matrices and an associated asymptotic probability for obtaining a smaller value of the test statistic are given and applied to change detection, edge detection and segmentation in polarimetric SAR data. In a case study EMISAR L-band data from 17 April 1998 and 20 May 1998 covering agricultural fields near Foulum, Denmark, are used. Soon the Japanese ALOS, the German TerraSAR-X and the Canadian RADARSAT-2 will acquire space-borne, polarimetric data making analysis based on these methods important. [C666]

"Cross-Polarization Radar Integrated Debugging Platform"

For debugging cross-polarization radar and testing polarization algorithms, new cross-polarization radar integrated debugging platform is proposed in this paper. The polarimetric signal processing are developed with rapid speed nowadays, but cost of polarimetric radar is so expensive that most programs and algorithms can't be tested by real radar usually. Last but not least, most radar experiments are one-off, but these are not enough for research. For resolve these problems, a kind of multifunctional integrated device is required. In the paper, the cross-polarization radar integrated debugging platform is designed in detail. Firstly, the index of integrated debugging platform is given; secondly, the debugging platform is divided into 3 modules to be analyzed; thirdly, the key techniques are analyzed; finally, the performance of platform is tested. [C667]

"Masonry investigation through Very Large Bandwidth CW-SF radar"

In this paper, a number of experimental tests aimed to evaluate the potential of Very Large Bandwidth Continuous Wave Step Frequency (CW-SF) radar for investigating masonry structures, are reported. Furthermore, an innovative polarimetric technique able to detect the double-bounce signal due to corner inside a masonry is proposed and tested. [C668]

"Data fusion of multiple polarimetric SAR images based on combined curvelet and wavelet transform"

Data fusion is a very effective technique which can be applied to many remote sensing areas such as battle awareness, monitoring of environmental surveillance and man-made target detection. In this paper, we test fusion of multiple polarization (HH, HV, VH and W) SAR images, which is performed using multiscale image fusion technique based on combined curvelet and wavelet transform. Curvelet transform provides a flexible multiresolution, anisotropy and directional expansion for SAR images. Compared with wavelets, it can afford more efficient presentation of image edges. The fusion approach exploits the advantages of both curvelet and wavelet in multiscale domain. The example result of four polarimetric SAR image fusion show that the proposed method has a good performance. [C669]

"Compact PolInSAR for vegetation characterisation"

In this paper, we analyse the potential associated with a compact polarimetry (CP) P band spaceborne SAR system. Indeed, this architecture allows polarimetric acquisition without the usual reduction in swath. The CP data is shown to be almost equivalent to the full polarimetric data over extended targets, and the PolInSAR analysis can be performed without a significant loss of performance. [C670]

"Potential of forest height estimation using X band by means of two different inversion scenarios"

Polarimetric SAR interferometry (Pol-InSAR) is a powerful remote sensing method for forest height estimation by using the random volume over ground model (RVoG). At higher frequencies implementation of forest height estimation in X band is limited to less dense and low forest types where X band is able to penetrate through the volume to the ground. However, the penetration depth at X band is insufficient to cover all forest types. In the paper, forest height inversion at X band using two different approaches is demonstrated with focus on the impact of extinction on forest height estimation. [C671]

"Multibaseline POL-InSAR analysis of urban scenes for 3D modeling and physical feature retrieval at L-band"

This paper generalizes a multibaseline interferometric SAR signal model taking polarization diversity into account. Based on this formulation, two high-performance spectral analysis techniques are extended to the multibaseline POL-InSAR configuration. These new algorithms enhance the height estimation of scatterers by calculating optimal polarization combinations and allow to determine their physical characteristics. Applying the methods to urban scenes, experimental results show the retrieval of building height and polarimetric properties by means of single-baseline polarimetric datasets. Dual-baseline observations permit the solution of the layover problem by separating two contributions within one resolution cell. The algorithms are tested using multibaseline Pol-InSAR data acquired by DLR's E-SAR system over Dresden city. [C672]

"Vertical profile reconstruction with Pol-InSAR data of a subpolar glacier"

The last decade has seen an increasing demand for accurate mapping and wide-coverage monitoring of glaciers and ice sheets in order to measure and predict their response to global climate change and their contribution to sea level rise. This in turn requires a more complete understanding of their properties including topography, accumulation rates and vertical profiles. One promising new technique for vertical profile reconstruction using polarimetric interferometric SAR (Pol-InSAR) data is polarization coherence tomography (PCT) and for the first time, PCT is adapted here to a glacier scenario. The inversion algorithm to reconstruct vertical ice profiles is applied to both simulated data to assess its accuracy and sensitivity to input parameters, and to airborne Pol-InSAR data at L- and P-band and InSAR data at X-band collected using DLR's E-SAR system over the Austfonna ice cap in Svalbard, Norway. [C673]

"Volume and double-bounce decorrelation effects in the OVoG model for Single-Tx PolInSAR"

The formulation of the complex interferometric coherence for the oriented volume over ground model (OVoG) has been recently proposed for the case of dominant double-bounce mechanism from the ground when the interferometer is operated in single-transmit (bistatic) mode. This paper analyzes the two contributions to the total coherence function: the volume and the double-bounce terms. The study is performed by observing the model predictions of the coherence loci for several agricultural crop scenarios and with system parameters corresponding to the TanDEM-X mission. For low vegetation depths (up to 1 m) neither of the two contributions is negligible when the ground-to- volume ratio is low. However, when the backscattering returns from ground and vegetation are similar, i.e. ground-to-volume ratios around 0 dB, the volume decorrelation terms does not affect the coherence so much. As predicted by theory, higher vegetation layers yield an increase of the influence of the volume term and more differences between polarimetric channels. [C674]

"POLINSAR for FOPEN using flashlight mode images along circular trajectories"

The airborne radar system RAMSES collected data over the Sweden forest to investigate the capabilities of detection at P-band and influences of different SAR parameters like resolution, central frequencies, and look angle. During this campaign, circular trajectories have been performed in order to analyze the presence of anisotropic scattering from the targets at P-band. We show the treatment of two circular trajectories using the Flashlight imaging mode and its ability to collect several SAR data with different look angles. The scope of this paper includes a general description of the operating mode of flashlight SAR images in the interferometric mode and the use of it for FOPEN purpose. The capabilities of detection of such polarimetric images have already been investigated, but without using the interferometric mode [1]. It had been shown that using circular trajectories at P-band was necessary to detect targets: first in our configuration detection was very difficult because the forest was very dense, secondly the targets were very sensitive to the orientation angle of the radar, which should not be the case at lower frequencies. Moreover, polarimetry and polarimetric interferometry are useful tools once the acquisition conditions ensure that detection is possible. Now, the full polarimetric and interferometric information are used in order to explore the potential of the POLINSAR circular mode to yield high detection rate. [C675]

"Wavelet polarimetric SAR signature analysis of sea oil spills and look-alike features"

Marine dark features in SAR imagery related to oil spills, biogenic look-alikes and low wind areas are analyzed by means of the wavelet polarimetric signature (WASP) tool. The WASP encapsulates in a graph the dependency of the wavelet variance on dyadic scale and polarization state. Experiments on SIR-C/X-SAR C-band data showed the effectiveness of this analysis in characterizing textural features of the areas of study. [C676]

"Polarimetric microwave emission from snow surfaces: 4th Stokes component analysis"

The effect of ice on polarimetric 4thStokes component observations is investigated using WindSat data over Antarctica. The difference in the magnitude of the signal observed during (July 2003) and summer (February 2004) months are investigated using a second harmonic sine function of the azimuth look angle. The seasonal variations are further investigated by a time series of the 4,th Stokes component for a location in Wilkes Land in east Antarctica and compared with a time series observed by the ERS scatterometer (ESCAT) from a previous work. The paper discusses the potential of a polarimetric radiometer in providing information about scattering and thermal properties of a snow ice pack. [C677]

"Disaster monitoring and environmental alert in Taiwan by repeat-pass spaceborne SAR"

The prevailing complex geological and ecological conditions of Taiwan have drawn considerable attention from various geo-ecological communities because of their vulnerability to produce various natural hazards at different scales. Located in the tropical/subtropical zone of the Pacific Rim, its ecological and rugged mountainous properties are environmentally sensitive making monitoring and observations especially difficult because of the high population density. For example, in terms of natural hazard mitigation tectonically active regions are used for analyzing the cause of abundant risk events, such as earthquakes, landslides and land subsidence. In fact Taiwan is well suited as a test site for studying those geologically disastrous processes. Implementing novel techniques of space remote sensing has proved to be an effective means in recent years for greatly improving our understanding of these phenomena. In this paper we report on the monitoring of such events using multi-modal polarimetric and/or interferometric SAR images at C and L band from ERS, JERS-1, RADARSAT-1, ENVISAT, and from the recent ALOS satellite. For crustal and surface deformation, we used radar image pairs with long temporal baselines and large areas of coverage for investigating deformation over Western Taiwan. Pre-seismic and co-seismic deformation patterns are spatial-temporally analyzed. The other topic deals with the coastline changes observed from a sequence of ERS-1/2 SAR images within the years of 1996 to 2005. Waterlines were extracted using multi-scale procedures of edge detection and were corrected with tidal motion data. Substantial analyses were carried out in conjunction with ground surveys and lidar mapping. The topographic feature changes due to large scale landslides triggered by torrential rains were also monitored. In addition, the SAR interferograms were used to analyze the deposition changes along the riverbeds and riverbanks for short-intervals using optimal baselines. Su--mmary and remarks on the implementation of such multi-modal polarimetric and/or interferometric SAR imagery for environmental monitoring are provided. [C678]

"Classification of stricken residential houses by the mid niigata prefecture earthquake based on POLSAR image analysis"

This report attempts to apply a hybrid classification technique based on POLSAR image analysis to detect the man- made residential houses in a local mountainous area stricken by the Mid Niigata Prefecture Earthquake.

The present hybrid scheme includes the scattered power decomposition method based on physical scattering nature and the scattering feature extraction method using polarimetric correlation coefficient. From the results of the image analysis for actual POLSAR data, it is verified that the present hybrid scheme provides us accurate classification of the man-made targets even in the severe mountainous [C679]

"High resolution millimeterwave SAR for the remote sensing of wave patterns"

High resolution imaging of the ocean swell was performed using data collected with the polarimetric millimetre wave synthetic aperture radar MEMPHIS. The data, representative for a region off the south Spanish Atlantic coast in spring, have been evaluated using imaging and non-imaging statistical methods. The influence of high resolution processing on the clutter statistics for the Ka- and the W-band is discussed. [C680]

"High resolution SAR imaging along circular trajectories"

After a first series of full circle SAR acquisitions in L and P-bands during a 2004 joint FOI-ONERA campaign in Sweden, ONERA experimented in 2006 high resolution (15 cm) polarimetric, full circle acquisitions in France and Germany using its X-band sensor. In order to cope with narrower antenna pattern and aircraft attitude fluctuations, a steerable antenna was used. Furthermore, an experimental setup for retrieving high accuracy trajectory was installed. This paper describes the processing of this signals. [C681]

"The effect of polarization ratio on RADARSAT wind vector retrievals"

In this presentation, the polarization ratios were calculated from AIRSAR polarimetric SAR data and ENVISAT ASAR dual-polarization data; and their empirical CC parameters which depend on incidence angle were obtained. Five C band HH polarization RADARSAT-1 SAR images are used to validate these polarization ratios and we found that the empirical parameter alpha = 0.5 is superior to other possible parameter alpha values. [C682]

"Ship detection with the fuzzy c-mean clustering algorithm using fully polarimetric SAR"

A fuzzy c-mean clustering algorithm to detect ships is proposed using fully polarimetric SAR data. The algorithm is unsupervised. It does not need the statistical decision and the performance is not data specific, as often arises with CFAR methods. A distance measure, based on a complex Wishart distribution, is applied using the fuzzy c-means clustering algorithm. The algorithm makes use the statistical properties of polarimetric data, and takes advantage of a clustering algorithm. It is thus expected that the algorithm could include fully polarimetric backscattering information for ship detection. Its effectiveness is demonstrated by applying it to detect the targets in a set of AIRS AR data. [C683]

"Evaluation of the interaction between SAR L-band signal and structural parameters of forest cover"

The objective of this paper is to evaluate the interaction between backscatter (sigmadeg) from polarimetric L-band SAR data (collected by the airborne sensor R99-B/SIPAM) and biophysical parameters of the primary forest and secondary succession sites. The area under study is located in the region of Tapajos (Brazil), where SAR data were collected in May 2005. Another approach under investigation is the evaluation of the contribution from basic backscatter mechanisms, using the Freeman-Durden decomposition technique, applied to complex SAR images, where the physiognomic-structural characteristics of the forest stands give a significant contribution. In brief, it was possible to verify that the variable "tree height" has better relations with the backscatter values, when compared to other biophysical variables, especially when the model also includes variations of the incidence angle of the stripes imaged. The decomposition technique showed that the volumetric scattering component has the strongest influence on the SAR response at primary and secondary tropical forests. [C684]

"Robust forest height extraction using polarimetric SAR interferometry"

Recently, many researches have demonstrated that polarimetric SAR interferometry is the most promising technique for forest parameter extraction. In this paper, we present a robust forest height extraction technique based on reliable phase estimation. The more accurate interferometric phase estimation can be attained with the reliable ground phase and canopy phase using three-stage inversion process and ESPRIT technique, respectively. We show the validity of the method by applying it to L-band simulated polarimetric and interferometric SAR data. The experimental results are also provided to give the availability of this method. [C685]

"Polarimetric Calibration Experiment of ALOS PALSAR with Polarization-Selective Dihedrals"

Polarization-selective dihedrals are developed for poalrimtric calibration of the PALSAR. The PALSAR is the first spaceborne polarimetric SAR boarded on the ALOS satellite launched in January 2006. This paper presents calibration experiments of PALSAR with the dihedrals in the ALOS initial calibration and validation phase. The reflectors are deployed in open fields of Tomakomai forest, to be imaged by not only the PALSAR but also the airborne polarimetric SAR, Pi-SAR. [C686]

"Two-dimensional synthetic aperture radiometry over land surface during soil moisture experiment in 2003 (SMEX03)"

Microwave radiometry at low frequencies (L-band, ~ 1.4 GHz) has been known as an optimal solution for remote- sensing of soil moisture. However, the antenna size required to achieve an appropriate resolution from space has limited the development of spaceborne L-band radiometers. This problem can be addressed by interferometric technology called aperture synthesis. The Soil Moisture and Ocean Salinity (SMOS) mission will apply this technique to monitor global-scale surface parameters in the near future. The first airborne experiment using an aircraft prototype of this approach, the Two-Dimensional Synthetic Aperture Radiometer (2D-STAR), was performed in the Soil Moisture Experiment in 2003 (SMEX03). The L-band brightness temperature data acquired in Alabama by the ID- STAR was compared with ground-based measurements of soil moisture and with C-band data collected by the Polarimetric Scanning Radiometer (PSR). Our results demonstrate a good response of the 2D-STAR brightness temperature to changes in surface wetness, both in agricultural and forest lands. The behavior of the horizontally polarized brightness temperature data with increasing view-angle over the forest area was noticeably different than over bare soil. The results from the comparison of 2D-STAR and PSR indicate a better response of the 2D-STAR to the surface wetness under both wet and dry conditions. Our results have important implications for the performance of the future SMOS mission. [C687]

"Ku-band, polarimetric, combined, short pulse scatterometer-radiometer system for stationary fixed platform, vessel and airborne applications"

In this paper a Ku-band (~15 GHz), dual polarization, combined scatterometer-radiometer system is described. The system allows carry out polarimetric (vv, vh, hh, hv), simultaneous and coincident microwave active-passive measurements of the observed surface (soil, vegetation, snow and water surface) parameters. The originality of the developed system is in the spatial-temporal combination of microwave active and passive channels of observation and its possible application for short distance sensing (the minimum operational range for the scatterometer is ~6 m) from low altitude platforms under far field conditions for both radar and radiometric observations. [C688]

"Ortho-rectification and terrain correction of polarimetric SAR data applied in the ALOS/Palsar context"

Methods for terrain correction of polarimetric SAR data were studied and developed. Ortho-rectification resampling and amplitude correction utilized Stokes matrix data. The Stokes matrix of thermal noise was subtracted before amplitude normalization. Application of an azimuth-slope correction algorithm resulted in slightly narrower distribution of orientation angles compared to input data. [C689]

"New polarimetric calibration proposal and its evaluation using ALOS PALSAR calibration campaign measurements"

We propose new polarimetric calibration algorithms using two reference targets: a polarization-preserving reflector and a polarization rotating one. In this method, iteration procedure is adopted for accuracy improvement in deriving transfer matrices of radar transmitting and receiving antennas, FR(Faraday rotation) matrix and actual scattering matrix of observed target. Availability of this method was evaluated by measured results obtained in calibration campaign of PALSAR(phased array type L-band synthetic aperture radar) boarded on ALOS(advanced land observing satellite). It is proved that the proposed method can derive each matrix component separately. [C690]

"Emissivities of rough surface over layered media in microwave remote sensing of snow"

The rough surfaces in Greenland are exhibited as sastrugi. The roughness heights are less than 8 cm for much of the year except in late winter and spring, when they increase to 25 cm or less. Roughness profiles were also related to snow and firn ventilation. WindSat, launched in January 2003, was the first spaceborne polarimetric radiometer to measure all 4 elements of Stokes vector, viz., the vertical polarized brightness temperatures, the

horizontal polarized brightness temperatures, and the real and imaginary part of the cross-correlations of the vertical and horizontal polarizations. It was shown by Tsang (1984, 1990) that azimuthal asymmetry will create nonzero third and fourth Stokes parameter in passive microwave remote sensing. Thus the third and fourth Stokes parameters contain information of the azimuthal structure. Usually the third and fourth Stokes parameters are quite small between 0.5 K to 1 K over land and less than plusmn2.5 K over ocean. However, measurements of third and Stokes parameters over Greenland show surprising values of 10 K for the third Stokes parameter and between -10 K and 20 K for the fourth Stokes parameter. In this paper, we use physically based electromagnetic model to study the passive polarimetric remote sensing of snow in Greenland by consider the scattering and emission from a random rough surface over multi-layered media. We consider the random rough surface varied in only one horizontal direction so that azimuthal asymmetry exists in the 3-D problem. Dyadic Green's functions of multilayered medium (Tsang et al., 2000) is used to formulate the surface integral equation so that the polarization dependence of emission and scattering is accounted for systematically. The surface integral equations are solved by using the method of moments in conjunction with fast numerical algorithms such as the multilevel UV method. Numerical results of brightness temperatures are illustrated for all four Stokes parameters to demonstrate the si- gnatures of sastrugi in passive microwave remote sensing. To account for the large third and fourth Stokes parameters, we also consider the case of anisotropic scatterers in volume scattering. Full multiple volume scattering are studied with numerical solutions of the radiative transfer equations for non-spherical scatterers with preferred orientation. [C691]

"Airborne Ku-band radar remote sensing of terrestrial snow cover"

Preliminary analyses of the POLSCAT data acquired from the CLPX-II in winter 2006-2007 are described in this paper. The data showed the response of the Ku-band radar echoes to snowpack changes for various types of background vegetation. We observed about 0.4 dB increase in backscatter for every 1 cm SWE accumulation for sage brush and agricultural fields. The data also showed the impact of surface hoar growth and freeze/thaw cycles, which created large snow grain sizes and ice lenses, respectively, and consequently increased the radar signals by a few dBs. [C692]

"The SARALPS-2007 measurement campaign on Xand Ku-Band Backscatter of snow"

The retrieval of snow parameters, and snow water equivalent in particular, are key parameters in hydrology and climate research. Theory, ground-based signature research and analysis of spaceborne scatterometry suggests that the high- frequency combination of Ku- and X-band active microwave sensors is an excellent tool for the retrieval of snow physical properties. In order to validate this, a snow measurement campaign was carried out with the University of Cranfield's portable Ground-Based Synthetic Aperture Radar (GB-SAR) System during the winter of 2006/7 at two test-sites in the Austrian Alps close to Innsbruck. Fully polarimetric X-and Ku-band backscatter signatures were acquired over a range of incidence angles (~20deg-70deg), with the active sensor operating predominately in SAR mode, but occasionally also in InSAR mode. Microwave signatures and snow properties were measured on seven different dates. Detailed complementary meteorological and snow metamorphic conditions were also recorded. [C693]

"ALOS PALSAR Calibration and Validation Results from Sweden"

In 2006 calibration activities for ALOS PALSAR were conducted in Sweden. Four five-metre trihedral corner reflectors and three smaller dihedral reflectors were deployed and operated during eight months. 23 PALSAR scenes were acquired over the calibration site allowing an evaluation of the quality and temporal stability of the data. Results show that the co-polarized data have been stable during the whole calibration period with variations in the trihedral responses lower than 0.7 dB. The measured resolution in azimuth was 4.4 m and in slant range 4.7 m for single polarization images and 9.5 m for polarimetric data. For the cross-polarized data large variations in the dihedral responses were found. It is assumed that this is caused by a larger sensitivity to pointing errors. For the polarimetric data, estimation of Faraday rotation gave values ranging from 0.1deg to 3deg. [C694]

"Transpolarizing surfaces for polarimetric SAR systems calibration"

A novel transpolarizing or crosspolarizing surface has been proposed to be applied in polarimetric SAR calibrating systems, like trihedrals, since they can not provide initially a crosspolar response. So the trans- surface has been designed and measured in an anechoic chamber, providing good results for normal incidence. [C695]

"Empirical SWE retrieval using airborne microwave and in situ snow measurements"

We examine the response of microwave brightness temperatures to snow water equivalent over a wide range of

snowpack conditions observed during the Cold Land Processes Experiment (CLPX) in 2002 and 2003. Spatially intensive measurements of snow were collected over the CLPX study areas within the Colorado Rocky Mountains. The NOAA Earth System Research Laboratory's Polarimetric Scanning Radiometer (PSR) was operated to obtain coincident high-resolution (150-500 m) multiband microwave imagery of the snowpack. Together, a robust data set of over 2300 collocated in situ and remotely sensed observations were obtained for this analysis. For each point we modeled brightness temperatures using observed snow properties and the Helsinki University of Technology (HUT) snow emission model. Using observed and modeled data, we developed multiple regression algorithms to retrieve snow water equivalent (SWE). The algorithms use brightness temperature differences between 10.7, 18.7, and 21.5 GHz with 37 GHz and 89 GHz. Results show that the CLPX microwave data are consistent with a) historically established data and, b) after removal of cases with macro vegetation or possible wet snow, with theoretically derived curves for microwave dependence on SWE. [C696]

"Polarimetric feature fusion in GPR for landmine detection"

A polarimetric multi-feature framework for the detection of antipersonnel landmines with ground penetrating radar (GPR) is suggested. The features result from independently acquired and processed GPR measurements in co- and cross-polar configurations. The initial detection in the confidence maps is made independently after which the coordinates of the detected targets are co-located. The marginal feature distributions are normalized via Johnson's transform prior to the fusion process and a Maximum Likelihood based linear-quadratic classifier is used as a fusion rule. The framework makes use of secondary data acquired from an open test site to train the classifier. The framework performance is illustrated on the data acquired over a specifically designed test- site. [C697]

"Polarimetric phase gradient autofocus"

In the past decade the use of fully polarimetric SAR (polSAR) systems has increased significantly due to their effectiveness in target classification and detection applications. While polSAR imagery has been extensively used to distinguish between different scattering mechanisms in a scene, there has been a lack of research in the exploitation of polarimetry to assist in image formation and in particular autofocus for fine resolution SAR. In this paper an extension of the phase gradient algorithm (PGA) for polSAR imaging is proposed and its effectiveness is tested on simulated and real data. [C698]

"Automatic extraction of power transmission tower series from PolSAR imagery based on MRF model"

This paper describes a three-step algorithm for automatic extraction of power transmission tower series in full polarimetric SAR imagery. Firstly, the method uses a polarimetric whitening filter to combine the information in different polarimetric channels and reduces the speckle. Then the point-like targets are detected by an adaptive region classification CFAR detection approach, among which only a few are the potential power transmission towers. Finally, a graph linked the potential point targets is constructed and a Markov random field is defined on the constructed graph, the extraction result is obtained through an energy minimization process. The experimental result verifies the effectiveness of this algorithm. [C699]

"Experimental reaserch of unsupervised Cameron/ML Classification method for fully polarimetric SAR Data"

Fully PolSAR data provided by the NASA/JPL laboratory are widely used to classify PolSAR image. In this paper, an unsupervised Cameron/ML approach is proposed to classify airborne fully polarimetric data collected by a research institute in China. Cameron's method is used to initially classify the PolSAR image firstly. Secondly the initial classification map defines training sets for the maximum likelihood (ML) classifier. The classified results are then used to define training sets for the next iteration. The advantages of this method are the automated classification, and the interpretation of each class based on scattering mechanism. Formula of Cameron classification for the very measured data is also obtained here. The experiment demonstrates the proposed approach dramatically improves the classification result compared with the Cameron method. [C700]

"Analysis of fully polarimetric SAR data based on the Cloude-Pottier decomposition and the complex Wishart classifier"

An estimation of the number of clusters is proposed for fully polarimetric SAR data analysis, and a corresponding unsupervised segmentation algorithm is also given based on the Cloude-Pottier decomposition and the complex Wishart clustering. The Monte-Carlo Cross-Validation (MCCV) is used to estimate the optimal

number of clusters to reveal the inner structure of the data. Since it is a quantitative estimation of the classification performance, the MCCV algorithm also has the potential capability to perform the unsupervised segmentation validation. The effectiveness of the MCCV estimation and the segmentation algorithm is demonstrated using ESAR data acquired. [C701]

"Evaluation and bias removal of multi-look effect on entropy/alpha/anisotropy"

Entropy, alpha and anisotropy (H/alpha/A) of the polarimetric target decomposition has been an effective and popular tool for polarimetric SAR image analysis and geophysical parameter estimation. However, multi-look processing can severely affects the values of these parameters. In this paper, we evaluate the bias problem in H/alpha/A due to insufficient averaging. We found that the estimated bias is radar frequency dependent. A procedure for bias compensation is proposed. Data from L-band DLR/E-SAR and L-band JPL/AIRSAR, and X-band PI-SAR data are used for demonstration in this study. [C702]

"Analysis of non-Gaussian POLSAR data"

In this paper we present a generalised Wishart classifier derived from a non-Gaussian model for polarimetric synthetic aperture radar (POLSAR) data. Our starting point is to demonstrate that the scale mixture of Gaussian (SMoG) distribution model is suitable for modelling POLSAR data. We show that the distribution of the sample covariance matrix for the SMoG model is given as a generalisation of the Wishart distribution, and present this expression in integral form. We then derive the closed form solution for one particular SMoG distribution, known as the multivariate K-distribution. Based on this new distribution, termed the K-Wishart distribution, we propose a Bayesian classification scheme, which can be used in both supervised and unsupervised mode. Modelling and classification is tested on airborne EMISAR data. [C703]

"Classification comparisons between dual-pol and quad-pol SAR imagery"

We present a study of the polarimetric information content of dual-pol imaging modes, e.g. (HH, HV) and (VV, VH), and compare these against full quad-pol datasets. We discuss classification accuracies for various dual-pol datasets over several terrain/vegetation types with respect to the full quad-pol classification. The linear polarization modes implemented on space borne SAR systems are of primary importance. However, we also consider novel dual-pol modes, e.g. transmitting a circular polarization and receiving both H and V polarizations, and the so-call compact polarimetry models based on dual-pol data. Our primary emphasis is the inter-comparisons amongst the various dual-pol and compact polarimetric modes. [C704]

"Two methods for enhancing the coherence in PolInSAR data processing"

Two methods for enhancing the coherence are reviewed in this paper. The first one is based on similarity parameter and the second one on a mathematical optimization model. Both methods can be used to fuse the polarimetric information and enhance the coherence effectively. This is helpful for the processing of interferometric data. The equivalence of these two methods is proved. A physical analysis is given to explain this equivalence. The experiment is used to verify the performance of both methods. [C705]

"An analysis of coherence optimization methods in PolInSAR"

The combination of SAR polarimetry and SAR interferometry introduced many new research and application fields. The major parameter which is computed from observable of polarimetric interferometric SAR (PolInSAR) is the complex coherence. But coherences are easily influenced by many factors, like temporal or spatial baseline, or noise. In this paper, we probe into the several optimization algorithms of the PolInSAR, and they can be classified (E.C.W. Tabbara, 2006) to the two-mechanism (2MC) optimization and the single-mechanism coherence optimization (IMC) respectively, and these representative methods of coherence optimization are compared and their advantages and disadvantages are assessed and outlined. The comparison is carried out with SIR-C/X-SAR data over the Tienshan area of China. [C706]

"Algorithm of target classification based on target decomposition and support vector machine"

Since Huynen's original work, there have been many other proposed target decomposition theorems. In this paper, we provide a review of the different approaches used for target decomposition theory in radar polarimetry and classify three main types of theorems: those based on Mueller matrix, those using an eigenvector analysis of the coherency matrix, and those employing coherent decomposition of the scattering matrix. Support vector machine (SVM), as a novel approach in pattern recognition, has demonstrated a success in many fields. Here we first extract scattering mechanisms of radar targets by target decomposition and color composite. Then we propose a new algorithm of target classification by combining target decomposition and support vector machine.

We conduct the experiment on the polarimetric synthetic aperture radar data. Experimental results show that: it is feasible and efficient to target classification by designing SVM classifiers using target decomposition, and the effects of kernel functions and its parameters on the classification efficiency are significant. [C707]

"Parameter inversion models based on PolInSAR images"

Polarimetric SAR Interferometry (PolInSAR) can be used for parameter inversion of ground. An appropriate model is of most importance for parameters inversion. This paper derives a series of random scattering model that can be used for parameter inversion of forestry area, such as RV, RVoG, OV and OVoG. These models can reveal the characteristics of forestry area as well as establish the relationship between observed data and parameters of test area. Finally, these scattering models are compared. [C708]

"Iterative classification of polarimetric SAR image based on the freeman decomposition and scattering entropy"

In this paper, a new scheme for iterative classification of polarimetric SAR image based on the Freeman decomposition and scattering entropy is proposed. This technique extracts three decomposition coefficients of three scattering mechanism components through the Freeman decomposition and the scattering entropy through the H/Alpha decomposition first; then classifies the polarimetric SAR image into nine initial classes using the four parameters, and obtains the final result by iterative classification with Wishart classifier. This method, utilizing polarimetric scattering information of terrain, can acquire good effect of classification and requires less computation. The effectiveness of this method is demonstrated by the experimental results of polarimetric SAR data acquired practically. [C709]

"The boosting algorithm with application to polarimetric SAR image classification"

The boosting algorithm is a powerful tool to combine a set of classifiers for improving classification performance. There are two issues to be considered for classification in polarimetric SAR image analysis: (1) how to choose the measurement with discriminability on various categories with different scattering characteristics; (2) how to combine the classifier sets with minimum loss of performance. For solving both the problems, the authors propose a supervised classification method. Firstly, the result of the optimization of polarimetric contrast enhancement (OPCE) is employed as the distance measurement. Then the measurement is translated to a confidence rate, which describes the decision of a "weak" classifier on a refined scale. These classifiers are generated and combined to a powerful classifier under the boosting framework. This proposed method takes advantages of both the specific characteristics of polarimetric SAR image and of the powerful machine learning algorithm. Using polarimetric SAR image, the authors demonstrate the effectiveness of the proposed method. [C710]

"Man-made target discrimination based on scattering mechanism identification and spectral correlation property analysis of POLSAR images"

In this paper, a novel discrimination method is proposed to automatically discriminate man-made targets in diverse natural clutter environments of polarimetric synthetic aperture radar (POLSAR) images .The novel method, which makes fully use of the difference between man-made target and natural clutter on scattering mechanism type and spectral correlation property, permits to obtain a clear and credible target discrimination effect .The validity of our novel method is verified by fully polarimetric L-band POLSAR data acquired by DLR 's airborne E-SAR system. [C711]

"Unsupervised classification of polarimetric SAR Image by Quad-tree Segment and SVM"

This paper presents a new method for unsupervised terrain classification using fully polarimetric synthetic aperture radar image based on quad-tree segment and support vector machine techniques. This unsupervised classification method begins with quad-tree segment technique that ensures each segment contains the data of only one cluster. Then, the feature vectors are constructed by sampling those segments using polarimetric covariance matrix. Then, the feature vectors of the samples of every segment are selected to create training sets based on the number of support vector, which is obtained by support vector machine technique. Finally, the fully polarimetric SAR data is classified using the support vector machine trained by those training sets, and the classification results are analyzed in detail. According to the classification results, it is shown that the method presented in this paper have sound classification accuracy and flexibility. [C712]

"Review of existing monographs and books on radar polarimetry and polariemtric SAR with the aim of justifying the need of updates"

Radar Polarimetry, Radar Interferometry and Polarimetric SAR Interferometry represent the current culmination in active 'Microwave Remote Sensing' technology, but we still need to progress considerably more in order to reach the limits of physical realizability. Whereas with radar polarimetry the textural fine-structure, target orientation, symmetries and material constituents can be recovered with considerable improvement above that of standard 'amplitude-only radar', by implementing 'radar interferometry' the spatial (in depth) structure can be explored. With Polarimetric Interferometric Synthetic Aperture Radar (POL-IN-SAR) imaging, it is possible to recover such co-registered textural and spatial information from POL-IN-SAR digital image data sets simultaneously, including the extraction of Digital Elevation Maps (DEM) from either Polarimetric (scattering matrix) or Interferometric (dual antenna) SAR systems. However, in order to further advance this promising technology, we require pertinent basic educational and advanced research texts plus application oriented books for the practicing engineering scientists and users. Hitherto there are not available satisfactory updated sets of basic books or application oriented handbooks. Therefore, in this paper a succinct review of the existing pertinent monographs, books and guides will be presented with the aim of identifying particular topics that still need to be covered. We do now require these urgently associated sets of revised and updated multi-lingual (English, Japanese, Korean, Chinese) books. [C713]

"Pol-dinSAR: polarimetric SAR differential interferometry using coherent scatterers"

We investigate the impact of polarimetry and polarimetric effects on the Differential Interferometry (DinSAR) technique for the coherent backscattering reciprocal case, with the aim to obtain better accuracy and to extract additional information about the scatterer. Emphasis is given to the effects of Faraday and scatterer line-of-sight (LOS) rotations, and to the determination of the intrinsic scatterer scattering mechanism. [C714]

"Polarimetric temporal information for urban deformation map retrieval"

In this work, a preliminary study on the use of polarimetric persistent scatterers for differential interferometric applications within an urban environmental is presented. The PolSAR measurements campaign that the RSLab of UPC is carrying on in the village of Salient using an X-Band ground- based SAR sensor is first described. The work is then focused on the additional information the knowledge of full scattering matrix [S] may provide with respect to the single polarization approach. The problem of instability of the polarimetric signature of urban targets is also analyzed. Finally, a solution based on the search of repeated patterns in the long-temporal profile of pixels' polarimetric signature is briefly introduced. [C715]

"Sub-band interferometry on polarimetric SAR dataset"

Complex SAR image spectral analysis has been shown to provide interesting information about the scattering media, highlighting differences in behavior between homogeneous areas with a fully-developed speckle and point scatterers potentially presenting a more coherent radar spectral response. In the line of previously published works by other groups dealing with coherent scatterers, we have studied the statistics of their occurrence as a function of several parameters like frequency, resolution or polarization. The first step of our procedure consists in selecting two or more sub-bands in the Doppler spectrum (in the azimuth direction) or in the distance direction. The sub-bands are subsequently frequency-shifted in order to provide a nonzero correlation. The resulting inter sub-band interferograms are explored to identify the points presenting a significant coherence and the relevance of the associated phase is investigated. The number of detected coherent scatterers, and the associated complex correlation coefficient is analyzed, with respect to the different polarizations, the width of the sub-bands and the distance between the sub-bands. Different polarimetric high resolution SAR datasets acquired with the ONERA airborne system RAMSES have been used. The large panel of RAMSES acquired datasets allows the exploration of the influence of frequency (P, L and X bands) and landscape. The theoretical approach will be detailed, and experimental results will be discussed. [C716]

"Monitoring temperate glaciers by high resolution Pol-InSAR data: First analysis of Argentиre E-SAR acquisitions and in-situ measurements"

This paper highlights the potential to measure temperate glacier velocities and surface characteristics by airborne interferometric and polarimetric SAR remote sensing. Indeed, a novel SAR airborne campaign took place in October 2006 over two Alpine glaciers. Simultaneously to the acquisition of repeat pass interferometric, polarimetric and multi-band data, in-situ measurements were carried out to provide useful information for the SAR synthesis, for backscattering analysis and for performance assessment. Analysis of the experimental data as well as early PolInSAR processing results regarding information extraction are presented. [C717]

"Targets detection and analysis in coastal area using Polarimetric SAR images"

Polarimetric SAR (PolSAR) is sensitive to orientation and characteristics of object thus may yield several new descriptive radar target detection parameters and leads to improvement of radar detection algorithms. Ship detection is one of the most important tasks of the seaport surveillance. In this paper, some methods, such as polarimetric target decomposition, time-frequency analysis, and radon transform, are proposed to detect and analyze moving targets using PolSAR image. We generate a validity test using multi-look X-band PolSAR image acquired by PiSAR in coastal Area. Both moving target and stationary target are included in the images. Results show the potential capability of proposed methods for moving target detection and analysis. [C718]

"A novel segmentation method for fully polarimetric SAR images"

Several frequently used feature vectors and segmentation methods are investigated, and a novel method is proposed for segmenting fully polarimetric SAR images by starting from the statistical characteristic and the interaction between adjacent pixels. In order to use fully the statistical a priori knowledge of the data and the spatial relation of neighboring pixels, Wishart distribution is integrated with Markov random field (MRF), and then an iterative conditional modes (ICM) algorithm is used to implement a maximum a posteriori (MAP) estimation of pixel labels. Although ICM has good robustness and fast convergence rate, it is affected easily by initial conditions, so a Wishart-based ML is used to obtain the initial segmentation map, with the statistical a priori knowledge also exploited completely in the initial segmentation step. Using fully polarimetric SAR data, acquired by the NASA/JPL AIRSAR sensor, the new approach is compared with several frequently used methods. Better segmentation performance, as well as better connectivity, less isolated pixels and small regions, are observed. [C719]

"A Novel Unsupervised Iteration Classification Method For Fully Polarimetric SAR Image"

Based on the theory of eigen-decomposition of fully polarimetric synthetic aperture radar (SAR) and scatter criterion clustering method, an unsupervised iteration classification method is proposed. It is simple, flexible and with high precision. Several schemes of the iteration classification method are given in this paper. The characteristic of each scheme is carefully analyzed according to the properties of eigen-decomposition and scatter criterion, and each scheme holds its own merit. Experiments are done on SIR-C/X-SAR data near Tien Mountains and perfect classification results are obtained. More importantly, this method is robust and has high adaptability. [C720]

"Polarimetric Analysis of Radar Signature of a Manmade Structure"

Identification of manmade structures from radar images has always been a difficult task, especially for single-polarization radar. Fully polarimetric radar, however, can provide detailed information on scattering mechanisms that could enable the target or the structure to be identified. Complexity remains stemming from overlaps of single bounce scattering, double bounce scattering and triple and higher order bounce scattering from various components of manmade structure that makes physical interpretation a challenge. In this paper, we will present an interesting example using polarimetric SAR data of the Great Belt Bridge, Denmark, to illustrate the capability of polarimetric SAR in analyzing radar signatures. Polarimetric target decomposition is used to differentiate the multiple bounce scattering contributions contained in the polarimetric SAR images. Two C-band Danish EMISAR data takes, the first obtained during the bridge's construction and the second after its completion, are used to extract the scattering characteristics of the bridge deck, bridge cables and supporting structures. [C721]

"A New Approach for Ship Detection in SAR Imagery Based on Convolution between Different Polarization Channels"

A new approach is proposed for ship detection with SAR (Synthetics Aperture Radar) images based on the convolution between different polarimetric channels. The method takes advantages of different statistical behaviors among ships and surrounding ocean, interpreting the information through the convolution in order to provide a more reliable detection. The simulations show that the convolution is sensitive to the size and shape of ships not to sea state. The method can be used under high sea state and have no relation to the movement of ships. Moreover, the method is general which is not only suitable for dual polarization data but also for full polarization data. The detection performance over both simulated and real images confirms the robustness of the method. [C722]

"Polarimetric Radar Pulse Echoes from Lunar Regolith Layer with Scatter Inhomogeneity and Rough Interfaces"

To explore the potential utilities of lower frequency (L band) radar pulse for lunar exploration, a theoretical model of stratified lunar regolith media and numerical simulation of polarimetric radar pulse echoes are developed. The

lunar regolith layer consists of the low lossy regolith layer with randomly rough top and bottom interfaces, and a layer of random stone-scatterers (spatially oriented oblate spheroids are assumed) is embedded and overlays the underlying rock media. The time domain Mueller matrix solution is derived to take account for scattering mechanisms of the stratified scatter media. Temporal characteristics and structure of the polarimetric echo profile as functional dependence on model parameters such as the layer thickness and the content of FeO+TiO2, are numerically simulated, and well display an image of regolith structures. It demonstrates a potential new way to explore moon surface in future. [C723]

"Interferometric Phase Estimation in Polarimetric SAR Interferometry"

Polarimetric synthetic aperture radar (SAR) interferometry has been developed for the estimation of accurate terrain elevation and vegetation parameter. One of the important process steps is to estimate the interferometric phases of effective scattering centers which located in different height positions and represented different scattering mechanisms. The interferometric phases can be acquired by the fully polarimetric SAR scattering decomposition. The coherence optimization algorithm and the ESPRIT algorithm are analyzed for the interferometric phase decomposition. SIR-C/X-SAR L-band fully polarimetric data are used to estimate interferometric phase, experimental results verify the validity of the methods [C724]

"A New Approach for DEM Generation Based on Polarimetric SAR Interferometry"

In this paper, the polarimetric information is used to register the interferometric images and enhance the interferometric phase. The similarity parameter is employed to register the images. This approach is more robust than the traditional method. The combination of the best phase among three polarimetric channels can be used to improve the phase quality and reduce the residues. Then a new phase filter based on the weighted median filter is proposed. This filter is used to reduce the residues sufficiently and make phase unwrapping easily. Finally, a multi-path method is introduced to unwrap the phase [C725]

"An Improved Coherence Optimization Method in Polarimetric SAR Interferometry"

Because the important approximation in the optimization algorithm with one projection vector proposed by Colin is not proper in general cases, it is only applicable to process the special data with no temporal decorreladon. To avoid the shortage, an improved approach, which relies on iterative estimation to find higher coherence, is presented in this paper. In order to find higher coherence with same polarization states, the new method takes the results obtained by original one projection vector algorithm as initial estimate. Then it makes use of refreshed two parametric variables to yield new estimation until the coherence can not be improved any more. Finally, the improved method and the original one are applied to L band SIR-C data to demonstrate the better performance [C726]

"Bistatic Synthetic Aperture Radar Simulation for Forests including Border Effects"

A coherent model for simulating interaction of electromagnetic waves with forests in a bistatic configuration has been developed. It allows simulation of interferometric and fully polarimetric data. Forests considered include finite size ones. We focus here on border effects. Some simulations of imaging in L band are shown. Border effects are illustrated in monostatic and bistatic geometry [C727]

"A New Algorithm of Target Classification Based on Maximum and Minimum Polarizations"

The polarization signature of a given pixel in a radar image represents scattering mechanisms from various scattering elements. This paper presents an analysis of maximum and minimum polarizations of five kinds of polarization signatures: co-polarized, cross-polarized, completely polarized, completely unpolarized, and total available power signatures. We propose a new algorithm of target classification based on these maximum and minimum polarizations, then, conduct the experiment on the measured polarimetric SAR data. Experimental results show that this algorithm is robust to pixel-by-pixel target classification in radar images [C728]

"Fast Implementation of H / α-Wishart Classification to Polarimetric SAR Images"

A method of fast implementation of H/α-Wishart iterative classification is proposed in this paper. The fast method not only convergence stability, but also need less computing. The application to AIRSAR image of San Francisco shows the method's effectiveness [C729]

"Instantaneous Radar Polarimetry with Multiple Dually-polarized Antennas"

Fully polarimetric radar systems are capable of simultaneously transmitting and receiving in two orthogonal

polarizations. Instantaneous radar polarimetry exploits both polarization modes of a dually-polarized radar transmitter and receiver on a pulse by pulse basis, and can improve the radar detection performance and suppress range sidelobes . In this paper, we extend the use of instantaneous radar polarimetry for radar systems with multiple dually-polarized transmit and receive antennas. Alamouti signal processing is used to coordinate transmission of Golay pairs of phase codes waveforms across polarizations and multiple antennas. The integration of multi- antenna signal processing with instantaneous radar polarimetry can further improve the detection performance, at a computational cost comparable to single channel matched filtering. [C730]

"A Time Series Approach for Soil Moisture Estimation"

Soil moisture is a key parameter in understanding the global water cycle and in predicting natural hazards. Polarimetric radar measurements have been used for estimating soil moisture of bare surfaces. In order to estimate soil moisture accurately, the surface roughness effect must be compensated properly. In addition, these algorithms will not produce accurate results for vegetated surfaces. It is difficult to retrieve soil moisture of a vegetated surface since the radar backscattering cross section is sensitive to the vegetation structure and environmental conditions such as the ground slope. Therefore, it is necessary to develop a method to estimate the effect of the surface roughness and vegetation reliably. One way to remove the roughness effect and the vegetation contamination is to take advantage of the temporal variation of soil moisture. In order to understand the global hydrologic cycle, it is desirable to measure soil moisture with one- to two-days revisit. Using these frequent measurements, a time series approach can be implemented to improve the soil moisture retrieval accuracy. [C731]

"Polarimetric Analysis of Radar Signature of a Manmade Structure"

First Page of the Article [C732]

"Monte Carlo Evaluation of Multi-Look Effect on Entropy/Alpha /Anisotropy Parameters of Polarimetric Target Decomposition"

Entropy, alpha and anisotropy (H/alpha/A) of the polarimetric target decomposition of Cloude and Pettier has been an effective and popular tool for polarimetric SAR image analysis and geophysical parameter estimation. However, multi-look processing can severely affect the values of these parameters. In this paper, a Monte Carlo method is used to evaluate the multi- look effect on these parameters for various media of grass, forest and urban. The effect of pixel correlation due to over sampling, and the mixed pixel effects will also be investigated. DLR/E-SAR and JPL/AIRSAR L-band data are used in this study. [C733]

"The Role of C-band Dual Polarization Radars for GPM Ground Validation"

Dual polarization weather radars have brought in significant advancement to precipitation observation, as rainfall rate estimation, microphysical characterization, and hydrometeor classification. The improvements have been mostly demonstrated at S-band frequency where attenuation effects are usually negligible. In Europe C-band is largely adopted in operational and research radars because of larger differential phase measurements, reduced antenna size and an overall lower cost with respect to that of S-band systems. The major disadvantage is that the signal attenuation is not negligible. In the context of GPM Ground Validation, techniques to compensate the reflectivity measurements for propagation effects are thus necessary to obtain GV products from ground-based C-band radars. The attenuation correction methodology using differential phase shift as constraint has shown a good performance. One of the advantages of polarimetric radar measurements is their self-consistency. Starting from the initial guess of attenuation correction provided by the rain profiling algorithm, self-consistency is used in an iterative technique to improve the accuracy of attenuation correction at C-band. The obtained accuracy is evaluated in terms of bias and standard error using C-band profiles generated from S-band dual polarization observations. [C734]

"Recent Advances in Polarimetry and Polarimetric Interferometry"

Radar polarimetry radar Interferometry and polarimetric SAR interferometry represent the current culmination in 'microwave remote sensing' technology, but we still need to progress very considerably in order to reach the limits of physical realizability. Whereas with radar polarimetry the textural fine-structure, target orientation, symmetries and material constituents can be recovered with considerable improvement above that of standard 'amplitude-only' radar; by implementing 'radar interferometry' the spatial (in depth) structure can be explored. With polarimetric interferometric synthetic aperture radar (POL-IN-SAR) imaging, it is possible to recover such co-registered textural and spatial information from POL-IN-SAR digital image data sets simultaneously, including the extraction of digital elevation maps (DEM) from either polarimetric (scattering matrix) or interferometric (dual antenna) SAR systems. Simultaneous polarimetric-plus-interferometric SAR imaging offers the additional benefit

of obtaining co-registered textural-plus-spatial three-dimensional POL-IN-DEM information, which when applied to repeat-pass image-overlay interferometry provides differential background validation and environmental stress-change information with highly improved accuracy. Then, by either designing multiple dual polarization antenna POL-IN-SAR systems or by applying advanced POL-IN-SAR image compression techniques, will result in 'POL-arimetric TOMO-graphic' (multi-interferometric) SAR or POL-TOMO-SAR imaging. By advancing these EWB-D-POL-IN/TOMO-SAR imaging modes, we are slowly but steadily approaching the ultimate goal of eventually realizing airborne and spaceborne 'geo-environmental background validation, stress assessment, and stress-change monitoring and wide-area military surveillance of the terrestrial and planetary covers'. [C735]

"Polarimetric Temporal Decorrelation Studies by Means of GBSAR Sensor Data"

In this paper, a study of the temporal evolution of the elements of 3 x 3 covariance matrix using an X-band polarimetric ground-based SAR sensor is proposed. Although the heterogeneity of the scenario allows to select different target typologies, the study is mainly focused on the analysis of azimuthally symmetric distributed targets. The fluctuations of the most representative elements of [C] as a function of time and the decorrelation among the polarimetric channels are investigated. A relation with atmospheric parameters like temperature, humidity and wind is considered in order to make out the weight these parameters can influence the polarimetric signature of the observed area. [C736]

"A New Polarimetric CFAR Ship Detection System"

The objective of the proposed work is to develop optimal polarimetric Constant False Alarm Rate (CFAR) detector for ship detection. Polarimetric transformations and decompositions, clutter analysis, modeling, Principal Component Analysis (PCA), and multi-CFAR detection are the necessary components of optimal polarimetric CFAR ship detectors. The resulting CFAR detector outperforms the conventional polarimetric CFAR detector by providing higher probability of detection. Optimal polarimetric CFAR detection procedures are proposed in this report. Given the simulated polarimetric RADARSAT-2 data, different polarimetric transformations and decompositions are applied. The resulting images will be transmitted to an adaptive Principal Component Analysis (PCA) block. Through the adaptive PCA block, the image of the first principal component which has the highest SNR among all the images (including the original, transformed/decomposed images, and the images after the adaptive PCA) will be used for ship detection. Optimal multi-CFAR detection will be applied to this image and then the final decision will be made. [C737]

"Study of the Influence of Vessel Motions and Sea-Ship Interaction on Classification Algorithms Based on Single-Pass Polarimetric SAR Interferometry"

This paper analyzes the worsening effects the sea surface can induce on vessel classification algorithms working with SAR imagery. Two issues will be tackled, the complex motion history of ships and the polarimetric scattering mechanisms generated by the sea-hull interaction. Both can modify the information that allows to infer the geometry of ships dropping the classification capability. The current analysis will introduce a new classification approach based on polarimetric SAR interferometry that presents a low sensitivity respect the main distortions caused by the sea surface. Simulated SAR images obtained from GRECOSAR, a SAR simulator of complex targets, will show trustworthy vessel classification almost independent on the environmental conditions could be possible for incoming system configurations as Tandem TerraSAR-X. [C738]

"Polarimetric Characteristics of Radar Echoes from the Sea Surface as a Function of Incidence Angle"

This paper presents some initial results of polarimetric radar measurements made over a range of look-down angles using the DSTO high resolution multi-band radar. Specifically, X-band polarimetric measurements of the sea were made from 95 m high cliffs along the Great Australian Bight, for look-down angles of 3deg, 4deg, 5deg, 10deg, 15deg, 20deg, 25deg and 30deg. The analysis is addressing scattering matrix element statistics, entropy-alpha space distributions and correlation with visible spectrum imagery. [C739]

"Structural Parameter Estimation of Australian Flora with a Ground-based Polarimetric Radar Interferometer"

The application of polarimetric SAR interferometry technology is extended to ground based radar imaging (GB-POLInSAR), which has a limited field of view but provides wide band coverage. It also provides for easier deployment of broadband and multi-baseline techniques, from which we can estimate vegetation structure and extinction propagation using model based techniques. This micro-scale multi-parameter combination with good temporal resolution is a unique feature of ground- based sensors. In this paper we present both polarimetric and

interferometric coherence calibration results for such a GB-POLInSAR system we have developed at the University of Adelaide. We then show an initial study of height estimation of Australian native plants based on the coherence parameter retrieval models of the polarimetric SAR interferometry technique using the broadband GB-POLInSAR system. [C740]

"The UAVSAR phased array aperture"

The development of a microstrip patch antenna array for an L-band repeat-pass interferometric synthetic aperture radar (InSAR) is discussed in this paper. The instrument will be flown on an unmanned aerial vehicle (UAV) and will provide accurate topographic maps for Earth science by 2007. The antenna operates at a center frequency of 1.2575 GHz and with a bandwidth of 80 MHz, consistent with a number of radar instruments that JPL has previously flown. The antenna is designed to radiate orthogonal linear polarizations for fully-polarimetric measurements. Beam-pointing requirements for repeat-pass SAR interferometry necessitate electronic scanning in azimuth over a range of plusmn20degrees in order to compensate for aircraft yaw. Beam-steering is accomplished by transmit/receive (T/R) modules and a beamforming network implemented in a stripline circuit board. This paper focuses on the electromagnetic design of the antenna tiles and associated interconnects. An important aspect of the design of this antenna is that it has an amplitude taper of 10dB in the elevation direction. This is to reduce multipath reflections from the wing that would otherwise be detrimental to interferometric radar measurements. The amplitude taper is provided by coupling networks in the interconnect circuits as opposed to using attenuators in the T/R modules. Details are given of material choices and fabrication techniques that meet the demanding environmental conditions that the antenna must operate in. Predicted array performance is reported in terms of co-polarized and cross-polarized far-field antenna patterns, and also in terms of active reflection coefficient. Measured performance of a 4-element by 2-element antenna tile is presented [C741]

"Multi-Sensor Microwave Soil Moisture Remote Sensing: NASA's Combined Radar/Radiometer (ComRAD) System"

This paper describes the development of a ground-based radar/radiometer system called ComRAD. The system under development is an outgrowth of a network analyzer-based L, C, and X band polarimetric radar system developed jointly by NASA/GSFC and the George Washington University. The system is mounted on a 19-m hydraulic boom truck and has provided reliable calibrated radar data in soil moisture field campaigns across the United States since the early 1990's. The truck instrument system is now being upgraded with the addition of a dual polarized 1.4 GHz total power radiometer. The new system includes a temperature monitoring and control system to keep the radiometer at a constant temperature. All front-end components have been placed on an aluminium plate whose temperature stability has been achieved by using Peltier cells. Periodic switching to the internal noise sources is used to reduce the influence of gain variations in the output voltage. A novel broadband stacked-patch dual-polarized feed resonates at both the 1.4 GHz radiometer and 1.25 GHz radar frequencies, enabling both the radar and the radiometer to share the same 1.22-m parabolic dish antenna. Having the radar and radiometer utilize the same antenna with the same 12deg field of view greatly simplifies the development of active/passive microwave retrieval algorithms. With these new capabilities, ComRAD will be an important tool in examining Earth science research topics such as the synergistic effects between active/passive microwave sensors for soil moisture estimation in the presence of vegetation [C742]

"UAVSAR: a new NASA airborne SAR system for science and technology research"

NASA's Jet Propulsion Laboratory is currently building a reconfigurable, polarimetric L-band synthetic aperture radar (SAR), specifically designed to acquire airborne repeat track SAR data for differential interferometric measurements. Differential interferometry can provide key deformation measurements, important for studies of earthquakes, volcanoes and other dynamically changing phenomena. Using precision real-time GPS and a sensor controlled flight management system, the system will be able to fly predefined paths with great precision. The expected performance of the flight control system will constrain the flight path to be within a 10 m diameter tube about the desired flight track. The radar will be designed to be operable on a UAV (unpiloted aerial vehicle) but will initially be demonstrated on a on a NASA Gulfstream III. The radar will be fully polarimetric, with a range bandwidth of 80 MHz (2 m range resolution), and will support a 16 km range swath. The antenna will be electronically steered along track to assure that the antenna beam can be directed independently, regardless of the wind direction and speed. Other features supported by the antenna include elevation monopulse and pulse-to-pulse re-steering capabilities that will enable some novel modes of operation. The system will nominally operate at 45,000 ft (13800 m). The program began as an Instrument Incubator Project (IIP) funded by NASA Earth Science and Technology Office (ESTO). [C743]

"Scale Mixture of Gaussians Modelling of Polarimetric SAR Data"

This paper discusses a multivariate, non-Gaussian parametric modelling technique to analyse polarimetric SAR data. We investigate a simple class of multivariate non-Gaussian distributions, the 'scale mixture of Gaussians', and assess its "Goodness-of-fit" to the radar data. Four models are analysed and various characteristics of the models are interpreted, together with practical considerations with regard to parameter estimation. We observe that SAR data is often not Gaussian in distribution, being more highly peaked at zero and falling off more slowly than the Gaussian. It is shown that a single 'flexible' model is sufficient to capture the statistics of the SAR data, leading to a feature set of the modelled parameters. Image classification is then studied by means of the modelled data and compared with an existing land cover map [C744]

"Amplitude-phase method allowing the determination of the complex dielectric permittivity of underlying surfaces using polarimetric radar remote sensing"

An amplitude-phase method is proposed allowing the determination of the complex dielectric permittivity of underlying surfaces based on the results of relative measurements of the signals in the orthogonal channels of a polarimetric radar receiver. The method assumes the determination of the voltage ratio and the phase difference in the orthogonal channels [C745]

"A Low-Cost Shaped-Beam Hybrid-Feed Microstrip Planar Array Antenna for X-Band Polarimetric Radar Systems"

A novel dual-polarized microstrip patch array with a low-loss hybrid feed network suitable for X-band polarimetric airport surveillance radars (ASRs) is presented. A waveguide is used to excite a number of linear subarrays consisting of aperture-coupled microstrip cross-patch elements connected in series. The microstrip radiating part implements the dual polarization capability with low cross polarization, while the very reduced transmission line runs implied in the series-type feeding keeps ohmic and dielectric losses at a minimum. As a further major advantage of this antenna, the radiation pattern can be independently shaped in the two principal planes. In particular, the microstrip subarray is designed to produce a cosecant-squared pattern, whereas the waveguide provides a Taylor-like illumination distribution to have low side lobes in the longitudinal plane. As a result, the proposed array antenna is expected to stand out for high efficiency, polarization purity, simplicity of fabrication, light weight and compactness [C746]

"Performance Study of Quantized Linear Frequency Modulated signals and its application to CW radars"

Direct digital synthesizers (DDS) are frequently used to generate wideband CW-FM signals in precise high resolution radars. With respect to a perfect linear FM signal, the stepped version produced by DDS can produce undesirable artifacts after range compression. However selecting carefully the configuration parameters of DDS (clock frequency, number of steps, step size, etc.) it is possible to obtain a virtually free of artifacts operation if the compressed signal does not show noticeable degradation with respect to ideal operation. From a theoretical study a simple design guidelines are proposed for the DDS parameters selection. This study has been validated by simulations and experimentally. An experimental CW-FM full polarimetric interferometric ground-based SAR using a DDS as a chirp generator has been developed according to the design guidelines in the TSC labs. The empirical results and system impulsional response are in agreement with this study [C747]

"Study of dispersive and anisotropic scatterers behavior in radar imaging using time-frequency analysis and polarimetric coherent decomposition"

A fully polarimetric time-frequency analysis is proposed for radar imaging (SAR, ISAR) to analyse the anisotropic and dispersive behavior of deterministic target illuminated by a radar sensor. This method is based on the hyperimage concept which describes the response of scatterers as a function of the observation angle, of the emitted frequency and of the polarimetric decomposition. New polarimetric hyperimages point out a non-stationary behavior which can be interpreted by the physics parameters of the target (geometrical shape, relative orientation). They allow a best understanding of the scattering mechanisms. Basic statistics extracted from these representations show that they are tools to detect non-stationary scatterers and are the first step to a new classification. [C748]

"A versatile bistatic & polarimetric marine radar simulator"

We present a versatile simulator for marine radars that can, in particular, be used in multistatic configurations. Today, most simulators modelize the sea clutter by a random noise; however, no obvious relation exists between physical parameters (e.g. wind speed or salinity) and the shape of the probabilistic law of noise. On the contrary, we modelize the whole acquisition chain: antennas and their polarization, the shape of the emitted signal, etc.

