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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 27-1

“Polarimetric Radar Contrast”
(«Поляриметрический РЛ контраст»)

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"Contrast-Optimization-Based Range-Profile Autofocus for Polarimetric Stepped-Frequency Radar"

One of the main benefits brought by the use of fully polarimetric radars is the ability to identify scattering mechanisms, which are related to the 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 smearing. The distortions induced by the target motion produce, as a consequence, a signal-to-noise ratio loss. Recently, a method based on contrast maximization has been proposed in order to compensate target radial motions using single-polarization data. In this paper, an extension of such an algorithm is proposed that exploits fully polarimetric data in order to improve the target radial motion compensation. [J1]

"A Comparison of the Impact of QuikScat and WindSat Wind Vector Products on Met Office Analyses and Forecasts"

Several studies have demonstrated that retrievals of wind vectors from the WindSat polarimetric radiometer are of sufficient quality to be considered for assimilation in operational numerical weather prediction models. In this paper, WindSat data are used in a state-of-the-art global meteorological analysis and forecasting system. Each wind vector contains a directional ambiguity and so is assimilated in a similar way to that of scatterometer data. The forecast impact of using analyses containing information from WindSat data was investigated for a period during August and September of 2005, when a large number of tropical cyclones were present. Forecast errors were reduced in the surface pressure fields, and the average improvement across the forecast range was found to be 1.0%. This is comparable to the improvement of 1.1% found in the same fields when winds were assimilated from the QuikScat scatterometer. The impact on tropical cyclone tracks in the forecasts was also studied. The scatterometer improved (reduced) the track errors markedly by 25% in the analyses. When impacts across the forecast range out to five days were also included, the improvement was found to be 8%. In contrast, the assimilation of WindSat data improved the analysis track errors by 7%, although this figure was found to be 10% across the complete forecast range. [J2]

"Surface-Based Polarimetric C-Band Microwave Scatterometer Measurements of Snow During a Chinook Event"

This paper presents a case study of C-band backscatter observations of snow during a Chinook event. A surface-based C-band polarimetric data set collected in February 2006 is used to contrast the polarimetric response to sampled conditions of bare frozen ground, cold snow-covered ground, and snow during a Chinook event. Chinook activity is inherently spatially and temporally variable across the region in winter and produces considerable spatial variability of snow-cover physical properties associated with snow-water-equivalent (SWE) estimates. A temporal analysis of polarimetric backscatter sensed during a Chinook-induced ablation event on February 27, 2006 is used to describe the associated changes in snow conditions and scattering mechanisms. Analysis reveals that the polarimetric surface-based C-band scatterometer data respond to changes in snow parameters associated with the specific ground and snow conditions and to the temporal Chinook ablation event. Use of the copolarizations, cross-polarization, depolarization ratio, copolarization ratio, complex copolarization correlation coefficient, and the copolarized phase difference information show promise in describing changes in snow physical parameters, differing ground and snow conditions, and transitional ablation events, based on differing scattering mechanisms. This paper infers that an increase in volume scattering and fluctuations in surface scattering during the Chinook ablation event may be associated with specific physical changes such as density, crystal structure, and permittivity caused by wind speed. This paper has implications for remotely sensed estimations of snow-covered area (SCA) and SWE. Association of SCA and SWE with backscatter coefficients is not explicit in this paper; however, changes in SWE and snow properties are inferentially linked to changes in backscatter. [J3]

"Scale-Dependent Surface Roughness Behavior and Its Impact on Empirical Models for Radar Backscatter"

