WEATHER HAZARD INTERPRETATION AND FORECAST BY AN AIRBORNE RADAR

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1. INTRODUCTION

Weather surveillance is a crucial issue for aeronautical industry. Aircrafts must particularly avoid high convective cells (Cumulonimbus), since they are likely to indicate hail precipitations, lightnings, icing and turbulence phenomena. Cumulonimbus are often embedded in mesoscale systems, which appears on weather radar images as extended aeras of various intensity; local gray-level maxima corresponding to the convective cells. The pilot must choose a route, taking into account relative position, intensity of convection, trajectory and life cycle of each cloud. In order to improve the decision-making process, a method for analysing, tracking and nowcasting weather hazards is required.

We propose a multi-scale traking approach, matching the particular structures of convective mesoscale systems. The algorithm is based on the extraction of target's grayscale skeletons.

2. THE METHOD

2.1. Grayscale skeleton

In [1], Barbaresco describes a robust method for tracking precipitation clouds based on morphological skeleton. Morphological skeleton provides a shape simplification, and preserves the object topology. However, it depends on the object boundaries, that means, of a given threshold level (or any other segmentation technique). We improve the method by taking into account the non-homogeneity of mesoscale clouds system. We use the notion of grayscale skeleton as defined by Arcelly and Ramella in [2], since it is an adequate segmentation tool for any kind of data in which significant areas correspond to clusters of local gray-level maxima. Skeletal lines correspond to ridge lines of the grayscale picture. The example on Fig. 1 shows the advantage of this kind of skeleton: relevant points of each cloud (from a meteorological point of view) are selected as feature points of the skeleton, while classic morphological skeleton may miss them. Grayscale skeletonization is performed by iterative thinning algorithm, consisting in lowering the gray-level of each pixel identified as a simple point, i.e., whose gray level lowering does not modify topology features ([2],[3]).

The skeletonization process ends up in connected curves, which are simplified as set of segments and stored within a graph structure. Feature points (lcal gray-level maxima, i.e. convective cells centers) are the nodes of the graph; they can be associated with descriptors, extracted from the 3D reflectivity field exploration (maximum reflectivity value, stormtop altitude, etc.).

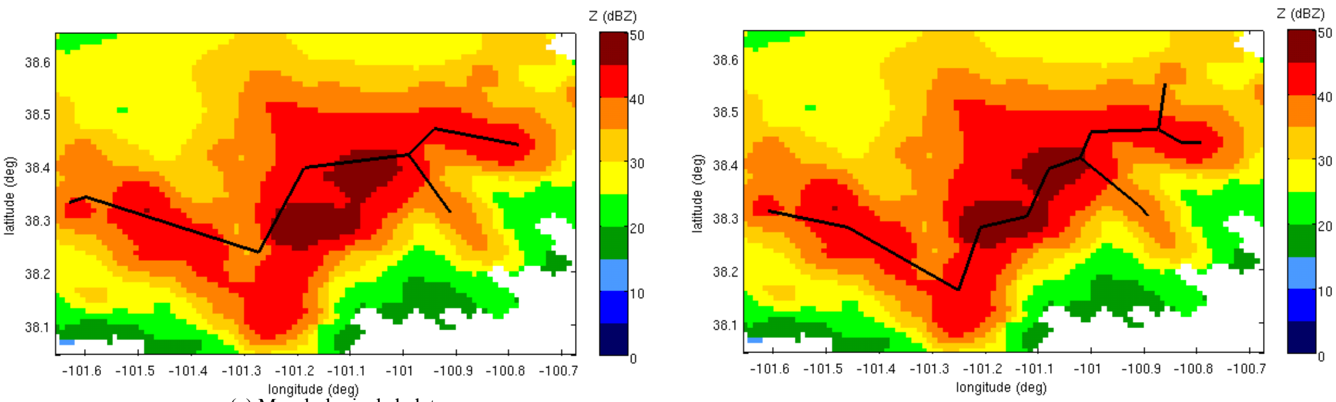
2.2. Tracking and forecasting

Issues of tracking clouds motions in the horizontal plane and estimating the internal evolution of each convective cell are both addressed.

To evaluate horizontal advection, we make use of geometrical resemblance between graphs of succesive images, as in [1]. Resemblance functions are computed and combined through relaxation labelling processes. The result is a set of matching vectors, next extrapolated to produce a motion field on the whole picture.

Finally, the advection step is a global displacement of pixels according to the motion vector field.

Subsequently, we exploit the computed matching function to precisely track feature points and their associated descriptors. In a weather interpretation frame, analysing evolution of these descriptors provides useful information on convective cells life cycle and future development (growing, maturity and collapsing stage). Temporal derivatives of these meta-data are computed for each cloud, then used to estimate its life cycle and its dangerousness relatively to an aircraft.



(a) Morphological skeleton

(b) Grayscalel skeleton

Figure 1. Morphological skeleton and grayscale skeleton (after linearization processing): by construction, relevant points lie on the grayscale skeleton

3. PRELIMINARY RESULTS

As expected, grayscale skeleton is really promising for modelling aspects, as it provides a basis which can be easily enriched.

The advection tracking results are similar to those observed by Barbaresco in [1]; however, in case of a global cloudy system including convective cells moving non-uniformly, grayscale skeleton modelling makes it possible to detect these individual motions. Moreover, the model can track accurately convective clouds patterns, involving vertical extension, maximum reflectivity value, etc. The forecasting quality is improved: e.g. the pilot can evaluate which part of a global convective system is likely to weaken first.

4. CONCLUSION AND FUTURE WORK

Grayscale skeleton definitively provides an adequate description frame for fluid and heterogeneous shapes. This descriptor is easily appended by meta-data; therefore, its use for compression data must be considered. Finally, linearized skeletons are robusts parameters for tracking algorithm based on shape matching.

Other point to be investigated is weather attenuation, which is of great importance for X-band radar. Boundaries are significantly disturbed by this phenomenon, while cores of convective cells are quite steady. We can then reasonnably expect good performance of the grayscale skeleton-based tracking.

5. ACKNOWLEDGEMENT

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