Realistic sea surfaces are generated using the two-scales model on a semi-deterministic basis, so as to be able to incorporate the presence of ship wakes. We present pseudo-raw signals obtained with our simulator. These signals can be further processed and fed to a ship detection and tracking chain. We aim at using this simulation as a tool to benchmark these algorithms and improve them by adding knowledge on the physical uncertainties and the sensor imprecisions. [C749]

"The ONERA RAMSES SAR: latest significant results and future developments"

The last SAR campaigns of the French ONERA RAMSES system have been dedicated to various applications, military or civilian, including very-high resolution, FOPEN (Foliage penetration) in cooperation with the FOI, MTI, bistatic SAR and vegetation characterization. These different projects gave us the opportunity to improve our SAR processing procedure (very high resolution) and to develop new algorithms (bistatic scenario). In parallel, the ONERA team has developed and applied many techniques (polarimetric analysis, PolInSAR, wavelet analysis) which proved to be efficient in these different thematic context. The current aircraft platform, a Transall C160 will be decommissioned at the end of 2008. In order to maintain our activities, we are developing a new system family compatible with smaller aircrafts. The challenge is two fold: migrating the existing radars in a airplane four times smaller and maintaining our innovation capabilities with the development of new radar concepts. These paper presents the most recent results on SAR techniques and describes the status of the development of the RAMSES successors: the first, SETHI, dedicated to military applications and earth observation, the second, BUSARD more focused on UAV applications. [C750]

"Classifying dielectric mine-like objects using the Huynen-Fork polarization parameters"

We present a polarimetric approach that can be used to characterize subsurface targets by means of ground-penetrating radar. Several quantities related to the Huynen-Fork parameters are basic to the study. These quantities are all expressible in terms of the elements of Sinclair matrix S, which in turn, can be determined as functions of frequency by an application of the method-of-moment (MoM). The method is applied to a mine-like object buried at various depths in a soil of specified dielectric and moisture properties. The quantities in question are the Stokes parameters, the elevation, azimuth, and polarizability angles, as well as the polarization ratios and the scattering eigenvalues which optimize the backscattered power. Some of these quantities are studied here and displayed in various graphs. These frequency dependent graphs exhibit useful symmetry properties. The plots of the polarizability angle (β) vs. frequency seem to remain invariant with target depth, and exhibit resonance features that are later shown to agree well with other standard methods to estimate resonances such as Prony method. A simple analysis of the early-time resonances thus estimated is used to obtain acceptable mine dimensions. The agreement found implies that polarimetric techniques, such as present one, can also be used in the arsenal of techniques yielding target-ID clues. [C751]

"Optimal Polarized Waveform Design for Active Target Parameter Estimation Using Electromagnetic Vector Sensors"

We develop optimal design methods of polarimetric radar signals that improve the estimation accuracy of the target parameters. A weighted sum of the Cramer-Rao bound (CRB) of the parameters of interest is used as the cost function of the optimization. We employ an array of electromagnetic vector sensors to fully recover the polarization information from the target returns. Simulation examples illustrate the improved system performance [C752]

"Design of Orthogonally Polarized Feed Horn for Polarimetric Radar Reflector Antenna"

An orthogonally polarized polarimetric radar feed horn was designed and developed. The radar feed showed 1.20 GHz bandwidth and very low port isolation at X-band frequency and acceptable radiation characteristics. A very complex elliptical aperture feed would be another design option meeting the edge illumination required for the elliptic aperture reflector. When this horn was employed as a feed source for the offset reflector, it showed acceptable radiation characteristics with the peak gain, peak cross-polarization and sidelobe levels of 36.90 dBi, -25 dB and -24 dB, respectively, for the both orthogonally polarized port excitations at 9.75 GHz. The prototype feed horn has been fabricated and was experimentally verified [C753]

"T- and X-arrangement of "dark eyes" antennas for microwave sensing array"

Ultrawideband radar imaging techniques are currently being studied as a promising tool for breast cancer detection. In this paper, we are proposing two different arrangements of the "dark eyes" antenna for sensing the cross-polarized reflections from the breast. The antenna is planar, compact and the arrangements can be used to form a cross-polarized antenna array. The use of either arrangement should be very promising for polarimetric radar-based imaging of the breast [C754]

"Polarization-Based High Resolution Radar Scatterer Classification"

We consider the use of polarization diversity for the detection, tracking and classification of scattering centers in high range resolution radar (HRR) data. Specifically, we propose a novel exploitation of polarization ratios to label moving scattering features into various geometrical classes including edges, tips or smooth reflectors. We demonstrate scattering-center labeling for both parametric and non-parametric classification algorithms. Experimental results on simulated HRR data are provided and indicate that polarimetric information can be exploited for geometrical typing of scatterers [C755]

"Identification of the Meteorological Objects on Doppler-Polarimetric Radar Data by using Fuzzy Logic Based Algorithm"

This article deals with the process of identification of dangerous meteorological objects. Zones of aircraft icing-in-flight and atmosphere turbulence are among them. Hydrometeors, such as water droplets and ice crystals, scatter incident electromagnetic waves (EMW). In common case, Doppler-polarimetric variables of backscattered electro-magnetic field depend on the velocity, shape, size, orientation, and type of the scatterers. The problem of simulation of EMW scattering on hydrometeors is rather difficult because a lot of different parameters of scatterers and conditions of sounding should be taken into account. This research does not claim to comprehensive description of all possible solutions of this problem. The key point of this paper is placed on the possibility of polarimetric weather radar to determine the type of hydrometeors in case of homogeneous medium (scatterers of one type) and in case of mixture of different types of scatterers in an ensemble of hydrometeors. The possibility to determine quantitatively the ratio of two types of hydrometeors is also a subject of consideration in this research. This item is especially important for providing flight safety by using both ground-based and airborne weather radars; it can be used particularly, for remote detection probable icing-in-flight zones to prevent icing-in-flight of modern aircrafts [C756]

"Use of Neural Network for Turbulence and Precipitation Classification Procedure"

This paper describes a methodology of precipitation and turbulence classification based on radar echo signal features measured by polarimetric radar. A neural network classifier is used to distinguish between different precipitation and turbulence classes. The classification procedure takes a decision about the type of precipitation and turbulence intensity by simultaneous feature consideration. In this paper the turbulence classification using multi-parametric decision technique is described [C757]

"Target Detection and Characterization using H/alpha Decomposition and Polarimetric Signatures"

Recently, the characterization and classification of terrain-cover using polarimetric SAR data has been extensively investigated and reported on (J.S.Lee, 1994). In this paper we re-examine the entropy-alpha approach (J.S.Lee, 1999) to radar polarimetry and show how the basic method may be augmented by the addition of the polarimetric signature parameters (F.T. Ulaby and C. Elachi, 1990), the propagation and helicity phase angles and the backscattering cross section. The method has been tested using the full polarimetric airborne data sets acquired with DLR's experiment SAR (E-SAR). The test region is the area of Oberpfaffenhofen, Germany acquired in the P-band. The results agree with the accepted understanding of radar backscatter and show that the use of the polarimetric signatures deliver complementary information to the entropy/alpha decomposition [C758]

"Improved Classification of Polarimetric SAR Data Based on Four-component Scattering Model"

In this, paper, we propose an improved classification algorithm which is based on the four-Component scattering model. Compared with the three-component model introduced by Freeman and Durden, the four-component scattering model introduces the "helix scattering" as its fourth component. Our algorithm emphasizes the existence of pixels with mixed scattering mechanism, and applies the result of decomposition as feature vector to initial merge and final iterative classifier instead of using the Wishart distance. We use L-band Pi-SAR images to demonstrate this new method. The experimental result verifies the effectiveness of this improved algorithm [C759]

"Joint Phase and Power Estimation for Polarimetric Interferometric SAR Based on TEL-ESPRIT Algorithm"

At present, among the known methods of extracting interferometric phase, some methods developed from spatial spectrum estimation and extracting interferometric phase by MUSIC or TLS-ESPRIT algorithm are being perfected. However these methods can bring on confusion of different scatter centers among interferometric

phase due to the lack of measures of mechanism's separation. By calculating the power of backscatter signals, the TEL-ESPRIT algorithm for joint estimation of interferometric phase and power of backscatter signals is proposed, TLS-ESPRIT algorithm can classify phase by power and achieve separation of scatter centers. Therefore it can improve estimate precision of vegetation height. In this paper, the new algorithm is described in detail. Using SIR-C/X-SAR L band data, its effectiveness is tested [C760]

"An Improved Cloude-Pottier Decomposition Using H/α/SPAN and Complex Wishart Classifier for Polarimetric SAR Classification"

An improvement is proposed for the Cloude-Pottier decomposition using H/α/SPAN and IHSL transform. Based on this decomposition, an unsupervised classification with SPAN is also given in this paper. The main advantages of this decomposition are that it uses SPAN to maintain the space information for further polarimetric analysis and provides a straight way to present the result. Our experiments show that this decomposition method provides better results than the general Cloude-Pottier method and the corresponding Wishart H/α/SPAN classification also achieves better performance than the current Wishart H/α/A method [C761]

"Data Quality of 3836 Polarimetric Radar and Its Observation of Melting-Layer"

The technical status of the upgraded 3836 C-band dual-linear polarimetric Doppler radar (3836 even radar) is reported first. Then this study analyses its data quality and its detection ability. A model is established in which the bright band can be identified by applying the fuzzy logic method to the four polarimetric radar observation variables. The radar data are used to assess the result from the model and the variety features of different phased hydrometeors in the melting-layer bright band are also discussed [C762]

"Combination of PolInSAR Coherence Optimization to Vector Filtering Tested on a Forested Area"

Applying a phase difference between two SLC SAR images acquired on the same area, radar interferometry is able to measure the topography or ground displacement with a good precision. Because of the noisy nature of interferograms, fully polarimetric data offers the possibility to separate scattering contributions of different natures. Polarimetric interferometry uses coherence optimization and reduces noise in interferometric phase. In this paper we propose the association of coherence optimization to interferogram filtering in order get a better result in the digital terrain model (DTM) quality. Interferometric filtering reduces the number of residues. We apply a vector filter to preserve interferometric phase statistics on polarimetric data [C763]

"Interpretation of high-resolution optical imagery with evidential fusion of spectral information and object attributes"

Since the past five years Lockheed Martin Canada is developing an advanced image interpretation system integrating classification tools and target detection operators for multispectral, hyperspectral and polarimetric SAR imagery. Improved classification maps and superior object detection and identification performances have been obtained with a pixel-driven evidential fusion of textural measurements and end-member respectively extracted from polSAR and HIS imagery. As in many applications objects to be extracted occupy several pixels in the image, the objective of current developments is to supplement the pixel-based fusion already performed with radiometric, textural, spectral features by adding specific object topological attributes (shape, size) and contextual description (spatial relationships). This paper presents a description of the new primitives and the results obtained on Ikonos imagery [C764]

"A lightweight, ultra wideband polarimetric W-band radar with high resolution for environmental applications"

A lightweight, ultra wideband (UWB), polarimetric millimetre wave 94 GHz radar with high resolution is described for environmental and other short range applications. UWB and random signal W-band radar technologies are combined with polarimetric and super-resolution processing techniques to provide a compact remote sensing capability that is man-portable. An all-weather capability is provided for accurate and high resolution measurement of the physical size, relative distance, bearing, altitude, direction, velocity and classification of stationary and moving objects at ranges of less than 10 km. Attributed information relating to the sensed environment such as local surface features, water depth, terrain topology and object classification is derived from remote millimetre wave radar measurements including polarization [C765]

"Meteorological Object Characteristic Calculation Using Doppler Spectrum Analysis with Neural Network"

In this paper, neural network usage for processing Doppler spectra from rain sounding is considered. Comparison of data calculated with the network and by ordinary methods is fulfilled. The paper describes architecture of one of the most compatible network used in radar processing. Teaching method, which gives reliable and truthful information, is considered. Perspectives of neural network usage in creation meteorological expert system are demonstrated [C766]

"Variational Unsupervised Segmentation of Multi-Look Complex Polarimetric Images using a Wishart Observation Model"

We address unsupervised variational segmentation of multi-look complex polarimetric images using a Wishart observation model via level sets. The methods consists of minimizing a functional containing an original data term derived from maximum likelihood Wishart approximation and a classical boundary length prior. The minimization is carried out efficiently by first order expansion of the data term and a new multiphase method which embeds a simple partition constraint directly in curve evolution. Results are shown on both synthetic and real images. Quantitative performance evaluation and comparisons with another method are also given [C767]

"Lossless Coding of Polarimetric SAR Images for Telebrowsing Applications"

In this paper, we address the problem of coding polarimetric multifrequency SAR images for storage applications. More precisely, a great attention is paid to telebrowsing applications which require progressive reconstruction. The contribution of the paper relies on the design of an extended version of the integer-to-integer S transform that handles floating point data. Simulations performed on SAR images indicate that a reduced data rate is obtained with the proposed method [C768]

"Similarity Parameter in Polarimetric SAR Interferometry"

The similarity parameter is used to measure the similarity between two different scattering matrixes. In this paper, the similarity parameter is introduced into polarimetric SAR Interferometry (Pol-In-SAR). For two scattering matrixes of every scattering cell, the similarity parameter can be used to register the pairs of images received by two flights and fuse the polarimetric information to enhance the coherence and reduce the phase noise. The quality of the interferometric phase is improved remarkably and the number of residues is reduced sufficiently. This is helpful in generating an accurate digital elevation model (DEM) [C769]

"nitary ESPRIT-Based Phase Estimation for Polarimetric SAR Interferometry"

At present, polarimetric SAR interferometry has been a new technology of measuring terrain parameters. Among the known methods of extracting interferometric phase, some methods developed from spatial spectrum estimation, such as MUSIC or TLS-ESPRIT algorithm, are being perfected. But using these methods we can not get higher phase precision due to few observation data with the SAR signals. An interferometric phase estimation method based on unitary ESPRIT can improve estimation precision by using the plural observation data and its conjugated data. In this paper, the algorithm is proposed and described in detail. Using SIR-C/X-SAR L band data, its effectiveness is tested [C770]

"L-band Polarimetric Interferometry in Boreal Forest Parameter Estimation, a Case Study"

In this study we concentrate on the application and validation of forest height estimation by polarimetric SAR interferometry for boreal forest. The study material was collected during the FinnSAR campaign, carried out in Finland in fall 2003. The main instruments of the campaign were E-SAR airborne radar (L- and X-band) and HUTSCAT helicopter-borne profiling scatterometer (X- and C-band). The validated forest height estimation algorithm is based on random volume over ground (RVoG) model inversion by using POLinSAR data. We compare POLinSAR-derived forest height with results from profiling HUTSCAT scatterometer measurements and with ground measurements and discuss the results. Our results show that the forest height values, estimated by means of two different instruments, are in good agreement. [C771]

"Relation between the Attenuation Coefficients and Interferometric Phase Center Heights Behaviors from P-band to L-band"

The objective of this paper is to examine the link between the attenuation coefficients and the interferometric phase center heights, for several frequencies from P-band to L-band, and to study in what extent it depends on the canopy architecture and description. This study relies on the use of a coherent and full polarimetric scattering model, which simulates the backscattered fields by a forested area. In a first part, we study the frequential behavior of the interferometric phase center heights and in the second part, we focus on the attenuation coefficients. The behaviors of these two quantities are compared and in a third part, we propose to empirically

derive a relation between these two quantities and the mean forest height. Finally, we investigate if a change of the incidence angle has an impact on the determination of this relation. [C772]

"Forest Height Estimation in Tropical Rain Forest using Pol-InSAR Techniques"

Tropical rain forest environments are highly complex and heterogeneous in terms of species composition and structure and is often difficult to access. Radar remote sensing is for large tropical regions the only available information source for monitoring. Pol-InSAR is a novel developed radar remote sensing technique sensible to the vertical structure of forest that allows the estimation and mapping of forest height. In this paper we demonstrate forest height inversion at two frequencies-L band and P band-by means of Pol-InSAR using INDREX-II data and addresses the problem of temporal decorrelation. [C773]

"Optimal Polarimetric Radar Rain Rate Estimator for Semi-arid Regions"

First Page of the Article [C774]

"Building Height Estimation using Fine Analysis of Altimetric Mixtures in Layover Areas on Polarimetric Interferometric X-band SAR Images"

First Page of the Article [C775]

"Variation of Radar Backscattering Coefficient of Tidal Mudflat Observed by Radarsat-1 SAR and Polarimetric Scatterometer"

First Page of the Article [C776]

"Polarimetric Covariance Matrix Least Squares Estimation for Weather Radar Applications"

First Page of the Article [C777]

"Spatially Variant Restoration for Polarimetric Synthetic Aperture Radar Imagery"

A. spatially variant speckle filter is proposed for multi-look polarimetric synthetic aperture radar (POLSAR) imagery. The central idea is that the filtering is applied only to homogeneous areas based on the scattering properties, while for detected edges, lines and point-like textural features, the original complex covariance matrix of these features is restored in order to preserve the actual features. The capabilities of the proposed filter were examined using nine-look NASA/JPL POLSAR C-band data. Based on the obtained results, the proposed filter showed a promising performance in speckle removal and radiometric preservation. Moreover, the point-like textural features as well as structural features (i.e. edges and lines) were well-retained in the filtered outputs. [C778]

"Comparison of PolSAR Speckle Filtering Techniques"

The objective of this paper is to compare the most widely used and the most recent speckle polarimetric synthetic aperture radar (PolSAR) filters. Two new conceptual approaches in PolSAR filtering are evaluated on simulated PolSAR images. The criteria of comparison includes indicator of speckle reduction capability, edge sharpness and preservation of scattering properties. Results indicate better performances with the partial differential equation (PDE) -based filters. [C779]

"Classification of Polarimetric SAR Data Using Spectral Graph Partitioning"

A new approach for classification of Polarimetric Synthetic Aperture Radar (POLSAR) data is proposed using segmentation that is formulated as a graph partitioning problem. This work is motivated by the fact that human experts are very good at visual interpretation and segmentation of POLSAR data, which is often challenging for automated analysis techniques. Spectral graph partitioning, a framework that has recently emerged in computer vision for solving grouping problems with perceptually plausible results, is used with modifications necessary to accommodate POLSAR data. Using the similarity of edge- aligned patch histograms and spatial proximity, classification performance that is superior to the Wishart classifier is achieved. This approach also provides a way to combine region-based and contour-based segmentation techniques, as it can accommodate different representations of polarimetric data as well as other data sources (e.g., optical imagery). [C780]

"Evaluation of Convair-580 and Simulated Radarsat-2 Polarimetric SAR for Forest Change Detection"

Radarsat-2 is a significant advancement in technological capability over Radarsat-1 in terms of better spatial resolution and polarimetric parameters. To determine the effectiveness of C-band polarimetry of Radarsat-2 data for applications of forest typing, structure recognition and disturbance detection, C-band polarimetric data from Environment Canada's Convair-580 were acquired. We also obtained simulated Radarsat-2 data, a degraded version of the Convair-580 data. Polarimetric techniques, such as polarimetric filtering and decompositions, were performed on these data sets. The underlying backscatter phenomena were examined and the results were compared. Historical fire disturbance patterns were detected clearly with the Convair-580 data by using the Entropy- alpha decomposition technique. Moreover, the combination of the surface scattering and volume scattering decompositions showed results in obtaining clearcut information in forested areas. By using the simulated Radarsat-2 data, we gained an insight into what could be expected from real Radarsat-2 quad-pol products. Even though the simulated Radarsat-2 data had more noise than Convair-580 data, the fire scars in the same area were still detectable. [C781]

"The Results of Spatio-Temporally Combined, Microwave Active-Passive Measurements of Snow, Bear and Vegetated Soil at 37GHz"

In this paper preliminary results of simultaneous and spatially coincident, polarimetric measurements of snow, bear and vegetated soil microwave reflective (radar backscattering coefficient) and proper radio thermal emission (brightness temperature) characteristics at 37GHz are presented. [C782]

"Polarimetric Passive Microwave Signatures and RFI Suppression During the Soil Moisture Experiment/ Polarimetry Land Experiment in 2005"

The Soil Moisture Experiments in 2005 (SMEX05) and Polarimetry Land experiments (POLEX) were conducted jointly by the US Naval Research Laboratory, the USDA ARS Hydrology and Remote Sensing Laboratory and other cooperators in Ames, Iowa between 13 June and 3 July 2005. Leveraging upon proven methodology and existing facilities and experience from the preceding SMEX02 experiment, SMEX05/POLEX was designed to address algorithm development and validation issues related to current and future soil moisture sensor systems, including enhancement of the Aqua AMSR-E and WindSat soil moisture validation. It also encompasses three unique elements in its scientific objectives: (1) Exploration of unique polarimetric information from satellite sensors such as WindSat and CMIS for soil moisture with supporting NRL aircraft instrumentation. (2) Exploration of diurnal effects associated with soil, vegetation and atmosphere at the 6 am/6 pm observing times of WindSat, CMIS, Hydros, and SMOS. (3) Statistics and mitigation of RFI for CMIS risk reduction. In this paper, we present an overview of the experiment and some preliminary data analysis. [C783]

"Use of Disdrometer Data for X-Band Polarimetric Radar Simulation and Tropical Rain Characterization"

Natural variations in raindrop size distribution (DSD) were studied for simulated X band radar response from October 2004 to July 2005 (normal no-storm conditions) and during September 15th to 16th, 2004 when the tropical storm Jeanne passed over the island of Puerto Rico. Three types of estimators of rain rates were examined: A classical estimator R(ZH) and two polarimetric radar estimators R(KDP) and R(ZH,ZDR) . According to simulation results, the normalized errors (NEs) with respect data disdrometer of R(ZH),R(KDP) and R(ZHZDR) for all DSD samples in October 2004 to July 2005 data are 40.85%, 14.73%, and 15.83% respectively, while for the tropical storm Jeanne they are 23.39%, 9.35% and 14.53%. The results show that the estimator R(ZH) is the most sensitive to variations in DSD. Calibrated R-Z relations where developed for X-band for two conditions: storm/no-storm. Data from NASA TRMM satellite and rain gauges, the rain rate per hour was used for pinpointing areas of heaviest rain and for validation. [C784]

"Polarimetric Characteristics of X-Band SAR Sea Clutter"

First Page of the Article [C785]

"An Adaptive Polarimetric SAR Speckle Filtering Algorithm Based on Unsupervised Classification"

In this paper, a new approach is proposed for speckle reduction in full polarimetric SAR images. Being different from others, it adopts an enhanced unsupervised classification method to estimate the parameters of the speckle filter and thus an adaptive moving window is formed to better speckle reduction and preservation of texture information. . Experimental results demonstrate the effectiveness of this new filtering algorithm. Comparisons with other methods are also made. [C786]

"Target Feature Extraction in Fully Polarimetric High Range Resolution Radar"

In this paper, the authors propose a technique for polarimetric feature extraction from radar range profiles. The technique, which is based on super-resolution algorithms, proves effective when applied to simulated data via an E.M. simulator, namely the EMvironment. [C787]

"Polarimetric Analysis of Radar Signature of a Manmade Structure"

Identification of manmade structures from radar images has always been a difficult task, especially for single-polarization radar. Fully polarimetric radar, however, can provide detailed information on scattering mechanisms that could enable the target or the structure to be identified. Complexity remains stemming from overlaps of single bounce scattering, double bounce scattering and triple and higher order bounce scattering from various components of manmade structure that makes physical interpretation a challenge. In this paper, we will present an interesting example using polarimetric SAR data of the Great Belt Bridge, Denmark, to illustrate the capability of polarimetric SAR in analyzing radar signatures. Polarimetric target decomposition is used to differentiate the multiple bounce scattering contributions contained in the polarimetric SAR images. Two C-band Danish EMISAR data takes, the first obtained during the bridge's construction and the second after its completion, are used to extract the scattering characteristics of the bridge deck, bridge cables and supporting structures. [C788]

"Implementation of differential repeat-pass SAR interferometry for (i) the search for earthquake precursory land-cover deformation in Taiwan in co-ordination with the integrated Search for Taiwanese Earthquake Precursors iSTEP' Taiwanese program for promoting research excellence; and (ii) the assessment of land-cover subsidence by ground-water withdrawal and/or sea-water infusion by coastal erosion"

Worldwide, medium-to short-term earthquake prediction is becoming ever more essential for safeguarding man due to an un-abating population increase, but hitherto, there have been no verifiable methods of reliable earthquake prediction developed -except for a few isolated examples of such in China and in Greece. This dilemma is a result of previous and still current approaches to earthquake prediction which are squarely based on the seismic measurement of crustal movements, observable only after a tectonic stress-change discharge (earthquake) has occurred. The prediction models derived from past histories of measurements were mainly carried out during the past 40-50 years, although initiated soon after the San Francisco earthquake of 1906. During the past decade it was proved and shown that it is not possible to derive reliable models for earthquake predictions from crustal movement measurements alone-as valuable and as indispensable those indeed are-and that an entirely new approach must be taken and rigorously pursued over many years and decades to come, and most likely throughout this twenty-first century. Of considerable importance will be the full integration of multi-band (P-K Band) repeat-pass differential interferometric Polarimetric Synthetic Aperture Radar (POL-SAR) space borne and high-altitude platform monitoring operations which will be considered here in conjunction with "seismo-electromagnetic " ground measurements. It will be shown that Taiwan is ideally suited for studying earthquake related electromagnetic precursor studies in that the island is separated from other continental regions, and there exist the resources, the dedication and will power for advancing our knowledge most rapidly. Both land-based and sub-oceanic measurement networks already exist, which need to be upgraded and perfected. With the aid of experienced and knowledgeable experts, this will be done soon. [C789]

"A New Approach for Polarimetric Calibration"

This paper presents a new calibration approach for polarimetric SAR using distributed targets with known scattering matrixes. A genetic algorithm based on complex-valued encoding is used to solve the polarimetric calibration problem, which has multiple variables and over-determined non-linear equations. This paper also describes the genetic algorithm in detail, and validates the algorithm by simulations. [C790]

"Methods to Increase Polarization Contrast of Radar Objects"

The scope of this work is to analyze methods for increasing radar-contrast between different scattering object surfaces. Methods for radar contrast enhancement by polarization analysis of the scattered signal, i. e, radar contrast control, orthogonalization and polarization compensation methods are analyzed in this paper for deterministic and stochastic cases, and compared with conventional RCS radar analysis. The results of the analysis show that radar contrast obtained by using polarimetric methods is enhanced compared to conventional RCS analysis, and indicate that to enhance contrast it is necessary to control the receive -transmit antenna polarization according to changes in the polarization state of the transmitted and the received waves. [C791]

"Amplitude-Based Measurment Technique in Polarimetric Radar Remote Sensing for Determining

the Dielectric Permittivity of Earth Media"

A new method for measuring the complex dielectric permittivity of underlying surfaces is described. The method only uses amplitude measurements in two orthogonally polarized channels of a non-coherent polarimetric radar. [C792]

"Variational Unsupervised Classification of Polarimetric Images"

First Page of the Article [C793]

"Multifrequency Full Polarimetric SAR Classification with Multiple Sources of Statistical Evidence"

First Page of the Article [C794]

"Estimation of Built-up Area Characteristics from Polarimetric Interferometric Multiple Track L-Band SAR Data"

First Page of the Article [C795]

"Methods of Turbulence Detection by Analyzing Precipitation Behaviour"

Recent advances in the radar system design allow to perform Doppler and polarimetric measurements simultaneously. This paper considers behaviour of different Doppler-Polarimetric parameters, such as slope of differential reflectivity, differential Doppler velocity, Doppler spectrum width, and mean Doppler velocity. Possibility of combining both polarimetric and pure Doppler measurements opens new horizons in turbulence and precipitation study. More and more new techniques appear every year. This paper describes some of these methods. [C796]

"A review and significance of bases used in polarimetric equations and different forms of change of basis matrices"

Precise bases are very important in presentation of polarimetric quantities. Several different kinds of bases are in use. The paper lists and defines those bases, justifies their use and presents the change of basis equations. [C797]

"Identification of the Dangerous Meteorological Objects on Doppler-Polarimetric Radar Data Using the Neural Network Based Algorithm. Part 1: Statistical Modeling"

This article deals with the process of identification of the dangerous meteorological objects using the neural network based algorithm. Dangerous objects are considered by the example of probable aircraft icing zones. In the first part of this paper theoretical models of microwave backscattering on water drops and ice crystals are considered. The results of statistical calculation on these models are used to train the network. In the second part of this research the identification algorithm will be discussed. Checking of the theoretical calculation of Doppler-polarimetric variables is done on the basis of the experimental data. [C798]

"Turbulence and Precipitation Classification based on Doppler-Polarimetric Radar Data"

This paper describes a methodology of precipitation and turbulence classification based on radar echo signal features measured by polarimetric radar. Estimation of turbulence parameters on the basis of Doppler spectrum width is used, but additionally some new polarimetric parameters and averaged velocity features are integrated into the classification procedure. After a detailed echo-signal analysis, a fuzzy logic classification procedure is applied. The classification procedure makes a decision about the type of both precipitation and turbulence intensity. [C799]

"Polar Decomposition and Polarimetric SAR Analysis: A Quaternion Approach"

We assess here the use of polar decomposition in SAR polarimetry, based on the quaternion formalism. Quaternions are helpful to obtain compact and original expressions of polar decomposition parameters, with straightforward extensions in bi-static polarimetry. Once the formalism of quaternions has been presented, both coherent and incoherent polarimetry approaches are discussed in this joint framework of polar decomposition and quaternions. Preliminary tests and comparisons with Cloude-Pottier parameters are conducted on ONERA/Ramses SAR data takes. [C800]

"Differential Reflectivity Calibration for NEXRAD"

There are now many S- and C-band weather radars around the world that are either dual polarized or soon will be. The most common polarization basis is horizontal and vertical. Dual polarization is accomplished via fast alternate transmission of horizontal and vertical polarization or simultaneous horizontal and vertical polarization transmission. In either case, such radars can measure copolar differential reflectivity (Zdr) and copolar differential phase (Phidp). It has been shown that accurate estimation of these parameters can improve identification and quantification of precipitation. To minimize rainfall estimation error, measurement uncertainty of Zdrshould be less than 0.1 dB. Three methods for Zdrcalibration are presented and operational implementation is discussed. Concepts are illustrated with data from S-Pol, NCAR's polarimetric S-band radar. [C801]

"Self-organizing Neural Networks for Unsupervised Classification of Polarimetric SAR Data on Complex Landscapes"

This paper refers to a study on the pixel-by-pixel unsupervised classification of a polarimetric SAR image of a Central Italy landscape. The polarimetric data have been processed by self-organizing neural networks to test their performance in classifying a complex landscape. The discrimination accuracy attained by the self-organizing map method is compared both against that of H/A/alpha-Wishart unsupervised procedure and of a supervised scheme. [C802]

"Multi-temporal High-resolution Polarimetric L-band SAR Observation of a Wine-producing Landscape"

In continuation of the BACCHUS project, aimed at establishing a reference high quality geographic information system for vineyards, an airborne SAR survey has been carried out in fall 2005 in the Frascati area, near Rome (Italy) to demonstrate the potential of airborne radar remote sensing in vineyard characterization. This contribution reports on the polarimetric L-band and dual polarization C-band SAR data acquisition campaign supported by ESA and carried out on two dates in October 2005 (the first during the grape harvest and the other after the vintage completion). [C803]

"Characterization of Rain Microphysics based on Disdrometer and Polarimetric Radar Observations"

Characterization of rain microphysics requires information on raindrop size distributions (DSDs). DSD measurements and retrievals, however, contain errors. In this paper, data from side-by-side disdrometer comparisons are presented to provide information that is not possible from single disdrometer measurements alone, allowing error effects to be quantified and a rain DSD model for radar retrieval to be improved. We also propose methods to mitigate sampling errors by filtering with sorting and averaging and by fitting to a Gamma DSD model with truncation and extrapolation. The Constrained- Gamma DSD model has thus been refined for the Southern Great Plains region of the United States. [C804]

"Automated Content Extraction from SAR Data"

Segmentation algorithms are often used in many image processing applications like compression, restoration, content extraction, and classification. In particular as for content extraction works carried out in the past decade have demonstrated that multi-frequency fully polarimetric SAR observations are particularly interesting, thanks to physical properties of the backscattered signal at various frequencies and polarizations. To achieve a good classification, the main difficulty is that SAR images are often embedded in heavy speckle. Segmentation of multi/hyperspectral (optical) imagery is obtained by means of algorithms based on image models, which exploit the spatial dependencies of land-covers. Unfortunately, speckle noise hides such spatial dependencies in observed SAR data. With the aim of investigating on a content extraction algorithm capable of discriminating cover classes present in the observed SAR image, heterogeneity features are used here to emphasize spatial dependencies in the data. Thus, observed pixel values are mapped into features, that take "similar" values on "similar" textures. This allows for using the same procedure of the optical case. Obviously, homogeneity/heterogeneity feature and segmentation quality are fundamental for classification accuracy. Here, the problem is tackled through the joint use of information theoretic SAR features and of a segmentation algorithm based on Markov Random Fields (MRFs). [C805]

"Automatic Change Detections from SAR Images Using Fractal Dimension"

It is very difficult to detect changes from SAR images because of two major difficulties associated with SAR, which are the removal of speckle noise and the registration of information between images. Speckle is a chaotic phenomenon because that the scattering signals within a resolution cell are summed up coherently. Therefore,

SAR signal can be modeled by a spatial chaotic system and characterized by its fractal dimension. Then, simplified procedures for SAR image change detection are proposed because that the process of image despeckling is unnecessary. The proposed approach is applied to multitemporal polarimetric SAR images for change detections. The experimental results of using a simple image difference (DI) technique, the principal component analysis (PCA), and the proposed (Fractal) approach are compared. The effects of misregistration for different approaches are also presented. Simulation results reveal that misregistration affects less and less as SNR is increased. When SNR is low, by using DI or PCA methods, the overall performance of change detection is degraded by spurious differences due to misregistration. On the contrary, Fractal method can tolerate misregistration effect at low SNR. In addition, when the difference between changed classes is small, it is fail to detect changes by using of either DI or PCA method. In contrast, the Fractal method can still effectively detect land cover changes. [C806]

"A Complex of Multi-Frequency at 3GHz, 5.6GHz, 20GHz and 37GHz, Polarimetric, Combined, Short Pulse, Short Range Action Radar- Radiometers for Soil and Snow Remote Sensing and Surveillance"

A complex of polarimetric (dual polarization), spatio- temporally combined active-passive devices of S (~3GHz), C (~5.6GHz), Ku (~0GHz), and Ka (~37GHz) band of frequencies is represented, for bare and vegetated soils, waved water surface and land snow cover microwave reflective and emissive characteristics multi-frequency, polarimetric, simultaneous and spatially coincident measurements. The complex is dedicated to solve problems applied to soil (bear and vegetated) and snow moistures retrieval, to near water surface wind and wave field parameters retrieval, by synergetic application of various kind microwave means of remote sensing, as well as applied to surface and sub-surface targets detection and identification tasks solution. The complex is set in ECOSERV Remote Observation Centre's control-test experimental site, in Armenia, which is equipped by facilities for microwave devices absolute calibration, by spatially distributed stations for in-situ measurements of soil and moistures and temperatures, and has a local meaning small weather station. This paper has an aim to attract attention of researchers who are interested in such kind measurements and to invite them to perform their own or joint measurements using available facilities. [C807]

"Calibration of Spaceborne Polarimetric SAR Data using Polarization Orientation"

For ALOS/PALSAR in orbit, removal of not only polarimetric system distortion but also the effect of Faraday rotation is important. The author investigated a new calibration method using polarization orientation induced in build-up areas. Its fundamental concept is simple and is that two polarization orientation angles from two polarization combinations should be identical after calibration. This method is applied to simulated data that is distorted from JAXA L-band Pi-SAR data. An advantage of this method is that strong backscatters from buildup areas can be used to decrease an influence of noise. [C808]

"The Gradient Structure Tensor as an Efficient Descriptor of Spatial Texture in Polarimetric SAR Data"

In this paper, the analysis of spatially nonstationary texture from polarimetric SAR data is studied. A previously introduced model named Anisotropic Gaussian Kernel (AGK) was shown to be a pertinent descriptor of local orientation and allowed a simple representation of the complex spatial structure in SAR images. Here, two methods for the estimation of the model parameters are proposed. The first one is an enhancement of the previously developed algorithm and the second one is a new approach based on the Gradient Structure Tensor (GST) operator. These two methods are employed to analyse texture in PolSAR intensity channels. [C809]

"Target Classification by Means of Fully Polarimetric ISAR Images"

In ISAR systems, fully polarimetric capabilities have not been fully exploited for target classification or recognition. In this paper, a full system that reconstructs the polarimetric ISAR image and classifies the target is proposed and tested on simulated data. [C810]

"The Application of Polarimetric Calibration using Polarimetric Scattering Characteristics of Urban Areas to ALOS PALSAR"

This paper discusses an ambiguity resolution of polarimetric calibration parameter. Since ALOS was successfully launched on January 24, 2006, the utilization of polarimetric data observed by PALSAR is expected for various remote sensing applications. Thus, polarimetric calibration becomes important issue. However, there is a possibility that calibration algorithm has a 180deg sign ambiguity with respect to cross-polarized components of a calibrated scattering matrix. The reason is that two polarimetric calibration parameter sets are derived. On the

other hand, we found that a 180deg phase shift of cross-polarized component occurred due to the change of an angle between a direction parallel to a building wall and a radar line of sight in azimuth plane. Thus, we examined that this scattering property was applied for selecting a correct polarimetric calibration parameter set. The experimental result shows that urban structures can be used for polarimetric calibration. [C811]

"Use of the SVM Classification with Polarimetric SAR Data for Land Use Cartography"

Yhis study comes within the framework of the global cartography and inventory of the Polynesian landscape. An AIRSAR airborne acquired fully polarimettric data in L and P bands, in August 2000, over the main Polynesian Islands. This study focuses on Tubuai Island, where several ground surveys allow the validation of the different results. Different decompositions, such as H/A/alpha, or based on the Pauli formalism have shown their potential for land use discrimination. In order to take into account these different parameters into a supervised classification scheme, the SVM (Support Vector Machine) method is investigated. When dealing with only the coherent matrix elements, the results show that the SVM classification gives comparative results to those obtain with Wishart classification. Results are significantly improved when adding to the coherent matrix elements, other polarimetric parameters, as H/A/alpha or the co-polarized circular polarization correlation coefficient, rhorrll, for the Support Vector definition. Finally the best results are given when merging all the parameters for P and L bands, in addition to the only VV single channel acquired in C band. [C812]

"Polarimetric SAR Detection of Man-Made Structures Using Normalized Circular-pol Correlation Coefficients"

Polarimetric synthetic aperture radar (SAR) backscatter from man-made structures is often quite different than scatter from predominantly natural areas. Backscatter from natural areas is often characterized by near zero values for linear-basis covariance matrix off- diagonal terms of the form <SHVS*HH> and <SHVS*VV>. A new approach is proposed to detect man-made structures using circular-pol RR-LL correlation coefficients. This method uses a normalization term, which enhances the return from man-made structures and eliminates most of the unnecessary details of the backscatter from natural areas. [C813]

"Mapping and Projection Algorithm: A New Approach to SAR Imaging Simulation for Comprehensive Terrain Scene"

A novel fast algorithm of polarimetric image simulation for SAR observation over comprehensive terrain scene is developed based on the mapping and projection principles. It incorporates penetrable and impenetrable objects, volumetric and surface scatterers in the imaging space with the extinction, attenuation, shadowing and multiple scattering effects. Scattering of the vegetation canopy is modeled as a layer of random non-spherical particles by using the vector radiative transfer model. Scattering from the ground surface and building objects is calculated by using the IEM rough surface model. As an example, the polarimetric SAR images for a virtual terrain scene, composed by tree canopies, farmland, buildings, rough land surface, hills and rivers, are simulated. [C814]

"FPGA-based Implementation of a Polarimetric Radiometer with Digital Beamforming"

In [1] a general overview of the PAU system is provided. This work describes in more detail the implementation of the polarimetric and pseudo-correlation radiometer (PAU-RAD) that measures the four Stokes parameters. [C815]

"Design and implementation of PALSAR Ground Data System at ERSDAC"

The Phased Array type L-band Synthetic Aperture Radar (PALSAR) is one of the imaging sensors onboard the Advanced Land Observing Satellite (ALOS) launched on January 24, 2006. The antenna of PALSAR is beam steerable to realize a variety of off-nadir angles. There are multi-polarimetric (dual and quad) observation modes and single polarimetric modes. It has also ScanSAR modes to observe a wide swath (250 km-350 km). PALSAR Ground Data System (GDS) has been developed at ERSDAC since 1999. In the system, raw data provided from JAXA are processed to SAR images as final products which are archived and distributed to the worldwide users. The SAR data processor of PALSAR GDS is designed to achieve optimal data quality as well as maximum performance to meet the requirements from various users. [C816]

"Wetland Characterization using Polarimetric RADARSAT-2 Capability"

Wetlands play a key role in regional and global environments and are critically linked to many major issues such as climate change, water quality, the hydrological and carbon cycles, and wildlife habitat and biodiversity. Mapping wetlands and monitoring their change in a systematic and repeatable manner for the Canadian Wetland Inventory (CWI), led by the Canadian Wildlife Service of Environment Canada (EC), are important in order to

manage and protect significant wetland areas in Canada. The use of RADARSAT-1 Synthetic Aperture Radar (SAR) data has been shown to be important for wetland water extent characterization. However, the limited capability of RADARSAT-1's single-polarization C-band SAR in vegetation type discrimination makes the use of clear-sky- dependent visible near-infrared (VNIR) satellite data necessary for wetland mapping. In this paper, the unique polarimetric capability of RADARSAT-2 is investigated for wetland classification. The roll invariant incoherent target decomposition, the TSVM-ICTD [11], is used for optimum characterization of wetland target scattering. It is shown that like RADARS AT-1 HH polarization, the magnitude of the complex symmetric scattering is not effective for vegetation type discrimination. The phase of the symmetric scattering type has to be used for a more complete characterization of wetland vegetation species. This new phase scattering parameter introduced in [11] has been shown to be very promising for wetland classification using Convair-580 polarimetric SAR data. [C817]

"Consideration of the Correlation between Beta-angle and Lineament Patterns by Using Polarimetric SAR Images"

This paper describes the relationship between a polarimetric parameter, the beta-angle, and the lineament features based on the eigenvalues and eigenvectors of the coherency matrix of the polarimetric SAR (POLSAR) data. First, coherency matrix was calculated from the Pauli vector of the POLSAR image set. Then, eigenvalues and corresponding eigenvectors of the coherency matrix were calculated. Subsequently, beta-angle, derived from the eigenvalue and the corresponding eigenvectors. However, the beta-angle has the potential to represent the orientation of the scatterer about the radar line of sight. In addition, alpha-angle has been obtained using the same eigenvector above. We validate them using fully polarimetric L-band SAR data. The relationship between these two angles is also discussed, and a two-dimensional feature space is constructed (beta-alpha space). We then show initial results of applying the beta-alpha space to the Japanese airborne polarimetric and interferometric SAR (Pi-SAR) to extract features of lineaments as one of the geological features of the land surface. The results demonstrate that the effectiveness of the proposed extraction algorithm. [C818]

"Relation Between Coherence, Forest Biomass, and L-band 0"

Relation between coherence, forest biomass, and L-band sigma0were examined by using the L-band data taken by Japanese Polarimetric and Interferometric Airborne SAR (PiSAR). Several PiSAR observations were performed over a well-managed national forest, in which four kinds of conifers were dominantly planted. A coherence map over the forest area was made from two flight data, whose observation interval was about 30 minutes. The coherence in this site are ranging from 0.5 to 0.8. High coherence values of 0.7 ~ 0.8 were appeared at the young stands. On the other hands, some stands with high biomass also show high coherence value. Since the coherence values are weakly correlated with sigma0HHand sigma0HVat the stands with high biomass, the high coherence value and the high sigma0value are considered to be the same origin. The regression curve between the coherence and a stem volume derived in this analysis shows higher coherence value than the other two JERS-1 (L-band) 44-day pair data and one ERS 1/2 C-band 1-day pair data. This may be due to the shorter repeat-cycle of the PiSAR pair data and difference of the scattering elements. [C819]

"Scattering and Propagation of Polarimetric Radar Signals in Storms and Clouds"

The introduction of differential reflectivity (Zdr) and propagation differential phase (Phidp) was originally intended for improving radar estimates of rainfall rate. These parameters together with the effective reflectivity factor (Zh) proved to be very useful for other applications as well. They have been shown to produce significant improvements over conventional single polarization radars in discriminating liquid and ice phase hydrometeors and, with the aid of several other polarimetric parameters (linear depolarization ratio and co-polar correlation coefficient), for classifying different hydrometeor types. Radar techniques developed for these purposes are being used in research applications and will soon become operational tools. The classification of ice phase hydrometeors and the quantitative estimation of their bulk parameters (e.g., median size, ice mass content, etc.) are necessary for better understanding storms and clouds. As methodologies are developed for extracting more information about hydrometeors using polarimetric radars, it becomes increasingly important to model the hydrometeors more accurately. Their shape, size, fall behavior, and composition must be represented with sufficient detail, capturing the dominant features that influence the measured radar parameters. This paper reviews developments in hydrometeor modeling for dual-polarization radar remote sensing applications. The use of these modeling results in various applications such as rainfall rate estimation and hydrometeor classification are illustrated with the aid of experimental measurements. The first application of the "self-consistency" principle is discussed using dual-frequency polarimetric radar parameters (S-band Zhand Zdrwith X-band Zhand specific attenuation Ah). [C820]

"Development of a C-band Polarimetric and Pulse Compression Radar in Okinawa, Japan"

National Institute of Information and Communication Technology (NICT, formally CRI) has developed a new C-band (5340 MHz) multi-parameter Doppler radar system with a bistatic Doppler radar network to establish the next-generation technology of rain observation for meteorological and hydrological applications such as weather forecasts and run-off analysis in predicting floods. This new radar is named COBRA (CRI Okinawa Bistatic polarimetric RAdar). The weather targets of this system are typhoons, Baiu-frontal rainfall, meso-scale precipitation in subtropical zones, and clear air turbulence. Two transmitter (klystron) units are used for the polarization observation. The transmission polarization for each pulse is selected from six possible polarizations. Additionally, NICT has developed equipment for weather radar that modulates the transmitting signal and demodulates the received signal (i.e., a pulse compression function). This equipment has been added to the existing COBRA system, forming a new system referred to as COBRA+. The COBRA+ system uses two traveling-wave tube amplifier (TWTA) transmitter units. [C821]

"Dual-polarization Developments at CNR: Past and Present Research"

This paper reviews the research activities carried out by the radar meteorology group that was established at the Institute of Atmospheric Physics of the National Research Council of Italy. The group started in the late 1970s, and, after the publication of a keystone paper on the use of linear polarization by Seliga and Bringi (1976), its primary focus has been on po- larimetric radar techniques and their meteorological applications. The research efforts, realized through close cooperation first with Pennsylvania State University and later with Colorado State University, have produced positive results that have contributed to a spread in the knowledge of dual-polarization techniques and in learning important information about microphysical processes in clouds and precipitation. This paper highlights some of these research achievements. [C822]

"A New Set of the Parameters for the Terrain Surface Classification in Polarimetric SAR Image Based on Deorientation of Polarimetric Scattering Vector"

Deorienation theory of polarimetric scattering targets is developed, which transforms the scattering vector of spatially oriented targets into a certain status with minimization of cross polarization. A new set of the parameters u,v,w,Psiis defined to describe and classify different terrain surfaces. Based on the vector radiative transfer (VRT) model of non-spherical particles above a rough surface, numerical simulations illustrate the parameters u,v,w,Psiand the entropy H. These parameters are applied to the unsupervised classification in polarimetric images. The terrain surfaces of polarimetric SIR-C and airborne SAR images are classified and orientation-analyzed. [C823]

"Two Novel Polarimetric Indices and Their Application on the Target Enhancement in POLSAR Images"

In this paper we introduce two new parameters for polarimetric SAR (POLSAR) images. For this purpose, the eigenvalues and corresponding eigenvectors of the coherence matrix is calculated. It can be assumed that there are different land cover features, and they are represented by different or slightly different coherence matrix so that eigenvalues and corresponding eigenvectors. However, the condition number and perturbation in the solution of the coherence matrix are calculated for each pixel in the POLSAR image. The results indicate that different scatterer properties so that the scattering mechanisms could be represented with these parameters. [C824]

"A New Unified Approach to Channel Imbalance and Cross-Talk Calibration of Polarimetric Data"

A new unified approach to channel imbalance and cross-talk calibration of polarimetric data is described. This approach is applied during the SAR image formation, employing the multilook SAR processing technique and the covariance matrix of observed data. This method makes no assumptions about the reciprocity of the distortion model and noise system, and about the presence of dominating target with azimuthal symmetry. The standard linear and nonreciprocal distortion model for the received signal is assumed for each polarimetric image obtained from three looks without overlapping. This leads to a set of equations that relate the observed covariance matrix and the distortion system parameters. The non-linear solution of the calibration parameters is solved by iterative approach based on numerical methods. Fully polarimetric SAR L-band data, acquired by CENSIPAM Airborne R99-SAR on the Tapajos Forest (Brazilian Amazon), was used to evaluate the method as well the polarization signature response of some trihedral corner reflectors deployed in the area. [C825]

"An Unsupervised Classification for Fully Polarimetric SAR Data Using IHSL Transform and the FCM Agrithm"

In this paper, the IHSL transform and the fuzzy C-means (FCM) segmentation algorithm are combined together

to perform the unsupervised classification for fully polarimetric SAR data. We apply the IHSL colour transform to H/alpha/SPAN space to obtain a new space (RGB colour space) which has a uniform distinguishability among inner parameters and contains the whole polarimetric information in H/alpha/SPAN. Then the fuzzy C-means algorithm is applied to this RGB space to finish the classification procedure. The main advantages of this method are that the parameters in the color space have similar interclass distinguishability, thus it can achieve a high performance in the pixel based segmentation algorithm, and since we can treat the parameters in the same way, the segmentation procedure can be simplified. The experiments show that it can provide an improved classification result compared with the method which uses the H/alpha/SPAN space directly during the segmentation procedure. [C826]

"Building Extraction Using C Band Pol-SAR Image"

This paper introduces a method for building location information extraction using airborne C-band polarimetric SAR data. The method is based on the analysis of building feature. The method decomposes the scattering covariance matrix into three simple mechanism, i.e., odd-bounce; even-bounce; cross-bounce. Taking into account that the typical strong T-shaped echoes from quite large buildings are visible, a method is introduced to extract the location of the buildings. [C827]

"S-Band, Polarimetric, Combined, Short Range Action Scatterometer-Radiometer for Platform and Vessel Application"

In this paper S-band (~3 GHz), polarimetric, combined, short pulse scatterometer-radiometer is described, for simultaneous and spatially coincident measurements of sea surface, snow, bear and vegetated soil microwave reflective, and emissive characteristics, and for backscattered radar signal frequency distribution statistical parameters estimation. The system may be successfully used for near sea surface wind and sea surface wave fields' parameters precise and unambiguous retrieval, as well as for land and sea surface signatures and targets detection and identification their origin. [C828]

"TerraSAR-X for Oceanography"

TerraSAR-X is a german X-band radar satellite to be launched in 2006. The system will provide synthetic aperture radar (SAR) data with high spatial resolution for both commercial and scientific use. The spacecraft will be equipped with a phased array X-band SAR, which can operate in different polarisations and has furthermore beam stearing capabilities. In addition the system has a split antenna mode, which is able to provide along track interferometric information. The instrument is designed for multiple imaging modes like Stripmap, Spotlight and ScanSAR. Due to its polarimetric and interferometric capabilities as well as the high spatial resolution of up to 1 m, the TerraSAR-X sensor is a very interesting tool for oceanography. The presentation will give an overview of several applications, which are of both scientific and commercial interest like current and ocean wave measurements, monitoring of morphodynamical processes or high resolution wind field retrieval. The potential as well as limitations of the instrument are summarized and compared with existing sensors. Necessary steps to translate existing C-band SAR inversion algorithms for wind and wave measurements to X-band are discussed. A strategy is outlined to achieve this by a combination of theoretical investigations and the use of existing experimental data acquired by both airborne and groundbased X-band radar. [C829]

"Application of multiresolution and multispectral polarimetric techniques for reliable vessel monitoring and control"

