HAIL CELLS FEATURES AND PROBABILITY OF HAIL EQUATIONS IN THE REGION OF EBRO VALLEY

Manuel Ceperuelo[1], María del Carmen Llasat[1], Tomeu Rigo[2], José Luís Sánchez[3]

[1]*Department of Astronomy and Meteorology, University of Barcelona, Spain, ceperuel@am.ub.es*

[2]*Meteorological Service of Catalonia, Generalitat de Catalunya, Spain*

[3]*Laboratory for Atmospheric Physics, University of León, Spain*

(Dated: September 12, 2007)

I. INTRODUCTION

Hail events are typically related to crop losses, buildings and cars damages or casualties. Different kinds of techniques are used in order to identify hail and to help risk management. There exist methods that try to find different relationships between environmental conditions and radar observations (Stumpf et al, 2004) with the purpose to identify hail in surface, for example, the use of maximum reflectivity (Geotis, 1963), the persistence of maximum reflectivity values (Knight et al, 1982; Waldvogel et al, 1987), the use of radar data combined with radiosonde observations (Edwards and Thompson, 1998; Waldvogel et al, 1979), VIL technique (Greene and Clark, 1972) and VIL density method (Amburn and Wolf, 1997), the use of kinetic energy flux (Waldvogel et al, 1978; Schmid et al, 1992), the hail detection algorithm (Witt et al, 1998), the use of logistic functions that try to minimise the false alarm ratio (Billet et al, 1997) or by using the combination of different hail indicators (Kessinger and Brandes, 1995).

The objective of this contribution is to obtain the best relationship between hail observations and radar parameters in case of Ebro Valley region, NE of Spain (Fig. 1). This area is usually affected by spring and summer hail storms mainly in the south-western part with an average of 32 thunderstorm days per year over an area of 25000 km^2 and a medium size of hailstones less than 20 mm (Pascual, 2000; López, 2003), which are usually registered around 16:00 UTC. To achieve this end, 2004 and 2005 hail campaigns (from May to September) have been analysed. During these periods, a number of 814 ground hail observations corresponding to 70 hail events have been produced and the largest recorded hailstones have had a size of 43.9 mm (2004) and 39.4 mm (2005).

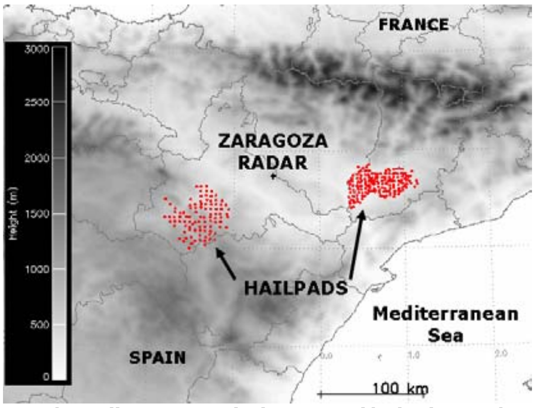

FIG. 1: Ebro valley region, radar location and hailpad networks.

This contribution shows the 3D cells analysis obtained by using RHAP, Rainfall events and Hailstorms Analysis Program (Ceperuelo et al, 2006), which has an adapted version of the SCIT algorithm (Johnson et al, 1998; Rigo and Llasat, 2005), and integrates meteorological radar data, meteorological model outputs, radiosonde observations and surface observations, like hailpads. Finally, conclusions are presented.

II. CONVECTIVE CELLS ANALYSIS

A total number of 9537 convective cells have been identified, and 4863 of them (51%) have been detected within the valid radar range: (20-150 km). Moreover, taking into account the hailpad areas and hail events, 706 convective cells affected these regions and 25% of them produced hail in surface. In hailpads areas, the maximum storm formation occurrence (MSO) has been obtained between 17 and 19 UTC, two hours before the MSO of the all Ebro Valley region (15 UTC - 16 UTC). In case of hailpad areas, the analysis shows: 1) no hail cells displacements have a Gamma distribution with medium value of 21.4 km and a pronounced maximum between 4 and 8 km; 2) hail cells have a medium displacement value of 46.8 km and two maxima between 15 and 20 km and between 30 and 35 km. This fact is due to a major organisation of the associated precipitation system in hail case. Considering 3D cells direction, the mean value is similar for both cases, nonetheless hail cells have more SW-NE component.

