MESOSCALE FEATURES OF SEVERE HAILSTORM DAYS CLASSIFIED IN CLUSTERS

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I. INTRODUCTION

The forecast of precipitation using NWP models is an open problem. Different parameterizations used by cloud resolving models provide different scenarios that make the verification of these results a complicated task. In particular, hailstorms are one of the most difficult phenomena to predict and identify, given that they are usually associated with the onset of convection and are highly located in space and time. The characterization of the synoptic particularities of days with hailstorms and the study of their mesoscale characteristics consist of two fundamental stages for the improvement of prediction systems for these phenomena.

The Middle Ebro Valley (MEV) is one of the European regions with the highest frequencies of hailstorm days. The geomorphology of the valley and its location between two seas grant the special characteristics for the understanding of atmospheric mesoscale patterns present on hailstorm days (HD).

The database of the Group for Atmospheric Physics (GAP) of hailstorm days in the Ebro Valley was used to establish a classification of five synoptic patterns related to hailstorm events (Garca-Ortega et al., 2011). This cluster classification constitutes a very useful tool for the prediction of hailstorms in the NE of Spain, via synoptic characteristics of HDs.

However, the intracluster variation observed in the geopotential height and temperature fields have led us to study the corresponding deviations. This has allowed us to determine areas that present greater intracluster variation and are more or less susceptible to undergoing important changes according to the representative cluster pattern.

It has been detected that a direct correspondence among HD belonging to the same cluster and the corresponding precipitation patterns does not always exist. Moreover, HD belonging to different clusters allow for spatial distributions of precipitation that, occasionally, show similarities. Consequently, the study of mesoscale factors is necessary and, at this level, the geomorphologic characteristics of the study area should make the interpretation of the results easier.

In this context, our main goals are two: on the one hand, we try to identify certain deviations within the clusters that make hailstorms especially intense and extensive. On the other hand, to establish relationships between these synoptic features and the mesoscale factors responsible for triggering convection. Both factors determine the onset conditions and the presence of an adequate environment to maintain convection.

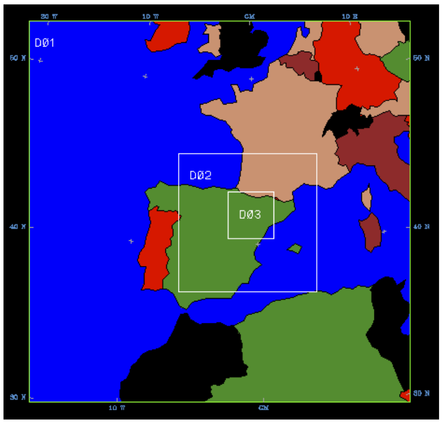

FIG. 1: Three nested domains of the MM5 simulations

II. DATA BASE AND METHODOLOGY

The greatest deviations found are related to the position and intensity of the principal perturbations of each cluster. It is necessary to point out that the period of study covers from May until September. During these months the associated climatologic variability affects the area of study. Nevertheless, the results on a synoptic scale do not allow us to accurately predict the areas that can be affected by hail precipitation.

For the mesocalar study, a series of HD were selected in each cluster where hail events either affected extensive areas or, although contained in a smaller area, were very intense. The characterization of these hail events was carried out through networks of measurement and observation. C-band radar images have been used with an algorithm that allows the identification of hailstorms (López and Sánchez, 2009). Additionally, in the same study area, two networks have been deployed with more than 300 hailpads on terrain and a network of 255 rain gauges. Both networks have allowed us to quantify the intensity and extension of hail events and study their size distributions.

To identify the mesoscale factors, HD simulations were done using the MM5 model (Dudhia, 1993; Grell et al., 1995). We selected three nested domains (FIG. 1) with horizontal resolutions of 36, 12, and 4 km following a two-way nesting strategy, and 35 vertical σ-levels.

