SEASONAL ANALYSIS OF HAILSTORM TRENDS AND THEIR RELATIONSHIP TO METEOROLOGICAL FACTORS

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I. INTRODUCION: AREA OF STUDY

The Ebro Valley (FIG. 1) is one of the European regions with the greatest incidences of days with hailstorms. The Group of Atmospheric Physics (GAP) at the University of León has developed several studies in the region during the last ten years (López et al., 2007; Sánchez et al., 2008). During this time, an ample database has been gathered through the use of various tools and instrumentation developed in the area by the GAP.

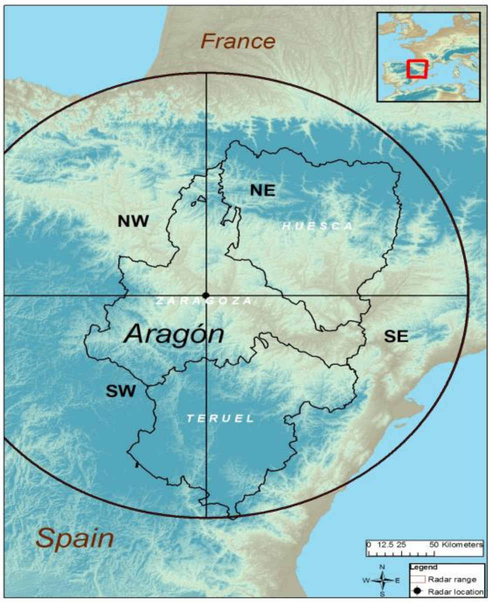

FIG. 1: Ebro Valley. The circle show the area of influence of radar.

In order to register hailstorms in the Ebro Valley, hailpad networks and observers were distributed in the study area. Additionally, meteorological C-band radar was installed in the SW of Zaragoza.

This radar has a tool implanted which allows for the identification of hail using an algorithm probability scale (López and Sánchez, 2009). This algorithm is constructed using four radar variables: VIL, maximum reflectivity, maximum reflectivity height, and variation in reflectivity over time. The presence of an elevated rate of precision and low false alarms allows for its use in evaluating the surface area affected by hail at the ground level.

II. PRESENTATION OF RESEARCH

First, the database for days with hail was used to obtain the probability of hail proportioned by the radar algorithm in each event. This way, climatology with hail occurrences in the area was constructed, although it is necessary to point out that we only considered the last ten years. Also, in a preliminary manner, we studied the trends of the extensions affected by hail in the last decade by using the radar data.

Additionally, given the difficulty that hail prediction currently presents using numerical models, this database was used with the objective of obtaining a valuable tool for the prediction of these phenomena. As an early step in the improvement of hailstorm prediction, García-Ortega et al., 2011 classified synoptic situations that produce hailstorms in the Ebro Valley in five clusters. From these data on the probability of hail obtained by radar, we were able to establish the regions that have a greater impact of hail in relation to these synoptic scale atmospheric patterns. As such, from the synoptic atmospheric situation, we can predict the regions that are going to be most affected by hail.

Lastly, with the same objective, various thermodynamic preconvective factors were obtained using radiosounding from the 12UTC in Zaragoza on a day with a hailstorm. From these radiosoundings, a series of variables were obtained that show the convective instability (CAPE, Liftex index, Showalter index, Totals totals index, k index, precipitable water, thickness of the 1000-500hPa layer and convective inhibition).

The objective is to be able to establish a relationship between the extension of hail fall and these factors in order to estimate which factors that have the greatest correlation to the extension of hail fall.

III. RESULTS AND CONCLUSIONS

a) Analysis of the evolution of hail extension

First, the annual extension of hail fall in the last decade was studied.

We were able to prove the existence of an enormous variability of the area affected between some years and others. This means that there are years with very little hail activity, such as 2004, 2007, and 2010, interestingly proceeded by years with very high activity, which was the case in 2003, 2006, and 2009. The years with a high extension of hail fall are not characterized by a high number of instances rather because a greater number of exceptional hailstorms were registered.