On the other hand, the evaluation of the radar parameters has been done in order to obtain the best parameter to identify hail or no-hail in surface. For this purpose, contingency tables and the score indexes have been built. Results can be summarised in table I, which shows that there are no significance differences between the most important radar parameters related with hail precipitation. Then, considering hail and no hail observations, probability of hail equations have been constructed (table II) and might be used taking into account the obtained score indexes.

This study gives the kinetic energy flux (KEF) as the best parameter to identify hail in surface with a linear function to model the hail probability. Moreover, if only hail larger than 10mm is considered, an adapted version of the probability of severe hail (POSH) has been shown as the best parameter to identify it (table II, figure 2). This adapted version has been obtained for the Ebro Valley region on the basis of 10 severe hail events and is based on the Hail Detection Algorithm (Witt et al, 1998).

Radar parameter	CSI	Value
Zmax	0.3776	52.0d BZ
WP	0.3633	3.5 km
VIL_{Zmax}	0.3795	16.0 kg/m^2
VIL_{grid}	0.3753	14.0 kg/m^2
VIL_{cell}	0.3473	12.0 kg/m^2
$VILD_{Zmax}$	0.3734	2.0 g/m^3
$VILD_{cell}$	0.3170	1.8 g/m^3
KEF	0.3929	0.5 J/m^2/s
SHP	0.3976	0.5

TABLE I: Highest critical success index (CSI), and corresponding value to identify hail and no hail cells.

Radar parameter	a	b	c
Zmax	0.0001	0.155	-0.062
WP	0.200	0.184	-0.111
VIL_{Zmax}	0.018	-0.009	non
VIL_{grid}	0.017	0.069	non
VIL_{cell}	0.023	0.044	non
$VILD_{Zmax}$	0.179	-0.106	non
$VILD_{cell}$	0.242	-0.079	non
KEF	0.333	0.135	non
POSH	0.0001	0.155	-0.062

TABLE II: Parameters for exponential ($POH = a \cdot e^{bx} + c$) and linear ($POH = a \cdot x + b$) distributions of hail probability (X is the radar parameter).

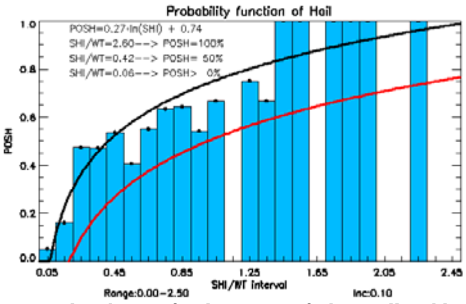

FIG. 2: POSH distribution for the region of Ebro Valley, black line, and POSH distribution obtained by Witt et al. (1998), red line.

III. RESULTS AND CONCLUSIONS

After analysing 46 hail events, a total number of 9537 hail and no hail cells have been detected. Mean directions of the cells movement have no significant differences, with WSW-ENE as the mean direction. Hail cells have displacements longer than no-hail cells, with mean values of 46.8km and 21.4km respectively. This fact agrees with the organisation degree of the precipitation systems with hail, which leads us to see the MUL system as those with the highest hail probability.

The KEF parameter with a linear distribution of hail probability is the best parameter to identify hail in surface, nonetheless there exist no significance differences with the other radar parameters. When hail size is larger than 10 mm the best parameter is the adapted version of POSH for the region of Ebro Valley. These results joined to the dependence found between some radar parameters lead us to apply a new methodology based on principal components analysis, in order to improve the distinction between hail and no-hail cells. Then, the methodology will be applied to realize a cluster analysis of all the 3D cells to model the life cycle of the radar parameters.

IV. AKNOWLEDGMENTS

The authors thank the MONEGRO (REN2003-09617-C02-02) Spanish project for enabling the drawing up and presentation of this contribution. Our thanks to the Associació de Defensa dels Vegetals, to the University of Leon and to the Instituto Nacional de Meteorología for the hailpad data and radar data.

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