An ensemble of simulations has been done, using different parameterizations schemes for convection and moisture, taking into account the presence of microphysical processes of hidrometeors growing in mixed phase. In order to obtain the best mesoscalar scenarios, a validation of the different parameterization combinations was done using the precipitation field. Due to the difficulty of adequately reproducing the spatial distribution and the quantities of this field, we considered that if the precipitation output of the model is correct, the simulation is valid for carrying out the mesoscalar analysis. This verification was done by two ways, subjectively via an analysis of precipitation structures and objectively via a Bias score.

Once selected, the optimal ensemble of parameterizations for the study of mesoscale conditions, different fields to study the factors that favor the beginning of convection were selected (Garcia-Ortega et al., 2009): the water vapor flux divergence averaged in the layer 1000-700 hPa, the convective instability in the 900-700 hPa layer, defined as the difference between the equivalent potential temperature at 700 hPa and at 900 hPa, and the low-level wind and humidity.

III. SOME RESULTS

The days with more hail activity present synoptic environments that are more favourable for severe convection than those of the average cluster. In general, the perturbations associated with HD are better defined, more intense, and are spatially located in a way that, over the region, positive warm surface advections and height vorticity are produced.

Once the subjective verification by structures was done, the Goddard moisture scheme and the Kain-Fritsch cumulus scheme for domains one and two were selected, with explicit resolution of equations in the inner domain. Later on, an objective verification of the simulated precipitation has been held using a Bias Score, defined as the ratio between the forecast event and the observed event frecuencies, for different thresholds of precipitation amounts.

In FIG. 2, we can see how the precipitation field accurately adjusts for quantities below 20 mm, while at 20 mm and above, the model begins to infra-estimate the precipitation. These results are similar to those found in similar studies of severe convection phenomena.

The mesoscale analysis of HD shows that the fields of convection instability and the divergence of water vapor at low levels are two of the factors that best explain storm formation. All of this is highly influenced by the geomorphologic characteristics presented by the study area. The topography of the Ebro Valley affects the formation of convergences and flux of humidity at low layers.

In clusters 1 and 2, the perturbation affects the study area more tangentially and precipitation is restricted to mountainous zones. In these cases, convective instability is not enough for convection initiation and the convergences produced in mountainous systems are the triggering factor that originates precipitation.

In cluster 3, the region is affected by two perturbations. Initially, precipitations are formed because of convergences in mountainous systems. Lately convergence areas are produced in the Valley displacing the precipitations from the mountains to the MEV .

Clusters 4 and 5 are characterized by the presence of a trough at the vertical height of the study area. In this case, precipitations begin in the Valley because of the elevated convective instability, and they intensify with convergences that cause changes in the low-level flux of the MEV.

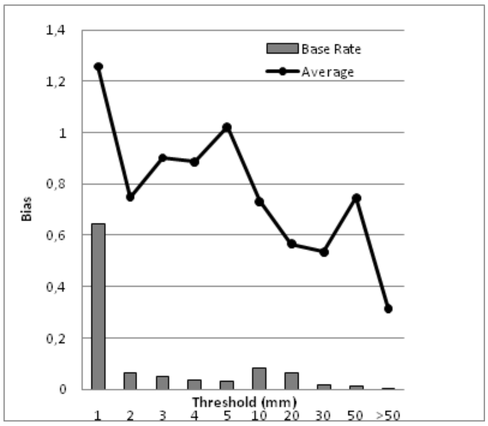

FIG. 2: Frecuency Bias for MM5 simulations of the HD, with the selected parameterizations. The Base Rate shows the frecuency of the observed event by rain gauges network.

In every case, the humidity flow at low-levels plays an important role in convection initiation. The flow in the Valley from the SE is a consequence of the ageostrophic wind, forced by the mountain range, producing a significant humid and warm air advection from the Mediterranean. This fact, together with the sudden changes in the wind direction at NW of the Valley, generate strong convergences in the study area resulting in a proper environment for convection development.

IV. ACKNOWLEDGMENTS

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