We cannot affirm that an increase of the number of instances was produced during the last few years, but we can show that an increase in the number of large hailstones was produced. As seen in FIG. 2, although with large variability, in the last few years of the decade the number of instances tends to increase, since the majority of extensive hailstorms over 5000km^2, have been produced in the second half of the decade.

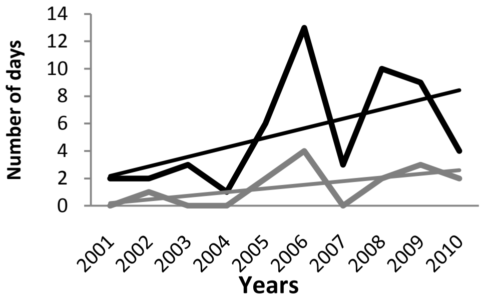

FIG. 2: Number of days with an extension of hail superior to $1000km^2$ (black line) and $5000km^2$ (grey line) respectively.

b) Distribution of hailstorms in the area of study

Secondly, a climatologic map of hail fall instances in the area during the last ten years was created. In FIG. 3, the number of hail fall instances in the different areas is represented, and in this map it is necessary to consider the existence of interferences (Marked in the FIG.3 with red lines).

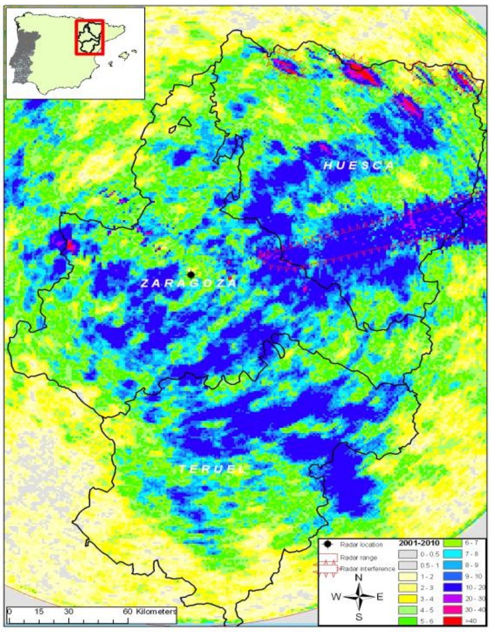

FIG. 3: Number of hail fall instances in the last ten years.

Additionally, the regions which are most affected by hail appearance depending on the classification cluster are shown (TABLE I).

Cluster 1 is characterized by the formation of a low of 500hPa in the SW of the Iberian Peninsula. With this situation, the area most affected by hail is the Southern part of the area of study, especially in the Southeast, with a high incidence of hail in the surrounding Gúdar Mountain Range.

Clusters 2, 4 and 5 are characterized by the presence of a trough of 500hPa in the West of the Iberian Peninsula, variations in the position of this trough affect the distribution of hailstorms in the area of study. Thus, in Cluster 2 the trough is farther toward the West of the Peninsula, and affected similarly to the total region. In Cluster 4, the trough is situated in the center of the Peninsula and produces hailstorms mainly in the East of the area of study. In the case of Cluster 5, the trough is toward the North, affecting mainly the North of the region.

Cluster	NW	NE	SW	SE
1	68,48	89,81	89,53	160,75
2	139,60	136,11	139,86	138,18
3	126,29	391,75	87,29	292,52
4	62,25	149,99	89,11	180,22
5	115,62	155,02	66,46	128,78

TABLE I: Average extension in km^2 of hailstorms in four subzones depending on cluster classification.

Cluster 3 predominates the influence of the two perturbances in 500hPa, one being situated in the same position as Cluster 1, provoking hailstorms in the Southeast of the area of study, and another in Central Europe that affects mainly the Northeast of the region.

Identification of the exact areas that are most affected by hail depending on the atmospheric pattern, will be done via the construction of probability cluster maps.

c) Relationship between the extension of hail and convective indexes

Lastly, a linear regression model was created with the objective of determining variables with greatest influence in the extension of hailstorms over the region. The results obtained show that the Showalter index (Showalter, 1953) and the CAPE index (Moncrieff and Miller, 1976) are the best variables when determining the extension of hail fall.

IV. ACKNOWLEDGMENTS

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