Carrying out an effective monitoring and control of fishing activities is indispensable to guarantee a sustainable exploitation of sea resources. Nowadays, it is widely assumed that spaceborne synthetic aperture radar (SAR) constitutes a valuable and effective tool for this purpose. Nevertheless, automatic interpretation of SAR images is often puzzling. Hence this paper proposes a new framework for the understanding and handling of SAR data based on the wavelet transform. Specifically, a novel algorithm for ship detection is proposed, justified and tested. On the other hand, this paper aims at bringing some insight at ship detection capabilities of light polarimetric systems. [C830]

"Extraction of maintenance information on irrigation ponds using polarimetric SARdata"

{no data available} [C831]

"Comparison of polarimetric SAR techniques for the measurement of directional ocean wave spectra"

Several methods have been investigated which use fully polarimetric synthetic aperture radar (POLSAR) data to

measure directional ocean wave slope spectra. Independent techniques have been developed to measure wave slopes in the orthogonal SAR (azimuth/range) directions. In this paper, wave spectra measured using two polarimetric methods are investigated. Spectra developed using: a) intensity-based polarimetric SAR methods and b) a more recent orientation/alpha angle algorithm are compared. NASA/JPL/AIRSAR L-band data from two-sites in California coastal waters have been used. [C832]

"Investigating polarimetric SAR data for cryospheric monitoring in a Canadian environment"

Since the early 90's, INKS has been developed tools for snow monitoring, river ice characterization and seasonal frost mapping in Canada. The focus to date has been on the use of monopolarized or multipolarized SAR data. With the forthcoming of RADARSAT-2, we have undergone a series of studies to asses the potential information gain from polarimetric SAR data. Airborne polarimetric SAR data from the Canadian CV-580 have been acquired over three different Canadian sites in winter: 1) a boreal forest 2) an agricultural watershed and 3) the Saint-Francois River. This paper presents the preliminary results obtained from the polarimetric data set over the Saint-Francois River in February 2003. [C833]

"Evaluation of the ESPRIT approach in polarimetric interferometric SAR"

This paper presents a first evaluation of the ESPRIT approach in polarimetric interferometric SAR. This evaluation is carried out by using 3D images obtained by SAR tomographic like an alternative to the acquisition of ground-truth data, which is an extremely complex task in the case of volume areas. All parameters over a volumetric area are directly visible in a tomographic image and can, therefore, be employed to validate the ESPRIT approach by comparing parameters generated by ESPRIT and the SAR tomography approach. This allows to identify the principal deficiencies of the ESPRIT method, which occur over high vegetation areas, where there is a misinterpretation of the ESPRIT results. Whereas, the ESPRIT approach is useful for building characterisation, identifying a good applicability area. Airborne L-band repeat-pass interferometric data of the German Aerospace Center (DLR) experimental airborne SAR are used to perform this evaluation. [C834]

"Polarimetric calibration for low frequency UWBSAR system"

{no data available} [C835]

"Polarimetric calibration of space SAR data subject to faraday rotation -a three-target approach"

{no data available} [C836]

"Statistical method for data compression and enhancement of multifrequency polarimetric SAR imagery"

{no data available} [C837]

"Estimation of forest height and forested area with polarimetric SAR interferometry"

{no data available} [C838]

"Measurement of scattering properties of vegetation at Ka-band by 35GHhz polarimetric scatterometer"

{no data available} [C839]

"Intensity-driven-adaptive-neighborhood technique for POLSAR parameters estimation"

{no data available} [C840]

"Incorporating a vegetation index into a soil moisture retrieval model $results from Convair-580 SAR data"

A flexible method of introducing a SAR vegetation index into the Dubois model for soil moisture retrieval using polarimetric SAR data is introduced. Based on the vegetation sensitivity at each pixel, the vegetation index is incorporated on a pixel by pixel basis using the water cloud model. An approach for minimizing the need for ground measurements, by remotely estimating the parameters required for the vegetation index, is suggested. The proposed model is applied to CV-580 airborne SAR data and the vegetation correction was found to reduce the rms error in the model. [C841]

"POLSAR speckle filtering with structural feature and scattering property preservation"

In this paper two speckle filters for multi-look polarimetric synthetic aperture radar (POLSAR) imagery are proposed, which preserve structural features, i.e. edges and line, as well as scattering properties. The filtering operations are performed spatially variant for the edges/lines along their orientation and for the homogeneous areas based on the scattering properties. The capabilities of both filters are demonstrated for the NASA/JPL nine-look POLSAR C-band data, whereby comparisons with the Boxcar, Lee refined and Annealing filters are provided. In summary, both proposed filters show a good performance in speckle removal, structural feature retention and radiometric preservation. [C842]

"The MOSS VHF/UHF spaceborne SAR system testbed"

Summary form only given. This paper details our recent development of a system prototype for a spaceborne sensor that addresses the current NASA science priority of measuring soil moisture "under a substantial vegetation canopy and reaching a useful depth within the uppermost soil layer". The mission is named MOSS, for the Microwave Observatory of Subcanopy and Subsurface. It will enable measurement and derivation of data products not obtained from any other current, planned, or proposed instrument, with a solution that offers high science value through a low-mass and, in the long-term, low-cost approach. The proposed system is a spaceborne synthetic aperture radar (SAR) operating at the two low frequencies of 435 MHz (UHF, P-band) and 137 MHz (VHF) to enable sensing through vegetation and down into soil. The future mission scenario is achieved from a Sun synchronous orbit of 1313 km altitude, with a swath width of 430 km, incidence angle ranges of 17-30 degrees, resolution of 1 km, and a 7-day exact repeat consistent with the temporal scale of variations of the subcanopy and subsurface soil moisture. We describe a tower-based test-bed that we have developed to validate the spaceborne measurement concept. The processing software, including polarimetric calibration aspects, is detailed, and example science products are presented. The procedures and algorithms to estimate subsurface moisture are presented in detail, and the use an iterative estimation procedure is explained. The results are validated by comparing against detailed ground truth. [C843]

"Salient features of radar nodes of the first generation NetRad System"

The recently established National Science Foundation Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA) will be deploying the first generation of an automated network of four low-power, short-range, X-band, polarimetric, Doppler radars, known as NetRad, in central Oklahoma in late 2005. This network is developed with the goal of tracking tornadoes with high spatial and temporal resolution as well as mapping severe weather events in the lowest 2 km of the troposphere. Each radar node has been developed to accomplish this system goal through the coordinated interaction with other radars in the network via a real-time, closed-loop software control system. This paper will describe the characteristics of the individual radar nodes in the system, with emphasis on those aspects of the design that lend themselves toward operation as a coordinated network. Calibration results and performance characteristics of the single node radar of the first generation system will also be presented. [C844]

"Polarization discrimination ratio approach to retrieve bare soil moisture at X-band"

An observation has been carried out at different incidence angle by X-band scatterometer for like polarizations (i.e., Horizontal-Horizontal and Vertical-Vertical) to retrieve the soil moisture of bare field. To retrieve the soil moisture with minimizing the surface roughness effect on the soil moisture a polarimetric discrimination ratio (PDR) (PDR = (σ° VV-σ° HH)/ (σ° VV + σ° HH) where σ° is scattering coefficient for VVand HH-polarization) approach is proposed. Generally in microwave applications, polarization is sensitive to the size, shape and orientation of target elements, whereas frequency functions primarily as a size filter with important consequences regarding attenuation. In the polarization, the horizontal polarization gives a measure of the horizontal dimension of the emitting elements, while the vertical polarization essentially gives a measure of the vertical dimension. The power observed to the system is a complicated function of each particle size, shape and density, therefore we have normalized the value of HH- and VV-pol to the range -1≤PDR≤1 to partially minimize the effect of orientation and shape on dielectric properties of the scattering elements and results mainly the effect of dielectric (i.e., moisture content) on σ° . The angular dependence of PDR on moisture is observed and it was found that the suitable incidence angle to observe the soil moisture at X-band with PDR is 35°. An empirical relation has been developed between PDR and soil moisture to retrieve the moisture content at X-band. The results are validated with another set of data. The retrieved values of soil moisture are in good agreement (standard error-1.02) with observed values of soil moisture. The significance of the results has been tested by F-ratio test and quite significant results were obtained. This type of results are helpful to use the microwave techniques to assess the soil moisture by the air-borne or space borne sensor and propose the suitable angle of incidence to observe the soil moisture with minimum effect of surface roughness at X-band. [C845]

"A new classification method based on Cloude Pottier eigenvalue/eigenvector decomposition"

In this paper, a new polarimetric scattering parameter, the averaged intensity (I), is introduced to present the backscatter intensity of fully polarimetric SAR data. According to the particular analysis on the properties of I, α angle and entropy H, the mapping rule of I-α-H feature space onto the intensity-hue-saturation (I-H-S) color space is proposed. We use the IHS transform instead of segmentation algorithm to finish the classification. The important advantages of this method are that the information contained in the I-α-H feature space is preserved without any loss in the resulting image, and the execution time is saved since IHS transform is faster than most complicated segmentations. The result shows that I has the additional information which is not contained in α and H, and the classification result is more readable than that of H/α/A. [C846]

"Polarimetric characteristics of radar echoes from near shore wave fields at low grazing angles"

This paper presents the results of polarimetric measurements of the near shore wave fields made in the low grazing angle regime. The variations in the distribution of the polarimetric entropy, anisotropy and mean scattering alpha of the radar echoes are examined in the H-A-α~ space to characterise the dominant scattering mechanisms for two situations; one where the incident wave field is almost monochromatic and the other where a broader spectrum of waves is present. [C847]

"New eigenvalue-based parameters for natural media characterization"

The aim of this paper is to present two novel polarimetric parameters, the eigenvalue relative difference (ERD) and the single bounce eigenvalue relative difference (SERD), to characterize natural media. These parameters are derived from the eigen-decomposition of the coherency matrix considering the reflection symmetry hypothesis. An analysis of these parameters is performed on multi-frequency polarimetric SAR data acquired on bare soils and forested areas. [C848]

"Polarimetric SAR image classification employing subaperture polarimetric analysis"

Polarimetric SAR image classification remains an important research area. Various methods continue to be developed for specific applications. High-resolution polarimetric SAR systems and advances in computational and data storage capabilities have revived interest in novel polarimetric analysis techniques. Accordingly, subaperture analysis of polarimetric SAR data has received renewed attention. A central assumption of SAR image formation is that individual radar scatterers are stationary; they have no structure and provide a constant reflectivity during the imaging process. However, with increased resolution, and hence fewer scatterers per pixel, the nonstationary response from any given scatterer is more likely to influence total radar backscatter of a pixel. We present a method to assess the polarimetric variability across the full aperture. [C849]

"Synthetic aperture radar (SAR)-based mapping of wildfire burn severity and recovery"

New radar based techniques for efficient identification of forest damage caused by wildfire and subsequent recovery are applied to data acquired over the 2002 Rodeo-Chediski, Arizona and 1988 Yellowstone National Park wildfire complexes. Fully polarimetric C-, L- and P-band airborne synthetic aperture radar data were acquired in approximately east-west and north-south swaths over the northern half of the Rodeo-Chediski wildfire scar on August 1, 2002, 25 days after the last active fire was contained. The AIRSAR instrument also acquired fully polarimetric data in C-, L- and P-band over Yellowstone on October 11, 1994, approximately 6 years after the event. We combine single frequency polarimetric parameters in composite images for optimal identification of fire-induced damage to the forests. For the Rodeo-Chediski fire, we demonstrate that polarimetric parameters-such as average scattering mechanism-readily identify bare surfaces, pine trees with intact needles, trees with exposed branches, and trees with residual burned trunks. In particular, a single-pass of polarimetric SAR provides identification of the perimeters and within-burn variability. This work shows that fully polarimetric SAR is sensitive to scattering changes wrought by wildfire in two types of predominantly coniferous forests. By extension, this technique should help quantify different degrees of burn severity in ecosystems where the canopy is altered. We anticipate that these results will provide a new method of responding to wildfires, perhaps even at the tactical fire-fighting level. [C850]

"Polarimetric SAR stereo using Pi-SAR square loop path"

This paper shows first results of polarimetric SAR stereo applied to urban areas. SAR stereo is known as a useful technique for three-dimensional mapping. Until now many approaches and results have been reported, based on single polarization measurements. But stereogrammetry has not been used with polarimetric information. In this paper, we use polarimetric SAR measurements acquired during a square loop flight. It is

shown that typical objects, like a TV tower can be reconstructed and its polarimetric properties analysed using this method. [C851]

"A study on the use of SAR polarimetric data to observe oil spills"

In this paper a new procedure to discriminate different surface films by means of SAR polarimetric data is proposed. SAR data were acquired on October 11, 1994 during SIR-C/X-SAR mission, named SRL-2. The dark features characterizing different surface films are analysed using eigenvalues and eigenvectors of the coherence matrix. Results of this study give rise to the conclusions that SAR polarimetric data are a key tool to discriminate oil spills from biogenic/anthropogenic surface films to reduce the number of false alarms. [C852]

"Oceans 2005-Europe (IEEE Cat. No. 05EX1042)"

{no data available} [C853]

"A broadband millimeter-wave dual polarized phased array for radar front end applications"

A broadband millimeter-wave phased array system is presented which allows for independent control of vertically and horizontally polarized beams in azimuth and elevation. The complete system is based upon low profile tray architecture with compact spacing between adjacent elements and ease of integration with multiple linear arrays. Using stereolithography, a dual polarized waveguide structure was fabricated which allowed for a low loss transition between an array of miniature horn antennas and the array ports of the phase shifting network. A broadband switch network with low noise amplifier was designed to achieve a compact electronically controlled phased array. [C854]

"Polarimetric interferometry and time-frequency analysis applied to a urban area at X-band"

{no data available} [C855]

"Status of a UAVSAR designed for repeat pass interferometry for deformation measurements"

NASA's Jet Propulsion Laboratory is currently implementing a reconfigurable polarimetric L-band synthetic aperture radar (SAR), specifically designed to acquire airborne repeat track interferometric (RTI) SAR data, also known as differential interferometric measurements. Differential interferometry can provide key deformation measurements, important for the scientific studies of earthquakes and volcanoes. Using precision real-time GPS and a sensor controlled flight management system, the system will be able to fly predefined paths with great precision. The expected performance of the flight control system will constrain the flight path to be within a 10 m diameter tube about the desired flight track. The radar will be designed to operate on a UAV (unpiloted aerial vehicle) but will initially be demonstrated on a minimally piloted vehicle (MPV), such as the Proteus built by scaled composites or on a NASA Gulfstream III. The radar design is a fully polarimetric with an 80 MHz bandwidth (2 m range resolution) and 16 km range swath. The antenna is an electronically steered along track to assure that the actual antenna pointing can be controlled independent of the wind direction and speed. Other features supported by the antenna include an elevation monopulse option and a pulse-to-pulse resteering capability that will enable some novel modes of operation. The system will nominally operate at 45,000 ft (13800 m). The program began out as an Instrument Incubator Project (IIP) funded by NASA Earth Science and Technology Office (ESTO). [C856]

"Antennae variety for remote sensing of surroundings"

This paper is an overview of different types of antennae applications for observation of surroundings including remote sensing of Earth surface, atmosphere, ground penetration, and aircraft collision avoidance. The overview covers all frequency bands from millimeter waves up to very long waves. Some recently obtained results on Doppler-polarimetric methods of atmosphere research as well as on new airborne collision avoidance system creation are included. Specificity of antennae of different applications is discussed. This paper mainly reflects the works, which were done with author participation, and does not aspire to saturation coverage of the entire infinite field of antennae application. [C857]

"A multiresolution cooperating multiple-swarm pso algorithm for automatic target recognition in polarimetric SAR images"

First Page of the Article [C858]

"Nonstationary array processing for tracking moving targets with time-varying polarizations"

This paper presents an approach for tracking nonstationary moving sources with both time-varying directions-of-arrival (DOA) and time-varying polarization signatures. The proposed approach is based on the spatial polarimetric time-frequency distributions (SPTFD). Unlike the conventional correlation matrix based approaches that sacrifice the source signal polarization properties and are not properly structured to utilize polarization diversity, the proposed approach uses the signal instantaneous polarization and instantaneous frequency information for improved target tracking and polarization estimation. [C859]

"Technique for selection of optimum polarimetric angles in radar signature classification"

In this paper an automated technique for adaptive radar polarimetric pattern classification is described. The approach is based on a genetic algorithm that uses probabilistic pattern separation distance function and searches for those transmit and receive states of polarization sensing angles that optimize this function. Seven pattern separation distance functions, the Rayleigh quotient, Bhattacharyya, divergence, Kolmogorov, Matusta, Kullback-Leibler distances, and the Bayesian probability of error, are used on real, fully polarimetric synthetic aperture radar target signatures. Each of these signatures is represented as functions of transmit and receive polarization ellipticity angle and the angle of polarization ellipse. The results indicate that based on the majority of the distance functions used; there is a unique set of state of polarization angles whose use leads to improved classification performance. [C860]

"P-SAR: an advanced miniature synthetic aperture radar for forestry applications. Preliminary design"

A preliminary study of the design of a small, low cost, P-band airborne, polarimetric synthetic aperture radar (SAR) is presented. The design was requested by the Wageningen University and the Borneo Orangutan Survival Foundation (BOS) to carry out forest biomass monitoring in Indonesia. The requirements of the application are established and the main radar parameters are derived from them. A preliminary design of the system, based on commercial off-the-shelf components is also presented. Some novelties of the system are the use of direct digital synthesis (DDS) to perform the modulation, the use of dual-polarized microstrip square patch antennas and the reduced size and power consumption of the system. [C861]

"Automatic classification of hydrometeors based on polarimetric weather radar measurements"

With the development of modern electron and computer techniques, the ability of weather radar detecting precipitation echo has been greatly improved. However, the improvement of the of echo detecting precision doesn't mean the improvement of quantitative precipitation estimates due to different distribution and type of precipitation particles as well as other hardware factors. In this paper, the author propose to construct the membership function of fuzzy logic method based on the characteristic of scattering and orientation of different kinds of hydrometeors. The authors also present details of the algorithm for classification of hydrometeors and a methodology for sensitivity analysis to the various polarimetric variables used for classification. [C862]

"A four-component decomposition of POLSAR image"

{no data available} [C863]

"Ocean features separation from multifrequency polarimetric SAR imagery"

{no data available} [C864]

"Polarimetric analysis of the disastorus environment by using Pi-SAR"

{no data available} [C865]

"The relation between the order parameter of K-distribution in high-resolution polarimetric SAR data and forest biomass"

{no data available} [C866]

"Natural objects monitoring using polarimetric interferometric ground-based SAR (GB-SAR) system"

{no data available} [C867]

"Polarimetric analysis of fine resolution X-band SAR sea clutter data"

{no data available} [C868]

"Polarimetric interferometry over urban areas: information extraction using coherent scatterers"

{no data available} [C869]

"Resolution effects on polarimetric high resolution X band data"

{no data available} [C870]

"The development of a ground based polarimetric SAR interferometer (GB-POLInSAR)"

{no data available} [C871]

"Scatterer characterisation using polarimetric SAR tomography"

{no data available} [C872]

"Unsupervised classification of a central italy landscape by polarimetric L-band SAR data"

{no data available} [C873]

"Speckle filtering influence on unsupervised terrain classification based on polarimetric scattering mechanisms"

Two scattering model-based decompositions (the first one, developed by Freeman and Burden (1998), where pixels are divided into three scattering categories: surface, volume, and double bounce, and the second, developed by Cloude and Pottier (1997), where scattering mechanisms, characterized by entropy H, and α-angle, are used for classification) were investigated in terms of speckle filtering influence on classification parameters. Freeman and Burden decomposition gives us less problems with relation to speckle filtering. Whereas in Cloude and Pottier decomposition, speckle filtering and averaging are very critical moments. Polarimetric radar images of Moscow region acquired in 1994/10/09 by SIR-C/X SLC L-band data are used for illustration. Results from unfiltered and Lee-filtered (Lee et al., 1999) Burden and Freeman decomposition images and entropy images are compared. A great influence of speckle filtering on Cloude and Pottier classification parameters was demonstrated. [C874]

"Characterisation of buildings using polarimetric interferometric multiple track L-band SAR data"

In this paper a multiple view POL-InSAR approach for the analysis of urban areas is introduced: as a first step, a polarimetric classification scheme is applied that allows the identification of three basic scattering mechanisms: volume diffusion, double bounce and surface reflections. A relation between the interferometric phases of the Pauli polarization basis and the polarimetric scattering mechanisms is established. A method to estimate the phase corresponding to the surface is introduced. These phases are used to extract the height of buildings. Finally, the data is geocoded in order to synchronize images acquired from different positions. The proposed methods are applied to fully polarimetric and repeat pass interferometric data at L-band acquired by the DLR's experimental E-SAR system on August 1st, 2000 over the city of Dresden in Germany. The flight tracks form a rectangle [C875]

"The distribution of interferometric phase differentials and a self-initialising PolInSAR classifier"

This paper describes an unsupervised classifier for polarimetric interferometric SAR (PolInSAR) data. Expectation maximisation is used to estimate class parameters that maximise the probability of a dataset for a given number of classes. Polarimetric information, in the form of coherency matrices, and interferometric information, in the form of complex coherences, is taken into account. Phase differentials between complex coherences in different polarisation bases are used to make the classifier sensitive to the vertical structure of the scene under observation, and a distribution of such phase differentials is developed. The classifier is self initialising in that it does not rely on decompositions or thresholds. Classification results based on real data are presented and discussed [C876]

"Evaluating PolInSAR parameter estimation using tomographic imaging results"

This paper concentrates on the forest height and ground topography estimation by means of polarimetric SAR interferometry and tomography. In polarimetric SAR interferometry, one of the most important methods described in literature is the line-fitting approach in the complex unitary circle (S.R. Cloude and K.P. Papathanassiou,

2003). Although it has shown their principal potential, an open issue is still the precise validation of the estimated parameters, as ground-truth collection is an extremely complex task in the case of forest parameters. SAR tomography is an alternative technique, which generates a fully three-dimensional representation of the imaged scene through coherent combination of a greater number of tracks (A. Reigber and A. Moreira, 2000) (S. Guillaso and A. Reigber, 2005). Forest ground and canopy are directly visible in a tomographic image; a tomographic image can therefore be used as an ideal validation base for PolInSAR forest parameter estimation. This paper compares high-resolution polarimetric SAR tomograms with PolInSAR forest height estimations, both derived from the same data set. This allows to identify areas of good applicability, as well as principal deficiencies of the different PolInSAR approaches [C877]

"PolSARpro v2.0: the versatile polarimetric and interferometric SAR data processing toolbox"

The objective of this paper is to make a review of the current status of the PolSARpro v2.0 software (polarimetric SAR data processing and educational toolbox), developed under contract to ESA ("Development of a Polarimetric SAR Image Analysis Tool", ESA-ESRIN Contract ndeg 17863/03/I-LG) by a consortium comprising I.E.T.R at the University of Rennes 1, DLR-HR and University of Adelaide. The objective of this current project is to provide educational software that offers a tool for self-education in the field of polarimetric SAR data analysis at university level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. The PolSARpro v2.0 software establishes a foundation for the exploitation of polarimetric techniques for scientific developments and stimulates research and applications developments using PolSAR and PolInSAR data [C878]

"Polarimetric SAR with simultaneous backscattering matrix estimation"

In the paper the concept of a polarimetric SAR performing a simultaneous full target backscattering matrix estimation is proposed. The block diagram of the system and the signal processing algorithms are developed; main characteristics of the system are defined. Simultaneous backscattering matrix estimation implemented in the system allows avoiding errors existing in other systems. SAR PHARUS (P. Hoogeboom et al., 1992), developed in FEL TNO, that performs pulse-to-pulse method of BSM estimation, and the project of radar COMESA jointly performed by IRCTR TUDelft and TUCSR (2004) are used as prototypes [C879]

"New eigenvalue-based parameters for natural media characterization"

The aim of this paper is to present two novel polarimetric parameters, the eigenvalue relative difference (ERD) and the single bounce eigenvalue relative difference (SERD), to characterize natural media. These parameters are derived from the eigen-decomposition of the coherency matrix considering the reflection symmetry hypothesis. An analysis of these parameters is performed on multi-frequency polarimetric SAR data acquired on bare soils and forested areas [C880]

"Influence of acquisition conditions on forest classification using L-band Pol-inSAR data"

This paper introduces an approach to forest mapping and classification using complementary polarimetric and interferometric information. Strictly polarimetric and polarimetric interferometric data are first analyzed and classified separately. Pertinent polarimetric indicators permit to classify the observed scene into three canonical scattering types, whereas the segmentation of an optimized interferometric coherency set leads to the discrimination of decorrelating volumetric media used ton infer a forest map. The classification of forest constituents is achieved by means of a supervised Pol-inSAR classifier. The influence of temporal and spatial baselines is investigated and it is shown that temporal decorrelation may be a severe limitation for forest classification at L band [C881]

"Time-frequency analysis of polarimetric SAR images"

This article demonstrates the usefulness of time-frequency tools in SAR imagery through two applications. A new method is proposed to analyse moving targets. It uses a two dimensional matching-pursuit algorithm, over a time-frequency dictionary. Point targets speed and scattering characteristics (frequency comportment, angular and polarimetric behaviour) can be retrieved, thus permitting a better knowledge of the target. Urban areas analysis is carried on in a time-frequency framework. The behaviour of pixels in the frequency domain is studied and employed as an input for two new indicators, allowing a classification of urban areas pixels [C882]

"Quantitative assessment of physical information retrieved via multidimensional radar systems"

The advent of multidimensional synthetic aperture radar (SAR) systems in the last decade has made possible the quantitative retrieval of physical parameters to characterize the Earth's surface. As a result, nowadays, radar

technology has an important and leading role in remote sensing. Despite the clear advantages respect to other remote sensing techniques, the presence of speckle noise in SAR systems represents still an important drawback, which is even more critical for multidimensional systems. This paper is devoted to present a novel multidimensional speckle noise model which, as demonstrated, allows the characterization of multidimensional data and permits to identify and quantify the effects of speckle in the process to estimate physical information. Special attention is devoted to polarimetric systems [C883]

"Dry snow extent monitoring using multi-frequency and multi-temporal polarimetric indicators"

A new method to discriminate dry snow in alpine regions is presented. Due to the wide variety of Alpine environments, the scene under study is first segmented into surface and forested area classes from L and C-band summer polarimetric SAR data. Dry snow is then discriminated over each class using adapted methods. A new polarimetric multi-temporal optimization procedure, named PCVE, is proposed to increase the slight polarimetric contrast due to the presence of snow over surfaces. Snow covered forests are discriminated using performing polarimetric indicators resulting from a decomposition of incoherent matrix representations. The effectiveness of this method is demonstrated over a French alpine test site using SIR-C L and C-band polarimetric SAR data [C884]

"Reliability of detection of radar signals from hailstones by using parametric and non-parametric algorithms"

New algorithms for polarimetric radar signals processing were developed and applied for the detection of hail zones in clouds and precipitation. This paper presents and analyzes two algorithms: parametric algorithm and adaptive non-parametric algorithm. Reliability of detection of radar signals from hailstones is investigated by statistical simulation with application of experimental researches as initial data. The results demonstrate the limits of both algorithms as well as higher viability of non-parametric algorithm. Polarimetric algorithms are useful for the implementation in ground-based and airborne weather radars [C885]

"Polarimetric SAR with simultaneous backscattering matrix estimation"

In the paper the concept of a polarimetric SAR performing a simultaneous full target backscattering matrix estimation is proposed. The block diagram of the system and the signal processing algorithms are developed; main characteristics of the system are defined. Simultaneous backscattering matrix estimation implemented in the system allows avoiding errors existing in other systems. SAR PHARUS (Hoogeboom et al., 1992), developed in FEL TNO, that performs pulse-to-pulse method of BSM estimation, and the project of radar COMESA jointly performed by IRCTR TUDelft and TUCSR (Project EWI 04 044, 2004) are used as prototypes. [C886]

"C-band, narrow pulse, polarimetric Doppler-scatterometer for platform application"

In this paper C-band (5.6 GHz), polarimetric (dual polarization), narrow pulse (30 ns) Doppler scatterometer is described. The scatterometer was developed for a short distance (6.5 m) remote sensing application and for simultaneous and coincident measurements of water surface microwave reflective and backscattered signal's spectrum characteristics. In spite of the system was developed for a platform application, it may have successful vessel and airborne application for both land and sea surface remote sensing. [C887]

"Utilization of fully polarimetric SAR data for improved measurement of directional ocean wave spectra"

New methods have been investigated which use fully-polarimetric synthetic aperture radar (SAR) image data to measure ocean wave slope spectra. Independent techniques have been developed to measure wave slopes in the orthogonal SAR (azimuth/range) directions. These measurements must still contend with motion-induced nonlinearities in the SAR processing. The methods are, however, physically based, robust, and utilize a parametrically simpler modulation transfer function. NASA/JPL/AiRSAR L-band data from California coastal waters has been used. Wave spectra measured using the new methods are compared with spectra developed using both conventional SAR intensity-based methods and NDBC buoys. [C888]

"A measuring complex of polarimetric, combined radar-radiometers of S-, and Ku-band of frequencies for vessel and airborne application"

A complex of polarimetric (dual polarization), combined active-passive devices of S (3 GHz), and Ku-band (20 GHz) of frequencies for sea surface microwave reflective and emissive characteristics simultaneous and coincident measurements is presented. The complex is dedicated to solve the problem applied to near sea surface wind and surface wave fields' parameters precise and unambiguous retrieval, as well as for sea surface

signatures detection and identification. Developed systems are set on a mobile bogie moving on the height of 6.5 m along a stationary platform of 26 m of length. The measuring platform allows carry out polarimetric (vv, vh, hh, hv), multifrequency, simultaneous and coincident measurements of pool water surface microwave reflective and emissive parameters at the same or at various angles of incidence from the while of 0-60°. This paper has an aim to attract attention of researchers interested in measurements by such kind sensors and to invite them to perform their own or joint measurements using available microwave devices and in-situ and calibration facilities. [C889]

"A "Real-like" polarimetric weather radar data generation using physical and statistical models"

Realistic model of rain radar returns is of interest to improve the performances of rainfull estimation applications and to develop new approximations in case of lack of measured data-bases. In this paper, we propose a method to generate a "Real-like" polarimetric rain radar data based on a dual approach referring to both a physical and a statistical models of rain target. Combining informations from these two models accords us an opportunity to obtain more realistic results than a single model based approach. Theoretical foundation of the actual work was exposed all along the paper. An example of data generation, for a fixed physical configuration, was given so as to illustrate comparison between ideal and realistic rain radar data. [C890]

"Satellite calibration and validation utilizing the Airborne Polarimetric Microwave Imaging Radiometer (APMIR)"

The Airborne Polarimetric Microwave Imaging Radiometer (APMIR) was designed and built by the Naval Research Laboratory, Washington, D.C., as a tool for calibration and validation of the Coriolis WindSat and Defense Meteorological Satellite Program SSMIS satellite radiometer sensors. The satellite sensor data aids in short-term weather modeling and general climatic information via measurements of ocean winds, water vapor, soil moisture, rain rates, and ice/snow characteristics. The APMIR sensor was designed to assist in the fulfillment of the airborne portion of the calibration/validation effort. By underflying a satellite, the airborne sensor data is coincident in space and time with the satellite, allowing an accurate comparison of the viewed scene. Extensive testing of the APMIR system included tip curves, pool views, and radiative transfer model comparisons. The encompassing test methods achieve a high degree of confidence in the APMIR system. APMIR underflew the SSMIS satellite during a March/April 2004 field campaign. Based on the high confidence of the APMIR sensor, and the excellent data comparison of the SSMIS satellite, the APMIR instrument demonstrates itself as a precision tool for calibration and validation activities. The results of the underflights during the March/April 2004 field campaign for the SSMIS satellite are presented. [C891]

"The signal processing system design of polarimetric weather radar using DSP and FPGA"

A new signal processing system of polarimetric Doppler weather radar is described in this paper. The new system is based on advanced Altera FPGA stratix 1S25 and Analog DSP TS101. The new system follows in the footsteps of the Chinese new generation radar (CINRAD) hardwired signal processor (HSP). The simulation results and test results are also described in the paper. [C892]

"Novel Features for Polarimetric SAR Image Classification by Neural Network"

This paper presents a set of effective features derived from the coherence matrix of polarimetric SAR data. Neural network is used as the classification engine. The maximum likelihood estimator (MLE) result is used as the reference to compare the result of the proposed method. It is demonstrated that the average classification accuracy by the proposed method is more than that by the MLE. The maximum overall efficiency obtained by the proposed method is 95.4% [C893]

"PolSARpro v2.0: the versatile polarimetric and interferometric SAR data processing toolbox"

The objective of this paper is to make a review of the current status of the PolSARpro v2.0 Software (polarimetric SAR data processing and educational toolbox), developed under contract to ESA ("Development of a polarimetric SAR image analysis tool", ESA-ESRIN Contract n° 17863/03/I-LG) by a consortium comprising I.E.T.R at the University of Rennes 1, DLR-HR and University of Adelaide. The objective of this current project is to provide Educational Software that offers a tool for self-education in the field of polarimetric SAR data analysis at University level and a comprehensive suite of functions for the scientific exploitation of fully and partially polarimetric multi-data sets and the development of applications for such data. The PolSARpro v2.0 software establishes a foundation for the exploitation of polarimetric techniques for scientific developments and stimulates research and applications developments using PolSAR and PolInSAR data. [C894]

"A cross-entropy based parameter for ship detection from a polarimetric SAR image"

A cross-entropy based parameter is proposed to measure the difference between a river area and others. This parameter can be employed for ship detection from a polarimetric SAR image. After deciding the boundaries of the river area, ships are detected only in the river area instead of the whole site. Therefore, most of the false alarms are eliminated. Finally, the performance of this new approach is validated by the X-band full polarimetric SAR data in Niigata area of Japan [C895]

"Speckle filtering of polarimetric SAR image and the enhancement for classification"

In this paper, a new approach to speckle filtering of synthetic aperture radar (SAR) data is presented. We define a parameter space consisting of two orthogonal subspaces-the signal subspace and the noise subspace. Then, the full polarimetric information from the signal subspace is obtained after speckle filtering. Moreover, edges of different kinds of targets are preserved. Using polarimetric SAR data, the effectiveness of the proposed method is not only validate by the standard-deviation-to mean ratio, but also by target classification [C896]

"Polarization target detection algorithm based on instantaneous Stokes sub-vector"

Firstly, the statistics of random polarized wave's instantaneous Stokes sub-vector is analyzed and its probability density function (PDF) is obtained. Secondly, the target detection problem is skillfully translated into the detection problem of three equivalent polarization signals. Thereby, a novel fusion detection algorithm is presented based on the difference statistical distribution of Stokes sub-vector between targets and clutters. Experimental results show that no matter the target is random polarization or invariable polarization, the algorithm is effective. Its performance can be comparative to that of the optimal polarization detector (OPD) and better than that of the polarization white filtering detector (PWF). Considering variable conditions of polarimetric measurements, it can be used more widely than the optimal polarization detector [C897]

"Calibration of ALOS/PALSAR polarimetric data affected by faraday rotation"

{no data available} [C898]

"A framework for investigating space-borne polarimetric interferometry using the ALOS-PALSAR sensor"

{no data available} [C899]

"Ship detection in SAR images using multi-polarimetric information"

{no data available} [C900]

"Applying polarimetric SAR interferometric data for forest classification"

{no data available} [C901]

"A unified model for decomposition of coherent and partially coherent target scattering using polarimetric SARs"

{no data available} [C902]

"PolSARpro v2.0: the polarimetric SAR data processing and educational toolbox"

{no data available} [C903]

"Investigation of physical characteristics of intertidal zone using NASA/JPL fully polarimetric AIRSAR data"

{no data available} [C904]

"Polarimetric doppler measurements for weather radar applications"

{no data available} [C905]

"The role of LiDAR data in understanding the relation between forest structure and SAR imagery"

{no data available} [C906]

"A comparisons of model based and image based surface parameters estimation from polarimetric SAR"

{no data available} [C907]

"Examination of the semi-empirical polarimetric scattering model using field-measured data and existing theoretical models"

{no data available} [C908]

"New blind source separation technique for removing vegetation bias in polarimetric SAR interferometer measurements"

{no data available} [C909]

"COBRA 94-ultra broadband experimental radar for ISAR applications"

For airborne reconnaissance day/night/all-weather capability and high resolution of imaging radar sensors is mandatory. For the development of related processing algorithms an experimental, polarimetric 94-GHz radar has been developed using a FM/CW waveform with a bandwidth of 4000 MHz resulting in a resolution [C910]

"Multi-campus courses via video conference: an assesment"

In order to increase the level and continuity of research at the University of Puerto Rico at Mayaguez, a memorandum of understanding (MOU) has been developed and signed between this institution and two universities in the U.S. to establish a collaborative doctoral program. The students accepted in this program obtain their PhD degrees from one of the U.S. universities, but perform most of their research work at UPRM. As part of these collaborative programs and as part of the NSF Engineering Research Center CASA, the students have the capability to take courses given by faculty in other campuses and attend research meetings via video conferencing. This effort has been possible thanks to the strong collaboration among professors from the four campuses involved in the Collaborative Adaptive Sensing of the Atmosphere Engineering Research Center (CASA). The CASA core partners are UPRM, CSU, OU and UMass. Two such courses took place in the Spring semester of 2005; these are "Polarimetric Doppler Weather Radar" by Dr. V. Bringi from CSU and "Hazardous Weather Detection" by Kelvin Droegemeier from OU. Another course in the fall of 2003 was also offered from OU to UPRM students by Dr. Yeary. Some of the challenges found during the development of these courses have been administrative, technical and of personnel. [C911]

"Polarimetric SAR Region Boundary Detection Using B-Spline Deformable Countours under the G^H Model"

In this paper a new approach to polarimetric Synthetic Aperture Radar (SAR) image region boundary detection is presented. It is based on a new model for polarimetric SAR data and the use of B-Spline active contours for image segmentation. In order to detect the boundary for a region, an initial B-Spline curve is specified and the proposed algorithm uses a deformable contours technique to find the boundary. In doing this, the statistical parameters of the polarimetric G^H model for the data are estimated, in order to find the transition points between the region being segmented and the surrounding area. This algorithm can be regarded as a local one, in the sense that it works on the region to be segmented instead of on the whole image [C912]

"Space-time ambiguity matrices for synthetic aperture radar"

In the paper the concept of space-time ambiguity matrices of radar signals is introduced and investigated for polarimetric synthetic aperture radar. The results can be used for signal processing optimization in polarimetric SAR systems and their potential performance estimation [C913]

"Applications of polarimetric interferometric ground-based SAR (GB-SAR) system to environment monitoring and disaster prevention"

Polarimetric and interferometric ground-based synthetic aperture radar (Pol-GB-SAR, In-GB-SAR) system has been developed. In this paper, two measurements of outdoor test sites in polarimetric and interferometric configurations are introduced and results are presented. In the developed In-GB-SAR system, the technique of differential interferometry is used to detect small changes at different times and under different conditions.

Experimental results demonstrate that the system is very efficient and can detect small changes of the scale of 2 cm at the range distance of 5 m. Polarimetric analysis was done using the Pol-GB-SAR system with a coniferous tree as a target. The system has superior ability in polarimetric applications. Applying polarimetric and interferometric analysis which were developed for spaceborne and satellite radar remote sensing datasets, we can find detailed scattering mechanisms and detect deformations. The GB-SAR has a wide range of applications like environmental monitoring, resources management as well as monitoring of different natural phenomena [C914]

"The story of Glory: Earth and solar science on one unique satellite"

The Glory satellite program is underway at the orbital sciences campus in northern Virginia. This program is under contract with NASA Goddard Space Flight Center (GSFC). The Glory satellite bus was previously used for the vegetation canopy LIDAR (VCL) program, a mission designed to measure the Earth's vegetation coverage, depth, and topography by using short laser pulses from a LIDAR (light detection and ranging) system. The Glory program is refurbishing the VCL bus that was in the middle of integration and test when the VCL program was shut down. Many changes are being made to the VCL bus to configure it to serve the Glory science mission objectives. The Glory science mission includes polar atmospheric aerosol measurements with cloud observation and total solar irradiance monitoring. The low Earth orbit satellite (LEO) is scheduled for launch in late 2007 with the intention of broadening the search for the causes of global warming. The mission is intended to measure the composition of greenhouse gases, which little is known about currently, as well as solar effects on the environment using the following instruments: an aerosol polarimetry sensor (APS), cloud cameras and a total irradiance monitor (TIM). The APS instrument is a multispectral polarimetric sensor designed for collection of visible, near-infrared, and shortwave infrared polarized radiometric data scattered from aerosols and clouds. The APS is a continuous scanning, nadir-viewing sensor that makes along-track, multiangle observations of Earth and atmospheric spectral radiance. The cloud cameras are dual-band, imagers that employ a nonscanning, staring detector array that is akin to a star tracker, but Earth-viewing. The cloud cameras provide continuous cross-track coverage over a narrow swath centered on the APS along-track footprint using an optical imaging system. The TIM is an active cavity solar irradiance radiometer that consists of four identical radiometer cavities to provide redundancy and help- detect changes in instrument response caused by exposure to solar radiation and other orbital effects. It takes data continuously throughout the orbit and does periodic calibrations on the disc of the sun and of the redundant cavities to monitor the effects of aging. Using a combination of heritage data and knowledge from the Orb View 3 and 4 programs as well as VCL, the Glory program is dedicated to a successful mission. This paper describes the design differences at system and subsystem levels between VCL and Glory focusing on the science missions, as well as the heritage program influences that are employed. [C915]

"Ka-band, short pulse, polarimetric, combined Doppler radar-radiometer system"

{no data available} [C916]

"A complex of polarimetric, combined, short pulse radar-radiometers of S-, Ku, and Ka -band of frequencies for platform and vessel application"

{no data available} [C917]

"TerraSAR-X: science exploration of polarimetric and interferometric SAR"

{no data available} [C918]

"Level set curve evolution partitioning of polarimetric images"

We investigate a method of segmentation of multichannel polarimetric images, such as in laser illuminated or synthetic aperture radar, into a given but arbitrary number of regions via curve evolution and level sets. The algorithm consists of evolving closed curve, within an explicit correspondence between the interiors of curves and regions segmentation, to minimize a multivariate criterion corresponding to the complex Gaussian polarimetric model and a term of smoothness of the boundaries of regions. Results are shown on a polarimetric image. [C919]

"Optimum polarization for foliage camouflaged target discrimination using a genetic algorithm"

The coherent scattering model can be ran for many realizations of foliage around a hard target to obtain the statistical variations of foliage and target response in a Monte Carlo simulation. Foliage camouflaged target detection at low microwave frequencies is investigated, using a powerful foliage and hard target simulation tool

which accounts for near-field interactions between the hard target and foliage. Based on fully polarimetric simulation results of a foliage camouflaged metallic target a polarization synthesis optimization method for improving signal to clutter is examined. A genetic algorithm is implemented for finding an optimal set of radar transmit and receive polarizations that maximizes target backscatter to clutter ratio [C920]

"Characterization of the electromagnetic response of maize crops with polarimetric backscatter profiles"

An exhaustive analysis of the electromagnetic response from a maize sample, measured in laboratory conditions, is presented. Fully polarimetric wide-band radar data have been collected in order to compute backscatter profiles (i.e. 1D images) as a function of height. First results consist on backscatter images expressed in Pauli and linear basis. These plots demonstrate that the extinction coefficient is higher for vertical polarization than for horizontal polarization due to the predominant vertical orientations of the components of the corn plants (mainly the stems). In addition, the crosspolar backscattered power decreases importantly as the frequency increases, and it is always lower than the copolar returns, again as a result of the oriented morphology, which produces a very low depolarization of the signal. On the other hand, the second kind of results is based on the polarimetric target decomposition proposed by Cloude and Pottier. Height profiles of alpha, entropy and anisotropy have been calculated. These parameters have been carefully analyzed in order to extract information to be used in the application of parameters inversion algorithms [C921]

"Pipeline encroachment monitoring using polarimetric SAR imagery"

Mechanical damage incurred from unauthorized third party activities remains a leading cause of onshore oil and gas pipeline failure, indicating the need for effective strategies to monitor encroachment over extensive sections of pipeline right-of-way (ROW). In this paper, the use of polarimetric SAR imagery (as will be available from RADARSAT-2) for pipeline monitoring of encroachment activities is explored. Experimental data were acquired of a test area near the shores of Lake Simcoe (north of Toronto, Ontario) in September 2001 by the C-SAR on board the Convair-580. The vehicle deployments and ground truthing were conducted by C-CORE with processing from signal data (including calibration) and analysis performed at the Canada Centre for Remote Sensing [C922]

"Improvement of polarimetric SAR calibration based on the Quegan algorithm"

The polarimetric cross-talk calibration algorithm proposed by Quegan, which is more general than the one proposed by van Zyl, is modified to improve polarimetric SAR calibration. L-band polarimetric SAR data acquired by the JAXA/NICT airborne Pi-SAR, including a variety of natural and artificial targets, are calibrated introducing noise imbalance of cross-polarized channels into the Quegan algorithm and deriving the cross-talk parameters from areas with low correlation between like and cross-polarized observed echoes. The achieved enhancement in stability of cross-talk parameter estimation and removal over is demonstrated in terms of CR response analysis and polarimetric classification result [C923]

"Matching-pursuit based analysis of fluctuating scatterers in polarimetric SAR images"

This paper addresses the problem of moving and nonstationary objects analysis in SAR images. A method, based on Matching Pursuit (MP) algorithm is proposed to decompose the SAR signal into a set of chirplets. Chirplets parameters can be related to physical characteristics of the SAR scene constituents and used to produce a multidimensional polarimetric bright point model of the object of an observed object [C924]

"Polarimetric SAR image classification-exploiting optimal variables derived from multiple-image datasets"

Polarimetric SAR image classification remains an important research area. Various methods continue to be developed for specific applications. Instead of focusing upon one specific problem, we have developed nonlinear dimensionality reduction techniques that extract information from inherently high dimensional datasets. We present computationally tractable, suboptimal extensions of the full nonlinear dimensionality reduction techniques. We apply these suboptimal techniques to polarimetric SAR image classification. Comparisons will be made between optimal and suboptimal techniques, and, as a reference, to standard statistical Wishart classifiers. [C925]

"Influence from polarized galactic background noise on L-band measurements of the sea surface salinity"

The polarimetric EMIRAD radiometer, based on novel digital down conversion and detection techniques, has

been installed on a C-130 aircraft from the Royal Danish. Air Force during the L-band Ocean Salinity Airborne Campaign (LOSAC) in 2001 and 2003. Full 360° circle flight patterns around the same target area as well as clover leaf patterns have been measured, and both provide an azimuth signature of the ocean at a constant incidence angle. The resulting azimuth signatures show significant variations in all the three first Stokes parameters, and a correlation is found between the downwelling galactic background signal and the measured results. The measured 3rdStokes parameter has variations of the same order of magnitude as the two linear polarizations, and to verify this result, an experiment for direct observation of the sky over long time is set up. This experiment confirms the presence of a polarized galactic background signal, and conclusions are made with respect to the necessity for polarimetric corrections in future measurements over the sea at L-band. [C926]

"Full maximum likelihood inversion of polinsar scattering models"

We expand upon the maximum likelihood inversion approach presented in Flynn, Tabb, and Carande ["Direct estimation of vegetation parameters from covariance data in polarimetric SAR interferometry", IGARSS 2002], and show how to optimally combine the polarimetric channels to form a bare earth estimate for the case of single layer ground scattering. In addition, for the two layer randomly oriented volume over ground (RV+G) scattering model, we show how to optimally recover the canopy structural parameters (bare earth and tree height) as well as the ground and volume backscatter polarimetric covariance matrices. This approach outperforms other techniques in terms of both estimation accuracy and computational complexity [C927]

"Retrieval of height and topography of corn fields by polarimetric SAR interferometry"

Polarimetric SAR interferometry (Pol-InSAR) has been applied successfully to retrieve biophysical parameters from forest areas. This technique employs a scene model composed of a random volume over the ground. However, that model is based on the assumption that the wave propagation through the vegetation canopy is independent of polarization, which is not valid for agricultural crops because the medium shows a strong anisotropic behavior. In this work we have studied the implications of the polarization dependence of the extinction coefficients, and a redefinition of the line fit inversion model is proposed and validated with indoor measurements. As we will show, provided that agricultural vegetation is short, the influence of the different extinction coefficient is minor. Consequently, it is demonstrated that an accurate inversion of the vegetation height and the underlying topography is still possible. However, it is also shown that the model is not sensitive to changes in the extinction coefficient, so this parameter is not well estimated. Implications about the necessity of fully or partially polarimetric data have been also analyzed [C928]

"Local orientation analysis of spatial texture from polarimetric SAR data"

In this paper we present two methods to estimate the local orientation of spatial texture in polarimetric SAR data. The first approach is based on an original spatial parametric modelling of the 2D autocorrelation function, and was introduced in a previous paper. The second method is based on orientation interpolation between a reduced set of basis functions called steerable filters. Both are applied to measured polarimetric SAR data [C929]

"On the assimilation of C-band radar data into CERES-wheat model"

Based on recent experimental studies which have found a strong correlation between a multitemporal series of C-band HH/W backscatter ratios acquired at 40deg incidence angle and wheat biomass, this work investigates the effect of the assimilation of the radar retrieved information into CERES-Wheat crop model. A sensitivity analysis has shown that an inaccurate knowledge of some model inputs, concerning soil properties and crop management, can lead to erroneous predictions. However adopting a reinitialisation assimilation strategy, significant improvements in the model estimations have been obtained [C930]

"3-D broadband ground-based polarimetric SAR data processing for the monitoring of vegetation growth variations"

SAR is usually used for airborne or space borne remote sensing. It can also advantageously be exploited in a ground-based radar imaging system named Ground-based SAR (GB-SAR). We extended earlier approaches and developed an ultrawideband, ground-based, fully polarimetric SAR (Pol-GB-SAR) system for the monitoring of vegetation growth variations. Measurements on three type trees in different conditions were carried out by the developed SAR system. We proposed effective 3D broadband Pol-GB-SAR data processing algorithms in the paper. In situ polarimetric calibration obviously improved the features of the system. 3D images were reconstructed from the acquired data by a series of signal processing procedures based on a variety of wave equation migration methods. By implementing methods of radar polarimetry, the broadband GB-SAR system has possibility for monitoring changes in tree structure characteristics due to seasonal variations. Interpreted results

demonstrated the target scattering characteristics in different vegetation growth situations showed good agreement with the ground truth [C931]

"A study of rough surface thermal emission and reflection using Voronovich's small slope approximation"

Monte Carlo simulations are used to compute average direct surface thermal emission and reflected atmospheric radiation using the "active" small slope approximation of Voronovich. The surface used are realizations of an ocean-like spectrum, and contain features ranging from 64 to 0.5 electromagnetic wavelengths. The parallel computing approach used in these simulations is described, and results are compared with predictions from the commonly applied "two-scale" theory of sea emission. Results show a reasonable level of agreement in a small height surface case, which degrades as the surface height is increased [C932]

"Windsat validation using seawinds, windrad and polscat mesaurements"

Global mapping of near surface ocean wind vectors is crucial for many oceanographic and atmospheric studies. The US Navy together with the National Polar Orbiting Environmental Satellite System (NPOESS) launched the WindSat with multifrequency polarimetric radiometers in January 2003 to demonstrate the passive polarimetry for large spatial coverage of ocean surface wind vector measurements from space. We derived the geophysical model function (GMF) for Windsat polarimetric brightness temperature measurements using six months of matchup dataset. The Windsat GMF was compared with the aircraft radiometer and radar measurements and the SeaWinds scatterometer winds with good agreement up to about 20 m/s wind speed [C933]

"Use of backscatter differential phase in weather surveillance radars"

The polarimetric technique consists of simultaneous transmission and reception of Horizontally and Vertically polarized waves. Thus, transmitted polarization will be elliptical with equal horizontal and vertical components and arbitrary phase between the two. This scheme has been tested at NSSL on the NOAA research and development WSR-88D radar. Here reports on backscatter differential phase measurements with this radar. The radar also has a mode of transmitting horizontal polarization and receiving both the strong H and the weak V component (for short we refer to this mode as Linear Depolarization Ratio mode, LDR). Backscatter differential phase is considered a secondary polarimetric variable of lesser value for precipitation measurements than (the forward) specific differential phase or differential reflectivity. This is because backscatter differential phase is seldom significant. At 10 cm wavelength the only precipitation that can cause appreciable backscatter differential phase is hail. But it turns out that backscatter differential phase from other scatters provides two benefits. (1) it is suitable for discrimination between nonmeteorological scatters and precipitation and (2) it offers a way to calibrate (measure) the system differential phase. Of relevant and special importance is that, for some scatters, the measured total differential phase in the SHV scheme can differ from the value obtained in the sequential H, V scheme. The radar system contributes two distinct phases to the total differential phase. One is the differential phase in the transmission channel, the other is the differential phase in the receiver channel [C934]

"Biomass estimation from polarimetric SAR interferometry over heterogeneous forest terrain"

Polarimetric SAR interferometry (Pol-InSAR) permits an accurate forest height extraction by inverting the SAR data with the Random Volume over Ground-model (RVoG). These forest heights were subsequently converted to forest biomass through forest height-biomass relation (allometry). Both the height extraction (L-band) and the allometric biomass conversion proved a good performance over dense forest stands. In open forests and stands of variable canopy height (here referred to as heterogeneous stands), the behaviour of the height extracting algorithm is unknown, and height-biomass allometry cannot easily be applied. To facilitate a direct biomass comparison of the Pol-InSAR-height extraction with ground measurements, the effective height heffwas introduced as a direct biomass equivalent. Examples from spruce dominated sites of variable stand densities showed a sensitivity of the height extraction to the stand density, though not in correlation with the heff. It might be promising to exploit additional information from the shape of the extracted heights-histogram for an accurate biomass estimation even over dense and heterogeneous forests [C935]

"Repeat pass SAR interferometry of the Pi-SAR (L) for DEM generation"

This paper describes generation of the digital elevation model (DEM) using the L band repeat pass airborne polarimetric Interferometric SAR (Pi-SAR) system, which is jointly developed by Japan Aerospace Exploration Agency (JAXA) and National Institute for Communication Technology (NICT). An image pair acquired over the Tottori calibration site in 2000 had a baseline of less than hundred meters and was used for this interferometric data analysis. Although the quantitative evaluation has not been conducted, the result shows that the detailed feature of the topography in the target area was well obtained [C936]

"Microwave remote sensing: a perspective from the last few field experiments"

There have been numerous field experiments which have tested the effectiveness of microwave remote sensing, both active and passive under varied land surface conditions. The Southern Great Plains Experiment 1999 (SGP99) was held in Chickasha Oklahoma where winter wheat and rangeland was the predominant land surface type whereas at the Soil Moisture Experiment 2002 (SMEX02) in Walnut River watershed in Ames Iowa it was a mixture of corn, and soyabeans. In the SMEX03 (Soil Moisture Experiment in 2003) in Little River Watershed, the land surface was a mixture of peanuts, vegetables, cotton and pasture and for SMEX04 (Soil Moisture Experiment in 2004) in Walnut Gulch, Arizona, the land surface cover is primarily brush and grass covered rangeland vegetation. Given that microwaves have low sensitivity to soil moisture in the presence of vegetation, these field experiments offer an opportunity to examine observations of sensitivity in the presence of varied (and varying with time) vegetation densities. In addition, in each of these experiments, there were different instruments on aircrafts and satellite sensors that were deployed. In SGP99, we had observations from the PALS (Passive Active L and S band Radar and Radiometer), PSR (Polarimetric Scanning Radiometer) from the C130 aircraft and the TMI (TRMM Microwave Imager) and SSM/I (Special Sensor Microwave Imager) from space. In SMEX02, we had PALS, PSR, AIRSAR (Airborne Synthetic Aperture Radar) from the aircraft platforms and in SMEX03 PSR only. Satellite sensors in SMEX02 and SMEX03 included AMSR (Advanced Microwave Scanning Radiometer), TMI, and SSM/I. In the recently concluded SMEX04, PSR was used from the aircraft and AMSR, TMI and SSM/I satellite observations were available. We will use these sensors and observations in the microwave channel in conjunction with ground observations of vegetation characteristics and soil moisture to study the sensitivity of microwaves to soil moisture under varied land surface conditions. [C937]

"Polarimetric analysis of scatterometer data for ocean surface wind measurement"

