Advanced Clouds Tracking for Airborne Weather Radar & Ground Primary Surveillance Radar

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***Abstract*— A method for modeling and tracking convective clouds within radar images is presented. An object modeling approach is used, based on the extraction of either morphological or grayscale skeletons from 2-dimensionnal cross-section of 3-dimensional radar data. Grayscale skeletons are appropriate shape descriptors for non-rigid and heterogeneous objects, in which gray-level local maxima correspond to regions of interest. The modeling scheme is enhanced by meta-data linked to some chosen points of the skeleton; this provides a good representation of the weather scene in terms of hazards for an aircraft. Skeletons are stored within a graph structure and tracked among successive pictures by means of relaxation labeling processes. The deduced advection field is used to nowcast the clouds evolution. Satisfying results are obtained concerning advection forecasts. Convective activity forecasts are promising, even if they must be carrefully interpreted.**

I. Introduction

Weather surveillance is a crucial issue for aeronautical industry. Ground-based radars of air traffic surveillance stations and airborne radars on civil aircrafts provide real-time information and prevent from main weather threats. Aircrafts must particularly avoid high convective cells (Cumulonimbus), since they are likely to indicate hail precipitations, lightnings, icing and turbulence phenomena. In order to improve the decision-making process, a method for tracking and nowcasting clouds motions is required.

II. Problem analysis

A. General approach

We are interested in providing accurate information on the weather situation / evolution to controllers and aircrafts pilots. The main information sources are ground-based weather station and airborne weather radar. In case of transoceanic flight, the airborne radar can be the unique available sensor. Transmission of synthetic information between successive aircrafts following the same route is also possible.

In case of radar with vertical agility, a huge quantity of data is available: 3-dimensional scans repeated every few minutes. Traditional radar display is composed of a 2D range-azimuth snapshot demonstrating the weather environment (position of convective cells). The vertical exploration is also useful, since it provides the storm top altitude of each cloud. The life cycle of the cloud can be deduced from this storm top evolution: growing, stable or collapsing phases are directly connected with the storm top altitude tendency.

These considerations lead to analyse description models which synthesize useful information, in order to transmit a small amount of data on ground-air and air-air links. Moreover, the forecasting task must be based on robust parameters, describing the cumulonimbus evolution in term of horizontal motions, vertical tendency, and dynamic behavior: merging, splitting, convection intensity, etc.

B. Available data

Algorithms described in this paper have been applied by Thales Airborne Systems on S band ground-based radar data from Nexrad network, and partially on simulated X-band airborne radar data. Inputs for forecasting are two radar scans separated by 5 minutes.

Reflectivity is expressed in dBZ, which is the traditionnal unit for weather radar data.

Depending on the user's needs, the simulation may include path attenuation due to weather clutter; ground clutter is not yet simulated.

Another version of the algorithm, based on morphological skeletons, have been applied by Thales Air Defense on STAR2000 weather channel image sequences. Results on wind field retrieval presented in this paper are obtained with DLRs POLDIRAD radar (Doppler & polarimetric C-Band radar) and associated results of Wind field estimation by bistatic radar measurements.

III. The method

F. Barbaresco and B. Monnier propose in [1] a method based on morphological skeleton matching. Skeleton is definitively an interesting shape descriptor, especially for fluid targets tracking. In this paper, we suggest another extraction method, in order to reinforce the skeleton's dependency upon convection hearts ; we then propose an indicator of each convective cell's evolution phase.