One goal of radar remote sensing is the extraction of terrain statistics and surface dielectric properties from backscatter data for some range of wavelengths, incidence angles, and polarizations. This paper addresses empirical approaches used to estimate terrain properties from radar data over a wider range of roughness than permitted by analytical models. Many empirical models assume, at least implicitly, that roughness parameters like rms height or correlation length are independent of the horizontal length scale over which they are measured, in contrast to recent surveys of natural terrain, which show that self-affine, or power-law scaling, between horizontal scale and roughness statistics is very common. The rms slope at the horizontal scale of the illuminating wavelength s(lambda) is directly related to the variogram or structure function of a self-affine surface, can be readily obtained from field-measured topography, and, when used in an empirical model, avoids the need for arbitrary wavelength-dependent terms. To facilitate comparison with earlier approaches, an expression that links the rms height at some profile length with the rms (Allan) deviation at an equivalent horizontal sampling interval is obtained from numerical simulations. An empirical model for polarimetric scattering as a function of s(lambda) at 35deg-60deg incidence from smooth to rugged lava surfaces is derived and compared with earlier models for backscatter from modestly rough soil surfaces. The asymptotic behavior of polarization ratios for the lava flows suggests that the depolarization of linear-polarized illuminating signals occurs as a first-order process, likely through single scattering by rock edges or other discontinuities, rather than as the solely multiple-scattering effect predicted by some analytical models. Efforts to fully understand radar scattering from geological surfaces need to incorporate wavelength-scale roughness, perhaps through computational simulat--ions. [J4]

"A Characterization of Shannon Entropy and Bhattacharyya Measure of Contrast in Polarimetric and Interferometric SAR Image"

We analyze the application of Shannon entropy and Bhattacharyya distance for the characterization of polarimetric interferometric synthetic aperture radar (PolInSAR) images. We discuss the relevance of the decomposition of the Shannon entropy of a homogeneous region into the sum of three physically meaningful terms that depend respectively on intensity, polarimetry, and interferometry. We also discuss an analogous decomposition property for the Bhattacharyya distance, which is an efficient measure of the contrast between two regions. We illustrate the application of this approach for analyzing different contributions in the information content of PolInSAR images. [J5]

"Polarimetric ISAR autofocusing"

Interest in polarimetric inverse synthetic aperture radar (ISAR) systems has been growing because of their capability to provide extra information about the imaged target compared with single polarisation ISAR systems. Target classification and recognition can be improved by exploiting full polarisation ISAR images. Moreover, full polarisation can be exploited for improving image formation and in particular image autofocusing. Two novel image autofocusing techniques are defined by extending two well-known single polarisation autofocusing techniques, namely the image contrast-based autofocus and image entropy-based autofocus. A performance analysis is carried out by comparing the results obtained by using the extended and the original autofocusing techniques. [J6]

"Measurement and Characterization of Entropy and Degree of Polarization of Weather Radar Targets"

To date, few polarimetric weather radars have exhibited the capability to measure full scattering matrices. In contrast, in the synthetic aperture radar (SAR) community, considerable experience has been gained in dealing with complete scattering matrices and their statistical behavior. This paper aims to place weather radar parameters in a wider context in order to exploit more general concepts like target decomposition theorems and polarization basis transformations. Entropy, which is a fully polarimetric variable derived from the Cloude-Pottier decomposition, and the degree of polarization, which is derived from Wolf's coherence matrix, are the subject of this paper. The theoretical analysis carried out in the first part is checked against fully polarimetric data from POLDIRAD, which is the german aerospace center research weather radar. The entropy and the degree of polarization are compared with the copolar correlation coefficient in order to understand whether they can add value to radar meteorological investigations. Because the degree of polarization is available to conventional dual-polarization coherent systems, it is important to assess its potential for operational use. [J7]

"Information Theory-Based Approach for Contrast Analysis in Polarimetric and/or Interferometric SAR Images"

We propose a new approach for evaluating the contribution of the different channels of polarimetric and

interferometric synthetic aperture radar (PolInSAR) images. For that purpose, we demonstrate that the Bhattacharyya distance between the probability density functions of neighboring regions in the image provides an efficient scalar contrast measure. We show that the analysis of this contrast measure allows one to precisely characterize the contribution of each channel for different system configurations, including intensity, polarimetric, and interferometric images. We illustrate this approach using a real synthetic aperture radar image to compare several polarimetric system architectures. Since PolInSAR imaging configurations can correspond to complex and expensive systems, the proposed method can be helpful in system imaging optimization. [J8]