An experiment using a polarimetric scatterometer (POLSCAT) has been conducted by JPL for ocean surface wind measurement. It shows that sigma0values for HH, VV, HV, and VH have the property of even symmetry with respect to the upwind direction, and correlation coefficients between co- and cross-polarizations have the odd symmetry property. In this paper, the symmetry properties will be further examined using polarimetric analysis to investigate the depolarization effect, the scattering mechanism, and the polarization orientation angle. Theoretical results based on a two scale model are used to verify the derived experiment results. The newly derived symmetry property has the potential to solve the 180deg ambiguity in wind direction, and to enhance the accuracy of wind vector measurements [C938]

"Knowledge-based sea ice classification by polarimetric SAR"

Polarimetric SAR images acquired at C- and L-band over sea ice in the Greenland Sea, Baltic Sea, and Beaufort Sea have been analysed with respect to their potential for ice type classification. The polarimetric data were gathered by the Danish EMISAR and the US AIRSAR which both are airborne systems. A hierarchical classification scheme was chosen for sea ice because our knowledge about magnitudes, variations, and dependences of sea ice signatures can be directly considered. The optimal sequence of classification rules and the rules themselves depend on the ice conditions/regimes. The use of the polarimetric phase information improves the classification only in the case of thin ice types but is not necessary for thicker ice (above about 30 cm thickness) [C939]

"Spiral eddy detection using surfactant slick patterns and polarimetric SAR image decomposition techniques"

Surfactant slicks are widely dispersed throughout the oceans. Current driven features, such as spiral eddies, can be made visible by associated slick patterns. In this study a combined algorithm using the Cloude-Pottier decomposition and the Wishart classifier is presented to produce accurate maps of slick patterns. The study then uses the classified slick patterns to detect spiral eddies. The competing background wave-field is eliminated. Satellite SAR instruments performing wave spectral measurements, or operating as wind scatterometers, regard the slicks as a measurement error-term. The maps produced by the algorithm facilitate the flagging of slick contaminated pixels within the image [C940]

"Applying a common allometric equation to convert forest height from Pol-InSAR data to forest biomass"

Forest biomass (wood volume) is the most integrative forest structural parameter. Since no remote sensing technique can measure wood volume or biomass directly, a direct biomass determination from air- or spaceborne images always has a regression character. A different approach is to estimate forest biomass indirectly from a

forest parameter that can be extracted more accurately than biomass, of which forest height is the closest related one. This makes it possible to utilize remote sensing methods that extract forest heights for biomass assessments: stereoscopic aerial photography, Lidar and Pol-InSAR. In this paper, forest heights were extracted from polarimetric interferometric SAR data (Pol-InSAR) over the spruce dominated test site `Fichtelgebirge'. The extracted heights proved a good correlation with the upper canopy height (h100, top height), and could be converted into forest biomass by means of height-biomass allometry. On this basis, the potential of Pol-InSAR systems for forest biomass estimation is critically discussed, and directions towards a performance optimisation are pointed out [C941]

"Optimum polarimetric analysis of backscattering from rough sea surface"

Using SIR-C/X-SAR that provided simultaneously images of Southern-China Sea at three microwave wavelengths, L-band quad-polarization, C-band quad-polarization and X-band with VV polarization, the present paper calculate and analyze the optimum polarization of the backscattering from the rough sea surface. The utmost applications of radar remote sensing of ocean come down to quantitative derivation of some oceanographic parameters instead of simple interpretation of patterns on the SAR image itself of ocean surface. Accordingly, we concern mainly the polarimetric parameters of return signals from sea surfaces relate some physical oceanographic variables. Since the backscattering matrix contains the backscattering information of moving sea surface, concentration should be on understanding the properties of this matrix alone. Meanwhile, polarization is a key to aim this goal. A physical approach is to study polarization optimization. The optimization result shows that an optimum polarization changes with position of sea surface. And as a heuristic derivation, we prove that there exist optimum polarimetric responses with orientations at all sea-wind conditions. [C942]

"Pol-InSAR for agricultural vegetation parameter estimation"

The quantitative bio/geo physical agricultural and land-use parameter estimation has attained significant prominence as it is a challenge to quantify complex and fast changing media in terms of geometry and material properties. In this work the behavior of agricultural vegetation in terms of polarimetric interferometric SAR (Pol-InSAR) observables is investigated. For this a two layer model, the Oriented Volume over Ground (OVoG) model, is discussed and validated against experimental data [C943]

"Data processing for mine-detection polarimetric ground penetrating radar array"

First Page of the Article [C944]

"Wave field decomposition of full-polarimetric data based on the two-way wave equation"

First Page of the Article [C945]

"Autonomous UXO classification using fully polarimetric GPR data"

First Page of the Article [C946]

"From airborne via drones to space-borne polarimetric-interferometric SAR environmental stress-change monitoring-comparative assessment of applications"

Very decisive progress was made in advancing fundamental POL-IN-SAR theory and algorithm development during the past decade. This was accomplished with the aid of airborne and shuttle platforms supporting single-to-multi-band multi-modal POL-SAR and also some POL-IN-SAR sensor systems, which are compared and assessed with the aim of establishing the hitherto not completed but required missions such as tomographic and holographic imaging. Because the operation of airborne test-beds is extremely expensive, aircraft platforms are not suited for routine monitoring missions which is better accomplished with the use of drones or UAVs. Such unmanned aerial vehicles were developed for defense applications, however lacking the sophistication of implementing advanced forefront POL-IN-SAR technology. This shortcoming is thoroughly-scrutinized resulting in the finding that we do now need to develop the most rapid POL-IN-SAR drone-platform technology especially for environmental stress-change monitoring with a great variance of applications beginning with flood, bush/forest-fire to tectonic-stress (earth-quake to volcanic eruptions) for real-short-time hazard mitigation. However, for routine global monitoring purposes of the terrestrial covers neither airborne sensor implementation-aircraft and/or drones-are sufficient; and therefore multi-modal and multi-band space-borne POL-IN-SAR space-shuttle and satellite sensor technology needs to be further advanced at a much more rapid phase. The existing ENVISAT with the forthcoming ALOS-PALSAR, RADARSAT-2, and the TERRASAT are compared, demonstrating that at this phase of development the fully polarimetric and polarimetric-interferometric modes of operation must be viewed and treated as preliminary algorithm verification support modes and at this phase of development, they

are still not to be viewed as routine modes. [C947]

"Doppler-polarimetric method of turbulence intensity retrieving in rain using remote sensing with microwave radar"

The developed procedure for turbulence contribution retrieval to the total Doppler Spectrum width can be succesfully used for measuring intensity of turbulence in rain by Doppler weather radar. Further improvement of the method can be achieved by increasing the accuracy of median drop diameter estimation. This can be done, for example, by using polarization diversity. Measuring ZDRgives good possibility for this, especially by airborne radar with horizontal sounding. Spectral differential reflectivity gives independent parameter for turbulence in rain characterization that can be used additionally to Doppler spectrum width. Further researches should be aimed to develop Doppler-polarimetric algorithm for real time signal processing. [C948]

"Neural detection for buried pipe using fully polarimetric GPR"

First Page of the Article [C949]

"An L-band SAR for repeat pass deformation measurements on a UAV platform"

We are proposing to develop a miniaturized polarimetric L-band synthetic aperture radar (SAR) for repeat-pass differential interferometric measurements of deformation for rapidly deforming surfaces of geophysical interest such as volcanoes or earthquakes that is to be flown on an unmanned aerial vehicle (UAV) or minimally piloted vehicle (MPV). To support the repeat pass deformation capability it is necessary to control flight track capability of the aircraft to be within a specified 10 m tube with a goal of 1 m. This requires real-time GPS control of the autopilot to achieve these objectives that has not been demonstrated on these aircraft. Based on the Proteus and ALTAIR's altitude of 13.7 km (45,000 ft), we are designing a fully polarimetric L-band radar with 80 MHz bandwidth and a 16 km range swath. The radar has an active electronic beam steering antenna to achieve a Doppler centroid stability that is necessary for repeat-pass interferometry. This paper presents the radar configuration along with some of the trade studies for the platform and instrument. [C950]

"Unsupervised classification of polarimetric SAR images using neural nets"

Classification of earth terrain components using fully polarimetric SAR images is one of many important application of radar polarimetry. In this paper, we are interested in unsupervised classification method because of their rapidity, automatic criterion and their independency on the images to be classified. [C951]

"PCA-ICA neural network model for POLSAR images analysis"

The POLSAR images are modeled by a mixture model that results from the product of two independent models, one characterizes the target response and the other characterizes the speckle phenomenon. For scene interpretation, it is desirable to separate between the target response and the speckle. For this purpose, a PCA-ICA neural network model is proposed. Based on its rigorous statistical formulation, a neuronal approach for the simultaneous diagonalisation of the signal and noise covariance matrices using a PCA transform is proposed. The PC images are uncorrelated and having an improved SNR. However, the speckle is a non-Gaussian multiplicative noise, the higher order statistics contain additional information about it. The ICA method is used to separate the speckle from the PC images and provide new IC images that have an improved contrast. The method has been applied to real POLSAR images. The extracted features are quite effective for the scene interpretation. [C952]

"Ultra-wideband polarimetric GPR-array stimulated by pseudo random binary codes"

First Page of the Article [C953]

"Discrimination of subsurface targets with a plane of symmetry using polarimetric bistatic radar"

First Page of the Article [C954]

"Biophysical parameter retrieval in production forest stands using C-band polarimetric radar"

A 40-km strip of polarimetric AIRSAR imagery over New Zealand's Kaingaroa Forest was analysed for retrieval of biophysical parameters. The imagery was collected in November 2000 as part of the PACRIM-2 mission. Only the C-band data were analysed, as we are most interested in the potential of applications using future C-band satellite imagery. A series of regressions between stand age and radar information are reported where the level

of radar complexity or use of additional covariate input is increased for each regression. The results show that stand age cannot be predicted using any single C-band polarisation. Promising results are found for dual-polarisation data, which will be available from future satellites. A regression using full-polarisation information yielded an adjusted R2of 82.3%. However, many of the common decomposition indices were found to be of little significance in this regression. The result is an improvement on methods based on backscatter intensity alone, and has important implications for inventory monitoring of commercial forestry stands. [C955]

"Two novel surface model based inversion algorithms using multi-frequency polSAR data"

The aim of this paper is to present two novel surface model based inversion algorithms using multifrequency and polSAR data. The first part of this work introduces a polarimetric scattering model using the integral equation model (IEM) with a transition model for the reflection coefficient. Polarimetric descriptors: the entropy (H), the anisotropy (A), and the mean alpha angle obtained from the Cloude/Pottier polarimetric decomposition theorem are employed for surface characterization. A new polarimetric parameter: the eigenvalue relative difference (ERD) is developed to overcome the anisotropy limitations in case of rough surfaces. Built on relevant polarimetric descriptors: H, alpha1 and ERD, two novel surface model based inversion algorithms using multifrequency polSAR data are presented. The first algorithm is built up in a "low frequency" (P to S band)-"high frequency" (C to K band) scheme. This algorithm retrieves the soil parameters by using multifrequency least-square fit [C956]

"Backscattering simulation for nonuniform forest canopies using multilayer MIMICS"

In this paper, we introduce a multilayer MIMICS for nonuniform forest canopies and present the model applications. The Michigan Microwave Canopy Scattering model (MIMICS) has been developed to simulate microwave backscattering from tree canopies. However, the crown-trunk canopy model is too restrictive for nonuniform canopy coverage. Multilayer MIMICS is developed to remove the two-layer canopy restriction. The model is a simulation solution to an array of radiative transfer equations and it includes the layer interactions between overlapping layers. This paper is focused on the model validation and application of multilayer MIMICS. Our collaborators have supplied us with extensive ground truth data from a 220,000 ha woodland and forest study areas within central Queensland, Australia. The field measurement is at the individual tree level. We can simulate the polarimetric backscattering for the ground measurement. AIRSAR data of the same area are obtained to validate the model simulation. The results show good agreement between the model simulation and SAR measurements. Analyzing an individual layer's contribution offers better understanding of canopy composition effects on backscattering. The multilayer canopy configuration improves the estimate accuracy over that from a crown-trunk layer model, as in the older version of MIMICS. [C957]

"Swiss alpine airborne sar experiment (SASARE) part I: multi-baseline polarimetric SAR inter-ferometry studies at L- and P-band"

In the frame of the Swiss Alpine Airborne SAR Experiment 2003 (SASARE) multitemporal/-baseline Pol-InSAR (polarimetric SAR interferometry) data sets were acquired with the German E-SAR (Experimental SAR) platform at L- (1.3 GHz) and P-band (350 MHz) in the region of the Great Aletsch glacier in Switzerland. For SASARE, several sub test sites had been selected below and significantly above the equilibrium line. One of the two campaigns was designed as a joint venture experiment and therefore also includes measurements of the Swedish CARABAS UWB (Coherent All Radio Band Sensing, ultra wide-band) sensor operating in the VHF frequency range (20-90 MHz). We provide first results from analysis of multitemporal/-baseline Pol-InSAR Land P-band measurements of the polarisation-dependent complex interferometric coherence of different glaciological surface types of an Alpine glacier [C958]

"Polarimetric feature of small urban area measured with SIR-C"

We analyzed the polarimetric backscattering characteristics of a small urban area measured with SIR-C using a target decomposition method and polarimetric entropy method. Relative contribution of cross scattering as well as polarimetric entropy increase as a function of building density. This result may suggest that the probability of scattering becomes large as the number of surfaces (roofs and walls) increases. [C959]

"Comparison of two inversion methods for retrieval of soil moisture and surface roughness from polarimetric radar observation of soil surfaces"

This paper presents comparison of the direct inversion method (DIM) and the genetic algorithm-based inversion method (GAIM) for retrieval of soil moisture and surface roughness from polarimetric radar observation of soil surfaces. Those inversion methods are based on the polarimetric semiempirical model (PSEM), which was

developed empirically to estimate the backscattering coefficients from the volumetric soil moisture content and the surface roughness parameters ks and kl, where k = 2pif/c, s is the rms height and l is the correlation length. The copolarized ratio p and the vh-polarized backscattering coefficient of the semiempirical model have been inverted directly to retrieve the soil parameters in the DIM. The cross-polarized ratio q can additionally be used to improve the inversion results in the DIM. A good agreement between the values of ks estimated by the inversion method and those measured in situfor ks<3.5, with a correlation coefficient of 0.822. The genetic algorithm (GA) is applied for an inversion method to retrieve both the volumetric soil moisture contents and the rms surface heights from multipolarized radar observations of bare soil surfaces. The cost function for each chromosome is evaluated using the semiempirical scattering model. Good agreement was found between the values of the rms height and the soil moisture content estimated by the inversion technique and those measured in situ. It was also found that the GAIM shows higher accuracy than the DIM in the estimation of the surface parameters from the radar observations [C960]

"Estimation of Doppler-polarimetric spectrum of signals reflected from distributed radar objects"

Polarization parameters and their Doppler spectrum of reflections characteristics coming from volumetric distributed radar objects are estimated for Doppler-polarimetric radar using complex modulations signal transmission the case of complex signals using. The influence of the sounding signal's ambiguity function on the possible joint estimation of the velocity spectra and separate backscattering matrix elements of objects is shown. Simulation results of our algorithms estimating the matrix Doppler spectrum are presented for the case of PCM and LFM transmissions. [C961]

"Recent advances in the development of polarimetric interferometric SAR imaging in microwave remote sensing of the terrestrial covers: need for developing multi-band single and multiple pass POLinSAR monitoring platforms in air and space"

In this overview, reasons are provided on why we do need to place multi-modal, multi-band single and multiple pass POLinSAR monitoring platforms into air and space. The questions "on what POLinSAR monitoring can provide that POL-SAR and IN-SAR by themselves cannot accomplish" is assessed; whereupon facts and justifications on placing POL-IN-BISAR satellite clusters into space are presented. Reasons for this technology becoming a basic requirement for current, near-future and much more so for future all-day & night year around monitoring of the terrestrial covers are analyzed in view of the un-abating and uncontrollable terrestrial population explosion, which has, does and for ever will result in unavoidable conflicts deteriorating unfortunately at times into terrorism. The pertinent questions on how to reduce the exorbitant cost for initiating this "home-globe security protection" technology are therefore also broached, and the expected benefits are laid out. The pertinent National and International airborne and space borne multi-modal, multi-band SAR remote sensing and security conflict surveillance support agencies are herewith invited for co-sponsoring our proposal, which is timely and fleets of orbiting multi-band space-borne POLinSAR platforms are urgently required. [C962]

"A multichannel spaceborne radar for the COSMO-Skymed Satellite Constellation"

This work briefly describes a multibeam synthetic aperture radar (SAR) for COSMO-SkyMed of second generation, that can be obtained by limited modifications to the design of the original design (first generation). The new system is characterized by multiple transmitting and receiving channels, to achieve the largest possible baseline. This is required for MTI (moving target indicator) surveillance, sea surface monitoring by along-track interferometry, and moving targets relocation in high resolution SAR images. Moreover, a fully polarimetric SAR is obtained by using an active antenna with transmit/receive (T/R) modules designed to receive only one linear polarization at each interrogation. [C963]

"Vegetation effects on soil moisture estimation"

Several successful algorithms have been developed to estimate soil moisture of bare surfaces. We previously reported a new algorithm using the tilted Bragg approximation. However, these algorithms are only applicable to bare surfaces. When vegetation is present, soil moisture is typically underestimated by bare surface algorithms. In order to derive soil moisture under vegetation, we have to understand the complex scattering process due to vegetation. Our main interest is to retrieve the global soil moisture information using Hydros L-band polarimetric radar data. The Hydros mission will provide the first global view of land soil moisture using L-band radar and radiometer. The unique characteristics of the Hydros data are the availability of the low resolution soil moisture information from radiometer data and the continuous time series radar data collected at the same incidence angle. In this paper, we will examine a potential inversion algorithm to retrieve soil moisture under vegetation canopies using Hydros L-band polarimetric radar data [C964]

"A solid state L to X-band flexible ground-based SAR system for continuous monitoring applications"

Continuous terrain fast changes monitoring is difficult to implement via airborne/satellite SAR systems, mainly due to the lack of flexibility and low revisiting times. Other SAR approaches based on small and simple ground-based systems, easy to deploy wherever are needed, must be considered. Transportability, low cost, and ruggedized structure are the main constrains, but the required resolution and performances have to be preserved. An experimental, short to medium range, ground-based, with optional polarimetric capability, Synthetic Aperture Radar (SAR) will be presented. First results of an experimental X-band SAR with a 100 MHz bandwidth, with 20 dBm of radiated power in differential interferometry operation will be shown [C965]

"Incorporating texture information into polarimetric radar classification using neural networks"

Most of the recent research on polarimetric SAR classification focused on pixel-based techniques using the covariance matrix representation. Since multiple channels are inherently provided in polarimetric data, conventional techniques for increasing the dimensionality of the observation, such as texture feature extraction, were ignored. In this paper, we have demonstrated the potential of texture classification through gray level cooccurrence probabilities (GLCP), and proposed an unsupervised scheme using the self-organizing map (SOM) neural network. The increase in separability of the feature space is shown via the Fisher criterion and also verified by increased classification performance. Compared to the Wishart classifier, promising classification results are obtained from the Flevoland data set. [C966]

"Improved ship detection using polarimetric SAR data"

The improvements in ship detection performance that can be obtained by using polarimetric synthetic aperture radar (SAR) data as compared to single-channel SAR data are investigated. Statistical decision theory is used to define decision variables that quantify the trade-off between the probability of missed detection and the probability of false alarm; performance is characterized by calculating receiver operating characteristics from single-channel and polarimetric SAR data by using likelihood ratio tests with the Neyman-Pearson criterion. It is shown that improvements in detection performance can be obtained with polarimetric SAR data as compared to single channel SAR data. We evaluate the results of these algorithms applied to single channel, dual channel amplitude only, dual channel with amplitude and phase, and fully polarimetric SAR data of known ships. In this way, the relative improvement in ship detection performance that is realized by introducing polarimetric information is quantified [C967]

"Improving coherence estimation for high-resolution polarimetric SAR interferometry"

This work presents a new method for filtering the coherence map issued from Synthetic Aperture Radar (SAR) polarimetric interferometric data. For each pixel of the interferogram, an adaptive neighborhood is determined by a region growing technique driven by the amplitude image information. Then, pixels in the derived adaptive neighborhood are complex averaged to yield the filtered value of the coherence, after performing a phase compensation step. The proposed method has been applied on airborne high-resolution polarimetric interferometric SAR images. Both subjective and objective performance analysis, including coherence edge detection, shows that the proposed method provides better results than the standard phase-compensated fixed multi-look filter and a linear adaptive coherence filter proposed by Lee et al. [C968]

"On the use of symmetric scatterers for calibration and validation of PALSAR polarimetric modes"

PALSAR L-band SAR is affected by Faraday rotation. In this study, PALSAR system is briefly described, and Freeman's method is considered for the calibration of PALSAR. Unless channel imbalances are measured abroad, a reference point target has to be deployed for each scene to be calibrated. For practical reasons, the use of symmetric targets is investigated for calibration and validation of polarimetric PALSAR data [C969]

"Multi-frequency polarimetric synthetic aperture radar for surface and subsurface sensing"

First Page of the Article [C970]

"The impact of forest heterogeneity on the height retrieval using X-band interferometry"

This paper assesses factors, which affect tree height retrieval using SAR phase coherence due to the heterogeneity within the forest stand. Factors such as edge effects, density, crown shape, slope, and emergent trees are assessed using a Polarimetric Radar Interferometry Simulator (PRIS). Results from the model simulation are compared to actual retrieved height from X-band Intermap data over pine plantations [C971]

"Potential of coherent decompositions in SAR polarimetry and interferometry"

A comparative study has indicated that coherent decompositions may have high potential in applications using fully polarimetric and interferometric SAR data, as an alternative or supplement to standard non-coherent techniques developed during the last decade. One important reason for this seems to be that the coherent techniques are better able to benefit from the coherent nature of the underlying data and scattering mechanisms. By avoiding averaging at the first processing stage, the coherent techniques can extract target features that may otherwise be lost in the early averaging process. On the other hand, averaging is indeed important in most cases for obtaining stable and reliable end results. [C972]

"Optimal polarization for the observation of ocean features with SAR"

Fully polarimetric synthetic aperture radar (SAR) data collected by AIRSAR and SIR-C/X-SAR are used to analyze radar signatures of ocean features such as ocean waves, oil slicks, ship wakes, ocean fronts and submarine topography in the China Seas. The optimal polarization (OP) for the observation of these features with SAR is given based on the analyses. [C973]

"Inversion of vegetation height using SIR-C dual frequency polarimetric SAR interferometry data"

From the frequency characteristic of L and C band, in this paper, a new phase based method of vegetation height estimation using dual frequency SIR-C polarimetric SAR interferometry data is presented. Compared the preliminary result with field measurement data, it indicates that the inversion algorithm can obtain the height of vegetation with an acceptable accuracy [C974]

"An experimental complex for multi-frequency, short distance, coincident, microwave active-passive and in-situ combined measurements of soil and snow moistures"

An experimental polygon is represented, equipped by a complex of polarimetric (dual polarization), combined, short pulse scatterometer-radiometer systems of L-, C-, and X-band of frequencies, for bare soil, soil vegetation and land snow cover microwave reflective and emissive characteristics simultaneous and spatially coincident measurements. The polygon equipped as well by facilities for microwave devices absolute calibration, by spatially distributed sensors for in-situ measurements of soil moisture, and has local meaning small weather station. This paper has an aim to attract attentions of researchers engaged in such kind of measurements and to interest them to perform their own or joint measurements using available facilities [C975]

"Raw signal simulation for very high resolution SAR based on polarimetric scattering theory"

A method for raw signal simulation for extended SAR scenes with very high resolution is described. This simulator can handle resolution better than 1 m, squinted geometry, elliptical orbit motion and use a polarimetric reflectivity matrix. Classical polarimetric scattering theory is based on electromagnetic harmonic fields using Maxwell's equations, Green's function, Huygens' principle and Kirchhoff's approximation. Here, the scattering theory is modified for a chirp field. Calculated expressions for the scattered chirp field or the reflectivity matrix are presented. Such a reflectivity matrix can then be input to the inverse-EETF4 for raw data generation [C976]

"A polarization-rotating Van Atta array reflector and its application to polarimetric radar calibration"

This paper presents the principle, design, and measured characteristics of a 90-degree polarization-rotating Van Atta array reflector with suppressed scattered field as a reference target for polarimetric radar calibration. A polarimetric calibration method that uses a trihedral and the present reflector needs no assumptions on scene characteristics and statistics and no independent phase calibration [C977]

"Unsupervised segmentation of the POL-SAR image using similarity parameters in sequential projection pursuit model"

A sequential projection pursuit model (SPPM) for unsupervised segmentation of the polarimetric synthetic aperture radar (POL-SAR) image is proposed in this paper. The features of the high dimension data are extracted out via orthogonal projection and the classification is accomplished by the Bayesian decision rule. Also the similarity parameters of POL-data are expressed as the characters of a target and form new target data. The SPPM utilizes new target data to classify the target into various subclasses. Good-segmented results have been obtained for the POL-SAR image processing. The segmented results using the SPPM are better than that of using entropy-alpha plane. [C978]

"Two dimensional bandwidth extrapolation technique for polarimetric radar images"

The resolution of a radar image, such as SAR (synthetic aperture radar) image, in range and azimuth is determined by the transmitted bandwidth and the synthetic aperture length, respectively. Various super-resolution techniques for improving resolution have been proposed, and the authors have proposed an algorithm that we call polarimetric bandwidth extrapolation (PBWE). To apply PBWE to a radar image, one needs to first apply PBWE in the range direction and then in the azimuth direction, or vice versa. In this paper, PBWE is further extended to two dimensional cases. Two dimensional PBWE (2D-PBWE) utilizes two dimensional polarimetric linear prediction model and expand the spatial frequency bandwidth in range and azimuth directions simultaneously. The performance of the 2D-PBWE is shown through a simulated radar image and a real polarimetric SAR (synthetic aperture radar) image. [C979]

"Polarimetric EM scattering and information retrieval in SAR remote sensing"

The advance of polarimetric SAR imagery technology. such as SIR-C and RADARSAT-2 has promoted extensive study and applications for information retrieval from polarimetric scattering measurements. This paper briefly reports our research on three issues: (1) solutions of the Mueller matrix, the eigenvalues of the coherency matrix and information entropy to directly relate with measurements of the co-polarized and cross-polarized scattering in SAR imagery; (2) an inversion approach for digital elevation mapping (DEM) by using a single pass instead of two-pass or interferometric SAR (INSAR), of polarimetric SAR data; (3) an algorithm of two-threshold EM (expectation maximisation) and MRF (Markov random field) for automatic analysis of the context change detection in the urban area from multi-year SAR observations. [C980]

"A method for characterizing a target in polarimetric radar remote sensing"

A method for characterizing a target is proposed in this paper, based on the eigenvalue decomposition of a scattering matrix. From this method, a set of parameters is derived. The parameters are not only independent of the spans of the scattering matrices, but also independent of the target orientation angles. With these parameters, we enhance the contrast between the road and forest of a SAR image, demonstrating the effectiveness of the proposed parameters. [C981]

"A review of ship detection algorithms in polarimetric SAR images"

In this paper, we take a brief review of the different approaches used for ship detection in polarimetric synthetic aperture radar (POL-SAR) images. After an introduction of the standard polarimetric detectors (SPDs) used in polarimetric detection for general targets, four main types of polarimetric detection algorithms with special respect to ship targets are summarized: the coherent target decomposition algorithm (CTD), polarimetric entropy (PE) algorithm, polarimetric detectors based on fusion, and segmentation based polarimetric method. Preliminary conclusion is drawn from the performance comparison of each type and indicates how these algorithms applied for ship targets respectively. [C982]

"Time-frequency analysis of polarimetric vector signal and its application in radar target recognition"

The time-frequency analysis technology for polarimetric vector signal is discussed in this paper. Considering the particularity of polarimetric vector signal, a series of time-frequency transforms for this kind of vector signal are presented. With these transforms, both the description of its energy property and of its polarization property can be obtained in the time-frequency domain, while using conventional methods, only the former can be obtained. Then, we apply these new methods to target recognition experiment, and the recognition results show that these new methods have better performance than conventional ones. [C983]

"Airborne polarimetric SAR monitoring for ships and coastal seas"

Airborne polarimetric and interferometric synthetic aperture radar (PiSAR) images are analyzed for monitoring ships and coastal seas especially for estimating sea surface wind speed and direction. Though in situships data through AIS (Automatic Identification System) were not available by the time of analysis, PiSAR's X band images showed the potential to map coastal wind vectors with high spatial resolution of 2.5 m [C984]

"Polarimetric technique for aircraft icing alert using airborne radar"

First Page of the Article [C985]

"Use of doppler-polarimetric parameters for wind phenomena localization"

First Page of the Article [C986]

"Modeling of polarimetric radar reflections from spatially-distributed objects and the algorithm based on coherent processing"

First Page of the Article [C987]

"Nonstationary array processing for sources with time-varying polarizations"

This paper presents a spatial polarimetric time-frequency distribution (SPTFD) based approach for direction-of-arrival (DOA) and polarization estimation of nonstationary signals with time-varying polarization signatures that are incident on an array of dual-polarized double-feed antennas. The use of a time-frequency distribution allows for the concentration of the signal energy in the time-frequency domain and the tracking of the signals' time-varying frequencies. It also allows for the instantaneous tracking of the signal's time-varying polarization. The proposed approach yields improved DOA and polarization signature estimation. Simulation results are provided to illustrate the performance improvement that this method provides. [C988]

"Design of a small, low cost, P-band airborne polarimetric synthetic aperture radar"

First Page of the Article [C989]

"Comparison between simulations and interferometric polarimetric SAR P-band data on a pine-trees forest"

The interpretation of SAR data remains particularly difficult in case of forests, which makes the use of modelling very helpful. On the other hand, the potential of combined use of interferometric and polarimetric data has been already demonstrated to provide key forest parameters. In this paper, we present comparisons between interferometric polarimetric images of a forest simulated by a coherent scattering model derived from L. Thirion (2003) and L. Thirion (2004), and real airborne and full polarimetric interferometric P-band data measured over maritime pine trees. Results are presented that demonstrate the efficiency of the model to retrieve polarimetric and interferometric parameters on this forest. Finally, a first step of simplification and inversion of the model, relying on the analysis of the scatterers contributions, is proposed [C990]

"Synthetic aperture radar for search and rescue: polarimetry and interferometry"

The use of synthetic aperture radar (SAR) provides an opportunity to assist search and rescue in the location of downed airplanes in particular in the northern areas of Canada. This paper presents results of examining the detection of crashed aircraft targets using airborne SAR data. Considerations for decreasing the number of "false targets" using a combined polarimetric and interferometric analysis have been tested with results indicating a promising approach for target detection using these SAR techniques. [C991]

"Relating polarimetric SAR image texture to the scattering entropy"

In our previous paper, an extension of the polarimetric product model to explain polarimetric variation of texture in high-resolution synthetic aperture radar (SAR) images has been proposed. The extended model suggests that existence of multiple scattering mechanisms provides the polarimetric texture diversity. In this paper, the polarimetric target decomposition theorem is utilized to validate the model. The entropy derived from the target decomposition is a useful sign of scattering randomness. The results of data analyses reveal that there is significant correlation between the variation of the K-distribution's order parameters and the entropy value. [C992]

"Analysis of the limitations of coherent polarimetric decompositions on vessel classification using simulated images"

This paper presents a study performed with high resolution simulated SAR data that outline the limitations of polarimetric coherent decompositions on vessel classification. In these days, these theorems have been set up as the most advisable alternative for this application but an evident lack of real data avoids know their true usefulness. In this way, this study overcomes this limitation opening the doors to other alternatives, which would provide better performances in this research line. [C993]

"A multi-frequency polarimetric scattering model for subsurface structure detection"

In this work an attempt is made to extract information about the subsurface soil layers by means of multi-

frequency fully polarimetric SAR data. The model of scattering from two-layer structure is proposed and analysis of experimental SAR data at L- and P-band is carried out. [C994]

"A new polarization state conformation and its application to coherence optimization in PolInSAR"

A new coherence optimization algorithm is proposed for PolInSAR applications by using the polarization state conformation (PSC) algorithm based on the polarimetric basis transformation along with the polarization signatures. After this algorithm applied the resemblance between the scattering mechanisms of the same invariant target in both images is maximized. Then, coherence maps between the multidate POLSAR images, before and after the algorithm has been applied, are generated. As a result, the coherence, after the PSC algorithm has been applied, gives the best coherence or optimized coherence between the multidate POLSAR images. The effects predicted by the theory are confirmed by the POLSAR data acquired by the Jet Propulsion Laboratory SIR-C mission. [C995]

"Study on the forest observation in Kushiro wetland by using dual-frequency and fully polarimetric airborne SAR (Pi-SAR) data"

We chose the Kushiro wetland in Hokkaido, Japan, as a test site to monitor wetland areas. Synthetic aperture radar (SAR) can carry out continuous observation in any weather conditions, and can therefore be used to observe high humidity areas such as wetlands. We applied multi-parameter SAR data (dual-frequency, multi-polarization, and multi-incidence angle) to monitoring the wetland forest. To find the optimum incidence angle and polarization for monitoring the wetland biomass, a simple backscattering model of wetland vegetation was developed and applied to estimate backscattering coefficients for different biomass and surface conditions. [C996]

"A study on extraction of urban areas from polarimetric Synthetic Aperture Radar image"

This paper discusses the polarimetric correlation coefficient to extract the urban areas from polarimetric Synthetic Aperture Radar (POLSAR) image. For classification of POLSAR image, several methods have been proposed to extract polarimetric feature, such as Polarimetric Entropy-Alpha, three-component scattering model, Huynen parameters and so on. However, there is a possibility that the polarimetric correlation coefficient has a potential for the objective of this paper, too. In order to verify the capability of polarimetric correlation coefficient, we examine the behavior of this coefficient between the urban areas and the natural distributed areas with respect to the several polarimetric scattering models and the difference of polarization basis. Moreover, we apply the polarimetric correlation coefficient to the actual polarimetric SAR data acquired by Pi-SAR/X-SAR. [C997]

"Determination of polarimetric calibration parameters of L band SAR using uniform forest data"

Proposes a new method to calibrate L band polarimetric SAR using the forest data. Model based covariance matrix containing the distortion matrices and the scattering components from the forest were solved using the Pi-SAR data over the Japan uniform forest of Tomakomai, Hokkaido. The result showed that the distortion matrices depend on the function of the incidence angle and the operation timings. [C998]

"Physical interpretation on eigen-analysis of the polarimetric coherency matrix for microwave scattering from vegetation"

The potential of using the eigen-analysis of the coherency matrix is discussed for improved understanding of microwave interaction mechanism in vegetated areas. Using a nonsymmetric vegetation scattering model, a theoretical target matrix is generated to compare the eigen-parameters of the coherency matrix with vegetated scattering mechanisms. [C999]

"Initialization of Markov Random Field clustering of large polarimetric SAR images"

Markov Random Field clustering, utilizing both spectral and spatial inter-pixel dependency information, often provides higher accuracy for remote sensing images, such as polarimetric SAR images. However, it is heavily sensitive to initial conditions, i.e. the initialization of parameters and the choice of the number of clusters. In this paper, an initialization scheme for MRF clustering approaches for polarimetric SAR images is suggested. The method takes into account spatial relations between pixels and provides a guideline to the choice of the number of clusters using Pseudolikelihood Information Criterion (PLIC) criterion. A well-known polarimetric SAR image of Flevoland in the Netherlands is given as an example, showing that this approach gives very good performance. [C1000]

"A wavelet multiresolution technique for polarimetric texture analysis and segmentation of SAR images"

A technique is presented for multiscale texture analysis and segmentation of polarimetric SAR images. Textural features are extracted using a multiscale wavelet decomposition based on a wavelet frame. The feature vector is composed of local variance estimates of the smooth image and of the wavelet coefficients. The decomposition is performed at two scales and using images derived by polarimetric power synthesis at a set of polarization configurations. This set is chosen based on a priori-knowledge of the texturally optimal polarization states. Alternatively a complete and nonredundant representation of the full polarimetric information consisting of nine backscatter intensities is used. Feature reduction is achieved by an approximate solution of the Multiple Discriminant Analysis (MDA) transform. A set of controlled experiments, based on Monte Carlo simulations, is set up to assess the performance of the technique with respect to texture segmentation problems. One case is reported concerning the simulation of a fragmented forest, where two vegetation classes with different structural characteristics are mixed. Finally, as an example of the application of the technique to real SAR data, texture segmentation of a high resolution image acquired by the DLR E-SAR sensor at L-band is illustrated. [C1001]

"Polarimetric, L-band, combined radiometer and short pulse scatterometer system"

In this paper L-band, polarimetric, combined, short pulse scatterometer-radiometer system is described, for short distance remote sensing application, under laboratory and field-control conditions. Developed system allows to carry out polarimetric (vv, vh, hit, hv), simultaneous and spatially coincident microwave active-passive measurements of observed surface (soil, soil vegetation, snow and water surface) microwave reflective and emissive characteristics at angles of incidence from the while of 0-80°. [C1002]

"TerraSAR-L SAR parameter simulation"

The TerraSAR-L system, currently being designed in a Phase B definition study, provides ESA with its most powerful radar-imaging programme to date. The platform, based on a Snapdragon configuration, is optimized for and built around the 11 mtimes2.9 m active phased array antenna of the L-band Synthetic Aperture Radar (L-SAR). The L-SAR features, on top of standard Stripmap and ScanSAR operations, full polarimetric capabilities, repeat-pass ScanSAR interferometry and a Wave Mode. The TerraSAR-L spacecraft flies in a near-polar sun-synchronous low Earth orbit. An attitude steering operation to reduce the Doppler frequency caused by the Earth's rotation is foreseen. The knowledge of the relative distance between the spacecraft in orbit and a point scatterer on Earth during the radar illumination time, the so-called slant range history, is a crucial input for SAR focusing. Usually, this trajectory is approximated by an appropriate function. The validity of the approximation within the required accuracy margins has to be ensured. The applied attitude steering is a major driver for the Doppler parameters and thus the allowed approximations. This paper introduces the major TerraSAR-L orbit parameters and imaging configurations. Based on the nominal Kepler reference orbit, the round-orbit Doppler characteristics for TerraSAR-L are derived. The DLR developed Total Zero Doppler Steering is investigated as a suitable candidate for the TerraSAR-L attitude steering. A range trajectory approximation is investigated [C1003]

"Implementation of systematic data observation strategies for ALOS PALSAR, PRISM and AVNIR-2"

The Advanced Land Observing Satellite (ALOS) is scheduled for launch by the Japan Aerospace Exploration Agency (JAXA) in 2005, and it carries three remote sensing instruments: an L-band polarimetric Synthetic Aperture Radar (PALSAR), an along-track 2.5 metre panchromatic resolution stereo mapper (PRISM) and a 10-metre multi-spectral scanner (AVNIR-2). The successor of the JERS-1 satellite (1992-1998), ALOS not only provides enhanced sensor performance, but also feature an entirely new acquisition concept. Abandoning traditional, local-focused instrument operations, JAXA is implementing a comprehensive acquisition strategy, in which geographical region, sensor mode, acquisition timing and repetition frequency, are fixed in advance, to achieve spatially and temporally consistent, global coverage on a repetitive basis, at the same time as reducing programming and user conflicts [C1004]

"The TerraSAR-L basic product tree"

The TerraSAR-L system, currently being designed in a Phase B definition study, provides ESA with its most powerful radar-imaging programme to date. The platform is optimized for and built around the 11 mtimes2.9 m active phased array antenna of the L-band Synthetic Aperture Radar (L-SAR). The L-SAR features, on top of standard Stripmap and ScanSAR operations, full polarimetric capabilities, repeat-pass ScanSAR interferometry and a Wave Mode. Specification of the L-SAR has been guided by a careful analysis of the product requirements resulting in a robust baseline design with considerable margins. Besides, a major contribution to applications in areas of climate change and oceanography, the TerraSAR-L design responds specifically to

requirements from interferometric applications. One key element of the TerraSAR-L operations strategy is a long-term systematic and repetitive acquisition scenario to ensure consistent data archives and to maximize the scientific and commercial exploitation of this SAR system. The other important factor is a systematic processing of all acquired data to Single-look Slant-range Complex (SSC) products to facilitate higher level product generation and services based on these products. This paper describes the TerraSAR-L basic product tree and explains the rationale behind. The nominal TerraSAR-L imaging modes are introduced and their performance characteristics are described. The generation concept of multi-look detected products based consistently on complex products-generated either at an intermediate stage during ground segment processing or serving as input product into a stand-alone tool-is introduced. A modular SAR processor design using the same complex product generation algorithms as far as possible independent of the underlying imaging mode is addressed [C1005]

"Analysis of polarimetric marine scattering at different range resolutions"

In this work we deal with the problem of analyzing and modeling marine (lake) surface scattering as seen by high resolution radars, with the aim of highlighting, where possible, the differences due to changes in the range resolution and polarization [C1006]

"Scattering mechanism identification based on the rotation and eccentric angles of polarimetric SAR data"

In this paper we introduce two novel parameters for polarimetric SAR (POLSAR) images. For this purpose, a 2times2 matrix is defined to take into account the independent elements of the covariance matrix. To understand the geometry of this new matrix, an equation of ellipse is defined. As a result, the geometry of the ellipse is completely tied up with the eigenvalues and eigenvectors. Two novel parameters, the rotation and eccentric angles of the ellipse which can directly be derived from the eigenvalues and eigenvectors, are presented. The results indicate that different scattering mechanisms can be represented with the rotation and eccentric angles. Results obtained from the proposed parameters, when compared with the results derived from existing features, were in agreement in terms of the scattering mechanisms, as well as terrain cover types present in the test site [C1007]

"The TerraSAR-L mission and system"

The TerraSAR-L system, currently in Phase B definition carried out by a European/Canadian consortium lead by EADS Astrium Ltd., provides ESA with its most powerful radar imaging programme to date. Key mission characteristics are a 5-year mission lifetime, global coverage from a 14-day repeat 635-km orbit, more than 20 minutes per orbit of SAR data acquisition in L-band, in both right-looking (nominal) and left-looking configurations, and a launch in late 2008. TerraSAR-L first mission priority is serving commercial applications focused on agriculture, forestry and marine applications. Joint products from TerraSAR-L and the German national programme TerraSAR-X use the complementary properties of the backscattering in L and X bands for high levels of classification performance necessary for crop monitoring, forest inventory and cartographic maps of different thematic content and scale. Scientific and institutional applications are defined focused on solid Earth monitoring relying on differential interferometry. L-band penetration of vegetation cover facilitates these applications also over vegetated surfaces. The high coherence of L-band assists the monitoring of ice sheet and glacier dynamics. Sea ice classification is supported with full polarimetric measurements. Large-scale land cover change detection, global forest biomass estimation, permafrost monitoring, wetland inventory, soil moisture retrieval and flood monitoring are also supported. A dedicated Wave Mode provides measurements of directional ocean surface wave spectra. Additionally for single-pass interferometry and generation of a global DEM, a complementary cartwheel system with different micro satellite constellations flying in close formation with TerraSAR-L has been investigated. The spacecraft is built around an active phased array antenna and provides full polarimetric capabilities, maximum bandwidth within the 85 MHz allocation for Earth observation in L-band, and repeat-pass ScanSAR interferometry.- The platform is based on a novel Snapdragon configuration. The TerraSAR-L Ground Segment provides the operational link between the spacecraft, the TerraSAR Exploitation and Service Infrastructure and the users. A high-performance modular architecture is designed to fulfil the high requirements on throughput, quality and accessibility of data, as well as the reuse of existing infrastructure elements and the interoperability with other missions, especially with the companion TerraSAR-X Ground Segment [C1008]

"Multi-frequency polarimetric snow discrimination in Alpine areas"

This paper presents a new method to map dry snow in Alpine areas. A supervised discrimination algorithm, based on polarimetric contrast, is proposed to enhance multi-temporal and/or multi-frequency polarimetric

behavior variations over snow-covered areas. This technique is shown to be more robust with respect to topography and underlying media diversity than classical contrast enhancement approaches. The effectiveness of the proposed method is demonstrated using SIR-C L and C-band polarimetric data sets [C1009]

"Characteristics of permanent scatterer in coastal area"

We have succeeded in estimating tide height in the coastal area with an r.m.s. error of 5.7 cm by exploiting interferometeric phase and image intensity of JERS-1 SAR data in our previous work. We used an array of oyster farming frames, composed of two vertical poles and one horizontal pole for each frame, as permanent scatterers. In this paper, we investigate the backscattering characteristics of the structure using AIRSAR data and results of experiment in laboratory. AIRSAR polarimetric images show L-band HH- and VV-polarization produce strong returns from the target structures. Classification of L-band polarimetric AIRSAR data confirms the double-bounce scatter is dominant scattering mechanism. Odd-number scatter is, however, not negligible. The ratio of single-bounce to double-bounce scattering depends of the relative radar look direction to the target array and sea surface conditions. Laboratory experiments were carried out using Ku-band according to the target scale. The results of the experiments can be summarized as: i) the structures produce a mixed signal of double-bounce and odd-bounce scatter; ii) the backscattering from horizontal pole is very sensitive to radar look direction; iii) the signals from vertical poles are stronger than that from horizontal pole. From the results, it is concluded that water level change can be most effectively estimated when vertical poles in the water are observed by L-band HH- or VV-polarization [C1010]

"Measurement of scattering coefficient dependence on soil moisture content and surface roughness by 35 GHz polarimetric scatterometer"

Polarimetric measurements of scattering coefficient sigma0 of a bare soil were performed changing a roughness of a soil surface and a soil moisture content using the 35 GHz polarimetric scatterometer. At Ka band, a few experimental results of sigma0 data are available. One of the purpose of this experiment is to obtain the surface backscattering characteristics to evaluate surface clutter interference with precipitation measurement from space using the Dual frequency Precipitation Radar (DPR, 13.8 GHz and 35.5 GHz), which is planned to be onboard the Global Precipitation Measurement (GPM) Mission core satellite to observe precipitation globally. In evaluation of surface clutter interference, sigma0data for various surface conditions are needed, especially sigma0dependence on soil moisture content and surface roughness. Another purpose of this experiment is to apply the measured sigma0data to estimate a soil moisture content globally after the launch of the GPM core satellite. An angular scan range of the DPR is from nadir direction though the incidence angle of 8.4 degrees (with the 35.5 GHz radar) or 17 degrees (with 13.6 GHz radar), so the measured data by the DPR is useful to observe the earth surface condition globally. In this study, the roughness of the soil surface was measured with a laser profile meter to determine the roughness dependence of the scattering coefficient. A soil moisture content was measured comparing the weight of the soil before and after the heating of the soil. The soil was heated enough to contain no water. To increase the number of the independent samples for each experimental conditions (soil moisture content/surface roughness/incidence angle), azimuthal angle is changed like clockwork using the turntable of 2 m diameter. The system of the scatterometer is network analyzer based polarimeter [C1011]

"Validation of raindrop size distribution retrieval from spaceborne radar using ground polarimetric radar observations"

The cumulative attenuation (A) along TRMM PR path given by the surface reference technique (SRT) can be distributed along the radar range using a power law relation between the specific attenuation (k) and reflectivity factor (z) written as, k=aZbeta. A commonly used approximation is that beta is constant and alpha changes according to the raindrop size distribution (DSD). More recently physical interpretation of alpha has been provided with the normalized drop size distributions. This paper evaluates the method to estimate the DSD parameters from TRMM PR observations. Coincident data collected with polarimetric radar on the ground during the TRMM field campaigns was used to compare the estimates of DSD retrieved from TRMM PR. This paper also introduces a new methodology for comparing DSD estimates from widely varying sampling volumes. The cross validation shows fairly good agreement, thereby validating the DSD retrieval process [C1012]

"Study on the sea ice thickness observation in the Sea of Okhotsk by using dual-frequency and fully polarimetric airborne SAR (Pi-SAR) data"

The Sea of Okhotsk is located in the most southerly region of the Northern Hemisphere in which sea ice exists during winter. Since the area and volume of the sea ice in this region are related to climate change locally as well as globally, it is important to develop methods for monitoring sea ice parameters around this region. Since

Synthetic Aperture Radar (SAR) can observe continuously in any weather conditions, it is useful for observing the sea ice covered region. In order to investigate the possibilities of dual frequency and polarimetric SAR to monitor the sea ice, we derived the relation between backscattering coefficients each polarization and sea ice physical parameters, and then we proposed a sea ice classification using a polarimetric decomposition and a sea ice thickness estimation using the backscatter ratio [C1013]

"Analysis of anisotropic behavior using sub-aperture polarimetric SAR data"

In this paper, a fully polarimetric analysis method is introduced to decompose synthesized polarimetric images into sub-aperture data sets, which corresponds to the scene responses under different azimuthal look-angles. A statistical analysis of polarimetric parameters permits to clearly discriminate media showing a non-stationary behavior during the SAR integration. A method is proposed, which eliminates the influence of azimuthal backscattering variations in conventional polarimetric SAR data analysis. [C1014]

"Classification of tree types by polarimetric Pi-SAR"

In order to classify tree types, we introduce a new technique, which detects the change of Polarimetric Entropy parameters. We define the difference of the two-dimensional polarimetric entropy parameters, and applied the proposed technique to Pi-SAR airborne polarimetric SAR data. The result in an urban area shows that the seasonal change is very random and we could not find significant changes between two scenes. Then, we applied the technique in a forested region. The change in coniferous trees and broadleaf trees is statistically different. Using the change in polarimetric entropy properties, we find this technique can be used for tree type classification. [C1015]

"Polarization orientation estimation and applications: a review"

We review estimation algorithms and applications of polarization orientation angle shifts induced by terrain slopes. We develop a unified analysis of estimation algorithms based on circular polarization covariance matrix. The effect of radar frequency, scattering media, and polarimetric calibration will also be discussed. Applications to DEM generation, polarimetric SAR data compensation and ocean surface feature characterization will be mentioned. SIR-C, and JPL AIRSAR L-band and P-band polarimetric SAR images are used for demonstration. [C1016]

"The use of polarimetric and interferometric SAR data in floodplain mapping"

Recent advances in polarimetric SAR show promise for augmenting the capability of traditional interferometric SAR. In particular, a polarimetric topography technique provides useful slope information, and polarimetric interferometry may be used to decompose the response into vegetation and ground surface contributions. Here we discuss an integrated approach that utilizes the combined capability of regular (single channel) interferometry, polarimetric interferometry and polarimetric topographic mapping for topographic mapping of flood-prone areas. [C1017]

"Influence of resolution cell size for surface parameters retrieval from polarimetric SAR data"

This paper introduces a study of the influence of the size of SAR resolution cell on polarimetric scattering characteristics over rough surfaces. Surface scattering is shown to be dependent on the cell size to correlation length ratio. SAR resolution is taken into account by dividing a surface spectrum in two parts: a low-frequency spectrum corresponding to local slopes and a high-frequency component, defining the roughness inside a resolution cell. Backscattering coefficients are calculated for each resolution cell with the IEM model using local incidence angles. Surface scattering is characterized with three polarimetric indicators H/A/α_, highly related to the soil characteristics. These models are validated on indoor polarimetric SAR measurements acquired at the JRC laboratory. [C1018]

"Full polarimetry versus partial polarimetry for quantitative surface parameter estimation"

The performance difference between full polarimetry (fp) and partial polarimetry (pp) systems is still an important open question according to Imbo and Souyris (2000) and Lee et al. (1995), especially in the frame of future low-cost spaceborne SAR studies. The aim of this paper is to briefly present a fully polarimetric model, the recent F-Bragg model (Breuer et al., (2002, 2003)), and compare it to its restriction to partial polarimetry. In a second step the inversion possibilities of fp and pp F-Bragg are investigated. [C1019]

"Pi-SAR image analysis using polarimetric scattering parameters and total power"

This paper tries to classify POL-SAR image data using polarimetric entropy, averaged alpha angle, and total power. Using unsupervised classification scheme with iterative Maximum Likelihood (ML) classifier, it is possible to classify residential areas with trees and vegetation areas. The results are shown using Pi-SAR image data comparing with other representative methods. [C1020]

"Unsupervised classification of polarimetric SAR images using neural networks"

We study two unsupervised algorithms for polarimetric SAR image classification. The first one is Cloude's decomposition algorithm. The main advantage of this unsupervised algorithm is to provide terrain identification information where the most important kinds of scattering medium can be discriminated. However, his main advantage is the arbitrary location of decision boundaries. To surmount this insufficiency, we present the second algorithm based on neural networks. We propose a new scheme of unsupervised classification that combine the most important kind of trained nets. [C1021]

"The SSCM for ship characterization using polarimetric SAR"

Ship characterization is investigated using the symmetric scattering characterization method (SSCM), which was introduced by Touzi and Charbonneau (2002). The SSCM method appears to be very promising for ship identification. Identification of ship targets with significant symmetric scattering is shown to lead to accurate pitch measurement, under certain conditions. [C1022]

"Classification of urban SAR imagery using object oriented techniques"

This paper describes the development of techniques for the production of urban mapping data from interferometric polarimetric synthetic apertures radar (SAR) data. The information contained in the radar originates from four types of data properties: radiometric, i.e. the channel intensities; polarimetric, e.g. decomposition properties entropy and alpha; interferometric, e.g. coherence and interferometric height; and geometric, e.g. shape and area. A multi-scale analysis, using the infrastructure provided by eCognition image analysis software, enables these different sources of information to be brought together. Ambiguities that result from the use of radiometric and polarimetric information alone are eliminated. A map product with broad classification information is produced. Validated results for urban scenes are presented, that were produced using data from the Deutsche Luft und Raumfahrt system E-SAR. [C1023]

"Soil moisture retrieval and AMSR-E validation using an airborne microwave radiometer in SMEX02"

Field experiments were conducted to evaluate the effects of dense agricultural crop conditions on soil moisture retrieval using passive microwave remote sensing. Aircraft observations were collected using a new version of the Polarimetric Scanning Radiometer (PSR) that provided C band and X band channels. Observations were also available from the Aqua satellite Advanced Microwave Scanning Radiometer (AMSR-E) at the same frequencies. Soil Moisture Experiments 2002 (SMEX02) was conducted over a three-week period during the summer near Ames, Iowa, an area which is dominated by corn and soybeans. Aircraft data were processed and channels selected to minimize radiofrequency interference. A preliminary comparison of he aircraft (PSR) and satellite (AMSR-E) 10.7 GHz data showed comparable brightness temperature values. Sensitivity of brightness temperature to soil moisture was observed for nearly all the ground validation sites, even under dense corn canopies. Similar sensitivities were observed for C and X band channels. These results illustrate the potential to develop soil moisture retrieval techniques for wide range of agricultural conditions using AMSR-E frequencies. [C1024]

"Integrating SAR and optical products for crop management (Isocrop) iophysical parameter retrieval using X and L band SAR data"

The Isocrop project has obtained near simultaneous L and X band SAR data, superspectral data and in situ ground truth data at two winter wheat test sites over several growing seasons using airborne DLR E-SAR and Specim AISA sensors. This paper describes the development of retrieval algorithms and information products based on the SAR data which are capable of providing useful information for the management of winter wheat crops. These algorithms are based on exploiting the correlation between biophysical parameters including mean backscatter, ratios of backscatter and components derived form a range of polarimetric scattering models. These algorithms and products are intended to support the application of X and L band data from the proposed satellite borne TerraSAR system. [C1025]

"Combining SAR and scatterometer data to improve high resolution wind speed retrievals"

With the December 14, 2002 launch of the SeaWinds scatterometer on Adeos-2 complimenting a similar instrument aboard QuickSCAT, we now enjoy global wind speed measurements at 25 km resolution from two active microwave scatterometers. WindSat launched on January 6, 2003 with the mission to test the possibility of making wind vector measurements of comparable precision and resolution as conventional scatterometry by using polarimetric radiometry. However, the relatively coarse resolution of these instruments makes it difficult to measure winds in coastal areas. Here we show that by combining scatterometer wind direction measurements with high, sub-kilometer resolution radar cross section measurements from the RADARSAT-1 synthetic aperture radar (SAR) we can make significantly improved wind speed retrievals in coastal areas. Recently ASAR data from ENVIASAT have become available. We have just begun using this data source for SAR wind speed retrievals and have found that these data avoid some of the problems encountered with RADARSAT-1 imagery. [C1026]

"A study of the X-band entropy of breaking ocean waves"

