A nowcasting tool for the analysis of the life cycle of rainfall structures using radar and lightning data

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INTRODUCTION

A radar-based nowcasting tool to identify, track and forecast precipitation has been developed and applied to a number of rainfall events. The system is fed with lightning (IC & CG) observations and a volumetric composite of reflectivity observations produced by the C-band weather radar network of the Catalun Meteorological Service. The tool is designed to support the weather surveillance and very short-range forecasting tasks of heavy rainfall events over Catalonia (NE of the Iberian Peninsula).

The tool generates different outputs, including 2-D and 3-D products. The 2-D radar product considers the lowest pseudo-CAPPI radar observations available and, after discrimination of stratiform and convective precipitation echoes, rainfall structures are identified according to a number of criteria such as horizontal reflectivity gradients and maximum intensity. A centre-to-centre product is built with lightning observations.

The 3-D product is obtained after examining the complete volumetric radar composite. Different reflectivity thresholds are applied to identify convective cells and centroids including characteristics such as area extension and echo top heights. The tracking and 3-D nowcasting of the precipitation structures in the 2-D and 3-D product is made considering cross-connection between consecutive images and also NOW model derived middle winds (100 hPa). Moreover, the evolution stage of convective cells (immature, mature and decaying) and if it is a 3-D product is also determined and forecasted.

The performance of the tool, currently in the verification stage, is examined with several precipitation events. The selected case, the life cycle of the structure is modeled and compared with lightning data, with the aim to examine the different information provided by each observation type.

METHODOLOGY (1): Radar-derived structures

Considering lightning observations (IC & CG separately) received by the SMN (Pineda et al., 2006) over the region of interest in a radar data acquisition cycle (60') and stored in an equivalent grid (aprox. 2x2 km²), a map of IC & CG flash density is built (Fig. 3). A similar approach is applied as described for the 2D radar structures, i.e.

- To identify pixels of the map with a density higher than a given threshold (different for IC & CG) (acquiring a “lightning structures”
- To track the structures and analyse their life cycle.

A forecasting product of significant lightning structures similar to the 2D radar one is planned.

METHODOLOGY (2): Lightning observations-derived structures

Regarding the nowcasting of the position of the convective structure shown in Fig. 6 before 18:12 Z (left) and after 18:12 Z (right).

- The evolution of the number of pixels and echo heights indicates that it was not a typical single-cell storm (caused by a single updraft); several intensification and decay stages.
- Three different temporal stages can be distinguished: 1). Development (growth of all variables) and nearly random movements—probably induced by topographical factors—ca.

- A higher activity (higher centroid density) for all structures in the coastal area

- A clear relationship was found between radar and lightning derived structures: 2D low level radar-derived structures with IC structures and 3D radar data structures with CG structures.

- A future version of the system is planned to integrate both the radar and the lightning structures in order to improve the characterisation of the evolution stage and the life cycle of the structures.

METHODOLOGY (3): Radar-derived structures

To identify and characterise precipitation structures in the lowest level, distinguishing convective precipitation structures with vertical development (Fig. 2).

To identify and track 2D structures from the pseudo-CAPPI techniques (Fig. 2).

To track 3D structures from the previous 60' following the centred movement (Fig. 2).

To analyse the life cycle of 2D structures.

To compute 60' forecasts of 2D structures using the observed field and NOW middle winds forecast.

To compute 30' forecasts of 3D structures using the observed field and NOW 700 and 500 hPa middle winds forecast.

CASE STUDIES

Two case-studies are presented to illustrate the methodology described above:

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The direction of predominant movement was WSW to SNE in the morning and S to N in the afternoon, when the precipitation decreased significantly. The analysis of the 60' field identified centroids of different structure types and their activity (flash density, reflectivity high values, etc.) seems to indicate a clear relationship between the 2D-radar and IC-identified structures and also between 3D-radar and CG-derived structures. Other remarkable aspects of the analysis are:

- A higher activity (higher centroid density) for all structures in the coastal area

- A clear relationship was found between radar and lightning derived structures: 2D low level radar-derived structures with IC structures and 3D radar data structures with CG structures.

- A future version of the system is planned to integrate both the radar and the lightning structures in order to improve the characterisation of the evolution stage and the life cycle of the structures.

CONCLUSIONS

A nowcasting tool to monitor radar precipitation structures has been developed and is currently being tested in pre-operational conditions. The system is designed to support weather surveillance and very short-range forecasting tasks of heavy rainfall events over Catalonia (NE of the Iberian Peninsula).

- To identify and characterise convective structures using meteorological radar observations and, after discrimination of stratiform and convective precipitation echoes, rainfall structures are identified according to a number of criteria such as horizontal reflectivity gradients and maximum intensity. A centre-to-centre product is built with lightning observations.

- To track the structures and analyse their life cycle.

A forecasting product of significant lightning structures similar to the 2D radar one is planned.

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