"Frequency Subband Processing and Feature Analysis of Forward-Looking Ground-Penetrating Radar Signals for Land-Mine Detection"

There has been significant amount of study on the use of ground-penetrating radar (GPR) for land-mine detection. This paper presents our analysis of GPR data collected at a U.S. Army test site using a new approach based on frequency subband processing. In this approach, from the radar data that have over 2.5 GHz of bandwidth, we compute separate radar images using the one wide (2 GHz) and four narrow (0.6 GHz) frequency subbands. The results indicate that signals for different frequency subbands are significantly different and give very different performance in land-mine detection. In addition, we also examine a number of features extracted from the GPR data, including magnitude and local-contrast features, ratio between copolarization and cross-polarization signals, and features obtained using polarimetric decomposition. Feature selection procedures are employed to find subsets of features that improve detection performance when combined. Results of land-mine detection, including performance on blind test lanes, are presented [J9]

"Spatial Variability of Barrow-Area Shore-Fast Sea Ice and Its Relationships to Passive Microwave Emissivity"

Aircraft-acquired passive microwave data, laser radar height observations, RADARSAT synthetic aperture radar imagery, and in situ measurements obtained during the AMSR-Ice03 experiment are used to investigate relationships between microwave emission and ice characteristics over several space scales. The data fusion allows delineation of the shore-fast ice and pack ice in the Barrow area, AK, into several ice classes. Results show good agreement between observed and Polarimetric Scanning Radiometer (PSR)-derived snow depths over relatively smooth ice, with larger differences over ridged and rubbled ice. The PSR results are consistent with the effects on snow depth of the spatial distribution and nature of ice roughness, ridging, and other factors such as ice age. Apparent relationships exist between ice roughness and the degree of depolarization of emission at 10, 19, and 37 GHz. This depolarization would yield overestimates of total ice concentration using polarization-based algorithms, with indications of this seen when the NT-2 algorithm is applied to the PSR data. Other characteristics of the microwave data, such as effects of grounding of sea ice and large contrast between sea ice and adjacent land, are also apparent in the PSR data. Overall, the results further demonstrate the importance of macroscale ice roughness conditions such as ridging and rubbling on snow depth and microwave emissivity [J10]

"Contrast definition for optical coherent polarimetric images"

We consider polarimetric images formed with coherent waves, such as in laser-illuminated imagery or synthetic aperture radar. A definition of the contrast between regions with different polarimetric properties in such images is proposed, and it is shown that the performances of maximum likelihood-based detection and segmentation algorithms are bijective functions of this contrast parameter. This makes it possible to characterize the performance of such algorithms by simply specifying the value of the contrast parameter. [J11]

"Generalized optimization of polarimetric contrast enhancement"

A generalized optimization of polarimetric contrast enhancement (GOPCE) is proposed in this letter. For this problem, it is not only necessary to find the optimal polarization states such that the received power ratio of a desired target and clutter is maximal, but also necessary to find three optimal coefficients such that the ratio of two factors associated with the desired target and clutter is maximal, where both the factors consist of three parameters, i.e., the Cloude entropy and two special similarity parameters. 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 synthetic aperture radar data. [J12]

"Full polarimetric calibration for radar cross-section measurements: performance analysis"

Full polarimetric scattering measurements are increasingly required for radar cross-section (RCS) tests. Conventional calibration fails to take into account the small amount of antenna cross-polarization coupling that

will be present for any practical antenna. In contrast, full polarimetric calibration takes into account and compensates for the nonideal couplings in the transmit and receive channels and paths. We use an existing full polarimetric calibration procedure and a simulation-based performance to study how well the procedure improves measurement accuracy over conventional calibration under practical measurement conditions. [J13]

"On the use of complex SAR image spectral analysis for target detection: assessment of polarimetry"