In this paper we develop a simple model for the polarimetric radar backscatter from breaking ocean waves. We show that the dynamics of the breaking process lead to characteristic variations in the wave depolarization processes. We compare the model prediction with X-band grazing incidence radar data collected for breaking ocean waves in the surf zone. [C1027]

"Measurement of ocean wave spectra using polarimetric SAR data"

New methods have been investigated which use fully-polarimetric synthetic aperture radar (SAR) image data to measure ocean wave slope spectra. Independent techniques have been developed to measure wave slopes in the orthogonal SAR (azimuth/range) directions. These measurements must still contend with motion-induced nonlinearities in the SAR processing. The methods are, however, physically based, robust, and utilize a parametrically simpler modulation transfer function. NASA/JPL/AIRSAR L-band data from California coastal waters has been used. Wave spectra measured using the new methods are compared with spectra developed using both conventional SAR intensity-based methods and NDBC buoys. [C1028]

"Coherence estimation and speckle filtering based on scattering properties"

In this paper, we propose a new speckle filter for polarimetric SAR that preserves pixels' scattering properties. The basic principle is to select pixels of the same scattering characteristics to be included in the average. To achieve this, the algorithm first applies the Freeman and Durden decomposition to separate pixels into three scattering categories: surface, double bounce and volume, and then unsupervised classification is applied. Speckle filtering is performed using the classification map masks. Pixels centered in a 9Ч9 window are filtered by including only pixels in the same and two neighboring classes from the same scattering category. This algorithm is extended to the coherence estimation of polarimetric interferometry SAR data. The effectiveness of this new algorithm is demonstrated with JPL AIRSAR and E-SAR data. [C1029]

"Multi-waveform full-polarimetric GPR for landmine detection"

A full-polarimetric ultra wideband GPR front-end has been developed in IRCTR especially for landmine detection application. A number of new ideas have been implemented in the design. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarization and in two different frequency bands are main novelty aspects of the radar. Additionally in comparison with commercially available video impulse GPR systems the front-end has considerably larger bandwidth, ability to measure polarimetric structure of the scattered field and very high precision of scattered field measurements. [C1030]

"A study of sea emission models for WindSat"

Three physical models for the microwave polarimetric brightness temperature of the sea surface are reviewed and compared. Two of these models are based on the composite surface theory, but use slightly different forms for the sea surface spectrum. The third model is based on a small slope approximation. All models are shown to predict similar zeroth, first, and second harmonic azimuthal variations of sea brightness and to show reasonable agreement with empirical results. However some discrepancies exist that is examined. [C1031]

"WindSat SDR and EDR on orbit calibration and validation"

The Coriolus spacecraft was successfully launched on 6 January 2003. Its primary payload is the WindSat fully polarimetric radiometer. WindSat is a first-of-its-kind instrument that will remotely sense the speed and direction of near surface winds over the ocean by measuring the partial correlation between orthogonally polarized components of natural thermal emission radiated by the ocean surface at microwave frequencies. The ability of

WindSat to successfully retriece wind vector depends critically on two issues, hardware calibration of the four Stokes brightness temperatures and the relationship between those TBs and the ocean surface wind vector. An approach is described to detecting and estimating possible errors in both the hardware calibration and forward model based on a new type of statistical analysis of the on-orbit radiometer measurements. [C1032]

"Scene characterization using sub-aperture polarimetric interferometric SAR data"

In this paper, a fully polarimetric analysis method is introduced to decompose synthesized interferometric SAR images into sub-aperture data sets, which correspond to the scene responses under different azimuthal look-angles. A statistical analysis of polarimetric parameters permits to clearly discriminate media showing a nonstationary polarimetric behavior during the SAR integration. A method is proposed to observe the polarimetric interferometric properties of anisotropic targets. [C1033]

"On the sensitivity of polarimetric coherence to small and large scale surface roughness"

The objective of this paper is to investigate the effect of a two-scale surface roughness description on the polarization coherence in circular polarization (i.e. PRRLL). Under the assumption of sufficiently smooth surfaces, the small-slope approximation (SSA) model is employed to derive a first order expression for PRRLL. In the paper the sensitivity of PRRLLto azimuth slopes is presented. [C1034]

"Polarimetric optimisation applied to permanent scatterers identification"

In this work, the potential of full-polarimetric SAR data to enhance the performance of permanent scatterers candidates (PSC) detection is investigated. In particular, the problem of finding the polarisation states that maximise the signal amplitude inverse coefficient of variation (ICV) is analyzed. Under the hypotheses of Rice statistics and high signal to clutter ratio (SCR), the problem can be cast into a form equivalent to the optimisation of the ratio between PS (target) and clutter backscatter. Then, solution can be derived for the optimal transmit and receive polarisation states. In the paper, selected typologies of PS and clutter are investigated. The approach is validated through Monte Carlo simulation of the multitemporal polarimetric response of PS-like SAR pixels. Results indicate that optimal ICV values of polarimetrically complex PSC pixels are higher than in the ERS case of the single VV channel, thus leading to increased stability of the subsequent parameter retrieval. Moreover, simulation of ICV vs. SCR suggest that a higher number of PSC may be detected by using optimal polarisation states than in the conventional VV channel alone. [C1035]

"Segmentation of textured scenes using polarimetric SARs"

The methods currently used for classification or segmentation of polarimetric SAR images are based on the multivariate complex Gaussian model. This should limit the application of these methods to "homogeneous" Gaussian areas, since their performances are significantly degraded in the presence of spatial texture. We show that image segmentation can be viewed as a likelihood approximation problem. The optimum criterion is derived for segmentation of K-distributed textured polarimetric SAR images. The product model is assessed and applied only within areas in which the model is valid. The new method is validated for ice type segmentation using Convair-580 SAR data collected in 1993 over Cornwallis Island in Canada. [C1036]

"Evaluation of the Wishart test statistics for polarimetric SAR data"

A test statistic for equality of two covariance matrices following the complex Wishart distribution has previously been used in new algorithms for change detection, edge detection and segmentation in polarimetric SAR images. Previously, the results for change detection and edge detection have been quantitatively evaluated. This paper deals with the evaluation of segmentation. A segmentation performance measure originally developed for single-channel SAR images has been extended to polarimetric SAR images, and used to evaluate segmentation for a merge-using-moment algorithm for polarimetric SAR data. [C1037]

"Optimal image classification employing "optimal" polarimetric variables"

Analysis of polarimetric SAR data often proceeds after first identifying important degrees of freedom in the data, thereby reducing the dimensionality of the problem. Various derived parameters (e.g. entropy, polarization fraction) and/or descriptions of polarimetric data (e.g. scattering matrix, covariance matrix, Stokes Parameters) are employed to effectively reduce the dimensionality of the data while at the same time preserving the relevant polarimetric information. The classification presented in this work involves two steps: first determine the reduced set of variables, from the data, that "optimally" represents the polarimetric information. Second, employ these newfound variables to segment (and classify) the polarimetric SAR image. Finally, the classification results are compared with standard statistical maximum likelihood techniques. [C1038]

"A hybrid scattering model for surface parameter estimation using polarimetric SAR interferometry"

In this work the potential of using the interferometric coherence at different polarization over surface scatterers to extract information about surface parameters is investigated. The sensitivity of the individual coherence contributions to surface roughness and moisture conditions is discussed and simulated using a novel hybrid polarimetric surface scattering model. The model itself consists of a coherent part obtained from the extended Bragg model and incoherent part obtained from the integral equation model. Finally, the experimental airborne SAR data are used to validate the proposed model at different polarizations. [C1039]

"Generalized optimization of polarimetric contrast enhancement"

The optimization of polarimetric contrast enhancement (OPCE) is one of important problems in radar polarimetry. The traditional OPCE is to choose optimal polarization states for enhancing a desired target versus an undesired target/clutter. The contrast enhancement enables us to discriminate or distinguish the desired target from background or from the undesired target. We propose a generalized OPCE (GOPCE). For the GOPCE problem, we need to find not only three coefficients such that the ratio of two factors associated with the desired target and clutter is maximal, but also optimal polarization states such that the received power ratio of the target and clutter is maximal. Both the factors consist of three parameters, i.e., the Cloude entropy (Cloude, S.R. and Pottier, E., IEEE Trans. Geosci. Remote Sensing, vol.35, p.68-78, 1997) and two special similarity parameters (Yang, J. et al., Electron. Lett., vol.37, p.193-4, 2001). The optimal coefficients of the GOPCE are obtained by solving an eigenvalue problem. Using an example, we demonstrate that the GOPCE can be employed for detecting roads in a forest area by using polarimetric SAR data. [C1040]

"Fusion of polarimetric infrared features and GPR features for landmine detection"

Currently no single sensor reaches the performance requirements for humanitarian landmine detection. Using sensor-fusion methods multiple sensors can be combined for improved detection performance. This paper focuses on the feature-level; fusion procedure for a sensor combination consisting of a polarimetric infrared imaging sensor developed by TNO and a video impulse GPR developed by Delft University of Technology. Feature-level sensor-fusion is the process where specific information (i.e. features) from objects detected by different sensors are combined and classified. The single sensor detection methods and the feature-level sensor-fusion methods are evaluated using a leave-one-out evaluation method. This evaluation method provides an independent evaluation set while retaining the largest possible training set. The detection results of both single sensors and the sensor-fusion methods are both presented in receiver operator characteristics (ROC) curves. They show that on the training set feature-level sensor-fusion always outperforms the best single sensor. Furthermore, on the independent evaluation set, there are ROC points of the feature-level sensor-fusion methods that are better than the best sensor. [C1041]

"Processing of polarimetric infrared images for landmine detection"

Infrared (IR) cameras are often used in a vehicle-based multi-sensor platform for landmine detection. Additional to thermal contrasts, an IR polarimetric sensor also measures surface properties and therefore has the potential of increased detection performance. We have developed a polarimetric IR setup, which has to be used in a forward-looking manner. This paper describes all the steps to reach detection performance. The first step is the acquisition of the polarimetric IR image data. The next step is the pre-processing to (re)construct polarimetric images. A subsequent segmentation step is made to identify objects. Features, like intensity, reflectivity and shape, of these objects are measured. For independent performance analyses, the data set is divided into a training and evaluation section. A classifier is trained on the training section and evaluated on the classification section. The detection performance of the forward-looking IR camera is shown in receiver operator characteristics (ROC) curves. [C1042]

"Detection of targets above rough surfaces using millimeter-wave bistatic radars"

In this paper, we report on a new set of indoor measurements aimed at characterizing the bistatic radar return from rough surfaces at Ka-band. The polarimetric response over the entire upper hemisphere, at both low and high incidence and scattering angles, and at near forward and backward directions are reported. This first of a kind data reveals the angular dependence of various polarimetric quantities such as the copolarization ratio, the crossto copolarization ratio, and the correlation between various polarized radar returns. It can be used to validate existing or new surface scattering models and to identify and evaluate bistatic configurations for radar operation. The potential of bistatic radars in detecting the presence of targets embedded in clutter is also demonstrated experimentally using a simple target above a rough surface. [C1043]

"Neural detection for buried pipes using fully-polarimetric ground penetrating radar system"

Ground penetrating radar (GPR) has been widely used for detecting and locating buried objects. However, the detection method using GPR is often subjected to operator interpretation due to large quantities of data and the presence of undesired clutter and noise. The artificial neural network (ANN) technique gives a promising approach to a more systematic and autonomous detection system. An automatic buried pipe detection algorithm, using a two-step ANN scheme on GPR data, is proposed. The detection performance of each ANN in the presence of different signal-to-noise and signal-to-clutter ratios is discussed. Estimating the linearity and orientation of the pipe by fully-polarimetric GPR is reviewed, and applying these factors to pipe detection is discussed. Examples of the two-step ANN detection application to actual field data measured by fully-polarimetric GPR is also presented. [C1044]

"Ground-based polarimetric SAR systems for environment studies"

Polarimetric SAR interferometry is a compound technique that has shown an ability to extract geophysical parameters from SAR images and is useful in terrain classification and surface change detection. SAR is a well-known technique for airborne or spaceborne remote sensing. It can usefully be exploited in a ground-based radar imaging system as well. By using radar polarimetry, a ground-based SAR system can be used for monitoring seasonal vegetation changes. We have developed a ground-based polarimetric SAR system for environmental studies. It is based on a vector network analyzer, polarized antennas and a scanning control unit. We describe the ground-based polarimetric SAR system and present some experimental results of monitoring trees with seasonal variation. [C1045]

"Full-polametric video impulse radar for landmine detection: experimental verification of main design ideas"

A full-polarimetric ultra wideband GPR front-end has been developed in IRCTR especially for landmine detection application. A number of new ideas have been implemented in the design. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarizations and in two different frequency bands are main novelty aspects of the radar. Additionally in comparison with commercial available video impulse GPR systems the front-end has considerably larger bandwidth, ability to measure polarimetric structure of the scattered field and very high precision of scattered field measurements. Experimental verification of these new design ideas is discussed in this paper. [C1046]

"Adaptive polarimetric detection in compound-Gaussian clutter"

In this paper we deal with the problem of polarization diversity detection in compound-Gaussian clutter with unknown covariance matrix. To this end we assume that a set of secondary data, free of signal components and with the same covariance structure of the cell under test, is available. Due to the lack of a uniformly most powerful (UMP) detector, we resort to a design procedure based upon the Rao test and the Wald test. Specifically, we first derive the Rao and the Wald tests assuming that the covariance matrix is known, and then we plug into the derived decision rules a suitable estimate of the clutter covariance. Interestingly, the newly proposed detectors share the constant false alarm rate (CFAR) property with respect to the texture statistical characterization. Moreover simulation results have shown that the Wald based detector ensures a performance level higher than the Rao test. We have also conducted a further performance analysis, in the presence of real radar data and in comparison with the previously proposed generalized likelihood ratio test (GLRT) based receivers, which highlights that in general the Wald test receiver outperforms its counterparts. Finally, since the newly proposed decision rules as well as the previously designed GLRTs do not ensure the CFAR property with respect to the clutter covariance matrix, we have conducted a sensitivity analysis on the probability of false alarm (Pfa), based on simulated clutter with covariance matrix estimated from real radar data. The results have shown that Pfais only slightly affected by variations in the clutter correlation properties and hence the CFARness is substantially achieved. [C1047]

"Performance evaluation of two polarimetric STAP architectures"

Space-time adaptive processing (STAP) is a powerful technique for detecting slowly moving targets in strong clutter. However, STAP performance is limited when used on radars with small apertures. Past research suggests polarization's potential to effectively discriminate between targets and clutter, thereby improving detection performance. We evaluate two methods of incorporating polarization into STAP, modeled after the polarimetric matched filter (PMF) and the polarimetric whitening filter (PWF). Our analysis serves to unify various proposed approaches to combining STAP and polarization, and benchmarks the benefits of polarization to GMTI detection. Using measured clutter and target characteristics from published sources as a baseline, we found that

the PMF technique offers up to 6-dB improvement over STAP. This significant advantage is realized in the center of the clutter spectrum, and the impact on minimum detectable velocity (MDV) is modest. However, the PWF offers increased performance over the entire Doppler spectrum, and can be easily implemented as a STAP post-processor. [C1048]

"Multi-Waveform Full-Polarimetric Video Impulse Radar for Landmine Detection"

A principally new multi-waveform full-polarimetric front-end of a Ground Penetrating Radar has been developed. In comparison with commercially available video impulse GPR systems the key advantages of the front-end are considerably larger bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements in two different frequency bands with two transmit polarizations are main novelty aspects of the radar. [C1049]

"Processing and analysis of polarimetric ground penetrating radar landmine signatures"

The paper presents an analysis of landmine signatures acquired with a polarimetric ground penetrating radar (GPR). First, preprocessing was applied to isolate the target signatures from other reflection events. This included a frequency-wavenumber (f-k) filter to remove unwanted side reflections, followed by background subtraction to remove the direct wave and the ground reflection. The obtained polarimetric signatures of the landmines indicated that these can contain significant cross-polar components, which is in contrast to expectation for a target with a cylindrical casing and most likely a result of internal structure. Making use of the reciprocity property of the scattering matrix, the polarimetric signatures were transformed into the target frame, yielding signatures that are independent of target orientation. From the transformed signatures target impulse responses were estimated using a newly developed deconvolution algorithm. The novelty of the deconvolution algorithm lies in the fact that it computes impulse responses, which adhere to a physical model. Accordingly, the computed impulse responses can be related to mine properties such as size and dielectric permittivity. An interesting application of this is the estimation of a mine's permittivity from its impulse response and the impulse response of a calibration target, of which an example is given. [C1050]

"Toward true amplitude processing of GPR data"

For proper imaging and inversion, four parameters need to be known accurately. These are position of the transmitter and receiver antennas, the wave velocity distribution in the medium, the polarization and the amplitude characteristics of the antennas used. The position information problem is solved by introducing an automated acquisition frame with high accuracy in horizontal and vertical positioning of the antennas over a fixed area. For object detection and characterization purposes, we use elevated antennas, which implies that at least a two medium background medium must be used for accurate velocity information. The velocity in air is known, while that of the Earth must be obtained from independent measurements. The polarization and amplitude characteristics can be obtained for elevated antennas by modeling the transmitter and receiver and validate the model with measurements in air. When the antenna model is accurate, it is possible and necessary to take direct coupling with the ground into account for surface laid antennas. In general, this leads to formulations of the direct source and receiver problems, which can be solved locally by finite element techniques or by global techniques such as integral equation formulations. For elevated antennas, or when time windowing is possible for surface laid antennas, a second way of obtaining information on the wave field, both polarization and amplitude, that is emitted into the ground is to record it in a certain plane in the air. In a configuration with constant velocity horizontal layers, only the down going wave field in the upper half space below the antennas, contributes to the down going wave field in the layered Earth. Accurate knowledge of this down-going wave-field allows the wave-field extrapolation into the layered Earth, which technique can be used in multi-component imaging algorithms accounting for polarization and amplitude. Here the effects of knowing the four parameters are shown. It demonstrated that the multi-component, or full polarimetric, imaging technique is a tool of full operational value only when all four parameters are accurately known. Only then the required increased acquisition effort pays off. [C1051]

"Proceedings of the 2nd International Workshop on Advanced Ground Penetrating Radar (IEEE Cat. No.03EX680)"

First Page of the Article [C1052]

"Ocean environment sensing using polarimetric and interferometric SAR"

New methods have been investigated which use fully polarimetric synthetic aperture radar (POLSAR) image data to measure ocean wave slopes. Independent techniques have been developed to measure wave slope spectra in

both the radar azimuth and range directions. Wave spectra measured using the new methods are compared with spectra developed using conventional SAR intensity-based methods, and with spectra from in situ buoys. Wave-current interactions may also be measured using the same measurement techniques. NASA/JPL/AIRSAR L-band image data from California coastal waters and from the New York Bight are used in the studies. NRL has also recently lead two collaborative field experiments that feature Along-Track Interferometric SAR (AT-INSAR) systems. In April, 2003, NRL, NASA JPL and UCLA collaborated in a study of sub-mesoscale coastal eddies that featured the NASA/JPL/AIRSAR. NRL has also recently collaborated with the University of Massachusetts in a deployment of their Dual Beam Interferometer on the west coast of Florida. This paper presents preliminary data from both of these experiments. [C1053]

"Demonstration of reduced false alarm rates using simulated L-band polarimetric SAR imagery of concealed targets"

Coherent scattering calculations have been performed to produce L-Band SAR images of targets below a forest canopy. The calculations, which are fully polarimetric, are described. High clutter levels permit detection of all concealed targets only at the cost of a very high false alarm rate. The simulated imagery is analysed using the entropy-alpha polarimetric decomposition technique. Using alpha and entropy in addition to a co-polar intensity channel, and combining the results of separate CFAR algorithms, the number of false alarms is reduced dramatically. The consequences for application of polarimetric SAR to concealed target detection and identification are considered. [C1054]

"Prescreening algorithm assessment within the analysts' detection support system"

This analysts' detection support system (ADSS) contains a suite of target detection algorithms for wide area aerial surveillance using synthetic aperture radar (SAR) imagery. The ADSS provides a framework to combine the operation of these algorithms in user-specified configurations. This paper compares and contrasts the performance of the various prescreening algorithms singly and in combination within the ADSS framework on a broad range of SAR imagery. The algorithms include adaptive threshold, K-distributed CFAR, average grey absolute difference magnitude map, and segmenting K-distributed CFAR. The performance of these algorithms is compared on polarimetric imagery to assess the contribution of polarimetry to target detection. [C1055]

"Triple-frequency radar for cloud and precipitation microphysics research"

The University of Massachusetts (UMass), Colorado State University (CSU) and the National Center for Atmospheric Research (NCAR) are collaborating to develop an advanced multifrequency radar (MFR) system for studying clouds and precipitation, which should become operational in 2004. This highly portable radar consists of three polarimetric Doppler subsystems operating at Ku-band (13.4 GHz), Ka-band (35.6 GHz) and W-band (95 GHz), a programmable scanning pedestal, and a unique single aperture antenna that generates colocated matched beams at each frequency. This combination of frequencies allows measurement of a wide range of atmospheric targets including weakly reflecting clouds and precipitation. [C1056]

"MM-wave meteoradars: development, design, and research data"

A review is given of recent activities undertaken in the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine for the development of millimeter-wave meteorological radars. Both, 36 GHz and 95 GHz Doppler polarimetric radars have been developed and produced. The radars are capable to perform real-time, high-resolution measurements of various parameters of clouds and precipitation. The set-up of these instruments and the signal processing technique introduced are discussed. Algorithms for an accurate realtime estimation of cloud and precipitation parameters with mm-wave Doppler radars are considered. The results obtained with the radars during measurement campaigns are presented as well. [C1057]

"A complex of polarimetric, combined active-passive sensors of L-, C-, and X-band of frequencies for vessel and airborne application"

Summary form only given. A complex of polarimetric (dual polarization), combined active-passive devices of L-, C-, and X-band of frequencies for land and sea surface microwave reflective and emissive characteristics simultaneous and coincident measurements is presented. The complex is dedicated to solve the problem applied to near sea surface wind and surface wave fields' parameters precise and unambiguous retrieval, as well as for sea surface signatures detection and identification. The methodology of experiments' performance and field calibration will be discussed. The results of preliminary measurements of sea surface radar backscattering coefficients and brightness temperatures under various conditions of observation (angle of incident, location and polarization), air-water temperatures, wind and wave parameters will be presented. Relationships between sea

surface radar backscattering coefficients, brightness temperatures, statistical characteristics of radar signal frequency's distributions and the parameters of observed media will be built. As well as correlative properties between fluctuations of sea radar backscattering coefficients, radar signal frequency distribution characteristics and brightness temperatures due to the change of sea surface principal parameters air-water temperatures, wind speed and direction, sea wave force and swell condition will be presented. Vessel and airborne application properties of such a complex application for sea surface mapping will be discussed. [C1058]

"An entropy-based approach to wake echo analysis [Cship wake radar detection]"

This paper addresses the problem of ship wake detection and analysis at low grazing angles using eigenvalue analysis of the covariance matrix. Polarimetric measurements of the wake produced by a pilot boat operating in Port Phillip Bay were obtained using the Defence Science and Technology Organisation's (DSTO) high resolution radar system. By employing a polarimetric decomposition on the covariance matrix data, the polarimetric entropy, scattering alpha and anisotropy plots were obtained. Wake and clutter regions were then identified using suitable thresholds. These results were compared with previous results obtained using analysis of the S matrix data and the distribution of cross-polar states and showed good agreement. The ratio of the maximum and minimum eigenvalues of the covariance matrix was also determined as an upper bound on the processing gain that might be achieved by exploiting the polarization domain. [C1059]

"Microwave remote sensing research at the ElectroScience laboratory"

The ElectroScience Laboratory (ESL) at The Ohio State University has made many important contributions to the development of microwave remote sensing, both in theory and practice. The term "remote sensing" is very broad, and could be interpreted to include ESL efforts in areas such as ground penetrating radar technologies, studies of microwave propagation through the atmosphere, contributions to the development of polarimetric concepts for radar, studies of the ionosphere, and experiments and modeling of optical propagation in the atmosphere. More general ESL contributions that play a role in the remote sensing area also include the development of new antennas, radar technologies, and general electromagnetic modeling methods. However, this paper focuses specifically on the "microwave remote sensing" area, where applications involve active or passive microwave sensors used to observe geophysical environments in order to retrieve information about those environments. [C1060]

"Urban area analysis based on ESPRIT/MUSIC methods using polarimetric interferometric SAR"

This paper describes the analysis of man-made area using fully polarimetric interferometric SAR data at L-band. This approach uses a polarimetric interferometric classification procedure to determinate the nature of the different media of the scene under study. An interferometric phase estimation based on ESPRIT methods is applied to the retrieval of the height of different media and specifically for the characterisation of the buildings. [C1061]

"Model-based processing of multifrequency polarimetric SAR images of urban areas"

In this paper, we describe a two-step classification scheme for fully polarimetric SAR images. The classification scheme is composed of the cascade of an optimum segmentation stage, and an ML supervised classifier. Different segmentation schemes are described, specifically designed for mono- or multifrequency images. The classification scheme is applied to a set of fully polarimetric, multifrequency SIR-C images of the town of Pavia, in Northern Italy, considering all the possible pairs of polarimetric channels and the two bands individually and jointly, aiming at identifying the best combination for practical applications. Results show that for urban areas, the best performance is achieved by jointly processing the three polarimetric channels, and the minimum performance degradation is achieved considering the HH and the HV channels. [C1062]

"POLInSAR regularisation using dual frequency interferometry"

In this paper, we employ a two-level coherent polarimetric vegetation scattering model to investigate forest parameter estimation using fully polarimetric single baseline radar interferometry. It is shown that model inversion requires regularisation to remove multiple solutions. Traditionally this is achieved by using assumptions about polarimetric ground scattering. Here we investigate the possibility of regularisation using an extra InSAR channel obtained from a higher frequency sensor. Given that dual band InSAR systems are already used for airborne mapping applications, and that the SRTM global data base is now widely available, such a regularisation strategy has important practical implications for the efficient use of radar interferometry for quantitative parameter estimation. [C1063]

"Multi-waveform full-polarimetric video impulse radar for landmine detection"

A principally new multi-waveform full-polarimetric front-end of a Ground Penetrating Radar has been developed. In comparison with commercially available video impulse GPR systems the key advantages of the front-end are considerably larger bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements in two different frequency bands with two transmit polarizations are main novelty aspects of the radar. [C1064]

"Target discrimination in the S.A.R. systems by using radar polarimetry"

For a SAR system that coherently transmits and receives both signals from an orthogonally polarized antenna pair, the elements of the resulting scattering [S] matrix can be measured. As a result, polarimetric processed imagery is visually much clearer than single-polarization channel imagery. In addition, fully polarimetric SAR imagery improves the performance of an ATR system, compared to the performance achieved by using single-polarization channel imagery. This paper gives a brief description of some polarimetric tools and techniques used to analyze and process polarimetric data. Several polarimetric discrimination results are displayed, demonstrating the potential capability of characteristic polarization imaging and the usefulness of polarimetric radar in the target discrimination process. [C1065]

"Ultra wideband endfire synthetic aperture radar for landmine detection"

The detection of landmines is an important and challenging application for remote sensing technologies. The use of ground penetrating radar is an established technique but requires close coupling between the antennae and the ground and generally suffers from a poor area coverage rate. In order to clear mines rapidly along a route using a vehicle mounted system, a forward looking sensor is required that can operate effectively in a stand off configuration and detect surface laid, flush and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried, clutter. The Remote Minefield Detection System (REMIDS) is a technology demonstration programme funded by the UK Ministry of Defence designed to use an Ultra Wideband Synthetic Aperture Radar (UWBSAR) and a polarimetric infrared camera. The UWBSAR is a 3GHz bandwidth impulse radar with onboard data collection and offline image processing. The UWBSAR has been successfully trialled against landmines. Previous trials have mounted the radar on an airship and employed a conventional side-looking imaging geometry. In contrast, for the trials reported in this paper, the radar was amounted on a trolley to simulate a ground vehicle and operated in a forward-looking mode. The resulting use of an endfire synthetic aperture radar rather than the more conventional broadside aperture is the principal development reported in this paper. This coarsens the resolution and introduces a left-right ambiguity into the data. Previous trials have also highlighted the lack of a comprehensive data set containing controlled targets and a range of clutter conditions. The current trials were therefore conducted on a purpose built 80m test track which contained five different soil types, a range of surface conditions and over 200 targets of varying types and burial depth. The trials campaign collected over 500 data sets by varying the conditions of data collection in terms of polarisation, antenna height, antenna separation, incidence angle, power levels and pulse repetition frequency. The experimental configuration allowed the track of the platform to be repeated to sufficient accuracy to allo- w the synthesis of multiple baselines in the vertical and horizontal. The principal conclusions from the trials analysis are 1) that the data set collected is of good quality and comprehensive in terms of targets and background; 2) the endfire synthetic aperture configuration worked as anticipated; and 3) the left-right ambiguity can be resolved if a suitable antenna configuration is used. [C1066]

"Improvement research on texture-detection in full-polarization SAR image filter"

The Polarimetric Whitening Filter (PWF) method for speckle reduction in polarimetric synthetic aperture radar (SAR) is stated with some traditional covariance matrix parameter estimate methods. Aimed at their defects in parameter estimation, an enhanced auto-adaptive edge-detection method for parameter estimating is presented. Because of the lack of point target and line detection in the above-mentioned methods, a new parameter estimation method is then introduced. Finally, results of the above-mentioned methods applied in PWF are submitted. Detail analyses and comparisons are also given. It is proved that the new parameter estimation method is the most robust. [C1067]

"Decision level fusion of multi-frequency polarimetric SAR and optical data with Dempster-Shafer evidence theory"

This paper investigated and tested the multi-source data fusion of multi-frequency SAR data with optical sensor, utilizing the mathematical theory of evidence. In this type of data fusion, the correct definition of uncertainty and

mass function is very important. Firstly each mono-source data is independently classified using the Bayesian maximum likelihood classification method and the fusion is processed during the decision making stage. For the representation of support and plausibility, mass of evidence is assigned to the candidate labels associated with the frequencies of neighborhood pixels' decision. Then the mass is weighted again by both the distance effect and the global source-specific reliability. In the combination and fusion stage, unions of classes get same mass values to emboss its uncertainty of decision making. Finally Dempster's orthogonal sum method was used to combine the evidence information and the associated level of ignorance, and then the maximum support rule decides the final land-cover types. Classification accuracies before and after each step of fusion processing are compared with reference training data set. We applied this method to the NASA/JPL polarimetric AIRSAR data and KOMPSAT-1 (KOrea Multi-Purpose SATellite-1) EOC (Electro Optical Camera) panchromatic data and obtained noticeably better land-cover classification results. [C1068]

"Analysis of high resolution polarimetric SAR in urban areas"

Parallel to the conventional (statistical, spectral) description of mixed urban classes for image segmentation, the description on the basis of cues and related spatial properties is used within the classification process. Recently we concentrate very much on strong model-based classification, which may lead to a classification not covering the whole area due to the implementation of insufficient models (class descriptions). Major interest is related to urban features like urban fabric, continuous urban fabric (dense, medium dense), discontinuous urban fabric (dense residential, sparse residential, residential blocks) as well as industrial areas. [C1069]

"Extraction of vegetation parameters based on simulated annealing algorithm using polarimetric SAR interferometry data"

An inversion scheme of vegetation parameters based on a simulated annealing algorithm using polarimetric SAR interferometry (Pol-InSAR) data is presented. Comparing the result of inversion with field measurement, it indicates that the inversion algorithm can obtain the height of vegetation with good accuracy. [C1070]

"A new parameter for IFPOL coherence optimization methods"

The interferometric coherence optimization methods are based on the definition of projection vectors, which is the way to combine the information occurring from the polarimetric channels of both interferometric images. Optimization algorithms have already been proposed. In order to know in which cases these algorithms really improve the scalar interferometric result, a new entropy parameter H' calculated with the eigenvalues found by the second optimization method and called IFPOL entropy is introduced. The physical significance of this entropy parameter is first explained. Particular cases where this parameter is equal to 1 are studied. Finally, we explain how this parameter H' can be used in order to obtain more information on the scene and, for example, to improve terrain classification methods. [C1071]

"Polarimetric SAR image processing: Wishart vs. "H/A/alpha" segmentation and classification schemes"

In this paper we analyze the potentialities of two different representations commonly used for polarimetric SAR images, for segmentation and classification purposes. The first representation is based on the covariance matrix of the considered polarimetric channels, while the second is based on the "H-A-alpha" decomposition. For both representations, we devise a segmentation + classification scheme, and we evaluate their performance on a set of C-and L- band polarimetric AirSAR images. On the basis of the achieved results, we devise a hybrid scheme, that uses a segmentation algorithm based on the full covariance matrix, then jointly classifies the pixels of the identified homogeneous regions considering the "H-A-alpha" representation. Results show that the hybrid scheme provides a significant performance improvement with respect to the approaches based on a single representation. [C1072]

"Classification of polarimetric synthetic aperture radar images using fuzzy clustering"

Clustering is a well known technique for classification in polarimetric synthetic aperture radar (POLSAR) images. Pixels are represented as complex covariance matrices, which demand dissimilarity measures that can capture the phase relationships between the polar components of the returns. Four dissimilarity measures are compared to judge their efficacy to separate complex covariances within the fuzzy clustering process. When these four measures are used to classify, a POLSAR image, the measures that are based upon the Wishart distribution outperform the standard metrics because they better represent the total information contained in the polarimetric data. The Expectation Maximization (EM) algorithm is applied to a mixture of complex Wishart distributions to classify the image. Its performance matches the FCM clustering results yielding a tentative conclusion that the

Wishart distribution model is more important than the clustering mechanism itself. [C1073]

"Passive polarimetric remote sensing of the ocean surface during the Rough Evaporation Duct experiment (RED 2001)"

This paper describes the deployment of a fully polarimetric K-band radiometer in the Rough Evaporation Duct (RED) experiment, which was conducted during August and September of 2001. The calibration of the four Stokes parameters is described, along with a comparison of the measurements with results of both the Klein-Swift and Ellison et al. sea surface dielectric models. The purpose of the experiment was to improve physical forward models of the ocean surface emission in order to improve wind vector retrieval algorithms. [C1074]

"Polarimetric analysis of P-BAND SAR data acquired over a forested area: "the PYLA 2001 experiment""

P-band airborne SAR (the French RAMSES facility) data were acquired in the framework of the PYLA 2001 project. Images from the Nezer forest are investigated by means of a Van Zyl classification scheme. A new relation between the classification in terms of backscattering mechanisms and the mean height of the trees is proposed. [C1075]

"Polarimetric properties of chaff"

The paper presents the scattering models of chaff that capture the essential polarimetric properties as well as some data to support the properties. Two simple scattering models are used to compute polarimetric variables. The models are Herzian dipole and thin wire antenna. The result shows that two models produce very similar results if the chaff length is half the radar wavelength or less. [C1076]

"A phase signature for detecting subsurface moisture using polarimetric L-band SAR: example of the Pyla dune-France"

We investigate the penetration capabilities of L-band microwaves for the mapping of subsurface moisture. Our experimental site is the Pyla dune, a bare sandy area allowing high signal penetration and presenting large subsurface wet structures (paleosoils) at varying depths. We established that a phase signal is correlated to the buried and wet paleosoils: a phase difference between HH and VV channels reaching 25° was clearly observed on L-band airborne SAR data. This phase signature was confirmed by fieldwork measurements and fits the semi-empirical model proposed by Oh et al. [C1077]

"Experimental validation of an electromagnetic model for rice crops using a wide-band polarimetric radar"

A physics-based electromagnetic model specially tailored for the computation of the radar backscatter from rice crops is being developed. The model produces estimates of the coherent polarimetric backscatter response as a function of the sensor parameters and the physical description of the scene. This model is currently under validation against experimental data gathered in the European Microwave Signature Laboratory (EMSL). First results, obtained by a direct comparison of simulated and measured backscattering coefficients (with HH, HV and VV polarizations), show a reasonable agreement. The dependence on incidence angle, frequency and morphological characteristics of the rice plants is currently being assessed. [C1078]

"An airborne campaign measuring wind signatures from the sea surface using an L-band polarimetric radiometer"

A series of circle flights have been carried out over the sea surface, using the EMIRAD L-band polarimetric radiometer. Motion compensation is applied, and polarimetric azimuth signatures are generated. Single tracks show geophysical noise, typically about 2 K, but averaging decreases the noise, producing signatures with variations below 500 mK. A harmonic analysis of the results provides no clear signature, and for the 2nd, 3rd, and 4thStokes parameters it is shown, that a significant part of the signal must be due to Gaussian noise. The 1stStokes parameter is shown to have a 500 mK 2ndharmonic, but a comparison of the signature to the downwelling galactic background radiation indicates, that the signature may not origin from the wind driven sea surface pattern. [C1079]

"P band data collection and investigations utilizing the RAMSES SAR facility"

ONERA, the French aerospace research agency, has developed a multi-frequency, full polarimetric and high resolution airborne SAR facility named RAMSES, which has been expanded with a P-band (435 MHz) capability

at the end of year 2000. The Gironde area was chosen as a suitable test-site for fieldwork validation of P-band capabilities in coordination with the "low frequency radar working group" set up by CNES (French Space Agency), the DGA (DOD Procurement Agency) and the CEV (French Flight Test Center). This experiment has explored the capabilities of this low frequency band for sub-surface moisture detection (on the "Pyla" sand dune), biomass assessment (on the Nezer forest), mapping of the ocean bathymetry/salinity (on the "bassin d'Arcachon", estuary of the Gironde), and archaeology (imaging of buried Roman-era artifacts). After a short description of the radar P and of the experience feedback of campaign "PYLA 2001" on the P-band radar, we present a preliminary synthesis of the results on the different sites. The "PYLA 2001" campaign results are encouraging. We therefore plan further experiments at the beginning of 2004 over Egypt (with simultaneous band P+L). In conclusion, we present the future research trend at ONERA in the domain of lower frequency (VHF/UHF) SAR. [C1080]

"The DSTO Ingara airbone X-Band SAR polarimetric upgrade: first results"

The Ingara airborne multi-mode X-Band imaging radar system developed by DSTO has been upgraded to a fully polarimetric collection capability with a 600 MHz bandwidth. The initial trial of the upgraded system in December 2002 included the collection of synthetic aperture radar data sets of a calibration scene including interferometric repeat passes. The application of calibration techniques to the data yields a measured channel cross talk less than -30 dB. [C1081]

"An unsupervised classification method for polarimetric SAR images with a projection approach"

Two unsupervised training algorithms are presented based on a projection method for polarimetric SAR images. For this, polarimetric features, including the entropy H, angle α, anisotropy A, the largest eigenvalue of the coherence matrix λ1and coherence γ, are computed. Based on these features three noncorrelated and independent variates, which are the first three principle components are extracted using the principle component analysis. Then, a three-dimensional Cartesian coordinate is constructed using those three resultant variates. In order to reasonably define the initial cluster centers for the unsupervised classification, a projection method is proposed. As a result, a sophisticated two-dimensional feature space is obtained. Two initial cluster center determination algorithms, the histogram and histogram-quadrant methods, based on the above two-dimensional feature space are presented. Unsupervised classifications (with a minimum distance decision rule) are conducted based on the defined initial cluster centers. The classification results show that these approaches have high performance in convergence, speed, data volume and accuracy of training and classifying. [C1082]

"Improved polarimetric SAR classification by application of terrain azimuth slope corrections"

In polarimetric SAR imagery, along-track or azimuth slopes cause a shift in the polarization orientation angles. By estimating the orientation angle shift, Schuler et al. have been able to generate topographic models in good agreement with DEMs produced by other means. An improved method for estimating the orientation angle was developed by Lee et al. along with a unified analysis of available techniques. Another way to view this work is as a means of correcting the polarimetric SAR imagery for the terrain-induced slope effects in order to improve the accuracy of geophysical parameters derived from the SAR imagery. In this paper the techniques of Lee et al. are used to correct C and L-band polarimetric AIRSAR imagery taken in 1996 over the flanks of Mt Tongariro, New Zealand. We then use the corrected and uncorrected data in classification schemes and compare the results to demonstrate the effects of the azimuth slope corrections. The volcanic Mt Tongariro provides a rich variety of surface slopes, and a variety of vegetation is present including exotic forest, native forest, scrub, grasses and bare ground. Class statistics extracted from fore- and back-slopes (in the azimuth direction) are observed to cluster more tightly than for uncorrected data. This effect is more pronounced for L-band than for C-band. The largest effects were seen in targets of low polarisation entropy such as exotic forest. These corrections result in a modest improvement in the overall classification accuracies. [C1083]

"A study of the effects of melting snow on communications links in Scotland"

Melting snow, or sleet, is recognised as a potentially serious form of impairment on communications links in cooler temperate climates. Current models neglect sleet, and base their precipitation-related fade depth solely on rain. To develop an improved understanding of the potential effects of sleet, the Radio Communications Research Unit at RAL has developed a 3 GHz fully scanning polarimetric Doppler radar and deployed it at the University of St Andrews in south-east Scotland. It is designed for long-term, statistical observations of rainfall spatial structure and melting layer effects in Scotland. Data from the radar will augment measurements of precipitation-induced attenuation along operational microwave and millimetre wave communication links in the radar coverage area. Results are presented of a continuing study to quantify the annual statistics of the radar-derived melting layer height and its vertical extent and the correlation with ground temperature and raingauge

measurements. Comparisons are made between radar-measured parameters and theoretical predictions from a melting layer model, developed at the University of Essex, UK, in an attempt to impose constraints on the model parameters. Once this is achieved, more confidence can be gained in the ability of the model to describe the additional attenuation to be expected in the melting layer. Finally, examples are shown where radar measurements support the idea that observed enhancements in link attenuation are related to a descent of the melting layer to intersect the link path. [C1084]

"Polarimetric time-frequency distributions and applications to radar imaging"

We introduce the polarimetric time-frequency distribution (PTFD) and consider its applications to radar imaging applications for polarimetric Doppler signature estimation and source discrimination. The PTFD integrates polarization with time-frequency analysis, specifically bilinear transformations. It exploits the time-varying nature of both polarization and frequency for improved target identification, classification, and characterization. [C1085]

"Reflection characteristics of a retrodirective PARC"

Reflection characteristics of a retrodirective PARC (polarimetric active radar calibrator) were measured in a radio anechoic chamber. The reflection beamwidth was twice as wide as that of a conventional array reflector of the same size, and the measured RCS was 40.8 dBm2that almost agreed with the predicted value of 41.5 dBm2. [C1086]

"Fully polarimetric classification accuracy"

Assuming that polarimetric data is entirely described by the underlying complex covariance matrix, this paper gives expressions for the maximum likelihood classification accuracy, and applies these to real data. This assumes negligible interclass environmental variation and a homogeneous image structure which is overly simplistic. By including a model of environmental variation, more realistic results may be possible. [C1087]

"Targets classification of semi-arid region using polarimetric SAR data $an example in Xinjiang, China"

This paper develops a classification way using polarimetric synthetic aperture radar (SAR) data. Polarization of radar electromagnetic wave is a very important factor of backscattering theory and geosciences applications. However, polarimetric SAR images are still difficult to interpret and therefore there is a need to improve the classifier that can make use of the polarimetric information. Under the certain circumstance the present paper attempts to classify remotely sensed scenes by all the complete polarization response parameters, which are presented as data dimensions for classification arithmetic. The test site is located in Hetian of Xinjiang, China. SIR-C data were acquired in the test site in 1994. Fully polarimetric SAR data can be processed as multi-dimensions images. But the polarimetric information is related greatly with variable targets. Firstly, we decompose the backscattering matrix and get polarimetric ratios, polarimetric degree, and polarimetric entropy. These polarimetric parameters are considered as data dimensions in which elements change in terms of probability functions with variable targets. Training samples were then generated from the outputs of the unsupervised classification of K-means, to be used in subsequent supervised classifications of two frequencies (C- and L-band for SIR-C data) and various polarization combinations. The estimation of the classifier tallies with the local municipal statistics. The result shows that classification precision can be improved finely with the polarimetric technique. [C1088]

"A bandwidth extrapolation technique of polarimetric radar data and a recursive method of polarimetric linear prediction coefficient estimation"

Resolution of a radar is limited in range by its bandwidth. One of the various super-resolution techniques for improving its resolution is bandwidth extrapolation (BWE). In the technique, a linear prediction model is fitted to the data, and the model is used to extrapolate the bandwidth. In this paper, the concept of BWE is extended, and a new algorithm called polarimetric bandwidth extrapolation (PBWE) applicable to polarimetric radar data is proposed. It is shown through numerical simulations that utilization of full polarization information allows PBWE to improve the resolution beyond the conventional BWE method. Some results of physical simulation experiment using a W-band polarimetric FMCW radar and corner reflectors are shown to confirm the advantage of PBWE. [C1089]

"Wideband radar phenomenology of forest stands"

In this paper, experimental ultra wideband radar backscatter response of a forest stand for remote sensing using applications are presented. The radar signal is a a zero-mean pulse with a duration of 1.5 ns, and rise time of

0.1 ns occupying a bandwidth 3 GHz from 0.5 GHz-3.5 GHz. The transmitter pulse amplitude exceeds 240 V in a 50 ohm transmission line giving rise to a peak power of about 1.15 kW. The transmit and receive antennas are broadband and with voltage standing-wave ratio of better than 1.2 up to 12.0 GHz. The radar is capable of transmitting both horizontal and vertical polarizations. Radar ranging of up to 180 m was achieved with a pulse repetition rate of 5 kHz. This radar was deployed to measure polarimetric backscatter from a 40-year old larch plantation stand with viewing angle varying from 50° to 75°. For calibration, a corner reflector with 1 m side length was applied. Attenuation of the radar signal propagating through the canopy was extracted from the backscatter response of the the forest. Two specific features are observed from the attenuation data one having an exponential and the other having a power law dependence with distance. For the pulse scattered by the trihedral reflector imbedded in the forest, a phase diagram representing the parametric relation between the quadrature components of the receive signal is analyzed. The results obtained in this study show new possibilities for radar remote sensing of forest parameters with ultra wideband radars. [C1090]

"Development of a new C-band polarimetric Doppler weather radar in Japan"

Communications Research Laboratory (CRL) has developed a new C-band (5340-MHz) multi-parameter Doppler radar system with a bistatic Doppler radar network. The purpose is to establish the next-generation technology of precipitation observation for meteorological and hydrological applications, such as weather forecasting and run-off analysis for predicting floods. This new radar is named COBRA (CRL Okinawa Bistatic polarimetric RAdar). The weather targets of the system are typhoons, Baiu-frontal rainfall, meso-scale precipitation in subtropical zones, and clear-air turbulence. Two transmitter (klystron) units are used for to observe the polarization characteristics of precipitation particles. The transmission polarization for each pulse is selected from six possible polarizations. The return signal is measured simultaneously by two receivers, one for the horizontal polarization and the other for the vertical polarization. [C1091]

"Orbital SAR simulator of fishing vessel polarimetric signatures based on high frequency electromagnetic calculations"

This paper continues the work developed in related to a numerical tool able to simulate the full-polarimetric raw data for a given orbital SAR system from a realistic vessel model. This simulator makes possible the construction of a precise database of vessel radar signatures that will be used to develop classification algorithms. The simulator will be also useful to determine the system parameters of a future orbital SAR sensor dedicated to sea activity monitoring. This paper is focused on the validation tests and the new improvements developed. [C1092]

"Utilization of the radar polarimetric covariance matrix for polarization error and precipitation canting angle estimation"

The 3Ч3 radar polarimetric covariance matrix provides a complete set of measurements from distributed particles. Via optimum polarization theory, radar system polarization errors and particle orientation distribution parameters can be estimated. While the theory of covariance matrices and associated optimum polarizations for random media have been known for some time, the application to retrieval of microphysical information of precipitation is much more recent. Well calibrated covariance matrices and in particular the calibration of the phases of the two co-to-cross covariance terms hhSvh*>and vvShv*>is necessary before optimum polarization analysis. [C1093]

"An overview of the Keys area precipitation project (KAPP)"

As part of the NASA tropical rainfall measuring mission ground validation (TRMM-GV) program, a field campaign was conducted in Florida Keys during August-September 2002. The purpose of the field campaign was to study the characteristics of rainfall over the Florida Keys, utilizing Key West WSR-88D, NASA's s-band polarimetric radar (NPOL), and a network of rain gauges and disdrometers. This study focuses on the performance of the rain gauges and disdrometers and its impact on the radar rainfall algorithms. [C1094]

"Current maps and bathymetry from P-band SAR images: preliminary results"

Microwave remote sensing at very long wavelength is already used and validated for coastal zone regions and regions covered by ice (Antarctica) using airborne systems. For many other applications, a high potential exists and the PYLA 2001 experiment allowed the acquisition of data for fields still under preliminary tests. The experiment was carried on a Transall aircraft (French army/DGA) and used the SAR sensor RAMSES (multifrequency/multipolarization) from ONERA by P. Paillou et al. (2001). For the experiment, the acquisition was performed in P band (435 MHz). The aim was to explore potentials of the low frequency domain for sub-

surface moisture detection (Pyla sand dune), biomass evaluation (Nezer forest), mapping of the ocean bathymetry and salinity (Arcachon inlet, estuary of the river Gironde), and archaeology (St Germain d'Esteuil, Dignac, Moulin du Fa). A dedicated P-band calibration site was set up in order to fully exploit the polarimetric information. This part of the study consists of analyzing SAR images from RAMSES (P band) in order to be able to take into account the effect of longer surface waves, winds and currents on the surface roughness in the Arcachon inlet. Tidal currents associated with long oceanic waves recorded at the mouth of the inlet, including the northern channel and sand banks of the ebb tidal delta. The analysis provides tools allowing the production of current maps, which are in turn compared to in-situ measurements by GPS on surface drifting buoys and to current velocity fields provided by a 2DH numerical model, MARS-2D. The evaluation of the ability of a 1D hydrodynamical model applied to SAR images in order to reproduce currents in the area presented. Multipolarization images can be used in order to separate the information associated with the ocean surface (tilt) modulation, which is different for each polarimetric image, from the hydrodynamic modulation, similar for each image. The tilt modulation is representative of a Real Aperture Radar-like (RAR) image. The data being available quite late, we just performed correlations between each set of data by using polarimetric coefficient. We obtain good answers on the information associated with the motion of the scatterers. [C1095]

"Variograms: practical method to process polarimetric SAR data"

Most application of polarimetric SAR imagery require more efficient processing technique which achieves two fundamental goals. The first one is to detect and classify the constituent remotely sensed scenes from pixels to pixels in the imagery. The second one is to reduce the data dimensions without loss of critical information because the fully polarimetric SAR data can be processed just as multi-dimensional images, which could like multi-bands spectrometer images. It is the increased use of spatial data in remotely sensed images that we can get the valuable extraction. But there is composing complexity among the polarimetric imagery texture comparing some hyperspectral images. Some strong backscatters may exist under arid surfaces and contaminate some adjacent pixels. The contamination of imagery decreases the precision of classification. To determine the pixel distance in spatial coordinate is a key to debar some difficulty in front of polarimetric SAR data. The approach to link the nature and cause of spatial variation in image is to use the variograms and subsequent Kringing theory. The data results from the fully polarimetric images prove that the variograms are the tool used to link models of radar backscattering scenes. Some directional variograms aim to indicate the backscattering anisotropy, the height of the sills of the variograms are related to the kinds of the remotely sensed objects and the range of the influence is related to the acting distance on pixels of scenes. [C1096]

"Performance of STAR-Light receivers during CLPX"

STAR-Light is a 10 element, 1.4 GHz aperture synthesis radiometer being developed at the University of Michigan. It features 3 new technologies: 1) 2-dimensional aperture synthesis using 3-bit correlation, 2) Direct Sampling Digital Receiver (DSDR) architecture, and 3) band definition in the digital definition in the digital domain. The instrument successfully completed Critical Design Review in the spring of 2002 and is being fabricated as funds become available. As a test of robustness of the receiver design, we are using four STAR-Light receivers in a dual-polarized 1.4 GHz radiometer, and two are used as IF amplifiers in a dual-polarized 6.7 GHz radiometer. Both radiometers will eventually be fully polarimetric. The system is currently deployed near Fraser, Colorado, as part of the NASA Cold Lands Processes Experiment (CLPX) to occur in February and April, 2003. We will report on the performance of these receivers in this relatively harsh environment. [C1097]

"A three-step phase correction approach for airborne repeat-pass interferometric SAR data"

The operational use of airborne interferometric SAR data acquired in repeat-pass mode for DEM generation, polarimetric SAR interferometry, SAR tomography, and differential SAR interferometry is restricted due to imperfections of the available GPS-based motion compensation data, as well as due to the adopted strategies for efficient SAR raw data processing and motion compensation. A three-step correction approach is proposed, partly based on the availability of a (high resolution) digital elevation model of the area of interest, which might be obtained e.g. through the use of single-pass SAR interferometry. Attention is given to the implementation of these methods for squinted geometries. The performance is demonstrated using data of he DLR-owned E-SAR system in repeat-pass imaging mode. [C1098]

"Sensitivity analysis of self-consistent polarimetric rain retrieval to C-Band radar observables"

Numerical simulations are used to investigate the sensitivity of C-Band rain retrieval to polarimetric radar observables. The simulator is based on a T-matrix solution technique, while the hydrometeor distribution have been characterized with respect to dielectric composition (water, ice, and mixed phase), raindrop size distribution (normalized gamma distribution), shape (ellipsoid with parameterized aspect ratio), and angle orientation. The

self-consistent ZPHI approach is here adopted and the sensitivity analysis is performed in order to evaluate the expected errors of this method to radar observables. Since differential phase shift KDPis affected by the spatial variation of the backscattering differential phase shift δ, a new neural-network estimation technique is applied to remove δ effects on KDPestimate. The performance of these correction procedures and the effects of an error bias on radar measurements is evaluated by using mono-dimensional Gaussian raincell models. [C1099]

"Application of Gaussian Markov random field model to unsupervised classification in polarimetric SAR image"

The aim of this paper is to demonstrate that the Gaussian Markov random field (GMRF) model can be successfully applied to the classification pf multi-frequency polarimetric SAR data. As a special case of MRF, the GMRF has been shown to be an accurate compact representation from a single-band textured images or multi-band textured images. To apply the method to the classification of inter-channel correlated polarimetric SAR data, we first transformed the data into combination of uncorrelated principal component images. Both intensities (hh, hv, and vv) and phase difference (φhh-vv) images of L- and P-band data are considered for classification in the study area in Jeju Island, South Korea. The properties of the transformed data reveal that the images tend to be Gaussian and they are mutually uncorrelated. The GMRF model therefore can be applied to the classification of the transformed polarimetric SAR data. As the GMRF model is a type of classifier based on segment merging, the classification process begins from the initial guess consisting of large amounts of segments. Spatially and statistically similar regions are combined to update the segmented map for each iteration. The final classification map based on polarimetric characteristics shows improvements in the accuracy and efficiency of the classification frame for the tested polarimetric SAR data. [C1100]

"Polarimetric study of scattering from dry snow cover in alpine areas"

This paper introduces a qualitative characterization of dry snow scattering behaviour in Alpine areas. An electromagnetic scattering model is developed, based on the vector radiative transfer equation, to simulate the fully polarimetric response of a snow cover. Multi-temporal and multi-frequency polarimetric SAR data acquired over Alpine test sites are analyzed by comparing polarimetric indicators to simulated ones with various sets of snow cover characteristics. [C1101]

"Millimeter-wave polarimetric bistatic radar scattering from rough soil surfaces"

Polarimetric measurements of the bistatic scattered fields from a rough, dry, soil surfaces, were performed recently at 35 GHz over the entire upper hemisphere, at both low and high incidence and scattering angles, and at near forward and backward directions. These measurements are discussed in this paper and the angular dependence of the bistatic scattering coefficients, σ0, and the correlation between various polarization combinations are presented as well. [C1102]

"Seasonal polarimetric measurements of soil moisture using tower-based GPS bistatic radar"

The results of GPS L-band (L1, λ = 19 cm) surface reflection measurements observed using multiple polarizations and receiving antenna gains are described. The measurements were performed using the 300 m tall ETL Boulder Atmospheric Observatory (BAO) tower during summer through fall of 2002. In this experiment, the first seasonal measurements of bare soil moisture from a stationary location using bistatic reflection of signal of opportunity were performed. Several receiving antennas offering various gain and polarization sensitivities were used. Theoretical modeling of bistatic surface scattering shows that the magnitude and width of the reflected waveform depend on the dielectric permittivity of the soil, vegetation cover, and soil roughness. By observing from a fixed tower over low grass, the roughness of the reflecting area remains constant, hence variations in the signal are uniquely related to changes in the dielectric permittivity, and therefore, to soil moisture. To investigate polarization sensitivity of the reflected signal to soil moisture, four endfire (12 dB) antennas with complete circular and orthogonal polarization sensitivities were used. The high-gain antennas increased the received dynamic range and reduced surface multipath radio wave interference. Seasonal retrievals of soil-moisture content from multi-polarization GPS reflection data is presented and compared with in-situ soil moisture measurements. [C1103]

"Visualisation of cross-polarised response patterns over short vegetation"

The analysis of polarimetric response patterns for earth science applications has been hindered by difficulties in attributing phenomenological response patterns to interactions between polarized waves and multi-layered landscapes, such as forested and agricultural areas. Traditional analysis of response patterns relies on the use of areal responses to characterize landscapes. It is shown in this paper, however, that the variability of response patterns within apparently homogenous areas may provide extra information on the nature of polarimetric

interactions. A new technique is described, which allows the synoptic analysis of response patterns over these sub-scenes. Using this technique, it is found that response patterns over forested areas are too variable to provide a basis for classification. However, an area of reed beds within the forest image produces a response pattern that is consistent over large areas. This distinctive pattern is more widespread in the agricultural scene, suggesting that it may be the result of coherent interactions between stalks and the underlying surface. The results of this approach are made more significant by the fact that the characteristic response pattern cannot be achieved by additively combining idealized response patterns, and suggests that the response is caused by coherent effects. As the use of additive modelling is common within polarimetric radar research, it is proposed that further research into the nature of the observed response patterns may provide useful additional information which can be incorporated into future models. [C1104]

"Examination of forest polarimetric backscattering with coherent cylinder model"

In this work a coherent backscattering model for cylinders has been employed to simulate L-band and C-band polarimetric backscattering form a pine forest. Scattering covariance matrix, entropy, alpha angle, polarimetric coherence and temporal coherence are calculated and compared with SAR measurements. The results show that direct backscattering from tree crowns is an important scattering mechanism. Realistic ground reflection modelling was shown to be very important. By simulating the tree growth, general agreement between the known biomass and backscattering parameters was achieved. [C1105]

"Development of a classification algorithm for operational polarimetric NEXRAD radar"

Classification of meteorological and nonmeteorological radar echoes will be one of the key functions of the operational polarimetric NEXRAD radar. In this paper, basic principles of the classification for several cases are presented. The data were obtained from the polarimetric prototype of the NEXRAD radar. [C1106]

"Synthetic Aperture Radar for Search and Rescue: studies at natural resources Canada-update"

The use of Synthetic Aperture Radar to assist Search and Rescue in the location of downed airplanes is being explored in studies at Natural Resources Canada (Canada Centre for Remote Sensing). Test imagery in polarimetric mode is being acquired b the C-SAR on board the Environment Canada Convair-580. This paper discusses algorithm studies and recent results. [C1107]

"Calibration and validation of palsar (II) use of polarimetric active radar calibrator and the Amazon rainforest data"

First Page of the Article [C1108]

"Analysis of built-up areas from polarimetric interferometric SAR images"

First Page of the Article [C1109]

"The dependence of polarimetric coherence on surface roughness for very rough surfaces"

First Page of the Article [C1110]

"Effective shape of raindrops. Polarimetric radar perspective"

In this study, polarimetric radar measurements are used for estimating mean shape of raindrops for several rain events. A linear dependence of the axis ratio on equivolume raindrop diameter is assumed, and the slope β of such dependence is obtained from the measurements of reflectivity factor Z, differential reflectivity ZDR, and specific differential phase KDP. Within-the-storm and between-the-storm variations of the parameter β are the primary focus of this investigation. [C1111]

"Potential of polarimetric SAR interferometry for forest carbon accounting"

First Page of the Article [C1112]

"Ocean wave spectrum and radar cross-section analysis from coincident ENVISAT ASAR observations and airborne polarimetric radar measurements performed during the VALPARESO experiment"

First Page of the Article [C1113]

"Estimating vegetation bias in polarimetric SAR interferometry"

First Page of the Article [C1114]

"Analysis of multi-frequency polarimetric data for assessment of bare soil roughness"

The aim of this study is to assess the bare soil surface roughness parameter, i.e. the root mean square height (hrms) when the moisture is constant, using anechoic chamber measurements based on fully polarimetric scatterometer data. An incidence angle based algorithm has been proposed to assess the bare soil height hrms. For this purpose, sets of experimental backscattering data have been evaluated on different types of rough surfaces (Rough Gaussian, hrms= 2.5 cm, Smooth Gaussian, hrms= 0.4 cm and Medium Mixed surface, hrms= 0.9 cm) with known geometrical and dielectric properties. The scattering matrix of those three surfaces under test was measured in monostatic mode vs. frequency (1-19 GHz) and incidence angles (θ = 10° to 50° in steps of 10° for hrms= 2.5 cm and 0.9 cm and 5° for hrms= 0.4 cm) data. An empirical relationship has been developed between backscattering, hrmsand incidence angle independently for L-, C-, X- and Ka-band for all polarizations (i.e. HH, VV and HV). This relationship provides the calculated backscattering values, which is helpful in the inversion process. A good agreement has been obtained between the observed and calculated hrms. The analyses show the strong dependence of hrmson incidence angle, polarization and frequency. This type of work is also helpful in the near future to predict the optimum sensor parameters (i.e. incidence angle, polarization and frequency) for measuring the bare soil roughness. [C1115]

"A soil moisture algorithm using tilted Bragg approximation"

A successful soil moisture algorithm using radar data must identify the soil moisture effect and the surface roughness dependence explicitly since rough surface scattering depends on both the roughness and the dielectric constant of an imaged surface. For bare surfaces, several algorithms have been developed to estimate soil moisture using polarimetric radar data. These algorithms were empirically derived from either experimental data or numerical data instead of starting from rough surface scattering theories. In this paper, we present a soil moisture algorithm theoretically derived using the tilted Bragg approximation. With appropriate approximations using the tilted Bragg theory, we have derived both co- and cross-polarization ratios. Then, a soil moisture algorithm is developed based on these two ratios. This new algorithm is compared with the existing empirical methods using input data from the IEM (Integral Equation Method) an experimental radar data. We also briefly discuss the effect of vegetation on this soil moisture algorithm. [C1116]

"Imaging of high-frequency full-vectorial GPR data using measured footprints"

For proper imaging and inversion, four parameters need to be known accurately. These are position of the transmitter and receiver antennas, the wave velocity distribution in the medium, the polarization and the amplitude characteristics of the antennas used. The position information problem is solved by introducing an automated acquisition frame with high accuracy in horizontal and vertical positioning of the antennas over a fixed area. For object detection and characterization purposes, we use elevated antennas, which imply that at least a two-medium background medium must be used for accurate velocity information. The velocity in air is known, while that of the Earth must be obtained from independent measurements. The polarization and amplitude characteristics can be obtained for elevated antennas by modeling the transmitter and receiver and validate the model with measurements in air. A second way of obtaining information on the wave field, both polarization and amplitude, that is emitted into the ground is to record it in a certain plane in the air. In a configuration with constant velocity horizontal layers, only the down-going wave field, in the upper half space below the antennas, contributes to the down-going wave field in the layered earth. Accurate knowledge of this down-going wave-field allows wave-field extrapolation into the layered earth, which technique can then be used in multi-component imaging algorithms accounting for polarization and amplitude. Here, the effects of knowing the four parameters are shown. It demonstrated that the multi-components or full polarimetric, imaging technique is a tool of full operational value only when all four parameters are accurately known. [C1117]

"Forest height feature extraction in polarimetric SAR interferometry by using rotational invariance property"

First Page of the Article [C1118]

"Polarimetric SAR interferometry applied to land ice: first results"

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"Surface parameter retrieval from polarimetric and multi-frequency SAR data"

The aim of this paper is to present a surface model inversion using the integral equation formulation of backscattering coefficients. A quantification of the influence of surface parameters such as roughness and soil moisture on polarimetric indicators for various frequency bands is led. Finally, a technique is introduced to retrieve a surface RMS height and dielectric constant from multi-frequency data. The inversion technique is applied to polarimetric and multi-frequency measurements acquired at EMSL, JRC laboratory. [C1120]

"Classification and interpretation of polarimetric interferometric SAR data"

In this paper is introduced an approach to the classification and interpretation of SAR data using the complementary polarimetric and interferometric information. An unsupervised polarimetric segmentation is applied to one of the separate interferometric dataset. The use of pertinent polarimetric indicators permits to give an interpretation of each resulting cluster scattering mechanism and to classify the observed scene into three canonical scattering types. The interpretation and the segmentation of an optimized interferometric coherency spectrum is applied, for each type of scattering, to initialize an unsupervised statistical interferometric classification procedure. [C1121]

"Eigenvector analysis of polarimetric SAR data"

Fully polarimetric SAR data analysis has found wide application for terrain classification, land-use, soil moisture and ground cover classification. New methods and algorithms continue to be developed and tested. One method that has gained great popularity is the Cloude-Pottier eigenvalue/eigenvector decomposition of coherency matrices (Cloude and Pottier 1996). The eigenvalue spectrum uniquely describes the scattering entropy, anisotropy and span (total power). The eigenvectors are employed in the calculation of averaged quantities. Typically though the eigenvector components have not been analyzed in much detail. Here we present a general analysis of the eigenvectors based on an earlier observation (Cloude 2001) that the eigenvectors may be parameterized by a set of rotations. [C1122]

"Polarimetry based on one transmitting and two receiving polarizations: the pi/4 mode"

The purpose of this study is to assess what can be learnt from polarization duality in reception for a SAR which transmits only one polarization. We focus here on a configuration where the two linear receiving polarizations are oriented at pi/4 of each side of the unique transmitted linear polarization. A procedure to estimate a full polarimetric (fp) information over extended targets from this design (hereafter called the pi/4 mode) is proposed, when the ity of complex correlation between co- and x-polarized terms is assumed. The behavior of point targets is subsequently considered. The performance assessment (based on SIR-C L band image analysis) relates to the level of information preserved comparatively to fp, but also to the concurrent space segment complexity, in terms of working pulse repetition frequency (PRF), processed swath and down link features. [C1123]

"Polarimetric SAR measurements of slope distribution and coherence changes due to internal waves and current fronts"

Studies have shown that polarimetric SAR may be used to measure terrain slopes and surface roughness. These measurement concepts have been extended here to study slope distributions generated by surface manifestations of internal waves, as well as, by convergent current fronts. Measurements/modeling of these ocean features are generally done using backscatter intensity modulations. In this work, internal wave induced changes in the polarimetric orientation angle are measured. These changes are then used to estimate those perturbations in the ambient wave slope distribution and coherence that are directly caused by the internal wave. [C1124]

"On the relationship between polarimetric parameters and soil moisture"

Rough surface scattering depends on both roughness and dielectric constant of a surface. Therefore, a polarimetric measurement is useful for estimating soil moisture since we can remove the surface roughness effect using multiple scattering components from a polarimetric measurement. In this paper, we examine the relationship between polarimetric parameters and soil moisture. For example, the co-polarization ratio is independent of surface roughness to the first order of the small perturbation approximation. As surface roughness increases, it can be shown that both co- and cross-polarization ratios depend on the surface slope under the tilted Bragg approximation. The effects of the surface roughness to these ratios are theoretically investigated. An algorithm is proposed to estimate soil moisture from both co- and cross-polarization ratios. We will also study other polarimetric parameters such as the average alpha angle and eigenvalues to understand their relationship with soil moisture. [C1125]

"Results from the Crusade ship detection trial: polarimetric SAR"

An experiment was conducted in March 2000 offshore of the Newfoundland, Canada coastline which involved several radar data sets. The objective of the experiment was to assess ship detection capabilities for several radar systems. In particular, image data were collected from RADARSAT, the polarimetric C/X SAR and the High Frequency Surface Wave Radar (HFSWR) at Cape Race, Newfoundland. These data were acquired over a period of ten days while three staged ships remained on site at specified positions. These types of experiments are very rare and hence the results from this experiment will be invaluable for validating ship detection techniques and providing direction for future research and experiments. HH and HV polarizations were found to be optimal for wide area ship detection applications. A moment method and polarimetric decomposition methods provided high ship detection rates. Polarimetric target decomposition results indicate potential capability for recognizing targets and reducing false alarm rates. [C1126]

"A new parameter for soil moisture estimation"

In this paper we introduce a new ratio of polarimetric scattering coefficients that we suggest is sensitive to surface moisture content and insensitive to roughness variations. The parameter is first derived from the extended Bragg surface model and then validated using wide band chamber measurements of surface backscatter collected at the European Microwave Scattering Laboratory (EMSL). [C1127]

"Multi-resolution analysis of polarimetric SAR data using wavelets"

An analysis technique is presented for quantifying statistically and under a unified framework non-stationarity in polarimetric SAR imagery. The unified framework is provided by a multi-resolution analysis (MRA) based on a particular wavelet frame that works like a differential operator. The wavelet MRA provides local estimates of a statistics called structure function, that in turn can characterize two types of non-stationary behavior: smoothed singularities (e.g. edges, point targets); self-similar processes with stationary increments (e.g. fractional Brownian motion). In the polarimetric case we are interested in the combined dependencies on scale and polarization state. To the purpose an extension of the wavelet MRA is introduced for deriving wavelet representations of an intensity image synthesized at any polarization state (pol-MRA). A novel formalism called the polarimetric structure signature condenses in graphical form the properties of points of discontinuity with respect to scale and polarization transformations. A test case illustrates the application of the pol-MRA technique to the analysis of weak but polarimetrically diverse linear features embedded in clutter. [C1128]

"Polarimetric mapping of ship wakes"

This paper addresses the problem of ship wake detection and analysis at low grazing angles. specifically, we examine the spatial distribution of the characteristic polarimetric signatures of the sea surface in and around the wakes of a pilot boat. The received signals were range-processed and polarimetrically decomposed to yield the characteristic polarisation states. Inspection of the locations of these states revealed that the polarisation signatures were highly non-uniformly distributed in the spatial domain, as expected, with interesting features attributable to nonlinear effects. Focusing on the cross-polar s, we found that the corresponding eigenvector distribution made a strong transition as one moved from the wake region to the surrounding sea. By defining appropriate scalar quantities we were able to identify wake and clutter regions. The results suggest that exploitation of the coherent polarisation domain may significantly enhance wake feature extraction and discrimination. [C1129]

"Extraction of surface parameters from multi-frequency and polarimetric SAR data"

The aim of this paper is to analyse the information contained in multi-frequency and polarimetric SAR data for an accurate retrieval of surface geophysical parameters. A two-scale surface scattering model is presented with the aim to develop an inversion algorithm. This model is represented by projection into a three-dimensional space defined by the H-A-α_parameters, which permits, for each observation frequency value, to obtain distinct curves with respect to the soil moisture content and large-scale roughness. Then, a comparison between multi-frequency and polarimetric data from the JRC laboratory and the two-scale surface polarimetric response is carried out. At last, two different multi-frequency parameter inversion methods based on artificial neural networks schemes are proposed. [C1130]

"L-band polarimetric AIR/Pi-SAR images around Niigata City"

Pacific Rim Campaign has been successfully carried out in 2000. The well known AIRSAR system by JPL flew over Niigata Area, Japan, on Oct. 2, 2000, which brought us the L-band fully polarimetric data set. On the other

hand, Pi-SAR, developed by CRL and NASDA, Japan, simultaneously (2 hours in advance) flew the same path taking the same area data in the L-band. It became possible for us to carry out comparative analyses using the same area data. Since the resolution and incidence angle of each SAR are different, we examined the difference in the two POL-SAR images using correlation coefficient in the Right-Left Circular (RL) polarization basis, polarimetric entropy, and three component scattering power ratio. [C1131]

"Modulation of polarimetric coherence by ocean features"

Fully-polarimetric SAR images from two scenes from the west coast are analyzed to study the modulation of polarimetric coherence by ocean features. Co-polarized and circularly polarized coherences are calculated for ocean surface waves, a weather front, a coastal plume and a ship wake. The study concludes that changes in short scale surface roughness did not modulate the co-polarized coherence. But changes in the dielectric constant did affect this coherence. [C1132]

"Analysis of temporal backscatter of rice: A comparison of RADARSAT observations with modeling results"

In this study, an established microwave backscatter model is used to predict the radar backscatter behavior of rice and to understand the interaction between backscatter and the rice canopy during its growth cycle. The emphasis of this study is to understand the effect of physical plant parameters on the backscatter signatures as a function of polarization and how these signatures vary during a complete growth cycle of rice. Inputs to the backscatter model included the physical parameters of rice as obtained through field measurements. These measurements were acquired within a few days of multiple RADARSAT acquisitions of the Zhaoqing test site in southern China. RADARSAT observations and the modeling results were then compared and analyzed. The results show that the interaction mechanisms change during the nice growth cycle and that polarimetric and/or multi-polarization measurements at C-band will contribute to rice monitoring programs. [C1133]

"Physics-based simulation of high-resolution polarimetric SAR images of forested areas"

In this paper, we present a comprehensive simulation of high-resolution, polarimetric synthetic aperture radar (SAR) images of forested areas. We model forest stands using realistic fractal trees over a lossy ground. The total response of the stand is calculated by coherently summing the responses of all the individual scattering components of the fractal trees, similar to the approach in Y.-C. Lin (1997, 1999). The major advantages of our simulation method are twofold: its potential high fidelity, since it employs a physics-based forest scattering model, and its ability to model high-resolution SAR response. We introduce our simulation method beginning with a description of our fractal mathematical models of trees. Next, we consider the polarimetric formulation of the received SAR signal from a forest of fractal trees. We describe methods of more efficiently calculating the received SAR signal and present a simple example of the efficiency of the simulation. [C1134]

"Bistatic radar scattering experiments of parallel wire grids"

The continued interest in bistatic polarimetric radar, particularly for SAR applications, has resulted in the requirement for additional simple, well characterized targets for external calibration. These targets must enable both bistatic and polarimetric radar modes to be calibrated, often to a precision of less than 1 dB. Previous research has shown that the use of wire grid structures could be a suitable bistatic calibration reference. In this paper we investigate the far-field bistatic scattering from a grid of parallel thin wires of different grid spacings. Experiments are conducted using the European Microwave Signature Laboratory (EMSL) over a frequency range of between 5 to 15 GHz for bistatic angles from 5 degrees to 150 degrees. The data was calibrated and compared to a Method of Moments (MOM) theoretical solution. [C1135]

"Improving the visualisation of polarimetric response in SAR imagery from pixels to images"

This paper presents a new method for the visualisation of polarimetric response patterns on a synoptic basis. The aim of this approach is to synthesise traditional polarimetric response graphs with the spatial overview provided by standard remote sensing image processing techniques. By doing this, an effective means of exploring phenomenological polarimetric response patterns is achieved, which may prove to be a valuable input for the development of modelling strategies and the application of polarimetry. [C1136]

"Generation of bald Earth digital elevation models as applied to polarimetric SAR interferometry"

In this paper we investigate the comparison of recently proposed schemes to retrieve the bald Earth elevation height of terrain under a vegetation layer, making use of interferometric, fully polarimetric radar remote sensing P-band data. These schemes base on the one hand on an interferometric optimization scheme, which is applied

to maximize the separation of scattering phase centers related to the pertinent interferometric coherences, and on the other hand on a nonlinear line fit along these coherences in order to extrapolate the different interferometric phases to those phase values which relate to the bald earth elevation height. A χ2-test is performed on the data to estimate the validity of the line fitting in forested areas. Experimental results obtained from P-band fully polarimetric single baseline interferometric data acquired over the Amazon rain forest are used in order to compare the different interferometric bald Earth phases obtained from the proposed approaches. Results are compared against a single polarization channel experiment in HHHH-polarization mode under same experimental conditions to demonstrate the clear superiority of Polarimetric Interferometric Synthetic Aperture Radar (PolInSAR) over single polarization InSAR. [C1137]

"Polarimetric segmentation using Wishart test statistic"

A newly developed test statistic for equality of two complex covariance matrices following the complex Wishart distribution and an associated asymptotic probability for the test statistic has been used in a segmentation algorithm. The segmentation algorithm is based on the MUM (merge using moments) approach, which is a merging algorithm for single channel SAR images. The polarimetric version described in this paper uses the above-mentioned test statistic for merging. The segmentation algorithm has been applied to polarimetric SAR data from the Danish dual-frequency, airborne polarimetric SAR, EMISAR. The results show clearly an improved segmentation performance for the full polarimetric algorithm compared to single channel approaches. [C1138]

"Estimation of basal area from Amazon tropical rain forest using airborne P-band SAR data"

Shows the capacity of P-band polarimetric images to define the space of attributes of primary forest and secondary succession, through the analysis of the relation among backscatter and basal area data. To ensure that different landscapes of Amazon upland forest are represented, a test-site located in the Tapajor's region was selected. Statistical regression model was used to verify the relation between basal area values (37 plots) and backscatter data derived from PHH, PHVand PVVimages. An analysis of the spatial configuration of backscatter values for primary forest and secondary succession is made, considering the intrinsic variations of these formations in terms of biometric parameters. For this thematic stratification, a contextual Markovian classification technique (Iterated Conditional Modes CM) was used in polarimetric P-band images, to delineate primary forest and regeneration areas, in association with basal area intervals. The advance that was reached with the treatment of P-band data could improve the regional monitoring process of the land cover change, a process whose speed was accelerated as a result of human action in the Amazon during the last two decades. [C1139]

"A technique for removing vegetation bias from polarimetric SAR interferometry"

This paper develops a technique for separating the ground and vegetation components from polarimetric interferometric SAR measurements. The objective is to use this technique to remove the vegetation bias in interferometric measurements of elevation in forested terrain. Initial results indicate that the technique is able to compensate for the vegetation bias and provide improved estimates of the terrain elevation. However, further work is needed to estimate geophysical information about the vegetation canopy. [C1140]

"Polarmetric SAR data compression using wavelet packets in a block coding scheme"

Previously progress has been made in designing wavelet compression schemes for SAR image data. In this paper, we propose an improvement to the wavelet method based on a subdivision of the image into blocks, so that an optimal bit allocation can be made based on each block's statistics. Unlike single-channel SAR data, polarimetric data have HH, VV and HV channels of radar intensity images, plus the phase differences between them. We examine the information redundancy among these channels, and optimize the block coding scheme across the polarimetric channels and spatial blocks to improve compression performance. Experimental results using SIR-C data show significant improvement in coding efficiency. [C1141]

"A new scattering enhancement scheme for polarimetric SAR images based on covariance matrix"

A new scattering mechanism enhancement scheme has been developed for natural targets based on the eigenvalues and eigenvectors of the covariance matrix in order to identify different scattering events. First, three new vectors were constructed by the eigenvectors of the covariance matrix with some modifications. Then, these modified vectors were weighted by the normalized eigenvalues of the covariance matrix as a weighting function. Thus, three vertices could be obtained in the three-dimensional space. In order to utilize them equally, a triangle was constructed by connecting these three vertices. The shape of the triangle may be changed due to the different scattering mechanisms because the vertices are obtained from the combination of eigenvalues and eigenvectors. The result indicated that different scattering mechanisms can be represented by using an exterior angle which derived from the interior angles of the triangle. [C1142]

"An extended model for characterizing vegetation canopies using polarimetric SAR interferometry"

Effective exploitation of polarimetric SAR interferometry data over vegetated areas requires the use of a vegetation model of sufficient complexity to capture the underlying scattering processes. The standard Treuhaft model (randomly oriented vegetation + ground) makes a number of assumptions that may not be true in general. This paper presents a two-layer extended model that allows canopy attenuation to be a function of polarization, does not require the canopy to extend all the way to the ground, and allows the ground to be sloped. It is shown that many cases exist in which the two models predict similar coherence region shapes for significantly different structural parameters. It is argued that a minimum of two baselines is required for robust model selection and inversion. [C1143]

"Robust parameter estimation using dual baseline polarimetric SAR interferometry"

In this paper we employ a two-level polarimetric coherent vegetation scattering model to investigate parameter estimation for dual baseline fully polarimetric radar interferometry. We show that the height and ground phase can be determined without assumptions about the minimum ground to volume scattering ratio and also we investigate the influence of vertical canopy structure on inversion. [C1144]

"Forward and inverse modelling of multi-baseline L-band Pol-InSAR E-SAR data"

The objective of this paper is the analysis of forward and inverse modelling of multi-baseline L-band polarimetric SAR interferometry (Pol-InSAR) data. The first part of this study deals with an analysis of the differential phase between interferograms in different polarisation states. It is shown that conventional polarisations in the (h, v)- or Pauli-polarisation basis, while identifying different scattering mechanisms, cannot provide unambiguous interferometric phase centres in vegetation volumes at L-band. On the other hand, the Pol-InSAR optimised singular polarisations provide the largest vertical separability of interferometric phase centres within volume scatterers. The representation of the interferometric coherence in the complex unitary circle as a function of polarisation complements these observations. The second part of the paper concentrates on the forward modelling of Pol-InSAR measurables using a well-known coherent scattering model. The behaviour of the coherence is simulated to provide a more detailed interpretation of the physical meaning of the singular polarisations than was possible in the first part of the paper. Physical parameter ambiguities are emphasised and analysed. In the third part of the paper, Pol-InSAR observables are obtained through inversion of the model mentioned above. The analyses make use of multi-baseline airborne L-band E-SAR data. [C1145]

"Polarimetric interferometry in the Glen Affric project: results & conclusions"

In this paper we summarise the recent results from the Glen Affric radar project, a multi-disciplinary program addressing the potential of polarimetric radar interferometry to provide vegetation structural information of importance in forest mapping and ecology studies. We present a comparison of results from L-band repeat pass SAR imagery with detailed in-situ measurements of forest height and topography. [C1146]

"Forest biomass estimation using polarimetric SAR interferometry"

Forest biomass is one of the most important and most unknown parameters for accurate global carbon stock modelling. In this paper we address an alternative methodology for estimating above ground forest biomass from radar remote sensing data, based on forest height estimates from single frequency polarimetric-interferometric SAR data. [C1147]

"Interferometric SAR polarimetry using a passive polarimetric microsatellite concept"

Recently, several passive interferometric configurations consisting of two or more receiving only micro-satellites operating in a fully polarimetric mode positioned ahead or behind a master satellite have been proposed as a cost efficient option for future single-pass interferometric spaceborne SAR systems. In this paper the potential performance of such a passive polarimetric and interferometric micro-satellite concept for the estimation of forest structure parameters in terms of polarimetric interferometry is investigated. [C1148]

"Polarimetric and interferometric noise modelling"

In this paper, a noise model for the extended six dimensions covariance matrix used in polarimetric synthetic aperture radar (SAR) interferometry is proposed. This noise model is able to interpret interferometric, as well as polarimetric noise characteristics for the diagonal and non-diagonal elements of the covariance matrix. [C1149]

"Speckle filtering of polarimetric SAR interferometry data"

Polarimetric SAR interferometry has generated much interest for forest applications. In this paper, we study problems associated with interferometric coherence estimation and propose two algorithms to improve the accuracy in the coherence estimation based on speckle filtering of the 6 Ч 6 polarimetric interferometry matrix. [C1150]

"Interferometric phase and coherence of forest estimated by ESPRIT-based polarimetric SAR interferometry"

Polarimetric SAR interferometry has been widely studied for forest observations. The technique utilizes polarization state difference among local scattering centers of the forest to decompose them. Using the method, we can estimate precise forest parameters. We proposed an alternative method based on the ESPRIT algorithm for the estimation. The method can detect as many as 3 local scatterers with fully polarimetric data, and can extract interferometric phase of each local scatterer. In this paper, we verify the availability of the method in 2- and 3-local-scatterer model for forest estimation, and show that forest analysis with 3-local-scatterer improve height estimation accuracy. SIR-C/X-SAR data were used for these verifications. In addition, experimental results of restricted dual-polarization data are also provided to show availability of the method. [C1151]

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First Page of the Article [C1152]

"The Mueller matrix solution for polarimetric scattering from inhomogeneous random media of non-spherical scatterers under a pulse incidence"

Polarimetric scattering from inhomogeneous random media of non-spherical scatterers under a pulse incidence is studied. The time-dependent Mueller matrix solution of vector radiative transfer for layering random media is derived. Co-polarized and cross-polarized, bistatic and back scattering are numerically calculated. The shape and intensity of polarized echoes well depict the inhomogeneous fraction profile of random scatterers. Its functional dependence upon the fraction profile, layering thickness, and other parameters is discussed. This technique is applicable to reconstruction of the inhomogeneous fraction profile and inversion of the media thickness. [C1153]

"Submillimeter-wave polarimetric compact ranges for scale-model radar measurements"

Fully-polarimetric, wide-band compact radar ranges based on transceivers operating In the submillimeter-wave regime have been developed for obtaining radar measurements on scale models (nominally 1:16). These transceivers use fixed-tuned Schottky-diode mixers and varactor multiplier sources to obtain reasonably wide-band performance. Optically pumped gas lasers, combined with tunable microwave sideband generation In corner-cube-mounted Schottky diodes, have been implemented to extend the operating frequencies into the THz regime. A dielectric material fabrication and characterization capability has also been developed to fabricate custom anechoic materials for the ranges as well as scaled dielectric parts for the models and clutter scenes. The general approach to designing submillimeter-wave compact ranges and the particular details of systems operating at 524 GHz and 1.56 THz will presented in this paper [C1154]

"A comparison of different kinds of orthogonal polarimetric bases"

Four kinds of polarization and phase orthogonal bases, all met in the literature, have been presented. Also their phasor representations on the Poincare sphere have been determined and compared. [C1155]

"The polar decomposition of the scattering matrix applied to the polarimetric image of the guard-rail"

The concept of scattering is one of the mechanisms that polarimetry seeks to express through data. A multiplicative decomposition of the scattering matrix is developed and it is applied to the polarimetric image of a guard-rail. The image contains just one scattering center and so it results are particularly suitable to investigate the information that the polarimetric property of an object can deliver. [C1156]

"Some new relationships between observables of Doppler-polarimetric radar and rain parameters"

This study establishes new relations between the microstructure and the dynamics of rain and Doppler-

polarimetric parameters of the radar signal. The rain rate and intensity of turbulence in rain can be retrieved on this basis. [C1157]

"Transportable multi-beam Doppler polarimetric radar"

TARA (transportable atmospheric radar), a unique radar system developed at the International Research Centre for Telecommunication transmission and Radar (IRCTR) of Delft University of Technology, can be used to observe the formation of precipitation and various other physical processes that occur in clouds. This provides important information that is used to map effects of global warming on the world's climate. The Delft radar system is sensitive enough to detect turbulent airflows. TARA may therefore be used to improve safety near airports. The TARA antenna system consists of a hybrid feed array in combination with a precision reflector to obtain instantaneous high-resolution, three-dimensional, dynamic measurements of wind and rain. The paper summarizes TARA's basic principles illustrated with initial measurements. [C1158]

"Optimal classification of polarimetric SAR images using segmentation"

The paper presents an optimised polarimetric segmentation technique for synthetic aperture radar (SAR) images, based on a generalised maximum likelihood approach. A full theoretical derivation is presented, together with a closed form analytical performance evaluation. The technique is compared to other known polarimetric segmentation schemes by application to a polarimetric SAR image of agricultural areas. A complete characterisation of the technique is provided in terms of polarimetric sensitivity and memory requirements. [C1159]

"A new solution to polarimetric radar discrimination problem"

A new solution is proposed for polarimetric radar discrimination problem by using cross-entropy to measure the difference between two scatterers. Two cross-entropy measures in favor of one scatterer over another are obtained for two independent probability mass functions that indicate the average scattering mechanism and the scattering randomness, respectively. These probability mass functions are formed by the modified similarity parameters and the eigenvalues of target coherency matrix. The cross-entropy measures utilize the polarimetric information efficiently to show the difference between scatterers. The advantage of using cross-entropy for solving polarimetric radar discrimination problem is demonstrated by the simulation results. [C1160]

"95 GHz Doppler Polarimetric Cloud Radar Based on a Magnetron Transmitter"

This paper presents the development and first operation of a 95 GHz Doppler polarimetric cloud radar. The radar provides high-resolution, real-time measurements of reflectivity, linear depolarisation ratio, Doppler spectrum, radial velocity mean, and velocity variance of clouds and precipitation. Compared to similar existing radars, the discussed one takes advantages from several innovative key components. In particular, the radar essentially benefits from the application of the spatial-harmonic magnetron with cold secondary-emission cathode as the transmitter oscillator. [C1161]

"A calibration method for polarimetric radar surveillance in a multi-path sea environment."

The scope of this work is to describe a novel method of calibration for polarimetric radar surveillance in a multi-path propagation environment. The method presented in this paper is based on a mathematical model which computes the errors in the estimate of the scattering matrix elements (amplitude and phase) of a radar object caused by multi-path propagation induced by scattering from the sea surface. The `correct' scattering matrix of the radar object and its polarization properties are derived in the calibration process by the compensation of these multi-path induced errors. The results of the model show that these errors in the scattering matrix depend on the wave polarization (by the reflection coefficients) and multi-path propagation parameters e.g. number of scatterers at sea, degree of correlation between scatterers, sea state. The model predicts larger errors with increased reflectivity from the rough surface e.g by an increase of the reflection coefficients, the number of (multiple) scatterers at sea, the correlation between scatters, and lower sea state. [C1162]

"A polarimetric adaptive detector in non-Gaussian noise"

We address polarimetric adaptive detection of targets embedded in compound-Gaussian clutter with unknown covariance matrix. To this end we assume that a set of secondary data, free of signal components and with the same covariance structure of the cell under test, is available. We resort to a design procedure based upon the generalized likelihood ratio test (GLRT): first we derive the GLRT assuming that the textures are known, then we plug into the derived test suitable estimates of these parameters. Remarkably, the newly proposed detector has the constant false alarm rate (CFAR) property with respect to the texture statistical characterization. Moreover,

even though it does not ensure the CFAR property with respect to the clutter covariance matrix, a sensitivity analysis shows that the probability of false alarm is only slightly affected by variations in the clutter correlation properties. Finally, the performance assessment, conducted via Monte Carlo simulations, confirms the capability of the receiver to operate in real radar scenarios. [C1163]

"Radar breadboard for DSP scatterometer"

The design and test results for the radio frequency (RF) portion of a breadboard polarimetric scatterometer operating at 13.402 GHz are presented. To evaluate the feasibility of a programmable digital signal processing (DSP) approach for a follow-on scatterometer similar to SeaWinds an integrated breadboard has been developed at the Jet Propulsion Laboratory (JPL). Early breadboards of this type have been identified as valuable assets in developing effective subsystem requirements for the eventual flight instrument. Many compatibility and partitioning issues between the RF and DSP hardware are addressed with empirical results derived from the aforementioned breadboard. The RF portion of the breadboard consists of a dual channel receiver, heterodyning the received signal of 13.402 GHz down to an IF of 37 MHz and a single channel transmitter, that converts the I/Q baseband transmit waveform up to Ku band. The breadboard makes provision for emulating capabilities such as programmable attenuators, loop-back calibration, and saturation effects in an actual instrument's power amplifier. It also provides control interfaces to allow early verification of software control algorithms. [C1164]

"Maritime target and sea clutter measurements with a coherent Doppler polarimetric surveillance radar"

Doppler polarimetry in a surveillance radar for the maritime surface picture is considered. This radar must be able to detect low-RCS targets in littoral environments. Measurements on such targets have been conducted with a coherent polarimetric measurement radar in March 2001 and preliminary results from that campaign are presented. The system provides estimates of the scattering matrix per range-Doppler bin. Several physical quantities that can be exploited to discriminate target echoes from sea clutter responses are discussed and an impression is given on their effectiveness. [C1165]

"Application of polarimetric synthetic aperture radar interferometry for land cover classification"

The development of radar polarimetry and radar interferometry is advancing rapidly. The textural fine structure, target orientation, system metrics and material constituents can be recovered with radar polarimetry; while with radar interferometry, the elevation structure of a target can be explored. Polarimetric synthetic aperture radar interferometric (Pol-InSAR) is interferometry between all possible polarization channels at each end of the baseline. Using polarimetric interferometry, the combination of the final structure properties and the spatial information of targets can be implemented. In this paper, we investigate the application of these three approaches to Earth terrain classification with results from the evaluation of fully polarimetric interferometric SIR-C/X-SAR data. The potential of Pol-InSAR for land cover classification has been demonstrated. [C1166]

"An effective polarimetric detection of small-scale man-made radar objects on the sea surface"

The effectiveness of object detection by polarimetric radar is demonstrated. The experiments were focused on small-scale and man-made radar objects floating on the sea surface. The method of the polarization detection is described based on measurements of polarization invariant parameters of the radar object. The Neyman-Pearson criterion is used for the theoretical evaluation of small-scale polarimetric target detection. The results of experimental data processing confirm the high effectiveness of using radar objects polarization invariants for this detection problem. [C1167]

"Advances in extra wide-band multi-modal air/space-borne radar polarimetry, POL-IN-SAR imaging and its applications"

Radar Polarimetry, Radar Interferometry and Polarimetric SAR Interferometry represent the current culmination in 'Microwave Remote Sensing' technology, but we still need to progress very considerably in order to reach the limits of physical realizability. Whereas with radar polarimetry the textural fine-structure, target orientation, symmetries and material constituents can be recovered with considerable improvement above that of standard 'amplitude-only' radar; by implementing 'radar interferometry' the spatial (in depth) structure can be explored. With Polarimetric Interferometric Synthetic Aperture Radar (POL-IN-SAR) imaging, it is possible to recover such co-registered textural and spatial information from POL-IN-SAR digital image data sets simultaneously, including the extraction of Digital Elevation Maps (DEM) from either Polarimetric (scattering matrix) or Interferometric (dual antenna) SAR systems. Simultaneous Polarimetric-plus-Interferometric SAR Imaging offers the additional benefit of obtaining co-registered textural-plus-spatial three-dimensional POL-IN-DEM information, which when applied

to Repeat-Pass Image-Overlay Interferometry provides differential background validation and environmental stress-change information with highly improved accuracy. Then, by either designing multiple dual polarization antenna POL-IN-SAR systems or by applying advanced POL-IN-SAR image compression techniques, will result in 'POL-arimetric TOMO-graphic' (Multi-Interferometric) SAR or POL-TOMO-SAR imaging. [C1168]

"Study of environmental issues with ALOS PALSAR data"

The Advanced Land Observing Satellite (ALOS) will carry three advanced sensors for addressing many environmental issues, such as vegetation change, water resource management, disaster and earthquake mitigation, and cryosphere monitoring, in a broad range of earth science disciplines. PALSAR has many unique features in its L-band, multi-imaging mode (high-resolution, ScanSAR, and polarimetric), varying incident angles, and multi-polarization, compared to other SAR satellites operating in the orbit now or in the past. In our research proposal for ALOS research announcement, we focus on the use of PALSAR data in flood management and surface change monitoring for the Yangtze River, detection of surface subsidence in oil field, monitoring of coastal expansion and land cover changes in the Yellow River estuary, and study for surface deformation related to potential volcanic activities, palaeo-environment evolution, and snow and ice etc. Although the launch of ALOS in 2003 makes us unable to give a report of research result with ALOS data, we will present our research plan and expectation with PALSAR and other sensor data, and give some results of our study using other SAR data in relation to the issues being addressed in our research with ALOS data. [C1169]

"Development of a retrodirective PARC for ALOS/PALSAR calibration"

A novel PARC of Van Atta array design is developed for polarimetric calibration of PALSAR onboard the ALOS satellite. The PARC consists of four dual-polaraized ЗЧЗ-cross-dipole subarrays. The Van Atta array configuration combining with dual-polarized nature of the subarrays provides the PARC the depolarizing and retrodirective characteristics simultaneously. [C1170]

"Helicity in radar remote sensing"

In this paper we investigate the use of radar polarimetry and polarimetric radar interferometry for measuring the properties of random chiral particle clouds. Helicity is an established concept in radar polarimetry but to date it has been restricted to coherent scattering mechanisms. Here we show how it can be used for random media studies and conclude as to its potential impact in the radar remote sensing of vegetation. [C1171]

"Surface parameter estimation using interferometric and polarimetric SAR"

In this work the potential of using the interferometric coherence at different polarisations over surface scatterers in order to extract information about surface parameters is investigated. The sensitivity of the individual coherence contributions to surface roughness and moisture conditions is discussed and simulated using a polarimetric surface scattering model. Finally, experimental airborne SAR data are used to demonstrate the discussed effects. [C1172]

"Scene characterization using sub-aperture polarimetric SAR data analysis"

In this paper is introduced a fully polarimetric sub-aperture analysis method. A deconvolution technique is developed in order to decompose synthesized SAR images into sub-aperture data sets which correspond to the scene global response observed under different azimuthal look angles. A polarimetric variation analysis is achieved, using pertinent parameters, to determine the nature of the non-stationary scattering mechanisms. A statistical analysis of the polarimetric parameters permits to clearly discriminate the media showing a varying behavior during the SAR integration. Decomposition and analysis techniques are applied to data acquired by the DLR airborne E-SAR sensor at L band. [C1173]

"Characterization of symmetric scattering using polarimetric SARs"

Cameron's coherent target decomposition (CTD) and classification are discussed in the context of SAR, and the limitations of Cameron's classification are examined. It is shown that these methods may lead to a coarse and misleading scattering segmentation because of the large radiometric dispersion tolerated in each of the elemental scatterer classes, as well as the implicit assumption on the coherence nature of target scattering. A new method, named the symmetric scattering characterization method (SSCM), is introduced to better exploit the information provided by the largest target symmetric scattering component, under coherent conditions. The SSCM, which expressed the symmetric scattering in term of the Poincare sphere angles, permits a better characterization of target symmetric scattering and the generation of coherent scattering segmentation of much higher resolution, in comparison with Cameron's segmentation. [C1174]

"Feasibility study on polarimetric use and calibration of ALOS/PALSAR"

Calibration and application of polarimetric synthetic aperture radar (SAR) onboard the Advanced Land Observing Satellite (ALOS) is discussed using airborne L-band SAR data. We find that even a simple calibration is useful for polarimetric classification, if the system has a small cross-talk and good channel valance. [C1175]

"Radar estimation of turbulence eddy dissipation rate in rain"

This paper deals with the algorithm for estimating the turbulence intensity in rain, which is developed on the basis of the model of Doppler-polarimetric spectra of radar signals, reflected from turbulent zones in precipitation. The relationship between the Doppler spectrum width of rain and the eddy dissipation rate is established at two orthogonal polarizations. The approximation of this relationship by Weibull model provides mathematical convenience for further analysis and synthesis. An algorithm for the estimation of turbulence intensity is developed on the basis of modeled and measured Doppler-polarimetric data. This algorithm is researched by statistical simulation. It is shown that the Doppler-polarimetric approach provides an accuracy increase in comparison with the Doppler method without polarization information. [C1176]

"Numerical modeling and characterization of fully polarimetric dielectric loaded horn-fed bow-tie (HFB) antenna for GPR applications usingFDTD"

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"Methods for solving inverse problems in radar remote sensing"

A general approach to solve inverse problems in polarimetric radar remote sensing is considered. Starting from the general statement of ill-posed problems in the mathematical sense the special case of inverse scattering problems in polarimetric radar is formulated. Regularization methods to handle inverse problems are described and an illustration leading to an inverse classification problem for determination of the soil humidity using radar measurements is given. [C1178]

"Polarimetric radar rainfall algorithms at S and X bands"

This paper presents a comparison of S- and X-band algorithms for rainfall estimate. This topic is fairly extensive and only limited results are presented for brevity. The results demonstrate that R(Kdp) at X-band can be useful at much lower rainrates compared to S-band. [C1179]

"ALOS-PALSAR image simulation in various polarization bases"

The ALOS-PALSAR is the first L-band space-borne SAR in the world equipped with a fully polarimetric data taking function. For the data utilization purpose, the authors have examined the polarimetric performance (scattering matrix and resultant images) over the Toyano area, Niigata City, Japan, using the airborne Pi-SAR radar. Since the resolution will be 20 m by 20 m on the ground surface by PALSAR, the Pi-SAR data (3 m by 3 m) are ensembled to be an equivalent size for ALOS-PALSAR image simulation. The polarimetric characteristics of terrain including paddy-fields, grass-fields, residential areas, etc., were examined to show the difference in the right-left polarization handedness basis and coherency vector, three-component scattering model, and polarimetric entropy. [C1180]

"Enhanced polarimetric radar signatures above the melting level in a supercell storm"

The dataset analyzed is the first simultaneous in-situ and radar survey of phenomena associated with observed "columns" of differential reflectivity Zdrand specific differential phase Kdpin a supercell storm. Further, no in situ measurements in regions of such enhanced Zdrand Kdphave ever been reported. The measurements were made in an Oklahoma convective storm that formed in Kingfisher County, on May 17, 1995. Parcel and environmental freezing temperatures were near the 600 mb level (3.5 km AGL). Official observations of 2.5 cm hail were reported as well as a 40 m s-1wind gust. Dual-polarization radar measurements were obtained with the NSSL's Cimarron radar. The in situ measurements are provided by the T-28 aircraft at a height of between 4.9 and 5.2 km (near 500 mb; about -5° C). These include temperature, vertical velocity and liquid water content (LWC), as well as hydrometeor size and concentration from the hail spectrometer and a foil impactor. [C1181]

"Evaluation of TRMM PR attenuation correction using ground radar estimations of the raindrop size distribution along the PR beam"

Estimation of the raindrop size distribution (RSD) is made along the beam-path of the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR). The PR is a nadir-pointing spaceborne radar that operates at 13.8 GHZ frequency. It is currently being used, along with other instruments aboard the TRMM satellite, for meteorological research. Short wavelength systems are used to reduce cost while maintaining the resolution near the Earth's surface required for meteorological sampling. The limitations are the high signal degradation of the return signal caused by scattering and absorption of the precipitating medium that it is intended to probe. Correction of the TRMM PR return echo is based on a single-frequency technique, which is evaluated using ground-based polarimetric radar observations. Quantitative estimation of a 3-parameter gamma model is made of the RSD along the PR beam. PR attenuation correction is compared to the median values of the RSD parameters. In particular, variations of the median drop size diameter (DO) and normalized intercept parameter (Nw) with PR correction is made along the PR vertical profile in the rain layer. Data collected during the TExas and FLorida UNderflights (TEFLUN-B) experiment and TRMM Large Biosphere-Atmosphere experiment in Amazonia (LBA) field campaign is used in the evaluation. [C1182]

"Inversion of surface scattering models: comparing criteria and algorithms to estimate bare soil parameters"

Estimates bare soil geophysical parameters (i.e. standard deviation of roughness height s, length of correlation l and soil moisture mv) using polarimetric SAR data. Two direct models have been implemented to simulate the radar measurements and were introduced in an inversion scheme. The methods have been tested on simulated data where speckle effects and model errors were taken into account. A correlation between the roughness parameters, as it can be expected in real measures, has been imposed in the simulation in order to evaluate its effect on the estimation accuracy. Different inversion algorithms based on a Bayesian approach, developed with simple optimization-integration procedures have been compared to neural networks. The comparison has assessed the accuracy achievable by different radar system configurations. Polarimetric data acquired during MAC Europe and SIR-C campaigns, over selected bare soil fields, has been processed to show preliminary estimation results. [C1183]

"Triple-wavelength radar for cloud and precipitation microphysics research"

The University of Massachusetts, Colorado State University and the National Center for Atmospheric Research are collaborating to develop an advanced Multi-Frequency Radar (MFR) system for studying clouds and precipitation, which should become operational in 2004. This highly portable radar consists of three polarimetric Doppler subsystems operating at Ku-band (13.8 GHz), Ka-band (33 GHz) and W-band (95 GHz), a programmable scanning pedestal, and a unique single aperture antenna that generates co-located matched beams at each wavelength. This combination of wavelengths allows measurement of a wide range of atmospheric targets including weakly reflecting clouds and precipitation. [C1184]

"Using multiparameter data to calibrate polarimetric weather radars in the presence of a partial beam blockage"

The paper describes a technique to calibrate dual-polarization weather radar in the presence of a partial beam blockage. Radar reflectivity factor Z and differential reflectivity ZDRcan be calibrated using an idea of self-consistency among Z, ZDR, and specific differential phase KDPfor rain medium and polarization properties of dry snow and light rain. [C1185]

"Identification of cloud ice crystals using a 95 GHz polarimetric radar"

The identification of various ice crystal types within a cloud, as well as the estimation of their ice water content are important goals with applications to cloud microphysical studies and to understanding the effect of clouds on the Earth's radiation budget. Millimetre wave polarimetric radars have the potential for accomplishing both of these goals. There are several millimetre wave radars operating at 95 GHz for the remote sensing of ice clouds from ground-based and airborne platforms. This paper brings together observations from experiments and modeling studies, and focuses on 95 GHz polarimetric radar signatures of ice crystals including pristine crystals such as columns, plates, and stellar crystals, as well as dendrites, ice crystal aggregates, and graupel. Results from simulations and from experimental data for several polarimetric radar observables are combined to generate different ranges of values for each observable corresponding to different crystal types. A simple fuzzy logic classification scheme is presented for identifying crystal types based on these ranges. Suggestions for further development and refinement of this scheme are given. [C1186]

"Cross-calibration of ground and space radar"

Presents results from comparing space radar and ground radar to cross-calibrate the Kwajalein polarimetric radar (KPOL) with the spaceborne TRMM Precipitation Radar (PR). Use of self-consistency of polarimetric measurements is implemented to check the absolute calibration of KPOL and is checked against the cross-calibration results of PR and KPOL. Differential reflectivity (Zdr) calibration is also done and compared with vertical looking scans through rain. [C1187]

"Radar remote sensing of Great Lakes ice cover"

Summary form only given, as follows. Remote sensing of Great Lakes ice cover uses various classes of radars including scatterometer, polarimetric Synthetic Aperture Radar (SAR), and interferometric SAR. Satellite wide-swath scatterometers provide large areal coverage with high temporal resolution data to map Great Lakes ice cover. They compliment the high spatial but lower temporal resolution of satellite SAR data. The approach is to use in-situ and ground truth measurements from our 1997 Great Lakes winter experiments (GLAWEX 1997) in conjunction with concurrent satellite SAR data from ERS-2 and RADARSAT-1 and scatterometer data from NSCAT to determine scatterometer backscatter signatures of lake ice. The backscatter signatures are used as a library to develop an ice mapping algorithm using first the NSCAT data acquired during GLAWEX 1997 and then SeaWinds data (currently operational on the QuikSCAT satellite). Verification of the ice mapping results are carried out with in-situ observations from US Coast Guard (USCG) icebreaker vessels operating on the Great Lakes under the jurisdiction of the Ninth Coast Guard District. In addition, we installed a web camera to monitor ice cover over an area in Lake Superior to verify time-series scatterometer results obtained from QuikSCAT data. Moreover, polarimetric radar backscatter measurements from a USCG icebreaker acquired during GLAWEX 1997 reveal that multi-polarization backscatter data for the typical snow-covered snow ice on lake ice in the Great Lakes can be used to map ice and open water without the ambiguity encountered in single polarization data due to variations in wind speed over water. During our 2002 winter experiment (GLAWEX 2002) NASA AIRSAR C-band and L-band polarimetric and interferometric measurements are collected over Lake Superior, Green Bay and northern Lake Michigan, and the North Channel together with in-situ field observations. Polarimetric C-band SAR data obtained form GLAWEX 1997 (shipborne radar) and GLAWEX 2002 (airborne SAR) are used to develop multi-polarization algorithms in view of ENVISAT and RADARSAT-2 multi-polarization SAR applications to lake ice mapping. Furthermore, interferometric SAR data acquired during GLAWEX 2002 are used to evaluate the utility of interferometric SAR da- ta for three-dimensional mapping for lake ice including aerial coverage and thickness. Because lake ice, unlike sea ice, has no salinity content, microwaves can propagate into lake ice unless the surface is wet due to melting. GLAWEX 2002 is a large-scale experiment including in-situ observations by webcam with all azimuth coverage, in-situ measurements from ship, air reconnaissance from helicopter, polarimetric and interferometric SAR from the NASA DC-8 aircraft, satellite scatterometer data from QuikSCAT/SeaWinds, and satellite SAR data from RADARSAT. [C1188]

"Data fusion of multiple polarimetric SAR images using discrete wavelet transform (DWT)"

Data fusion is a very effective technique which can be applied to many remote sensing areas such as classification, monitoring of environmental surveillance and man-made target tracking. In this paper, we tested fusion of multiple frequency (C-, and L-band), multiple polarization (HH, HV and VV) and multiresolution data sets. One can obtain a polarimetric SAR data after enhancing spatial resolution through the image fusion process. In order to fuse multiple SAR data and high spatial resolution data, they have to be geometrically co-registered over the same target area and have the same pixel size (spatial registrations). At this stage, we used the nearest neighbor resampling to avoid spectral distortion by interpolation. Multiresolution polarimetric SAR image fusion was performed using the multiscale image fusion technique-discrete wavelet transform after spatial registrations. To evaluate the spectral fidelity of fused polarimetric SAR data, spectral dissimilarity was calculated at each wavelet decomposition level. The resulting classification map based on polarimetric feature vectors shows better class separation after application of fusion processing than without fusion. The polarimetric SAR data over the Gong-ju areas, tested in this research, were acquired during NASA/JPL AIRSAR PACRIM-II experiment in 2000. [C1189]

"Recognition of hail areas with polarimetric radar by the method of potential functions"

In this paper the method of potential functions is proposed and developed for the recognition of hail areas in weather objects. The method can be applied to the processing of fields of any informative parameters of microwave remote sensing or fields of meteorological elements. [C1190]

"Classification of landslide surfaces using fully polarimetric SAR: examples from Taiwan"

Landslides typically denude forested hillsides, changing dominant scattering from multiple- to single-bounce. SAR polarimetry can be used to determine the dominant scattering mechanism of the terrain on a per pixel basis.