The objective of this paper is to assess the joint use of the magnitude and the phase of a synthetic aperture radar (SAR) polarimetric image for point target detection and analysis. We first consider a single-look complex (SLC), single polarized radar image including point targets embedded in clutter. A series of sublooks are generated from this SLC image, both in azimuth and in range in order to analyze the inherent speckle effects. The two-looks internal Hermitian product (2L-IHP) is defined and is further shown to qualitatively increase the target/environment contrast. The processing of azimuth and range spectra preliminary to the 2L-IHP derivation (spectral whitening, generation and overlapping of sublooks) is described. A simulation tool is developed to model a point target behavior. Then, the polarimetric extension of the 2L-IHP is proposed, and the optimized polarimetric 2L-IHP is defined. The gain is twofold: in comparison with single polarization, polarimetry is shown to enhance detection capabilities, but also to provide additional information for target analysis. [J14]

"Fully polarimetric bistatic radar scattering behavior of forested hills"

The bistatic radar scattering measurements of forested hills were performed at grazing incidence and at azimuth scattering angles from 28° to 66° from the forward scatter plane. Using pulse-to-pulse switching between orthogonal transmitted polarizations, the radar simultaneously measures two orthogonally polarized components of the scattered wave to obtain full polarimetric information about the scattering process. These are the first fully polarimetric terrain clutter measurements to be conducted at large bistatic angles. The complete Stokes matrix, computed by averaging successive realizations of the polarization scattering matrix, is used to examine the polarization sensitivity of the bistatic clutter. It is found that the polarization state of the EM wave scattered out of the plane of incidence strongly depends on the polarization orientation of the incident electric field. Unlike the monostatic case, these two incident wave polarization states are found to produce substantially different scattered wave behavior when trees are viewed at large bistatic angles. Scattered fields resulting from vertically oriented incident fields are found to be highly polarized and to produce bistatic clutter power levels that are strongly dependent on the polarization of the receiving antenna. In contrast, horizontally oriented incident fields are found to produce weakly polarized scattered waves with bistatic clutter power levels that are insensitive to the polarization of the receiving antenna [J15]

"Change detection for thematic mapping by means of airborne multitemporal polarimetric SAR imagery"

The paper addresses the detection of changes in multitemporal polarimetric radar images, focusing on small objects and narrow linear features. The images were acquired at C- and L-band by the airborne EMISAR system. It is found that the radar intensities are better suited for change detection than the correlation coefficient and the phase difference between the co-polarized channels. In the case of linear features, there is no obvious difference between the C- and L-bands, and slight variations of the flight tracks are acceptable at look angles larger than 35 degrees. Theoretical detection thresholds are evaluated from the statistical distribution of the intensity ratio due to speckle. For the linear features and for urban environments, the observed thresholds are larger than the theoretical predictions. This is interpreted as an effect of radar intensity variations on length scales smaller than the spatial image resolution. The signature of urban areas is very sensitive to deviations between the flight tracks, and the sensitivity is larger at C-band than at L-band. On the other hand, the intensity contrast between buildings and the urban background is smaller at L-band and larger at C-band. For change detection, thresholds may have to be chosen separately for each object class because the intensity ratios of different object classes vary differently as a function of time [J16]

"Discrimination of UXO in soil using broadband polarimetric GPR backscatter"

Polarimetric analysis of ground penetrating radar (GPR) backscatter offers a new means of discriminating subsurface metallic target shapes from one another. Such discrimination is urgently needed to distinguish buried unexploded ordnance (UXO) from other subsurface objects. To illuminate the underlying phenomenology of scattering from objects enveloped in soil, three-dimensional (3D) simulations are performed over a broad frequency band, characteristic of new low frequency GPRs. For moist soil, this means that the subsurface wavelength may range from a fraction of the target size to an order of magnitude larger With a transmitting antenna representation that produces typical subsurface GPR beam features, combined effects of positional,

orientation, and frequency diversity are investigated. Despite long wavelengths, results show distinctive features in reflections obtained from contrasting example target shapes. Full polarimetric analysis suggests the capability for inferring the length of elongated targets, aspect ratio and rotational symmetry, and gross shape along the axis for either elongated or flattened bodies of revolution in problematical orientations [J17]

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