Thus, hillslopes affected by landslides may be distinguished easily from adjacent, unaffected hillslopes. Based on the polarimetric eigenvalue decomposition and the relative amplitudes of scattering matrix terms, dominant scattering mechanisms can be determined. These mechanisms-odd- or single-bounce (bare surface), double- or even-bounce, and volume (diffuse) scattering-describe the total radar returns for each pixel. The modified approach of Kim and van Zyl (2001) include the radar vegetation index, pedestal height and entropy, all representative of forest. Our analysis follows Kim and van Zyl to reveal that at L-band, the landslide scar areas of the Tsaolong and Mt. Jou-Feng-Err mega-slides are dominated by single-bounce scattering and the surrounding forested regions are dominated by volume scattering. In addition, fully polarimetric SAR is sensitive to reforestation in tropical jungle environments as demonstrated by comparison with a panchromatic Indian Remote Sensing (IRS) image. Inversion of SAR polarimetry for terrain scattering mechanisms offers a new approach for landslide mapping that has significant operational advantages over traditional methods that rely on optical sensors for rapid response to and management of landslide disasters. [C1191]

"Generation and error analysis of DEM using spaceborne polarimetric SAR interferometry data"

From the SIR-C polarimetric L-band data of Hotan, China, on 9 and 10 October 1994, the DEM of polarimetric SAR interferometry (Pol-InSAR) and the conventional L-band HH-HH interferometric pair are extracted. The difference of DEM generation using Pol-InSAR and conventional InSAR is discussed in detail. Based on the result of comparison and analysis of two DEM, it is conclude that the accuracy of DEM generated from the polarimetric SAR Interferometry data is significantly improved, especially for the area covered by rich vegetation with enough high coherence, the error less than 10 m. Finally, error sources of DEM generated by polarimetric SAR interferometry are further analyzed. [C1192]

"Polarimetric scattering indexes and information entropy of the SAR imagery for surface classification"

The Mueller matrix solution and eigen-analysis of the coherency matrix for completely polarimetric scattering have been applied to analysis of the SAR (synthetic aperture radar) imagery. Usually, the polarization index is defined as a parameter to classify the difference between co-polarized scattering signatures from the terrain surfaces. In this paper, the eigen-values of the coherency matrix and information entropy are derived to directly relate with co-polarized and cross-polarized indexes. Thus, it combines the Mueller matrix simulation, the information entropy of the coherence matrix, and two polarization indexes to yield an overall theory for quantitative understanding of the SAR imagery. This theory is applied to the AirSAR images. [C1193]

"Polarimetric borehole radar and its applications"

We introduce applications of radar polarimetry in borehole radar. One example is classification of subsurface fractures, where we estimate the water permeability of each fracture by radar polarimetry. Then polarimetric borehole radar was then used for cross-hole radar measurement. Transmitted signal between boreholes having a 20 m separation was measured, and we could show that the polarization information can be used for estimation of the orientation of a subsurface cavity. [C1194]

"A multiwavelength airborne polarimetric lidar for vegetation remote sensing: instrumentation and preliminary test results"

Several spaceborne and airborne lidar systems have been launched for vegetation canopy studies. Previous research has shown that lidars are useful tools for remote sensing of vegetation architecture. To support its Airborne Remote Sensing Program, the University of Nebraska has developed a multiwavelength airborne polarimetric lidar system. This system employs a Nd:YAG laser which emits radiation at two wavelengths: the fundamental at 1064 nm and the frequency-doubled at 532 nm. Both laser beams are highly linearly polarized (100:1 extinction ratio) and have a beam divergence angle of 4 mrad. The receiver consists of four channels, which enable dual-wavelength and dual-polarization detection. In addition to the polarimetric information that could be gathered, this lidar system also has ranging capability and is able to record the whole lidar waveform. Thus, our lidar is capable of performing studies of vegetation canopy structure as well as characterization of vegetation depolarization. The system has been packaged to fly aboard a Piper Saratoga aircraft from a height of 1000 m. In this paper, we will present the details of the lidar system design, instrumentation, the system alignment and preliminary ground test results. [C1195]

"A synoptic visualisation of fully polarimetric SAR data-an annotated example icon"

This paper explores an example SAR data set that has been displayed using a new method of visualising polarimetric data. It is based on an iconic representation of information within a pixel, which allows for the

complete polarisation response to be viewed simultaneously across the image. An example from a test site in Sweden is presented, with a detailed description of how such an image can be interpreted. This will be through particular examples of polarimetric responses correlated with features in the landscape. [C1196]

"Velocity estimates from fully polarimetric SAR"

Fully polarimetric SAR data provides sufficient information so that some level of feature attribute classification, is usually possible for signatures found in these images. In particular, polarimetric analysis can provide structural information from SAR image signatures for some target types Additionally, although not commonly recognized, there is evidence that polarimetric SAR data collected from systems similar to the C/X SAR (and the future RADARSAT 2) can also provide velocity information. This velocity information is not an attribute of the polarimetric ellipse information, but rather a consequence of the system's data acquisition method and the provision that the reciprocity relationship is assumed. Here, an example is presented which indicates that this velocity information is likely available in polarimetric data. This capability has great potential for classification purposes, since both velocity and structural properties of an imaged feature may be deduced from the same data acquisition. While the velocity estimates may have some limitations compared to Along-Track InSAR systems, this information is readily available from fully polarimetric SAR systems, such as the future RADARSAT 2. [C1197]

"Simulation of polarimetric SAR vessel signatures for satellite fisheries monitoring"

This paper presents a tool able to realistically simulate the SAR raw data recorded by an orbital sensor while imaging a vessel. The simulator is based on a RCS prediction code developed at the UPC, but modified in order to take into account the characteristics of the chirp radar signal and the orbit of the satellite. The vessel models can be generated with commercial computed-aided-design packages with a high degree of detail and fidelity. The simulator is able to calculate the full-polarimetric raw data and will be used to develop vessel classification algorithms based on polarimetric decompositions. Existing or new sensors can be simulated to study its limitations and suggest new configurations to improve its applicability to the problem. [C1198]

"Seasonal and diurnal changes of polarimetric parameters from crops derived by the Cloude decomposition theorem at L-band"

The objective of this study is to analyse and interpret the seasonal and diurnal changes of polarimetric parameters derived by the Cloude decomposition theorem. The investigations were carried out on polarimetric E-SAR data at L-band. The seasonal scattering behaviour of cereals strongly depends on the local incidence angle. Mainly surface scattering and double bounce processes contribute to the radar backscatter. Broad-leaf crops are characterised by a pronounced contribution of all scattering processes to the radar signal. With respect to diurnal variations of the polarimetric parameters due to dew and interception no significant changes could be determined. Nevertheless, the changes of the σ0-values indicate an increase in volume scattering with moisture for all crops, whereby the contribution of the other mechanisms decreases for wet plant surfaces. [C1199]

"Evaluation of P-band foliage penetration through polarimetric high resolution SAR imaging with the RAMSES radar"

ONERA in association with DGA, CNES and several laboratories, conducted an experiment of P-band (435 MHz) imaging at high resolution (2 m) with full polarimetric capability. The test site is a cultivated pine forest in south west France. It is populated with appropriately scattered and oriented dihedrals and corner reflectors. Under-covered reflectors and vehicles are also included. Measures of the under cover reflector returns showed that attenuation in horizontal polarisation depends on the angle of view (more than in vertical polarisation). The wide antenna illumination pattern (±30°) allows one to image up to aircraft nadir, thus confirming an important penetration through foliage on its vertical profile. [C1200]

"The stability of polarimetric features for target classification from SAR imagery"

This study investigates the information content of polarimetric SAR imagery for use within automatic target detection and classification algorithms. Key questions such as the stability of polarimetric information and its relationship with image resolution are addressed. Using relatively simple polarimetric features, such as the percentage of pure odd and even bounce scattering events, we show how it is possible to identify the differences between two classes of military vehicle. The use of the radial power spectral density is proposed as a measure of the spatial distribution of these odd and even bounce scattering events, again enabling the two classes to be distinguished. [C1201]

"Target decomposition through polarimetric, disjoint Doppler and frequency band (I)SAR images"

A fully polarimetric (I)SAR image target decomposition process has been developed to aid automatic target recognition (ATR) for disjoint Doppler and frequency bands. In this paper the principle of target decomposition into scattering primitives is first demonstrated for a flat plate and then for a more complex target. [C1202]

"InSAR phase unwrapping: a polarimetric approach"

This paper addresses a polarimetric approach to improve the interferometric phase estimation based on an extension of the ESPRIT algorithm applied to different kinds of scatterers. The basics of SAR interferometry are presented. The article introduces the ESPRIT algorithm using polarimetric data with a description of the scattering model, the ESPRIT algorithm and the method used to determine the number of contributions. The results obtained using fully polarimetric SAR images of the DLR E-SAR airborne sensor in the L-band repeat-pass mode are discussed. [C1203]

"Doppler-polarimetric retrieval of rain rate and turbulence intensity in precipitation"

This paper deals with mathematical modeling and simulation of echo-signals of microwave remote sensing of precipitation in both the frequency and time domains. It establishes some important relationships between Doppler-polarimetric observables and the weather object under observation. [C1204]

"Edge and line detection in polarimetric SAR images"

A scheme for detecting edges and lines in multichannel SAR images is proposed. The line detector is constructed from the edge detector. The latter is based on multivariate statistical hypothesis tests applied to log-intensity SAR images. The raw results are vectorized by a traditional bright line extraction process. The scheme is illustrated by extracting dark linear structures on various full-polarimetric SAR images. [C1205]

"Target detection in ground clutter with W-band stepped frequency polarimetric radar system"

This paper presents a constant false alarm rate (CFAR) target detection scheme in ground clutter at W-band (94 GHz), making use of clutter decorrelation bandwidth and co- and cross-polarized received data. The scheme, based on the concept of a CFAR matched subspace detector, yields a CFAR with respect to clutter amplitude distribution. In order to investigate the detection performance, we carried out a Monte Carlo simulation and experiments using the W-band stepped-frequency polarimetric radar system. The results are also compared with the conventional CFAR detector. [C1206]

"High-resolution full-polarimetric video impulse radar for landmine detection"

A full-polarimetric ultra wideband GPR front-end has been developed. The front-end is suitable for subsurface imaging with resolution sufficient for antipersonnel mine detection and recognition. In comparison with commercially available video impulse GPR systems the key advantages of the front-end are considerably larger bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarizations and in two different frequency bands are main novelty aspects of the radar. [C1207]

"Assessment of digital elevation models obtained in Brazilian Amazon based on P and X band airborne interferometric data"

An airborne campaign in September of 2000 over Tapajor's National Forest, which is a region of Brazilian Amazon, Parar' State, has acquired P and X band interferometric data over a region which comprises primary forest, secondary forest in several stages of regrowth, pasture, crop plantations, bare soil, water and other classes. The AeS-1 polarimetric system, from AeroSensing Radarsysteme GmbH, Germany, provided P band polarimetric data for two-pass interferometry and X band single polarization, single-pass interferometric data. During the radar mission, a ground survey was carried out for target identification and collection of tri-dimensional differential GPS data for P and X band corner reflectors and other characteristic points. Georeferenced Digital Elevation Models (DEMs), with spatial resolution of 2.5 m, were generated considering X and P band interferograms. The X band DEM generally shows higher altitude than the P band DEM, especially over forested areas, because the considerably higher penetration of P band towards the forest floor, while X band DEM reflects the canopy altitude. X band DEM is called a Digital Surface Model (DSM), because it is related mainly with the top of the land cover. The difference between the DSM and the DEM (P band) potentially gives the forest height. The actual internal height of the forest was estimated, in the field, in transects opened in

the primary and secondary forest and compared with the DSM-DEM difference. The results showed that the DSM-DEM difference tends to underestimate the forest height under secondary forest, probably due to higher volume scattering of P band emission. The DSM-DEM difference over primary forest is closely related to the average height, in the transects, standing between the global average tree height and the average height of the upper storey trees of the forest transects. [C1208]

"Unsupervised learning rules for POLSAR images analysis"

It has been shown (see Chitroub, S. et al., Signal Processing, vol.82, no.1, p.69-92, 2002) that the model for POLSAR (polarimetric synthetic aperture radar) images is a mixture model that results from the product of two distributions, one characterizes the target response and the other characterizes the speckle phenomenon. For scene interpretation purpose, it is desirable to separate between the target response and the speckle information. We propose here to use some unsupervised learning rules for POLSAR images analysis via a PCA-ICA neural network model. Based on its rigorous statistical formulation (see Chitroub et al., Intelligent Data Analysis International Journal, vol.6, no.2, 2002), a neuronal PCA approach for the simultaneous diagonalization of the signal and noise covariance matrices is proposed. The goal is to provide PC images that are uncorrelated and have an improved SNR. Speckle is a non-Gaussian multiplicative noise, and the higher order statistics contain additional information about it. ICA is used to separate the speckle from the PC images and providing new IC images that have an improved contrast. The method has been applied on real POLSAR images. The extracted features are quite effective for scene interpretation. [C1209]

"Polarimetric SAR data classification method using the self-organizing map"

In this paper, we introduce a supervised classification method, which differentiates polarimetric SAR data into three categories using a self-organizing map (SOM) and a counter propagation learning approach after identifying the appropriate scattering classes. This classifier produces category maps corresponding to the Kohonen layers using training data for each scattering class. The SAR data are classified by inputting both like- and cross-polarization power elements into the learned SOM. In the experiment, PI-SAR data are employed since the resolution of aerial SAR data is higher than that of SAR data obtained from space. The proposed method yields higher-accuracy classifications than do conventional methods. [C1210]

"The Mueller matrix solution for polarimetric scattering from inhomogeneous random media of non-spherical scatterers under a pulse incidence"

Polarimetric scattering from inhomogeneous random media of non-spherical scatterers under a pulse incidence is studied. The time-dependent Muller matrix solution of vector radiative transfer for layering random media is derived. Co-polarized and cross-polarized bistatic and backscattering are numerically calculated. The shape and intensity of polarized echoes well depict the inhomogeneous fraction profile of random scatterers. Its functional dependence upon the fraction profile, layering thickness, and other parameters are discussed. This technique is applicable to the reconstruction of inhomogeneous fraction profile and inversion of the media thickness. [C1211]

"Polarimetric scattering from inhomogeneous random media under a pulse incidence"

Polarimetric scattering from inhomogeneous random media of non-spherical scatterers under a pulse incidence is studied. The time-dependent Muller matrix solution of the vector radiative transfer for layered random media is derived. Co-polarized and cross-polarized bistatic and back-scattering are numerically calculated. The shape and intensity of polarized echoes depict well the inhomogeneous fraction profile of random scatterers. Its functional dependence upon the fraction profile, layer thickness, and other parameters are discussed. This technique is applicable to the reconstruction of inhomogeneous fraction profile and inversion of the media thickness. [C1212]

"Statistical modeling of multipolarization and multifrequency SAR images of the sea surface"

A statistical analysis of polarimetric and multifrequency SAR images of the sea surface is presented. The analysis is carried out resorting to binary hypotheses tests aimed at verifying to what extent the texture value is shared between pixels of the same image in spatial proximity to each other, measurements of the same pixel acquired at different polarizations but in the same band, and measurements of the same pixel at different frequencies but with the same polarization. The data under test were acquired during a SIR-C/X-SAR mission in 1994. It is shown that cells in spatial proximity share the same value of the texture over sub-images of certain dimensions; moreover, while the HH and VV measurements of the same pixel possess a common value of the texture both in the L- and the C-band, the texture generally varies from the L- to the C-band (for both the HH and the VV channel). [C1213]

"Ku-band receiver and transmitter for breadboard DSP scatterometer"

The design and test results for the Radio Frequency (RF) portion of a breadboard polarimetric scatterometer operating at 13.402 GHz are presented. An integrated breadboard has been developed at the Jet Propulsion Laboratory (JPL) to evaluate the feasibility of a programmable Digital Signal Processing (DSP) approach for a follow-on scatterometer similar to SeaWinds (scheduled for launch in winter 2002). Early breadboards of an integrated system have been identified as valuable assets in developing effective subsystem requirements for the eventual flight instrument. Many compatibility and partitioning issues between the RF and DSP hardware are addressed with empirical results derived from the aforementioned breadboard. The RF portion of the breadboard consists of a dual channel receiver, heterodyning the received signal of 13.402 GHz down to an IF of 37 MHz prior to the analog to digital conversion, and a single channel transmitter, that converts the I/Q baseband transmit waveform up to Ku band. The breadboard makes provision for emulating capabilities such as programmable attenuators, loop-back calibration, and saturation effects in an actual instrument's power amplifier. It also provides control interfaces to allow early verification of software control algorithms. [C1214]

"A bandwidth extrapolation technique for improved range resolution of polarimetric radar data"

Radar resolution is limited in range by its bandwidth. One of the various super-resolution techniques for improving resolution is bandwidth extrapolation (BWE). In this paper, the concept of BWE is extended, and a new algorithm called polarimetric bandwidth extrapolation (PBWE), applicable to polarimetric radar data, is proposed. It is shown through simulations that utilization of full polarization information allows PBWE to improve the resolution beyond the conventional BWE method. [C1215]

"Polarimetric SAR interferometry for vegetable vertical structure parameters extraction"

Polarimetric SAR interferometry is much more sensitive to the distribution of oriented objects in a vegetated land surface than either polarimetric or interferometry alone. In this paper, we propose a polarimetric SAR interferometry technique for the estimation of parameters characterizing the vertical structure vegetated land surfaces. Based on simple physical model, we use SIR-C/X-SAR full polarimetric data to calculate the optimized interferometric coherences. The test site is Tianshan and its surrounding area, where pine trees are planted and the characteristics are well known. As a result, we could estimate the tree height distribution, and the quantitative evaluation is presented to relate the phase center differences and the tree types and the polarization combinations. [C1216]

"DOSAR: a multifrequency polarimetric and interferometric airborne SAR-system"

Presents the operational outlines of the multifrequency polarimetric airborne interferometric SAR system of the EADS/Dornier owned DOSAR. The simultaneous combination of full polarimetric with interferometric data makes it the only SAR system world-wide to collect cadastral information for mapping and land-use classification gathered within a single flight path. The DOSAR system is operational on a wide range of different aircraft. It is suitable for data collection for scientific, commercial and sovereignty as well as military applications. It has displayed its world-wide availability in a number of national flight campaigns in Germany as well as international applications in Austria, Switzerland, Indonesia and Thailand. Examples from these campaigns show the quality of high resolution SAR-data for mapping and classification. [C1217]

"EMISAR: a dual-frequency, polarimetric airborne SAR"

EMISAR is a fully polarimetric, dual frequency (L- and C-band) SAR system designed for remote sensing applications. The data are usually processed to 2Ч2 m resolution. The system has the capability of C-band cross-track single-pass interferometry and fully polarimetric repeat-pass interferometry. The SAR is operated at high altitudes on a Gulfstream G-3 jet aircraft. The system is very well calibrated and has low sidelobes and low cross-polar contamination. Digital technology has been utilized to realize a flexible and highly stable radar with variable resolution, swath width, and imaging geometry. Thermal control and several calibration loops have been built into the system to ensure system stability and absolute calibration. Accurately measured antenna gains and radiation patterns are included in the calibration. The processing system is developed to support data calibration, which is the key to most of the current applications. [C1218]

"Post-segmentation feature-based classification of synthetic aperture radar data"

Classification is one of the most important image analysis tasks as it provides image data with labels that transform it into information about the real world. In this research, classification of clutter in single and multichannel very high-resolution airborne SAR imagery is achieved by extending several classification methodologies to overcome limitations which exist when applied to SAR data. This is achieved by first pre-

processing the data using segmentation techniques, then classifying the resulting regions using a number of features calculated over the regions. By attempting to classify regions as opposed to single pixels we can increase the dimensionality of the feature space even for single channel data, and overcome the problems of speckle and texture inherent in SAR imagery. Both supervised and unsupervised classification methodologies have been adapted to feature-based region classification. The methodology has been extended to multichannel data, specifically polarimetric data. Examples of the application of the proposed method are given for several very high-resolution data sets from the QinetiQ airborne SAR. It is concluded that the proposed approach provides a successful and flexible, sensor independent solution to the problem of classification of very high-resolution SAR data for many different applications. [C1219]

"Review of the NASA/JPL airborne synthetic aperture radar system"

AIRSAR has served as a test-bed for both imaging radar techniques and radar technologies for over a decade. In fact, the polarimetric, cross-track interferometric, and along-track interferometric radar techniques were all developed using AIRSAR. We present the up-to-date system configuration, the expected performance and data accuracy in the standard radar modes. [C1220]

"High-resolution dual-bands interferometric and polarimetric airborne SAR (Pi-SAR) and its applications"

X-and L-band airborne SAR developed by CRL and NASDA has the capability of high resolution, polarimetry and cross-track interferometry. The radar has been operated since 1995 in the domestic area of Japan aiming at technical capability and validating for various applications. In this paper, we pick up the examples of the volcanic events to show the ability of the Pi-SAR. [C1221]

"Forest biomass retrieval using L-band polarimetric measurements"

Airborne L-band fully polarimetric SAR measurements over a boreal forest were analysed as a function of forest biomass. The HV backscattering coefficient was selected for inversion up to 70 m3/ha. HH appears to have information for stem volumes above 70 m3/ha. An inversion scheme was developed from this boreal forest and applied on a temperate forest site. [C1222]

"MEMPHIS-a fully polarimetric experimental radar"

The MEMPHIS polarimetric SAR is able to operate simultaneously at X-, Kaand W-band. After a detailed technical description, several examples are given to demonstrate its capabilities in the side-looking mode, in forward squinted Doppler beam sharpenung (DBS) mode and with across-track interferometry. Of great importance is the polarimetric calibration which is described in some detail. [C1223]

"Coastal imagery from the polarimetric airborne SAR PHARUS"

Polarimetric SAR imagery of a coastal scene is discussed, in terms of polarimetric and kinematic properties of waves on the sea and breaking waves in the surf zone. The coastal zone is a dynamic environment, and there is an increasing demand for monitoring it. Remote sensing can be an economic solution, and this paper explores some possibilities for extracting relevant coastal zone information from polarimetric SAR data. It focuses on the use of polarization for sea wave measurement, coast line determination, and estimation of surf zone parameters. While this work is based on airborne SAR, the results should also pertain to polarimetric satellite systems, especially as a steep incidence angle mode was used. When acquiring polarimetric data, a proper calibration is essential. As the use of dedicated calibration devices in the field is expensive, there is an interest in using scene parameters for calibration. The paper discusses some issues with this approach that arise in coastal areas. [C1224]

"The sensitivity of C-band polarimetric SAR to crop condition"

The Canada Centre for Remote Sensing conducted an intensive field campaign in 2000 at an agricultural test site at Indian Head, Saskatchewan (Canada). Airborne C-band fully polarimetric SAR data were acquired over the site. The supporting ground information is being used to establish the sensitivity of several polarimetric parameters to variations in crop condition. Preliminary results suggest that several polarizations are sensitive to variations in crop growth and crop stress, particularly in small grain crops like wheat. Information on crop growth gathered from sensors, like RADARSAT-2, could aid in strategies to better manage nutrient applications on agricultural fields. [C1225]

"Turning the scientifically possible into the operationally practical: RADARSAT-2 polarimetry applications"

RADARSAT-2, planned for a late 2003 launch, is an advanced SAR satellite. Key features of RADARSAT-2 are high resolution (3 m), polarimetry modes, enhanced ground system providing rapid satellite tasking and near-real time data processing, improved image location accuracy, and on-board solid state recorders. RADARSAT-2 offers three polarimetric modes: (1) selective polarization providing one co-pol channel (HH or VV) and the corresponding cross-pol channel (HV); (2) high resolution (3 m) single pol channel (HH or VV); and (3) a fully polarimetric mode providing both amplitude and phase. The fully polarimetric mode is significant since RADARSAT-2 is the first commercial satellite to offer this mode. The commercial focus of the RADARSAT-2 mission dictates the development of operational applications, and ultimately the extraction of information from the SAR data. [C1226]

"Numerical study of frequency and polarimetric dependence of the emissivities and backscattering coefficients of soil based on three dimensional Monte-Carlo simulation of Maxwell equations"

The backscattering coefficient and emissivity of wet soil surface are studied with the 3-dimensional numerical simulations. The study is focused on the angular, frequency, and polarimetric dependence of the scattering and emission. The simulation results are compared with the experimental measurements from real-life soil surface for backscattering coefficients at L and C frequency bands and at the multi-incidence angles. The fairly good agreements are observed for the fixed physical surface roughness parameters at two frequency bands. [C1227]

"HYDRO-POL-a spaceborne polarimetric radar-radiometer for land hydrology and ocean salinity"

Microwave sensors are of primary importance in mapping surface states and measuring some significant quantities which affect the hydrological cycle. A space mission aiming at monitoring soil moisture and surface salinity at a global scale is suggested. The mission is based on a combination of polarimetric active and passive microwave sensors. [C1228]

"Advanced classification of buried UXO using a broadband, fully polarimetric ground penetrating radar"

A broadband, fully polarimetric ground penetrating radar (GPR) system has been applied for classification of buried unexploded ordnance (UXO) for the past few years. It utilizes both late-time and early-time signatures extracted from GPR data collected with multiple antenna positions and multiple scan orientations. Various field measurements were conducted from 1999 to 2001 at UXO sites that have quite different environmental conditions. Lessons learned from these tests have led to significant system improvements. [C1229]

"A numerical study of the effects of realistic GPR antennas on the scattering characteristics from unexploded ordnances"

The detection and classification of unexploded ordnances (UXOs) is a difficult task, and it is even further complicated by the fact that the ground penetrating radar (GPR) antenna can significantly distort the scattering signal from the UXO. We consider the model of the real antenna which will be used in the numerical study of scattering from UXOs. We consider a rigorous finite difference time domain (FDTD) model of a fully polarimetric horn-fed bowtie (HFB) antenna and study how various modifications of the parameters of the antenna can affect it performance. [C1230]

"Model-based classification of polarimetric SAR sea ice data"

This paper discusses the role of scattering decomposition models in the classification of polarimetric SAR sea ice data. The iterative Wishart classifier was applied to 3-frequency airborne SAR data acquired in the Beaufort Sea, and the scattering models were found to be helpful in interpreting the assigned classes. In addition to using the full data set, reduced data sets based on an eigenvector decomposition were investigated for their potential for classification, as the eigenvectors provided a separation of scattering mechanisms. The surface scattering component was found to be the dominant one for this data set, and yielded a classification similar to the full data set. [C1231]

"Polarimetric C-band observations of soil moisture for pasture fields"

Soil moisture information is an important parameter in hydrological modelling, although providing reliable data is difficult due to its spatial variability and dynamic nature. The ability to estimate soil moisture from synthetic aperture radar (SAR) has been the topic of numerous investigations. To date, most of these investigations have

been limited to single or multiple linear polarized configurations. However, Radarsat-2 will be launched in 2004 and will have fully polarimetric C-Band SAR capability. In preparation for a new generation of spaceborne polarimetric SARs, Environment Canada's Convair 580 airborne polarimetric C-band SAR acquired data over an agricultural area west of Ottawa, Canada on September 22, 2000, April 26, 2001 and May 20, 2001. Coincident ground measurements (soil moisture, biomass, and surface roughness) were collected over pasture on all dates and bare fields in the spring of 2001. Analysis includes linear polarizations (σ°HH, σ°VVσ°HV), circular polarizations (σ°RR, σ°RL, σ°LL), as well as fully polarimetric parameters such as pedestal height, total power, phase difference, and polarimetric signatures. This paper presents preliminary results of the September 22, 2002 data. [C1232]

"Image classification in complex spaces"

Addresses issues related to classification of images in complex spaces. The image is represented in terms of phase and amplitude components. The classifier optimizes functions of joint real and imaginary conditional probability density functions. A bound on the total probability of errors in terms of Rayleigh quotient is derived and compared to the cases where a non-complex amplitude-only signal is used. Examples of application of the proposed approach on polarimetric radar imagery indicate several orders of magnitude improvement in performance. [C1233]

"Hierarchical segmentation of polarimetric SAR images"

A hierarchical stepwise optimization process is used for polarimetric SAR image segmentation. The process starts with small sets of pixels as segments and then sequentially merges the segment pair that minimises a stepwise criterion. The polarimetric information could be represented by a covariance matrix. The proposed criterion is based upon the testing of the equality of covariance matrices of adjacent regions. The segmentation of SAR images is greatly complicated by the presence of coherent speckle. We are using spatial constraints and contour shapes in order to improve the segmentation results. [C1234]

"Polarimetric remote sensing of sea ice-from theory to practice"

The employment of radars in remote sensing monitoring of polar regions is well known and largely proven practice today. In general the sea ice controls the heat transfer and mass-balance between the ocean-and the atmosphere. To interpret ice polarimetric signatures a composite microwave model is studied. The model relates the electromagnetic scattering from sea ice to its geophysical properties. [C1235]

"Potential of RADARSAT-2 for sea ice classification"

Polarimetric data acquired by the CCRS CV-580 airborne SAR are used to assess the capability of RADARSAT-2 for operational sea ice classification. The information content of the polarimetric data is illustrated by showing how specific scattering mechanisms are portrayed by the entropy, anisotropy and α-angle features. Ice type classes are derived from the full polarimetric data set using a complex Wishart classifier. The classes are then mapped into 2-D scatterplots to compare the information content between dual and fully polarimetric data. While dual polarimetric data are an improvement over single channel data, it is found that fully polarimetric data are needed to provide accurate ice classification performance. [C1236]

"Land cover classification of polarimetric synthetic aperture radar (POLSAR) data based on scattering mechanisms and complex Wishart distribution"

The use of C- and L-band polarimetric synthetic aperture radar (POLSAR) data for classifying land cover features in a tropical area is investigated in this study. The POLSAR data were acquired during the NASA/JPL PACRIM-1 mission over the northern part of Peninsular Malaysia on 3rd December 1996. Prior to classification, the Lee polarimetric filter was applied to the complex covariance matrix for speckle suppression. In unsupervised classification, the scattering mechanism of each pixel in the speckle-suppressed images was analyzed and grouped into one of the three categories: (1) odd-bounce, (2) even-bounce, or (3) diffuse scattering. Training samples were then generated from the outputs of the unsupervised classification, to be used in subsequent supervised classifications of various frequency and polarization combinations. The Kappa statistics computed for classification using single-frequency fully polarized C- and L-band data were 0.69 and 0.73, respectively. An improvement to 0.79 was achieved by using the dual-frequency (combined C and L bands), fully polarized data in the classification. [C1237]

"Polarimetric target decomposition and physical interpretation of NASA (JPL) AIRSAR data in mountainous terrain"

Two types of polarimetric Target Decomposition (TD) theories were used to investigate the effects of surface slopes on the physical scattering mechanisms over mountainous scattering surfaces. This study is implemented with the L- & P-band NASA (JPL) airborne SAR (AIRSAR) data, which was acquired during PACRIM-II Korea campaign in September 2000. Although the dominant scattering mechanism of mountainous forest area is volume scattering in pine forest scattering surface, detailed scattering mechanism varies with respect to the local incidence angle variations due to the local topography and wavelength. [C1238]

"Coherence region shape extraction for vegetation parameter estimation in polarimetric SAR interferometry"

Polarimetric SAR interferometry (POLINSAR) provides volumetric information about electromagnetic scattering processes, whereas standard INSAR assumes that only surface scattering is present. Instead of a single complex interferometric coherence for each pixel, POLINSAR observes a polarization-dependent coherence function whose range is called the coherence region. To estimate canopy parameters, the shape of this region must be matched to predictions from scattering models. For computational efficiency, the region must be represented by a small number of samples. Current sampling methods find the stationary points of coherence magnitude or phase; it is questionable whether the coherence region can be characterized adequately with so few samples. We have developed an algorithm for sampling the outer boundary of the coherence region. We formulate the problem of finding the minimum and maximum real part of the coherence as an eigenvalue problem. The solutions specify two points on the boundary. Other points are found by applying a phase shift to the POLINSAR cross-correlation matrix. The mathematical literature shows that the coherence region is convex, and hence the algorithm rinds the entire boundary. We present a comparison of boundary sampling to standard methods on L-band POLINSAR data from the SIR-C platform. It is evident that boundary sampling describes the shape of the coherence region more thoroughly than other methods. [C1239]

"Unsupervised approach for polarimetric SAR image classification using support vector machines"

In the previous works S. Fukuda et al. (2001), we developed the classification method of land cover from polarimetric SAR data using support vector machines (SVMs). As the extended study of the SVM-based classification method, an unsupervised approach is presented in this paper. Since SVM, originally a technique for pattern recognition, can not be applied to unsupervised classification straightforwardly, we propose the automatic selection scheme of representative training areas based on the number of the closest training samples to the separating hyperplane in the feature space; such samples are called the support vectors. In the experiment for a part of the AIRSAR Flevoland data including five classes of agricultural crops, the scheme performs successful classification, which can bear comparison with the supervised result. [C1240]

"Exploiting the polarimetric information for the detection of ship targets in non-homogeneous SAR images"

Ship detection in polarimetric SAR images of non-homogeneous sea areas is considered. We demonstrate the impact of non-homogeneous sea features on the false alarm rate and the need of extracting the image structure. We thus introduce polarimetric segmentation procedures that cooperate with high-resolution polarimetric detection features for the control of the false alarms. Different polarimetric segmentation-plus-detection procedures are tested over real data to devise the appropriate method to exploit the polarimetric information. [C1241]

"Sea ice classification using multi-frequency polarimetric SAR data"

This paper discusses the capability of the complex Wishart classifier for sea ice and classification using multifrequency, fully polarimetric SAR data. C-, L-, and P-band data acquired by the JPL AIRSAR in the Beaufort Sea was used. Classification using the unsupervised Wishart classifier is a two-stage process. An initial classification is required to seed the algorithm and can be derived using other classification methods. The Wishart classifier then used in iterations where the class means are updated after every step. The convergence of this approach is investigated. The Wishart classifier was found to be extremely dominant so that the classification result after a few iterations depends not necessarily on the initial classification used to derive the first class means. Even an initial classification derived with a random number generator leads to a good result after a few iterations. [C1242]

"Direct estimation of vegetation parameters from covariance data in polarimetric SAR interferometry"

Polarimetric SAR interferometry (POLINSAR) is an emerging technique for the characterization of volumetric

scattering processes. Each pixel of a POLINSAR interferogram is a 6Ч6 matrix of complex sample covariances among the polarimetric channels in the image pair. A model of polarimetric scattering from vegetation specifies the expected covariance matrix as a function of the vegetation parameters. The data matrix obeys a complex Wishart probability distribution that depends on the expected covariance. Using this, one can rind the maximum-likelihood estimate of the parameters from the data matrix. This paper presents the formula for the expected covariance matrix, as predicted by the model of Treuhaft and Siqueira for a random canopy over flat ground. An algorithm for computing the maximum-likelihood parameter estimate is derived. We test the algorithm on simulated data and compare its results to estimates derived from coherence samples. We conclude by discussing the extension of the direct estimation technique to more general POLINSAR scattering models. [C1243]

"Rain rate retrieval using airborne imaging radiometry during CAMEX3/TEFLUN-B"

A multiband Polarimetric Scanning Radiometer (PSR) was integrated onto the NASA DC-8 aircraft (N717NA) and flown from August through September of 1998 during the third Convection and Moisture Experiment (CAMEX3) and Texas-Florida Under-flight (TEFLUN-B) campaign. The PSR is a unique conically-scanned imaging radiometer with channels at 10.7, 18.7, 21.5, 37.0 and 89.0 GHz, measuring both vertical and horizontal polarizations at each of these frequencies. These channels correspond to several key bands of the DMSP (Defense Meteorological Satellite Program) SSM/I (Special Sensor Microwave Imager) and the NASA TRMM (Tropical Rainfall Measuring Mission) TMI (TRMM Microwave Imager). The PSR was developed by Georgia Institute of Technology and the NOAA Environmental Technology Laboratory. It is the first airborne imaging radiometer to provide a research quality set of high spatial resolution multiband polarimetric microwave imagery within and around a hurricane. A nonlinear statistical emission algorithm was developed for rain rate retrieval, similar to that described by Skofronick-Jackson and Gasiewski (1995). We use the PSR/A 10.7 GHz channels of horizontal and vertical polarization because of their predominantly monotonic response to near-surface rain rate from 0 to 50 mm/hr. An initial comparison of the PSR retrieved rain rate to coincidently observed rain rate retrieved using NASA JPL's Airborne Rain Mapping Radar (ARMAR) shows favorable agreement over at least an order of magnitude in rain rate intensity. Discrepancies are within the standard deviations of the PSR retrieval algorithm and can be explained by differences in the observation geometries of the sensors and by differences in the physical measurement principals between the two instruments. Further comparison of the PSR rain rate retrieval with the TMI level 2A12 rain rate product is similarly favorable. Some discrepancies can be explained by the differences in spatial resolution of the two passive microwave instruments and the different nature of the two retrieval algorithms. Despite these differences, the correlation coefficient between the TMI and the PSR coincidentally observed rain rates is 0.92 and 0.91 for PSR horizontal and vertical channels (respectively), for rain rates from -1 to 16 mm/hr. [C1244]

"Phenomenological models of Doppler-polarimetric microwave remote sensing of clouds and precipitation"

This paper deals with mathematical modeling and simulation of echo-signals in both frequency and time domains. It establishes some important relationships between Doppler-polarimetric observables and weather object under observation. [C1245]

"Forest parameter retrieval with JPL Airsar P-, L- and C-band data: a plot level analysis for slash pine stands in Georgia"

During an EOCAP-SAR project, Airsar P-, L- and C-Band data were used to test the capability of SAR to predict biometric parameters which are frequently used by timber managers as inputs to growth, harvest and yield models. The test site was a commercially managed area in Jesup, south-east Georgia, with stands owned by The Timber Company (TTC). Field campaigns provided an extensive plot-level georeferenced ground data set of four slash pine stands which was used to determine the correlation with the Airsar data. Additionally, 18 stands were surveyed and stand level summaries of biometric variables height, basal area, and volume were obtained. A statistical model was used to test all possible scenarios of polarimetric and frequency combinations. The best models were chosen to develop inversion models for basal area. These model results were applied to stands which are owned by a different timber company (Rayonier), and which were located in the Airsar strip. Within the TTC land holdings, R2correlation coefficients for volume prediction from SAR were 0.85. The correlation between predicted basal area and stand age on 65 Rayonier stands resulted in the an adjusted R2of 0.86. [C1246]

"Land use classification of SIR-C imagery based on a published database of multi-polarization backscattering"

Land use classification of polarimetric SAR imagery is carried out by referring not to training area data within the

image but to a published database consisting of independently measured backscattering data. The results are reasonable when the appropriate radar parameters are chosen in the measurement. [C1247]

"Using cross-entropy for polarimetric SAR image classification"

In this paper, the concept of cross-entropy is introduced for measuring the difference between two scatterers in polarimetric SAR image classification. The difference between two scatterers is composed of three parts, i.e., the difference of average scattering mechanism, the difference of scattering randomness and the difference of the two spans of scattering matrices. The minimum cross-entropy principle is adopted to make the classification decision. The capability of this method is demonstrated by the experimental results. [C1248]

"Development of a virtual radar environment"

The CSU-CHILL radar facility has embarked on an initiative to enable the real time operation of the radar over the Internet called VCHILL or Virtual CHILL. The concept of operation over the Internet can be implemented at several levels. The simplest one is to make the routine CHILL images available on the Internet as soon as the scans are completed. This type of data dissemination has been available with CSU-CHILL over 5 years. However such images are clearly not sufficient for aircraft coordination or actively conducting coordinated scans with rapid updates. The VCHILL initiative has a more ambitious goal of providing the same quality of service (QoS) at remote locations as at the radar site. In addition, the goal of the VCHILL initiative is to provide the educational experience of polarimetric radar at a remote location, without compromising on features of an on-site radar console. This paper describes some progresses and plans of the VCHILL initiative [C1249]

"Change detection in polarimetric SAR data and the complex Wishart distribution"

When working with multi-look fully polarimetric synthetic aperture radar (SAR) data an appropriate way of representing the backscattered signal consists of the so-called covariance matrix. For each pixel this is a 3Ч3 Hermitian, positive definite matrix which follows a complex Wishart distribution. Based on this distribution a test statistic for equality of two such matrices and an associated asymptotic probability for obtaining a smaller value of the test statistic are given and applied to change detection in polarimetric SAR data. In a case study EMISAR L-band data from 17 April 1998 and 20 May 1998 covering agricultural fields near Foulum, Denmark are used. The derived test statistic can be applied as a line or edge detector in fully polarimetric SAR data also [C1250]

"Multi-baseline polarimetric SAR data classification using the complex Wishart distribution and principal component analysis"

In this paper is introduced a classification approach for multi-baseline polarimetric interferometric SAR data sets, based on a principal component analysis of coherent scattering vectors. From the Wishart probability density function of a restricted data set, is defined a maximum likelihood decision rule to perform an iterative adaptive classification [C1251]

"A performance analysis of several bistatic calibration techniques"

Several popular bistatic calibration techniques are evaluated, and comparisons are made between the relative merits of various calibration objects. This analysis considers the following: sensitivity to object alignment error, sensitivity to polarization impurity, and ease of implementation. Both theoretical concepts and practical considerations are discussed, based on measurements accomplished at the European Microwave Signature Laboratory (EMSL) of the Joint Research Centre (JRC) in Ispra, Italy. This facility has the capability to produce far-field, fully polarimetric, bistatic measurements with an approximately 30 cm diameter quiet zone, with the necessary precision for comparing different calibration methods [C1252]

"Polarimetric SAR interferometry as applied to fully polarimetric rain forest data"

The scope of this paper is to establish a polarimetric SAR interferometry approach to estimate interferometrically observable forest and ground parameter. Three optimized interferometric coherences can be found through a properly weighted superimposition of all the interferometric coherences available from a fully polarimetric single baseline experimental set-up in repeat-pass mode. These proper weights can be found by solving an eigenvalue problem for each resolution cell [Cloiude and Papathanassiou 1998]. The result serves as the right hand side of a least square optimization problem which makes use of a scattering model based on a randomly oriented volume over an impenetrable surface [Treuhaft and Siqueira 2000] to estimate a set of physical forest parameters transformed through this model. A conjugate direction set iteration scheme is used to minimize the cost function of the optimization problem and to solve for the pertinent candidate parameters, which are the forest volume thickness, the volume extinction coefficient, the interferometric phase related to the underlying

topography, and the effective ground-to-volume amplitude ratios of the related interferometric coherences. Due to the non-uniqueness of this inversion problem an additional constrained is introduced via a Tikhonov regularization scheme. The results of the presented schemes are shown for the first time on P-band data takes acquired over tropical rain forest in Brazil [C1253]

"Applications of RADARSAT-2-polarimetric data"

Expected applications improvements provided by dual- and quad-polarised data from Radarsat-2 are identified. Dual-polarised data is expected to have a wide range of applications. More detailed information is provided by quad-polarised data but here applications are limited by the narrow swath width. A specific study on sea ice monitoring is focussed on as an example application. The effect of system noise on polarimetric data analysis is considered as is the potential for polarimetric interferometry. The latter will be limited by temporal decorrelation [C1254]

"Removal of additive noise in polarimetric eigenvalue processing"

This paper concerns with the problem of additive noise in fully polarimetric SAR data. Two approaches-the first one based on conventional four-channel polarimetry and the second one based on polarimetric interferometric data-for estimating and removing additive noise level are presented and discussed. The performance of the proposed approaches is demonstrated using experimental fully polarimetric P-band data acquired by the experimental airborne SAR system (E-SAR) of DLR [C1255]

"Sensor and data fusion contest: information for mapping from airborne SAR and optical imagery"

The concept of a sensor and data fusion contest on topographic mapping from SAR and optical imagery is presented. The image data to be used in the test will have a spatial resolution of approximately 1 m or better. The SAR data will be multi-frequency polarimetric INSAR data, the optical data will be multispectral. The goal of processing is the extraction of topographic objects which are commonly subject of mapping projects, e.g. roads, built-up areas and other land cover/land use classes. The final scope of the test will be defined after interaction with potential participants of the test. Besides the image data, digital reference maps will be compiled for the test sites. For this task, contributions from e.g. official mapping authorities would be very valuable. The data fusion contest will be organized in the framework of the IEEE GRSS data fusion technical committee (DFC), the ISPRS working group III/6 "Multi-Source Vision" which both have strong relations with scientists active in research on multi-sensor fusion and automation in mapping, and-as the provider of the main organizational framework-the European Organization for Experimental Photogrammetric Research (OEEPE) which is the research platform of national mapping agencies and other institutions regarding technology developments to optimise the use of core data in a geoinformation infrastructure context [C1256]

"Fuzzy clustering and interpretation of fully polarimetric SAR data"

Classification of Earth terrain components using fully polarimetric synthetic aperture radar (SAR) data sets is an important application of radar remote sensing. For the operational application some demands, besides the accuracy requirements, must be fulfilled. In order to make the handling of the classification easy for users, the algorithms have to be data set independent and the handling must be possible without aprioriknowledge. The ultimate aim is an unsupervised algorithm which is suitable for automation. In this treatment we propose an approach applying an unsupervised automatic clustering of the H/A/α/λ1space. From the resulting clusters rules are derived for a fuzzy rule based classification. The resulting clusters can then be assigned to the desired object classes by the user. The approach enables us to combine the wide range of information contained in polarimetric SAR data with the robust and still flexible strategy of fuzzy rule based classifiers and with a high degree of automation. The effectiveness of this approach is demonstrated using fully-polarimetric L-band airborne SAR data acquired with the E-SAR system of the DLR at the well know test site of Oberpfaffenhofen, Germany [C1257]

"Unsupervised classification and analysis of natural scenes from polarimetric interferometric SAR data"

In this paper is introduced a classification approach for polarimetric interferometric SAR data sets, based on the analysis of an interferometric (6Ч6) polarimetric coherency matrix properties. From the Wishart probability density function of this polarimetric representation, is defined a maximum likelihood decision rule to perform an iterative adaptive classification. Another classification scheme based on the derivation of the conditional probability of the cross-correlation between both data sets is presented [C1258]

"The SIVAM airborne SAR system"

In response to the significant task of mapping and monitoring the Amazon region, the System for Vigilance of the Amazon (SIVAM) program was initiated by the Brazilian government. One of the key elements of SIVAM is a group of three remote sensing aircraft, each equipped with a multi-mode synthetic aperture radar as the prime sensor. The SARs are extremely flexible and provide: multi-channel fully polarimetric SAR mapping modes, cross-track interferometric SAR modes, spotlight SAR, and wide area surveillance with ground moving target indicator (GMTI) capability [C1259]

"L- and P-band for surface parameter estimation"

This work presents a first qualitative and quantitative comparison of fully polarimetric SAR data at L- and P-band with respect to surface parameter estimation. The potential combination of these two frequencies in order to obtain more robust estimates and/or to extend the validity range of the inversion algorithms is investigated based on experimental data acquired by DLR's airborne SAR system [C1260]

"Estimation of comprehensive forest variable sets from multiparameter SAR data over a large area with diverse species"

Polarimetric and multifrequency data from the NASA/JPL airborne synthetic aperture radar (AIRSAR) have been used in a multitier estimation algorithm to calculate a comprehensive set of forest canopy properties including branch layer moisture and thickness, trunk density, trunk water content and diameter, trunk height, and subcanopy soil moisture. The estimation algorithm takes advantage of species-specific allometric relations, and is applied to a 100 km Ч100 km area in the Canadian boreal region containing many different vegetation species types. The results show very good agreement with ground measurements taken at several focused and auxiliary study sites. This paper expands on the results reported in Moghaddam and Saatchi (2000) and applies the algorithm on the regional scale [C1261]

"The scattering polarimetric response contrast between two wind-generated rough sea surfaces"

Polarimetry for SAR applications is an excellent technological method to extract more information about wind-generated rough sea surface according to the scattering mechanisms. With the use of the scatter matrix, i.e. Mueller matrix, and Stokes vector operator, the paper describes a comparison between the polarimetric responses of two types of wind-generated sea surface offshore Baogang, Hainan Province. It gives representative results for the polarimetric response of backscattering electromagnetic field from the rough sea surface and the characteristics of Mueller matrices' traces. The long wavelength sea surface and the short one can be determined by their polarimetric responses. The traces and determinant values of scattering matrices are related to the wind conditions. Some heuristic conclusions are given upon the results [C1262]

"The use of airborne P-band radar data for land use and land cover mapping in Brazilian Amazonia"

The aim of this work was to analyze the potentiality of polarimetric P-band data for land use and land cover mapping in a site of the Brazilian Amazonia. These data are the first P-band image set gathered in the Brazilian Amazonia, so they represent a unique opportunity of analyzing the potentiality of this frequency for classification purposes. The stratification of land use/land cover classes was performed using a classification system specially developed for polarimetric data. Results showed that P-band data were able to discriminate forest and regeneration areas from crop, pasture and bare soil areas. Moreover, regeneration areas (older than 12 years) were successfully distinguished from primary forest and other regeneration stages [C1263]

"Statistical properties of L-band sea clutter measured with a polarimetric synthetic aperture radar"

The limiting factor affecting the performance of most airborne radar systems in detecting targets on or near the surface of the sea is return echoes from the sea surface or sea clutter. The objective of this paper is to provide an analysis of the statistics of Australian sea clutter for an L-band VV-polarised airborne radar system from sampled measured values. Polarimetric synthetic aperture radar (POLSAR) image of the North-West region of Australia, acquired in 1996 by the Jet Propulsion Laboratory (JPL) was used to study, the backscattered statistics of the sea surface. Using this POLSAR image, a number of different candidate distribution functions have been investigated, and their goodness-of-fit have been carried out using the Kolmogorov Smirnov goodness-of-fit test. The log-normal, Weibull and K-distributions have been applied to model the statistical properties of multi-look polarimetric SAR sea clutter. The K-distribution has been found to have good agreement with the observed sea clutter intensity distributions [C1264]

"A low-cost polarimetric response tool using spreadsheets"

This paper describes a spreadsheet based low-cost tool for displaying polarimetric response graphs. It describes the actual implementation in detail and shows examples of the polarimetric signatures of various types of terrain that have been computed using the tool. These signatures are interpreted in relation to the geophysical characteristics of the ground features they represent. The tool can be found on the Canadian Space Agency website at www.space.gc.ca/csa_sectors/earth_environment/radarsat2/ [C1265]

"The Glen Affric project: forest mapping using polarimetric radar interferometry"

We describe the Glen Affric radar project, a multi-disciplinary program addressing the ability of polarimetric radar interferometry to provide quantitative vegetation structural information of importance in forest mapping and ecology studies [C1266]

"Super-resolution of polarimetric SAR images of a ship"

This paper deals with the application of modern spectral analysis (SPECAN) techniques to polarimetric Synthetic Aperture Radar (SAR) data. The purpose is to use all the information provided by images of the same SAR scene at the different polarimetric channels (HH-VV-HV-VH) in order to improve the geometrical resolution with respect to the resolution corresponding to the transmitted bandwidth an the synthetic aperture length. One practical motivation for this work is to improve radar image quality so that subsequent classification procedures will have greater chance of success [C1267]

"Lava-flow textural trends using SAR: the Virunga Volcanic Chain, East Africa"

Multi-frequency polarimetric Shuttle Imaging Radar-C (SIR-C) data acquired in October 1994 were analyzed for the Virunga Volcanic Chain, East Africa. The synthetic aperture radar (SAR) data can be used to define the roughness, texture, orientation, and dielectric properties of scattering elements of volcanic surfaces. SIR-C acquired C- and L-band SAR in two polarizations, horizontal transmit and receive (HH), and horizontal transmit and vertical receive (HV). The SAR backscatter from the volcanoes is mainly controlled by roughness and vegetation cover, as there is a correlation between radar intensity parameters and age of lava-flow. This is best illustrated by the ratio of C-HV/C-HH, and to some extent, L-HV/L-HH, which show positive linear relationships with age of flow until a threshold age of ~30 years (~12000 days) is reached. The H-polarized incident energy is converted to significant amounts of V-polarized backscatter, so that the cross-polarized backscatter intensity increases with flow age. For flows older than ~30 years, the backscatter signature is from volume scattering due to vegetation cover. The vegetation signature threshold with time can serve as an age proxy to determine recent flank eruption frequency [C1268]

"The effect of free vegetation water on the multi-frequency and polarimetric radar backscatter-first results from the TerraDew 2000 campaign"

This paper presents the first results of the TerraDew research project about the effects of free vegetation water on the radar backscatter signal. The investigations are based on intensive SAR and field measurements of diurnal free vegetation water changes in different vegetation types. The results show a systematic backscatter influence in dependence of the investigated backscatter features (wavelength, polarization, vegetation structure, amount of free vegetation water). The highest backscatter increase is found at C-VV and for grassland (up to 4.5 dB), no significant backscatter change is indicated for L-VV and forested areas. The further investigations will focus on the physical description and simulation of these effects to include them in backscatter models and the evaluation of the impacts for thematic SAR data analysis [C1269]

"Progress report on the NASA/JPL airborne synthetic aperture radar system"

AIRSAR has served as a test-bed for both imaging radar techniques and radar technologies for over a decade. In fact, the polarimetric, cross-track interferometric, and along-track interferometric radar techniques were all developed using AIRSAR. In this paper, we present the up-to-date system configuration and expected performance in the standard radar modes. In addition, we describe the various experimental modes available to researchers. Finally, we discuss on-going improvements with AIRSAR and future direction of the program [C1270]

"Retrieval of soil moisture content with the use of neural network-scattering model"

This research is a part of the PacRim-II AIRSAR experiment carried out over Korean peninsula in September 2000 and consists of two parts. One is the analysis of surface roughness characteristics and spatial distribution

of soil moisture contents of the test site, acquired as a part of the ground truth survey in Jeju island. The other is the test of neural network-scattering model based estimator for the surface parameter retrieval from polarimetric SAR data. At the time of preparing this paper, we have not received the actual polarimetric SAR data yet and this paper discusses the research approach and research plans. It was tested that when backscatter coefficients of surface are represented as fuzzy numbers, the physical surface parameters are also estimated as fuzzy membership functions [C1271]

"Multi-parameter airborne SAR remote sensing of soil moisture in agricultural area"

This study investigates issues and problems in soil moisture radar remote sensing in agricultural areas as part of the International Surface Parameter Retrieval Collaboration (SPARC). The analysis is based on multi-parameter E-SAR data and intensive field measurements of soil moisture and surface roughness. The analysis of multi-frequency, polarimetric and interferometric backscatter shows the dominance of the roughness signal compared to the variations in soil moisture. Problems on soil moisture mapping were described and discussed in a spatial error evaluation and in a physical backscatter modeling [C1272]

"Multi-sensor-systems at mm-wave range for automotive applications"

The concept of an automotive radar sensor and its design details in the 61 GHz ISM band are introduced. The sensor is capable of measuring several important parameters of automobile driving dynamics and boundary conditions at a time, e.g., velocity, pitch angle, distance to ground and condition of the road surface. The coherent system consists of two bistatically oriented microwave frontends with five receiving channels. There are two orthogonal polarization channels in each module and one additional reference channel. A dual frequency CW technique enables measuring of the distance and the Doppler shift while by measuring the polarimetric scattering matrix one can classify the road surface. To keep hardware costs low it is required to realize all the measurement capabilities in one multifunctional sensor device, which combines the two antennas and the microwave frontends in one case. For fast control a high update rate with a maximum of measurement accuracy is needed and the dual frequency mode is achieved with two fixed tuned sources by frequency stepping in time sequence [C1273]

"Target detection in ground clutter with stepped frequency CFAR detector at millimeter-wave"

This paper presents a constant false alarm rate (CFAR) stationary target detection scheme in ground clutter at millimeter-wave frequencies. The proposed scheme makes use of the clutter decorrelation bandwidth considered in the stepped-frequency radar system and the concept of a CFAR matched filter for the received data projection onto the signal and clutter subspace. Therefore, the scheme achieves the CFAR, where the knowledge of the clutter covariance matrix is not needed preliminarily. In order to investigate the detection performance, we carried out experiments with a W-band stepped-frequency polarimetric radar system at 94 GHz with a bandwidth of about 300 MHz. The results are discussed and compared with conventional CFAR detectors [C1274]

"Polarimetric classification of trees"

Since scattering matrix acquisition capability will be equipped with space-borne radar systems such as ALOS PALSAR to be launched in 2003, radar polarimetry is now an indispensable tool for monitoring the Earth's cover. The advantage of using the vector nature of electromagnetic waves is the information on the amplitude, phase and their relations pertaining to target. In this paper, we retrieve a useful index for classifying broad leaf trees and conifer (needle like leaf) trees based on the scattering characteristics of tree canopies. The index used is the polarimetric correlation coefficient derived by the elements of the Sinclair scattering matrix. It is shown that correlation coefficient defined in the circular polarization basis serves to distinguish conifer tree and broadleaf tree [C1275]

"Interpretation and analysis of polarimetric L-band E-SAR-data for the derivation of hydrologic land surface parameters"

Evaluates the use of polarimetric L-band synthetic aperture radar (SAR) information for applied derivation of important hydrologic parameters. In most cases empirical relationships between SAR-data and water cycle components are investigated as a first step towards hydrological information extraction. The use of polarimetric parameters for hydrological modelling is analysed. Furthermore, the dependency of the polarimetric parameters from the local incidence angle is investigated [C1276]

"Statistical and phenomenological recognition in polarimetric SAR imaging"

The maximum likelihood classifiers are of large interest because they allow one to simulate, quantify and compare easily the rate of correct recognition for various cases of partial polarimetries and symmetries hypothesis. In this paper, they are used within the framework of natural surfaces recognition from SAR polarimetric images. The purpose is to advise the choice of the more suitable partial polarimetry for a remote sensing satellite. The results of this work infer some questions about the validity of some properties often supposed in the analysis of SAR images and in the radar calibration method [C1277]

"Polarimetric radiometer sensing of sea surface winds using SHOWEX data to determine the Stokes harmonic coefficients"

This research utilizes the analysis of data acquired from microwave remote sensing instruments deployed on the Twin-Otter aircraft during the Shoaling Waves Experiment (SHOWEX 99) between November 11 to December 4, 1999. The principal data comes from the NOAA/ETL 37 GHz polarimetric radiometer and APL/UW coherent real-aperture radar (CORAR), a dual polarized X-band radar (which for the purposes of this investigation is being used as an incoherent scatterometer) A principal focus is the study of the magnitude and variance of the harmonic coefficients of the Stokes parameters (mainly the Fourier coefficients, "Q2" and "U2") at a variety of incidence angles, as a function of wind speed and friction velocity. An examination of the azimuthal variation of the polarimetric radiometer (PR) data from seven different flight days during SHOWEX (with winds ranging from 7 to 12 m/s) showed that the Stokes parameters (Q & U) increase with wind speed consistent with results obtained during the COPE Experiment in 1995. However, the variability observed at higher incidence angles increases the likelihood of errors in applications [C1278]

"Classification of polarimetric SAR images of suburban areas using joint annealed segmentation and "H/A/α" decomposition"

A joint segmentation-based classification technique is proposed for fully polarimetric SAR images of suburban areas. This is based on the joint use of the H/A/α_ decomposition and a multivariate annealed segmentation. This allows us to exploit the information available in the noisy estimate of the anisotropy parameter, retaining the highest possible spatial resolution. Specifically, the anisotropy is processed in conjunction with entropy and α_ angle, so that it is regularized by their more stable values. The application of the proposed technique to an AIRSAR image of suburban areas shows its practical effectiveness [C1279]

"Experimental Multi-Sensor GPR System for Humanitarian Demining"

The paper describes the design of a multi-sensor ultra wideband GPR front-end suitable for subsurface imaging with resolution sufficient for antipersonnel mine recognition. The front-end comprises two sensors: a multi-static video impulse radar and a bistatic stepped-frequency continuous wave radar. In comparison with commercially available video impulse GPR systems the key advantages of the video impulse system are considerably larger bandwidth, high precision of measurements of scattered field, ability to measure polarimetric structure of the scattered field and high pulse repetition rate resulting in fast data acquistion. The principal advantage of the stepped-frequency continuous wave sensor over its predecessors is very short data acquisition time, which is comparable with that of video impulse radars. [C1280]

"Technical aspects of a new S-band atmospheric profiler"

A Transportable Atmospheric RAdar, TARA, has been developed at the International Research Centre for Telecommunications-transmission and Radar, IRCTR. State of the art but commercially available technology has been integrated to build a sensitive, versatile research radar primarily intended for atmospheric research. The system is based on the FM-CW principle and is fully solid-state. This yields improved system lifetime in comparison to tube-based systems. The antennas are dual linearly polarized for polarimetric applications. Multiple beams at 15Г‚В° offset in two orthogonal directions in combination with the Doppler capabilities of the system are used for measuring three-dimensional wind fields. In this paper attention is paid to the technical realization of the system and some measurements are shown using the Doppler and multi-beam capabilities. [C1281]

"Atmospheric noise suppression for HF radar"

A new fast polarization filtering method is proposed. Some real time processing results show that it is suitable to suppress atmospheric noise or other stationary or non-stationary disturbances for HF ground wave radar [C1282]

"Radar target's reciprocity correction based on polarimetric measurement error model"

With the analysis of a polarimetric measurement error model, a novel radar target's reciprocity correction algorithm is presented based on a least degradation rule. After transforming the nonlinear optimal function of four variables with constraints to a nonlinear optimal function of two variables without constraints, the solution is given. Simulation results verify its feasibility and indicate its good performance [C1283]

"Scene understanding for settlements from metric resolution imagery"

Summary for only given, as follows. Satellite and airborne remote sensing has reached a new level of sophistication, but available interpretation methodologies cannot cope with the huge amounts of acquired data. At the same time, the new generations of metric resolution sensors, e.g: Ikonos, and the huge potential of synthetic aperture radar SAR have opened up the perspective on novel applications related to the understanding of high complexity settlement scenes. At meter resolution, mainly for man-made scenes, the complexity of the scene structures and of imaging phenomenology can be very high. This is reflected in the complexity of the observed images. New methods are needed for their interpretation, both for 2- and 3- dimensional analysis. The present article proposes methods of 2-dimensional information extraction from SAR and optical metric resolution observations. The presented methods are based on several assumptions: 1) the most compact encoding of the data is by the probabilistic model that describes it best, 2) a large number of sources of information coexist within the same observation data set, 3) the understanding of a scene requires complementary or multisensor observations. Thus, the concept developed aims at a description of the scene using data and information fusion. The primitive features, signal parameters, are extracted using model based methods such to obtain a quasi complete description of image content, i.e. radiometric/polarimetric attributes, structural information, geometric features, analysis at multiple scales. A hierarchic Bayesian modeling and learning paradigm is used for data and information fusion and for interactive exploration of the scene identity. The article presents the image formation phenomenology relevant for metric resolution observations, a concept for quasi-complete image content characterization, methods for supervised learning for scene classification by information. fusion, and examples using X-SAR, E-SAR (X band, and L band polarimetric) and Ikonos images [C1284]

"Polarimetric properties of boreal forest in L- and C-band SAR images"

In this study the usability of L- and C-band SAR polarimetry in boreal forest remote sensing is examined and discussed. The influence of snow cover, weather conditions, forest type and several other aspects to forest backscattering in L- and C-bands is investigated by using multitemporal polarimetric images [C1285]

"Radar remote sensing of mangroves: results and perspectives"

This paper gives an overview of our work conducted since 1993 and based on the analysis of AIRSAR data over a variety of mangrove forests. The effects of canopy structure on the polarimetric radar response of mangrove forests are analyzed from both an experimental and a theoretical point of view. Particularly, two mangrove stands of equal biomass but with great differences in their structural characteristics are also studied. Quantitative estimation of mangrove parameters is then discussed [C1286]

"Deriving forest characteristics using polarimetric InSAR measurements and models"

We report on a range of experiments designed to address previous shortcomings in microwave imaging of forests, by exploiting more sophisticated radar measurements and bringing physical models to bear. The experiments are based around a set of high-resolution airborne X- and L-band polarimetric interferometric radar acquisitions of Thetford forest, a managed plantation in the UK. The information content of the interferometric coherence, scattering phase centres and backscatter coefficients at different wavelengths and polarisations with respect to canopy structure is examined and compared with outputs from a coherent microwave scattering model to support interpretation of the data. The results suggest that improved resolution and interferometric information are important in retrieving biophysical parameters of interest to the forestry and carbon modelling communities [C1287]

"Wake detection in polarimetric SAR images"

Investigates wake signature in polarimetric imagery using the Radon transform. This paper describes two methods for the wake-shape detection: the first method reduces the dimension of the polarimetric data to a single channel image and the second method conserves the polarimetric information until the peak detection process. Results obtained from polarimetric C-band image data are presented [C1288]

"A joint classification technique based on multivariate annealing segmentation and "H/A/α_" decomposition for fully polarimetric SAR images of suburban areas"

A joint classification technique is proposed for fully polarimetric SAR images of suburban areas. The technique is based on the joint use of H/A/α_ decomposition and multivariate annealing segmentation. This allows one to exploit the information available in the noisy estimate of the anisotropy parameter, retaining the highest possible spatial resolution. This is obtained by jointly processing the anisotropy with entropy and α_ angle, so that it is regularized by their more stable values. The application of the proposed technique to a AIRSAR image of suburban areas shows its practical effectiveness [C1289]

"Polarimetric observations of wave breaking induced by ship wakes"

Describes two experiments conducted using the DSTO mobile high resolution radar facility to observe wave breaking events induced by ship wakes. In the first experiment high resolution polarimetric range profiles of the wake produced by a displacement hull vessel were recorded at X and Ku band frequencies. Periodic transient enhancements were observed, generated by wave breaking events precipitated by the superposition of the dominant wake components with the crests of the incoming swell. In order to identify the induced wave breaking events unambiguously, the measurements were carried out for ship headings directly into and directly opposed to the prevailing waves. Clear confirmation of the proposed mechanism was thus demonstrated. The second experiment employed a planing hull vessel. Because of the high speed of this ship, the measurement geometry was changed to set one of the diverging wake arms perpendicular to the radar beam. High resolution polarimetric range profiles were then recorded at X and Ku band frequencies [C1290]

"Polarimetric edge detector based on the complex Wishart distribution"

A new edge detector for polarimetric SAR data has been developed. The edge detector is based on a newly developed test statistic for equality of two complex covariance matrices following the complex Wishart distribution and an associated asymptotic probability for the test statistic. The new polarimetric edge detector provides a constant false alarm rate and it utilizes the full polarimetric information. The edge detector has been applied to polarimetric SAR data from the Danish dual-frequency, airborne polarimetric SAR, EMISAR. The results show clearly an improved edge detection performance for the full polarimetric detector compared to single channel approaches [C1291]

"Multi-baseline airborne Pol-InSAR measurements for the estimation of scattering processes within vegetation media"

Interferometric decomposition permits the identification of arbitrary scattering mechanisms in two interferometric SAR images and the optimisation of the interferometric coherence, using mathematically independent phase centres related to these scattering mechanisms. Polarimetric SAR interferometry (Pol-InSAR) is sensitive to the distribution of oriented objects in vegetation layers. It has been demonstrated that the calculated scattering mechanisms have different vertical loci that can be related to certain vegetation structures. Additionally, theoretical models allow for the reconstruction of the quasi-three-dimensional spatial distribution of such scattering mechanisms within multi-layer morphologies and the derivation of vegetation-related physical parameters. The paper presents an evaluation of a coherent Pol-InSAR scattering model using simulations based on the configuration of a real airborne experiment. This experiment provides multi-baseline L-band scattering matrices acquired by the DLR experimental SAR system (E-SAR) [C1292]

"Robust inversion of vegetation structure parameters from low-frequency, polarimetric interferometric SAR"

The Cloude model provides an approach to estimating vegetation structure parameters, such as bald Earth elevation, tree height, and canopy attenuation, using polarimetric interferometry techniques. We show that the model contains a degeneracy that allows the bald Earth elevation to be solved for reliably, but prevents accurate estimation of the other model parameters unless simplifying assumptions are made. We present results using UWB UHF data from the P-3 FOPEN sensor [C1293]

"Automated sea ice classification using spaceborne polarimetric SAR data"

This paper discusses the capability of spaceborne polarimetric C-band SAR data for sea ice detection and classification. Unsupervised classification using polarimetric decomposition and the complex Wishart classifier was performed on SIR-C data acquired off the coast of Newfoundland in April 1994. The algorithm is used for sea ice applications for the first time, and appears promising. In addition to polarimetric classification, three of the measured features were found to have ice edge detection capability: HV-intensity, HH/VV-ratio and anisotropy. These features show a clear separation between sea ice and open water and simple thresholds can be applied [C1294]

"Modelling returns from urban manufacts: simulation results for finite trihedrals"

Simulation results obtained by means of our polarimetric model for dielectric trihedral corner reflectors are presented in this paper. The model takes into account the dimensions of the reflecting surfaces, their dielectric properties and roughness, and evaluates contributions of coherent and diffuse scattering. The simulation has been carried out choosing values of input parameters able to describe an urban environment [C1295]

"Polarimetric detectors of extended targets for ship detection in SAR images"

This paper deals with polarimetric detection of ships in SAR images of medium/high resolution (about meters). The aim is to develop detection techniques able to exploit the polarimetric information in order to improve the detection capability of ships or generally man-made targets modelled as extended targets (i.e. occupying multiple pixels). Both a decentralized and a centralized approach are considered for the fusion of the polarimetric information and their performance are characterized [C1296]

"Polarimetric measurements of microwave emission from capillary waves"

The results of polarimetric microwave measurements of thermal emission from a water surface with artificial periodic structure are presented. The structure in a water tank was produced by a set of parallel threads raised a little over a surface. The measurements of the three Stokes parameters of the emission were carried out with the Ka-band polarimeter. The experimental setup allowed measurements over a wide range of elevation (from near-nadir to 70 degrees) and azimuth (over 300 degrees) angles. The experimental data show the existence of the resonant peak in the Stokes parameters predicted by the model. This result is evidence of the important ro€le the short gravity-capillary waves play in the sea-surface polarized microwave emission [C1297]

"Acquisition of sensing data on a reconfigurable platform"

Recent developments in wireless networking and re-configurable computing are making real-time processing of remotely sensed data and real-time information dissemination feasible. In this paper we describe the development of a single card reconfigurable hardware system that allows for both real-time acquisition and processing of radar polarimetric data. The proposed approach was developed after examining the architecture and implementation of several current data acquisition systems. Upon project completion it will be possible to support the acquisition, processing, bulk hard-disk data storage and Ethernet transfer of radar polarimetric data. This work will be particularly useful in supporting real-time operation due to speed improvements gained from reconfigurable devices [C1298]

"Remote Minefield Detection System (REMIDS): a UK programme for airborne minefield detection"

The UK Remote Minefield Detection System (REMIDS) Technology Demonstration Programme (TDP) is nearing the end of a five year programme that has developed emerging remote sensing technologies into an integrated system to demonstrate a capability for the reliable detection of minefields and mined areas from an airborne platform. The multi-sensor system demonstrator is being managed by DERA on behalf of the UK MoD. A novel Ultra Wide Band Synthetic Aperture Radar (UWB SAR) and a full Stokes Vector Time-parallel Polarimetric IR camera (IRPC) have been developed and a commercial VIS-NIR hyperspectral sensor is being considered for inclusion in the final system trials. While the UWB SAR is the lead sensor, with a capability for foliage penetration and target identification, confirmation and additional target discrimination is provided by polarimetric IR imaging to give a 24 hr capability. A ground station processor, based on COTS systems, has been developed to fuse all sensor outputs in a decision level process through a variety of target detection and identification algorithms. Probabilistic analysis is used on the resulting outputs to define the extent of a minefield to the system operator. In this paper we report on the development of the REMIDS programme by DERA from inception through to sensor trials, providing an overview of the sensor technologies developed and a discussion of the preliminary results [C1299]

"Model-based estimation of forest canopy parameters using polarimetric and interferometric SAR"

Synthetic aperture radar (SAR), interferometric SAR (INSAR),and polarimetric INSAR (POLINSAR) have been shown to be sensitive to various biophysical forest canopy parameters. The two general classes of models employed in parameter extraction are random-media and structure-based. Since the quality of canopy parameter retrieval depends on the attributes of the forward-scattering models that are inverted, we review the general characteristics of each type of model. The random-media models invoke simplifying assumptions, such as independent scattering statistics, to yield analytical expressions. Some of the central assumptions, however, do-not hold as resolution increases. Structure-based models can be used in these high-resolution scenarios. We are developing a new structure-based wideband SAR/INSAR/POLINSAR model to explore the effects of

increasing resolution on POLINSAR observables. A simple example of a structure-based SAR simulator is presented [C1300]

"Support vector machine classification of land cover: application to polarimetric SAR data"

Support vector machines (SVMs) have much attention as a promising approach to pattern recognition. They are able to handle linearly nonseparable problems by combining the maximal margin strategy with the kernel method. This paper addresses a novel SVM-based classification scheme of land cover from polarimetric synthetic aperture radar (SAR) data. The SVMs are successfully applied to the feature vectors which consist of several polarimetric features or the texture measure, and perform efficient image classification. Some important properties of SVMs, for example the relation between the number of support vectors and classification accuracy, are also discussed [C1301]

"Millimeter-wave radar detection of partially obscured targets"

We demonstrate the ability of millimeter-wave (MMW) radars in detecting partially obscured targets. In addition, we introduce two techniques; the first is a data acquisition and processing technique aimed at resolving the obscured target from foliage. The second technique is a post-processing technique that can enhance target detection by reducing the polarimetric distortions incurred by the foliage on the target signature. The techniques are particularly advantageous to MMW radar mounted on land vehicles. The analysis is performed on radar data measured indoors of partially obscured canonical point targets [C1302]

"Electro-optical systems for image recognition"

Detection and classification of targets by means of electro-optical sensors has been of interest for both defense and civilian applications for a number of years. In this presentation we emphasize two areas: extraction of more information from the sensors by polarimetric and frequency diversity, and reducing the processing and storage requirements by exploiting invariant attributes for detection and classification [C1303]

"Effect of the ionosphere on P-band spaceborne SAR images"

Radar backscatter measurements have proven to be positively correlated with above ground biomass and this correlation increases with the wavelength. Biomass retrieval algorithms have been developed for airborne P-band data collected over both boreal and tropical forests. Radar measurements are insensitive to cloud cover and can be operated during day and night. Hence a space-borne radar system, operating at low frequency, will permit the measurement, mapping, and understanding of these parameters with a spatial and temporal resolution suitable for modeling ecosystem processes at regional, continental, and global scales. Based on experience with airborne campaigns, a polarimetric low frequency or P-band SAR has been shown to be the most appropriate instrument to this purpose. One of the disadvantages of the P-band is that in this frequency band ionospheric distortion off the images is expected to be high. A quantitative estimation of the ionospheric influences on P-band imagery needs to be derived, which can lead to orbit parameters, which minimizes the impact of the ionosphere on biomass measurements [C1304]

"Development of polarization selective corner reflectors and its experiment for calibration of airborne polarimetric synthetic aperture radar"

As a part of polarimetric calibration efforts of CRL/NASDA airborne synthetic aperture radar system (Pi-SAR), we have developed corner reflectors to reflect a specific polarization channel. They include a 45° rotated dihedral, a 22.5° rotated dihedral, and a dihedral made of thin wires placed in the direction of polarization to be reflected, horizontal (H) or vertical (V). The wire-aligned dihedral we proposed has a thin dielectric frame to hold the wires, requiring no base material. In October 2000 we made a polarimetric calibration experiment of the X-band synthetic aperture radar, a part of the Pi-SAR. Those polarization selective dihedrals, together with conventional trihedrals, were deployed in the experiment. Preliminary results of the image data analysis showed that they were of practical use for polarimetric calibration, while there were some errors in reflected power probably due to their structure and their misalignment. It also showed that the corner reflectors were useful to determine phase calibration coefficients that is phase imbalances between polarimetric channels in the radar hardware [C1305]

"A new method for a posteriori polarimetric SAR calibration"

Fully polarimetric SAR data analysis has found wide application for terrain classification, land-use, soil moisture and ground cover classification. Critical to all analyses and applications is accurate calibration of the relative amplitudes of and phases between the various polarimetric channels. Here we develop a "minimalist" approach to polarimetric calibration, wherein only the weakest of constraints, reciprocity, is initially imposed upon the data.

Additional parameters are self-consistently estimated from the data. In this manner channel imbalances and cross-talk are estimated without unduly biasing the resulting polarimetric information [C1306]

"Cross-calibration experiment of airborne L-band polarimetric SAR"

Cross-calibration experiment of airborne L-band SAR systems, the JPL's AIRSAR and the NASDA/CRL's PI-SAR, was conducted on the Tottori sand dune. This experiment forms a part of PacificRim-2 campaign from July to October in 2000. Both AIRSAR and PI-SAR acquired the data over the test site within two hours on October 4, 2000. The track altitudes of airplanes were about 8000 m. Four rectangle trihedral corner reflectors with 80 cm of leg-length were deployed in order to derive absolute calibration coefficients. We also deployed four dihedral corner reflectors with different rotation angles for polarimetric calibration purpose. This report describes the results of calibration experiment for JPL's AIRSAR and NASDA/CRL's PI-SAR conducted on Tottori sand dune. Since the AIRSAR data has not been available yet, this report concentrates on the calibration of our PI-SAR system. The distortion matrices for both transmitting and receiving system can be calculated by using the data containing one trihedral reflector and two dihedral reflectors with different rotation angles. Gain balance between HH and VV was not good in this time, because the PI-SAR had some hardware degradation. The absolute calibration coefficient for HH channel has the almost same value as the previous calibration experiment in 1999. However, we found that the VV channel had been degraded more than 3 dB. The improvements of gain balance and cross-talk between H and V channels were confirmed after the calibration using the extracted distortion matrices [C1307]

"Segmentation of polarimetric SAR images"

In this paper, we proposed a new polarimetric SAR segmentation scheme based on the effect of speckle filtering for initial segmentation. We also incorporate a technique to preserve the scattering mechanism for pixels in each class [C1308]

"Polarimetric SAR processing using the polar decomposition of the scattering matrix"

The concept of scattering is one of the mechanisms that polarimetry seeks to express through data. A multiplicative decomposition of the scattering matrix is proposed in order to try to separate different kind of scattering and the applicability to polarimetric SAR images is investigated [C1309]

"Quantitative intercomparison of polarimetric ground radar and TRMM PR observations"

The Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) is a spaceborne radar operating in a nearly circular orbit at 350 km altitude with 35 degrees inclination and period of about 91.5 minutes. Simultaneous comparisons of radar observations were made between the National Center for Atmospheric Research (NCAR) S-POL radar and TRMM PR during the TExas and FLorida UNderflights (TEFLUN-B) campaign that took place near Melbourne, FL in 1998, and the Large Biosphere-Atmosphere experiment in Amazonia (LBA) near Ji-Parana, Brazil in 1999. Though direct intercomparison between space and ground radar observations is, in principle, straight forward, differences in viewing aspects between space and Earth point observations, propagation frequencies, resolution volume size and time synchronization mismatch between instrument measurements can contribute, in a significant way, to intercomparison errors and should be taken into account. Vertical profile of polarimetric radar variables, namely, reflectivity (Zh), differential reflectivity (Zdr), specific differential phase (Kdp), cross-correlation coefficient (ρco) and linear depolarization ratio (LDR) are used to describe the precipitation characteristics through the TRMM PR beam. These observations are, in turn, used to determine the type of hydrometeor along the PR beam using a fuzzy-logic technique [C1310]

"Segmentation and labeling of polarimetric SAR data: can wavelets help?"

In this paper we report about a novel approach to segmentation and thematic labeling of SAR polarimetric data. A pre-processing phase based on a wavelet frame that works as a differential operator generates piece-wise smooth approximations of the covariance matrix power term images. This step matches the signal characteristics with the requirements of well proven and computationally robust clustering algorithms of the Bayesian MAP, hard or soft labeling, and contextual type. Segments defined in this first phase are then used to estimate polarimetric quantities such as the Cloude's and Pottier's target decomposition parameters. The advantage over methods that use local statistics in a moving window is that the variance of the estimators decreases with the segment size, good accuracy can be obtained without sacrificing spatial resolution, and errors due to the signal discontinuities are avoided. The passage is then made from pixel based clustering to segment wise thematic classification. To the purpose reference feature vectors based on ground truth are needed, and segments are reassigned to the thematic labels. The per-segment feature vectors, including averages of polarimetric, radiometric quantities, or texture measures, can also be exploited to derive biophysical parameters and qualify additionally the

classification categories. The proposed approach seems to be appealing because it can tackle under a unified framework resting on solid mathematical foundations-such as Bayesian inference and wavelet theory-different data sources (microwave and optical) and different thematic contexts [C1311]

"A study of existing bistatic calibration techniques"

A performance evaluation of several existing polarimetric calibration techniques for bistatic radar cross section (RCS) measurements was performed. Several calibration test objects, including cylinders, a dihedral, a trihedral, a sphere, and other non-canonical objects were measured at the European Microwave Signature Laboratory (EMSL), Joint Research Centre (JRC), Ispra, Italy. Three calibration types were designated, based on their capability to predict each coefficient of a 20-term error model of the antenna polarization distortion matrix (PDM). Bistatic RCS predictions were completed using a commercially available method of moments code to validate the measurements for alignment precision and noise/distortion levels [C1312]

"Full spatial and polarimetric characterization of a UHF antenna for ultrawide SAR"

This paper describes the analysis performed on a developmental ultra-high-frequency (UHF) antenna intended to support ultrawide synthetic aperture radar (SAR) on a Global Hawk platform. Both full-scale and j-scale test articles were fabricated. The patterns of the j-scale articles were measured over a full 4pi steradians. Full-scale articles were measured over reduced angular regions sufficient to validate scaling. All measurements were fully polarimetric [C1313]

"Filters for polarimetric calibration of UWB SAR imagery"

Polarimetric synthetic aperture radar (SAR) imagery is susceptible to degradation due to non-ideal responses in antennas and other hardware. Image corruption is especially serious in SAR operating over ultra-wide bandwidths (UWB) and imaging over wide angles, as the system response becomes a complicated function of angle and frequency. The usual approach to removing the system response from measured UWB SAR images involves operations in the two-dimensional spatial frequency domain of the imagery. We show that correction can also be performed by convolving the polarimetric images with two-dimensional polarimetric calibration filters (PCF). When compared to the frequency domain procedure, filtering offers improved calibration on extended-area targets, lower sidelobe noise, and computational savings. PCF can be synthesized from knowledge of the system response, or by an adaptive equalization technique that uses clutter returns to generate filters to correct for leakage, or crosstalk, between channels [C1314]

"Issues in the calibration of bistatic RCS measurements"

A performance evaluation of several existing polarimetric calibration techniques for bistatic radar cross section (RCS) measurements is in progress. Several calibration test objects, including: cylinders, a dihedral, a trihedral, a sphere, and other noncanonical objects were measured at the European Microwave Signature Laboratory (EMSL), Joint Research Center (JRC), Ispra, Italy. Each object was measured with and without a systematic alignment error to determine the effects on each of the calibration techniques considered. Three calibration types were designated, based on their capability to predict each coefficient of a 20-term error model of the antenna polarization distortion matrix (PDM). The bistatic RCS predictions were completed using a commercially available moment method code to validate the measurements for alignment precision and noise/distortion levels [C1315]

"On CFAR detection of oil slicks on the ocean surface by a multifrequency and/or multipolarization SAR"

This paper addresses detection of oil spills on the sea surface as viewed by multifrequency and/or multipolarimetric synthetic aperture radars. We propose a two-stage processor: the first stage is a conventional detector designed to operate in a Gaussian environment; its detections are fed to a second stage designed to discriminate between candidate oil spills and templates of dark areas due to different phenomena, based upon different multifrequency and/or polarimetric signatures. Remarkably, the second stage possesses the constant false alarm rate property with respect to all of the unknown statistics of slick-free returns [C1316]

"Moving target imaging in foliage using polarimetric multi-frequency antenna array SAR"

Because of the low signal-to-clutter ratio, it is a difficult problem to detect and image moving targets in foliage. A multi-frequency multi-aperture polarimetric SAR (MFMA POLSAR) system is proposed for imaging of moving targets in foliage. The MFMA POLSAR extends the multi-frequency antenna array SAR (MF-SAR) system to multiple polarizations. Full polarization is used in MFMA POLSAR to achieve an optimal polarization adaptive to the environment, such that the images obtained by different apertures are of the best coherence that is used to

obtain the highest accuracy of the phase estimation. It is also shown that the MFMA POLSAR can not only accurately locate both slow and the fast moving targets, but also reveal moving targets in foliage [C1317]

"Effects of various image enhancement techniques on FOPEN data"

An investigation of FOPEN target discrimination performance is summarized using UHF SAR data gathered at Grayling, MI by the USA Navy's P-3 SAR Sensor. The fully polarimetric data are processed using polarimetric whitening; superresolution processing is then applied to enhance the resolution of the whitened data. Several superresolution approaches are investigated and target discrimination performance achieved using superresolution processing is quantified. Discriminator ROC curves showing probability of detection versus probability of false alarm are used to compare performance; an eigenvector-based superresolution approach is shown to provide the best performance improvement [C1318]

"Target-to-clutter contrast enhancement using radar Doppler polarimetry"

The connection between Doppler and polarimetric characteristics of targets is studied. It is shown that the Doppler polarimetric formalism provides more complete radar object description. These conclusions are supported by the model of simple compound object as well as by the radar observations of ground clutter. It is also shown that the clutter suppression which is based on Doppler polarimetric object description gives better contrast enhancement than the polarimetric optimization techniques [C1319]

"Segmenting polarimetric SAR images using robust competitive clustering"

POLSAR (POLarimetric Synthetic Aperture Radar) images have great potential for land-use management, provided that the images can be efficiently segmented. This paper describes the application of the Robust Competitive Agglomeration (RCA) clustering algorithm to POLSAR images to segment the images. Examples are presented and future efforts are discussed [C1320]

"Model of drop canting in microwave remote sensing of rain"

Doppler-polarimetric remote sensing techniques are powerful tools in microwave remote sensing of atmosphere. Combination of polarization. diversity with Doppler measurements opens new possibilities for research microphysics and dynamic processes in clouds and precipitation. Series of new sophisticated models, which relate atmospheric processes with behavior of scatterers' should be developed for radar data interpretation. It is especially important for mm-band facilities because of their sensitivity to small particles. The calculations and measurements have shown that small particles contribute significantly to the scattered signal from. rain at wavelength of 8 mm and especially of 4 mm and less. That is why well-known Marshall-Palmer dropsize distribution for rain, which is usually used to estimate radar reflectivity in X-band, can lead to errors in mm-band because it exaggerates strongly the number of small particles. This simple example clearly shows that one must be very careful when applying known initial models for mm-band modeling, simulation or data interpretation. In this paper, describing rain drop size distribution N(D),we use a very flexible gamma-distribution [C1321]

"Fully-polarimetric ground penetrating radar application"

The ground penetrating radar (GPR) has broad applications in the fields of geology, civil engineering, archeology and military . It is usually used as a non-destructive inspection sensor for monitoring, inspecting and characterizing obscured objects by means of electromagnetic radiation, propagation and scattering. Unlike radars operated in the open air, the medium between the GPR and the target usually determines the performance instead of the target and the radar. The sensitivity of GPR applications is limited by clutter instead of noise or radar system. The increasing needs for better detection and discrimination capability have driven GPR users and researches to investigate the pattern and polarization characteristics of the GPR antenna designs. New GPR antenna designs were developed to provide improved sensitivity and stability. An example of fully-polarimetric GPR application that has not been seen previously is presented. Some important issues such as clutter sources, radiation patterns and propagation efficiency faced by the most GPR applications are also discussed [C1322]

"MIMO FIR equalizers and orders"

A necessary and sufficient condition is given for the existence of a polynomial left inverse for a polynomial (FIR) system. Additionally, random systems are defined, and a sufficient condition is given for almost sure existence of a polynomial inverse. The two results extend previous work in single-input, multiple-output systems to the case of multiple input systems and to functions of several variables. An algorithm to compute minimal order equalizers is also presented. Corollaries describe calibration of polarimetric, wide-band radar imagery [C1323]

"Dual frequency synthetic aperture radar (SAR) mission for monitoring Earth"

Advances in spaceborne Synthetic Aperture Radar (SAR) remote sensing technology make it possible to acquire global-scale data sets that provide unique information about the Earth's continually changing surface characteristics. Short duration missions such as the Spaceborne Imaging Radar-C (SIR-C) and the Shuttle Radar Topography Mission (SRTM) have established the vast potential of SAR for expanding our knowledge of Earth. A long-duration (⩾5 year) free-flying SAR mission is essential to routinely provide valuable information about the dynamic characteristics of our planet. The SAR mission concept, consists of a dual frequency, polarimetric, interferometric system that has broad scientific, environmental preservation, operational, and commercial utility. A feature that greatly reduces the potential for tasking conflicts is the instrument's ability to operate both frequencies independently and simultaneously. The implementation approach includes an innovative government-industry collaboration that has the potential to lead to the creation of new information industries, in a manner similar to the Internet, Global Positioning Satellite (GPS) and commercial space telecommunications [C1324]

"Utilizing off-the-shelf parts for the next generation of space exploration"

Common components were evaluated for use in an orbiting Ku-band polarimetric scatterometer that will enable measurements of near-surface wind speeds for over 90% of the ice-free oceans. Designed as a successor to Seawinds, the new design may require two matched RF chains to attain adequate performance. Off-the-shelf DBS (Direct Broadcast System) and telecom components have significant potential to reduce development and equipment costs. However, space flight systems have requirements that are qualitatively different from the commercial or consumer applications for which the majority of new RF products are developed. Furthermore, the 13.402 GHz center frequency for scatterometers is somewhat higher than the commercial 12 GHz DBS band. Consequently, Jet Propulsion Laboratory (JPL) tested and evaluated these parts, and at present, work reports on RF performance measurements of selected commercial Monolithic Microwave Integrated Circuit (MMIC) components are encouraging and appear suitable for space applications. For evaluation, two MMIC Low Noise Amplifiers (LNA) (Filtronic, LMA246 and TriQuint(R), TGA8399B) and one mixer (Remec, part MM84MS-14) were selected. Test fixtures were constructed for the MMIC parts, which were then carefully examined in several test setups. Both dual and single chain configurations were necessary to completely define each component, where noise figure and gain tests of the Ku-band amplifiers were completed. Of more importance to the polarimetric application, the stability of relative phase and gain tracking with respect to temperature was extensively characterized in a variety of candidate LNA/mixer configurations. While the initial RF evaluation looks promising, further evaluation of these parts (radiation tolerance, reliability, etc.) will be required for flight qualification. ""Upscreened" Commercial, off-the-shelf (COTS) parts, in space applications are especially encouraging when the possibility of capitalizing on their extensive development for high-volume consumer applications is considered. Other applications for MMIC parts in space could possibly open new doors in the future [C1325]

"Advanced design concepts for a SeaWinds scatterometer follow-on mission"

The SeaWinds wind scatterometer was first launched in June of 1999, and has contributed significantly to the study of global climate phenomena and to the fidelity of operational weather forecasting. A second SeaWinds instrument is planned to be launched aboard the Japanese ADEOS-II platform in late 2001, and operate until mid-decade. To extend the important Ku-Band scatterometer data base to the end of the decade and beyond, a follow-on system to the SeaWinds series of scatterometers is being developed. The goals for this system are to continue the core Ku-Band backscatter measurement, to further improve spacecraft accommodation constraints so as to be easily operated on a variety of platforms, and-where possible under existing cost constraints-improve wind retrieval performance. It is shown that a system, which meets these objectives, can be achieved by the addition of polarimetric measurement capability to the existing SeaWinds approach. Polarimetric scatterometry is demonstrated to improve wind measurement performance without impacting instrument complexity or cost, and has the long term potential to further ease spacecraft accommodation requirements [C1326]

"Ship-sea contrast optimization when using polarimetric SARs"

The polarization information was investigated in Touzi (2000) for ship detection using calibrated polarimetric Convair-580 SAR data that were collected within the incidence angle range of 45° to 70°. It was shown that at operational satellite SAR incidence angles (lower than 60°), there is a significant improvement of ship-sea contrast when the full polarimetric information is used instead of the information provided by the (scalar) one channel polarization (HH, VV, or HV). In this paper, the investigation is extended to lower incidence angles, and the robustness of the polarimetric discriminators used for ship enhancement, is assessed at various wind conditions (7, 14 and 20 knots). Polarization channel phase information is also investigated. It is shown that the information contained in the HH-VV channel phase difference, looks to be very promizing for ship enhancement,

mainly when a dual-polarized SAR is used [C1327]

"An overview of the PACRIM 2000 Airborne Synthetic Aperture Radar (AIRSAR) mission in the Pacific, Australia and Asian region"

PACRIM 2 is a NASA-Australia sponsored science program whose primary purpose is to advance the development and use of polarimetric and interferometric radar in Pacific Rim countries including island nations of the South Pacific, New Zealand, Australia, Papua New Guinea, Indonesia, Malaysia, Cambodia, Philippines, Taiwan, South Korea, Japan and the United States. The deployment of AIRSAR on board NASA's DC-8 research aircraft has provided an opportunity to investigators with diverse backgrounds to collect, analyze and apply state-of-the-art data for Earth science studies in preparation for datasets likely to become available in the near future from satellite and commercial airborne systems [C1328]

"The data processing and calibration of the AIRSAR PacRim II mission"

In this paper, we present the results of raw echo data analysis with data error recovery, data processing, and the calibration results of the Jet Propulsion Laboratory's airborne synthetic aperture radar (AIRSAR) for the Pacific Rim II mission. We also present the key elements of the calibration techniques for both polarimetric SAR (POLSAR) and cross-track interferometric SAR (TOPSAR) processed with the AIRSAR Integrated Processor [C1329]

"Comparison of forest parameter estimation techniques using SAR data"

It is important to monitor forests in order to understand the impacts of global climate changes on terrestrial ecosystems. To characterize forest changes, it is useful to parameterize a forest using several parameters, such as biomass, basal area, tree density, tree height, and trunk diameter. These parameters are not independent and some of them are related by allometric equations. Remote sensing data can be used for estimating some forest parameters and others may be retrieved using allometric equations. Many researchers reported algorithms to estimate forest parameters using polarimetric SAR data. However, these algorithms cannot be applied to all types of forests without additional information on the forest type and environmental conditions since radar measurements depend on the tree structure, incidence angle, and environmental conditions. The backscattering cross section also saturates as forest parameters, such as biomass and the tree height, increase. Forest parameters also have been estimated using SAR interferometry. Specifically, the interferometric correlation coefficient has been used to estimate the angular range of volume scattering. In this paper, we compare and contrast polarimetric and interferometric approaches to understand their advantages and limitations using NASA/JPL AIRSAR data [C1330]

"Bistatic scattering measurements using near-field scanning"

Accurate characterization of bistatic scattering responses of targets is of practical importance for a number of military and remote sensing applications. In this paper a novel approach for efficient and accurate bistatic scattering pattern measurement of point and distributed targets using a near-field system is demonstrated. This system is equipped with a relatively large XY-table (3 mЧ3 m) and makes use of an HP 8720D vector network analyzer as its transmitter, receiver, and signal processing units. The near-field probe of this system is dual polarized to facilitate polarimetric bistatic scattering measurements. Issues such as calibration procedure for removing systematic errors such as channel imbalances, probe cross-talk, and characterization of radiometric calibration constants are discussed. Finally the feasibility and the accuracy of the proposed method are demonstrated by measuring the bistatic scattering of point and distributed targets with known bistatic RCS and scattering coefficient and comparing the measured results with the theoretical one [C1331]

"Discrimination between low metal content mine and non-mine-targets using polarimetric ultra-wide-band radar"

In this paper we show that wide band radar polarimetry can be used for discrimination between surface laid AP mine and non-mine targets. To do this we employ two types of coherent radar decomposition theorem applied to wide band chamber measurement data from the European Microwave Scattering Laboratory (EMSL). Our main conclusion is that radar polarimetry should be further investigated as an important way to secure low false alarm rate from radar sensors in stand off mine detection [C1332]

"Multi-polarization C-band SAR signatures of arctic sea ice"

The Advanced Synthetic Aperture Radar (ASAR) is scheduled to be launched on the ENVISAT satellite in summer 2001. For Arctic-sea ice mapping using future ASAR data, we carry out a study of multiple polarization

C-band SAR signatures of various sea ice types. We present polarimetric SAR data acquired over sea ice acquired by the Jet Propulsion Laboratory polarimetric AIRSAR system on the NASA DC-8 aircraft over sea ice regions in the Beaufort Sea and the Bering Sea. We use a physical sea ice model to study polarimetric scattering signatures of sea ice. The results also provides useful information to the future RADARSAT-2 multi-polarization SAR for sea ice mapping [C1333]

"Development of multistage procedures for quantifying the biomass, structure and community composition of Australian woodlands using polarimetric radar and optical data"

Focusing on woodlands in Queensland, Australia, this paper outlines a multi-stage approach to quantifying and scaling-up field-based measurements of vegetation structure, biomass and community composition to the landscape. The approach utilises remotely sensed data from a range of instruments (including SAR, hyperspectral and lidar) operating at different spatial and spectral resolutions. The research is anticipated to benefit the calculation of greenhouse gas emissions, conservation of biodiversity, and sustainable utilisation of woodlands in Australia [C1334]

"Object based analysis of polarimetric SAR data in alpha-entropy-anisotropy decomposition using fuzzy classification by eCognition"

Polarimetric SAR data possess a high potential for classification of the Earth surface. Various publications demonstrate detailed analysis of soil and vegetation properties and characteristics of man made structures on selected examples. To ensure wider application of these developments, integration in commercial systems should be studied. In a first approach, the object based image analysis eCognition is employed on alpha, entropy and anisotropy and the span of fully polarimetric L-band SAR data of the German airborne sensor, E-SAR. We show that by using eCognition land cover classes can be conveniently assigned to the scattering classes and ambiguities can be resolved by geometric and context object features [C1335]

"Tree height estimation using an airborne L-band polarimetric interferometric SAR"

Interferometric phase difference among the SAR and trees, composed of trunks, branches, and canopies, provides an information related to trees heights and structures at a given polarization. Vertical polarization (like) is sensitive on the vertical structure and the horizontal pot. (like) for the horizontal one. Cross pol. is sensitive to the inclined branches (inclined cylinder depolarizes the incoming signal). Thus, combination of the polarization based phase measurement might give tree height distribution and the structures when a scattering model that simulates electromagnetic signal interaction with the trees is used. Interferometric sensitivity to the height decreases with slant range and signal to noise ratio and increases with the baseline and the spaceborne sensor has some difficulty. Thus, we used the NASDA-CRL's airborne L-band Polarimetric Interferometric Synthetic Aperture Radar (PISAR), and its acquired polarimetric SAR interferometry datasets. Test site was the Tottori Dune and its surrounding area, where pine trees were planted and the characteristics were well known. Coherence and the phase differences obtained by the interferometric analysis were evaluated. As a result, we could estimate the tree height distribution if the polarimetric SAR images (co-pol and cross-pot) are acquired with larger baselines and smaller slant ranges. Quantitative evaluation is required to relate the phase center differences and the tree types and the polarization combinations [C1336]

"Polarimetric radar remote sensing of ocean surface wind"

Experimental data are presented to support the development of a new concept for ocean wind velocity measurement (speed and direction) with the polarimetric microwave radar technology. This new concept has strong potential for improving the wind velocity measurement accuracy and for extending the useful swath width by up to 35 percent for follow-on spaceborne scatterometers to NASA SeaWinds missions. The key issue is whether there is a relationship between the polarization state of ocean backscatter and ocean wind velocity at NASA scatterometer frequencies (13 GHz). A set of aircraft flights indicated clear and repeatable wind direction signals in polarimetric Ku-band scatterometer observations of sea surfaces at 10 m/s wind speed [C1337]

"Applying polarimetric interferometric methods to invert vegetation parameters from SAR-data"

In this paper the use of polarimetric interferometric SAR data for extracting vegetation parameters is studied. For this purpose an inversion algorithm is performed with indoor polarimetric interferometric SAR measurements by applying a simplified scattering model. The performance of the inversion algorithm is investigated by varying the carrier frequency of the PolInSAR system used to acquire the measurement data and by varying the polarimetric base. The results are presented and analyzed concerning the feasibility of the extracted parameters. Additionally sensitivity analysis of the algorithm are undertaken to investigate the stability of the output parameters with

respect to initial conditions and inversion progression [C1338]

"PACRIM-II AIRSAR/MASTER experiment in Korean (an overview)"

The advantages of the synthetic aperture radar (SAR) have been well known among remote sensing data users since the launching of SEASAT in 1978. However, one of the major limiting factors has been the limited spectral resolution with only a single frequency and single polarization data, even from the most sophisticated space-borne SAR systems today. The AIRSAR system, developed by NASA (JPL) in the late 1980s and became fully operation in 1990, has been a unique and valuable tool for the investigators interested in multiple frequency fully polarimetric SAR experiments. The PACRIM-I experiment in selected Pacific Rim countries in 1996 was a great success and the current PACRIM-II is the successor of PACRIM-I. In view of the new space-borne SAR systems: ENVISAT (ESA) ALOS (Japan) and RADARSAT-II (Canadian Space Agency) planned for launching in the 2002 and 2003 time frames, are all polarimetric SAR systems, and it is not only timely but also essential for any remote sensing community to develop polarimetric SAR application capabilities. The Korean participants in PACRIM-II include both the AIRSAR research teams and MASTER hyperspectral research team. The main objectives of the Korean participation in PACRIM-II include establishment of scientific and engineering knowledge base for the polarimetric SAR technology, training of qualified graduate students, and developments of new polarimetric SAR applications. Science and engineering disciplines participating in the Korean PACRIM-II experiment included agriculture, archeology, land use, forestry, geography, geology, geohydrology, coastal science, oceanography, environmental applications, natural disaster monitoring and disaster management [C1339]

"Biophysical forest type characterisation in the Colombian Amazon by airborne polarimetric SAR"

Fully polarimetric C-, L- and P- band data were collected by NASA's AirSAR system at the Araracuara test site, a well-surveyed forest reserve in the centre of the Colombian Amazon. The area is characterised by a high diversity of forest types, soil types and flooding conditions. A polarimetric classification technique is used to assess AirSAR's potential for forest structural type mapping and, indirectly, forest biophysical characterisation. Field observations were made at 23 0.1 ha plots to obtain additional quantitative descriptions on forest structure and ground surface conditions, but also to assess the suitability of existing map legends for SAR mapping. It could be shown that a new type of legend leads to physically better interpretable results. A method based on iterated conditional modes is introduced and is shown to yield radar-derived maps with a high level of agreement with existing maps, as well as with the ground observations. The following results may indicate the high level of accuracy obtained: 15 classes can be differentiated, the average radar map agreement ranges from 68-94% (depending on the type of map and approach) and for only a few classes the agreement is less than 70%. The relation between physical forest structure and polarimetric signal properties is studied explicitly using polarimetric decomposition. A new method is introduced based on the decomposition of polarimetric coherence, instead of power. It is based on simple physical descriptions of the wave-object interaction. The accuracy of the complex coherence estimation derived from the complex Wishart distribution. Thus several interesting physical relations between polarimetric signal and forest structure can be revealed. The physical limitations of this technique and its relation with sample size are indicated [C1340]

"The fusion of polarimetric AirSAR data with digital aerial photography to improve aquatic macrophtye classification in a tropical reservoir"

Previous attempts to map wetland environments in northern Australia using optical satellite sensors have highlighted the difficulties in mapping the vegetation in these systems using remotely sensed data. Recently, more promising results have been achieved through the use of polarimetric AirSAR obtained during the 1996 PACRIM campaign. The mapping has been conducted on a tropical floodplain containing a reservoir, Fogg Dam, that is characterised by a permanent water supply. A maximum likelihood supervised classification was implemented on four data sets: CIR photography; a Cloude decomposed 9 band AirSAR image; the optimum 3 band combination Cloude decomposed image; and the fused data. The macrophtye classification was improved when utilising AirSAR data, with the 3 band decomposed image yielding the most accurate results [C1341]

"Polarimetric SAR interferometry for forest canopy analysis by using the super-resolution method"

In this paper, we propose an polarimetric SAR interferometry technique for interferometric phase extraction of each local scatterer of the forest region. The proposed method formulated for local scattering center extraction is based on the ESPRIT algorithm which is known for high-resolution capability of closely located incidences. The method shows high-resolution performance when local scattered waves are uncorrelated and have different polarization characteristics. Using the method, the number of dominant local scattered waves and their interferometric phases in each image patch can be estimated directly. Validity of the algorithm is demonstrated

by using examples derived from SIR-C data [C1342]

"Inventory of forest biomass in Brazilian Amazon: a local approach using airborne P-band SAR data"

The objective of this study is to explore the use of airborne P-band SAR polarimetric data, to stratify biomass by primary and secondary vegetation typology. To ensure that different landscapes of Amazon upland forest are represented, a test-site located in the lower Rio Tapajos region, Pari State, was selected. The backscatter signals derived from the complex image of the P-band SAR were correlated with field data obtained from a forest inventory, for different physiognomic-structural aspects of the tropical rainforest The estimation of above-ground biomass for these forest types was modeled by DBH and total height measurements, including the use of general allometric equations. Statistical regression models were applied to establish the relationship between biomass and radar data at HH, HV and VV polarization. The overall objective of this P-band experiment is to improve the regional monitoring process of biomass dynamics as well as landscape changes, due to human action [C1343]

"Identification of the tropical forest in Brazilian Amazon based on the DEM difference from P and X bands interferometric data"

In this paper the difference between digital elevation models, derived from P and X bands interferometric data, is used as a main information to identify land cover classes. The radar data used in this work were collected on September of 2000 over Tapajos National Forest, which is a region of Brazilian Amazon, Para State. The SAR images were acquired from an airborne polarimetric system, AeS-1, that could provide P and X bands interferometric data. During the radar mission ground survey was carried out, and the georeferenced information about the forest typology were acquired, and used as a support for the thematic identification and calibration of the remoted sensing data. The X-band DEM was generated using one-pass interferometric data and the P-band DEM was generated using two-pass interferometric data. The grid of the DEMs has a spatial resolution of 2.5 meters. Images from P and X bands and coherence maps were also used in order to improve the classification. Supervised and unsupervised classifications techniques are used and their results are shown [C1344]

"A new method for characterizing depolarization effects in radar and optical remote sensing"

In this paper we consider a new approach to the parameterization of depolarization effects in electromagnetic scattering. We define a unitary reduction operator, which is used to generate an N-1 dimensional representation of depolarization in an N dimensional scattering problem. We illustrate the application of this technique to polarimetric radar backscatter from random media with various symmetries [C1345]

"Forest biometrics from ERS and JERS in Michigan"

Operational forest information gathering in the US is moving fast toward the increased use of remote sensing data for a broad variety of applications in the private and public forestry sector. To achieve the best information extraction from remotely sensed data the focus needs to be on combining the strength of active and passive sensor systems. While optical data have demonstrated strength, e.g., in forest species distinction and forest health monitoring questions, the structural composition of forests can be better detected with radar data. The excellent correlation of the radar signals with forest biophysical parameters has been demonstrated through multi-frequency and multi-polarimetric AIRSAR and SIR-C/X-SAR data and lead to significant knowledge about the specifications for the design of future SAR missions for natural resources mapping and monitoring. To test the capabilities of current SAR missions which provide global. coverage, i.e. ERS, JERS and Radarsat, we conducted an intensive study with multi-seasonal ERS and JERS data in the Raco test site in the Upper Peninsula of Michigan. The Raco test site was a SIR-C ecological supersite and intensive ground campaigns were conducted over the course of five years where more than 80 stands were repeatedly sampled. with fixed plots leading to an unprecedented set of ground truth data for research with the SIR-C data. This paper discusses the results of studies on forest parameter retrieval (basal area, height, stem density, biomass) with ERS-1 Cvvand JERS-1 Lhhdata for upland pines (jack pine, red pine, white pine). Statistical models (log-log) were generated to measure the correlation between the various forest biophysical parameters and the radar backscatter [C1346]

"Applications potential of planned C-band SAR satellites: leading to RADARSAT-2"

To date, satellite SAR data for civilian purposes, have been routinely available from single channel, i.e., single frequency and single polarization, radar systems. In the near future, we expect satellite SAR systems with enhanced capabilities in terms of polarization, frequency, spatial resolution, spatial coverage and temporal

resolution. In this paper, we discuss the increase in applications potential resulting from the progress in SAR technology, in particular in C-band systems. The application fields discussed include agriculture, forestry, geology, hydrology, oceans, and sea ice. Most applications are anticipated to benefit from the upcoming availability of cross-polarized C-band data. Likewise the introduction of fully polarimetric C-band satellite SAR systems is expected to improve the overall application potential [C1347]

"RADARSAT-2 calibration: proposed targets and techniques"

RADARSAT-2 is an advanced synthetic aperture radar satellite scheduled for launch in 2003. The satellite will be equipped with an active phased array antenna which will be used to provide a wide variety of beams and modes, including all the beams and modes of RADARSAT-1 and additional Ultra-fine resolution, dual and quad-polarimetric modes. The large number and variety of modes presents a major calibration challenge and, because the satellite is intended for operational use, efficient means for achieving and maintaining this calibration are essential. This paper identifies the three principal types of target which are planned for use in achieving radiometric, polarimetric, geo-location, and other types of calibration for RADARSAT-2, and describes how the data will be analyzed to generate the required calibration information [C1348]

"Initiating the ALOS Kyoto & Carbon Initiative"

The ALOS Kyoto & Carbon Initiative is an international endeavour initialized by NASDA, with the main objective to support information needs raised by the UNFCCC Kyoto Protocol and by the international global carbon cycle science community, by provision of systematic, consistent, repetitive and regional scale data of the global forest cover. Of central importance for the Initiative is a Dedicated Data Acquisition Strategy for the polarimetric Phased Array L-band Synthetic Aperture Radar (PALSAR) sensor onboard the Advanced Land Observation Satellite (ALOS) satellite, which, as a major project output, is foreseen to result in an extensive data archive with consistent time series of dual-polarization (HH/HV) PALSAR data over any given land area on the Earth. Tentative plans for derived data products include regional scale image mosaics, maps of annual forest change, wetland flood distribution/duration, and rice cultivation [C1349]

"Recent advances in extra-wide-band multi-modal POL-IN-SAR imaging"

Radar polarimetry, radar interferometry and polarimetric SAR interferometry present the current culmination in 'microwave remote sensing' technology, but we still need to progress very considerably in order to reach the limits of physical realizability. Whereas with radar polarimetry the textural fine-structure, target orientation, symmetries and material constituents can be recovered with considerable improvement above that of standard 'amplitude-only' radar; with radar interferometry the spatial (in depth) structure can be explored. With polarimetric interferometric synthetic aperture radar (POL-IN-SAR) imaging, it is possible to recover such co-registered textural and spatial information from POL-IN-SAR digital image data sets simultaneously, including the extraction of digital elevation maps (DEM) from either repeated-pass polarimetric (scattering matrix) or interferometric (dual antenna) SAR systems. Simultaneous polarimetric-plus-interferometric SAR imaging offers the additional benefit of obtaining co-registered textural-plus-spatial three-dimensional POL-IN-DEM information, which when applied to repeat-pass image-overlay interferometry provides differential background validation and environmental stress-change information with highly improved accuracies. Then, by either designing multiple dual polarization antenna POL-IN-SAR systems or by applying advanced POL-IN-SAR image compression techniques, will result in 'POL-arimetric TOMO-graphic' (multi-interferometric) SAR or POL-TOMO-SAR imaging. By advancing these EWB-D-POLIN/TOMO-SAR imaging modes, we are slowly but steadily approaching the ultimate goal of eventually realizing air-bome and space-borne 'geo-environmental background validation, stress assessment, and stress-change monitoring of the terrestrial and planetary covers' [C1350]

"Forest height mapping using space-borne polarimetric SAR interferometry"

In this paper we generate a statistical significance test for a 2-level coherent mixture model of interferometric radar scattering from forested terrain. We test the model against SIR-C L-band data and show that the assumption of a random volume scattering model for vegetation is fully justified for L-band remote sensing of forested areas. This has important implications for the design of future spaceborne radar sensors aimed at forest mapping applications [C1351]

"Polarimetric and interferometric SAR calibration verification methods"

It is necessary to calibrate SAR data in order to use the data for science applications. When both polarimetric and interferometric data are collected simultaneously, these SAR data can be used for cross-calibration and verification. The frequency of polarimetric and interferometric data does not have to be the same for this purpose. For example, the NASA/JPL AIRSAR system can acquire C-band interferometric data and L-band

polarimetric data simultaneously. The radiometric calibration of polarimetric data can be improved using the local slope information obtained from SAR interferometry. The accuracy of geophysical parameter estimation may be enhanced using true incidence angles derived from SAR interferometry. The calibration of interferometric SAR data can be verified by examining interferometric correlation coefficients. Both azimuth and range slopes estimated from an interferometric SAR DEM can be used to examine the polarization calibration accuracy. In this paper, we show several examples of cross-calibration verification between polarimetric and interferometric SAR data [C1352]

"Optimal polarimetric decomposition variables-non-linear dimensionality reduction"

Polarimetric SAR image analysis often depends upon proper identification of the relevant degrees of freedom for the problem at hand. Employing physical models of particular scattering processes simplifies identification of the appropriate polarimetric variables. Determining how well variables chosen on the basis of a particular model describe the region of applicability of that model is difficult. Here we attempt in a model independent manner to identify "optimal" variables to both segment an image and highlight the variation within each segment. The method presently employed is non-linear dimensionality reduction [C1353]

"Interpreting off-diagonal terms in polarimetric coherency matrix"

This paper addresses interpretation of off-diagonal terms in the coherency matrix of polarimetric SAR data. The off-diagonal terms, especially the correlations between copolarization and cross-polarization are frequently ignored in many studies. We will show that this misconception will introduce errors, especially when imaging rugged terrain areas [C1354]

"Remote sensing of surface roughness using polarimetric SAR data"

The circular polarization coherence, ρRRLL, is investigated in this paper as a measure of terrain surface roughness. The studies utilized data collected 1) from dielectric surfaces in an anechoic chamber and, 2) from a larger desert test site using P-, L-, and C-band NASA/JPL AIRSAR data. These experimental results, and supporting theory, indicate a sensitive decorrelation of |ρRRLL | with increasing surface roughness ks. Practical measurement issues and a performance comparison relative to the polarimetric anisotropy A are discussed [C1355]

"A numerical simulation of estimating snow wetness with ASAR"

In hydrological investigations, modeling and forecasting of snow melt runoff requires timely information about snow properties and their spatial variability. The liquid water content in snow pack is an important parameter. A fully polarimetric C-band synthetic aperture radar (SAR) has the capability to estimate the free liquid water content-snow wetness-in the top layer of a snow pack quantitatively as demonstrated in Shi and Dozier 1995). The objective of this study is to develop an algorithm under the configuration of ASAR's C-band dual-copolarization measurements, e.g., HH and VV polarization. We have established a model-simulated C-band data-base by using multi-scattering model. The data-base covers the most possible wet snow physical properties and surface roughness conditions. Using this data-base, an inversion algorithm has been developed for using C-band dual-copolarization measurements. The newly developed algorithm mainly involved two steps: 1) decomposition of the surface and volume scattering signals, and 2) then using each scattering component to estimate snow wetness [C1356]

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