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Study of the hailstorm of 17 September 2007 at the Pla d'Urgell. Part one: fieldwork and analysis of the hailpads

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Abstract

The plain of Lleida is a farming area with about 200,000 ha of crops. On 17 September 2007 a hailstorm hit 889 ha of fruit crops, especially the area of the Pla d'Urgell (Urgell Plain). That hailstorm was the largest since 1990, according to the data collected by the Agrupació de Defensa Vegetal de les Terres de Ponent (ADV-TP) (Group for the protection of plants in the Terres de Ponent): hailstones larger than 5 cm in diameter and 81 hailpads hit (the average in the Lleida area in September is 7 hailpads affected). A mesoscale convective system originating in the Iberian Range was reactivated when arriving to Catalonia, resulting in a hailstorm that was particularly virulent and affected a wide area (the second part of the study focuses on the synoptic and mesoscalar study). This first part presents the analysis of the data from the network of hailpads managed by the ADV-TP and the information obtained from observers in the affected area. The conclusion drawn from this analysis is that the location of the largest hailstones does not match with the more heavily impacted area. Regarding the qualitative information obtained from the contributors, the affected area is similar to that obtained from the hailpads. However, it should be noted from the comparative study between both sources of information that observers tend to perceive only the larger hailstones when there is a mixture of diameters. To conclude, a number of recommendations are presented in order to maximize the objectivity of the reports presented by the observers.

Key words: hail, hailpad, diameter, observers, ruler

1 Introduction

Hailstorms and graupel storms are some of the most fearsome meteorological phenomena for agriculture, especially for vegetable crops and fruit trees. A hailstorm can completely ruin the harvest of an entire year in just a few minutes.

Spain is the European country with the greatest losses in agriculture caused by hail. Between 1991 and 2001, insurance companies paid more than 2200 M€ in all of Spain in compensation for crop damage caused by hail, half of which went to the central area of the Ebre valley (Sánchez et al., 2003). According to Agroseguros (personal communication), in 2007 nearly 12.5 M€ were paid in compensation for crop damage caused by hail in Lleida.

The Lleida plain is an agricultural area with about 200.000 ha of crops. The impact of hailstorms in this area is significant, and the *Agrupació de Defensa Vegetal de les Terres de Ponent* (ADV-TP) (Group for the protection of plants in the Terres de Ponent) (ADV, 2001; Sánchez et al., 2007) conducted some hail prevention campaigns in Lleida in the period 1976-2004. Their impact is also evidenced by the number of studies done in the area (e. g. Pascual, 2002; Tudurí et al., 2003; Ceperuelo et al., 2006; and Aran et al., 2007).

The hailstorm on 17 September 2007 was the strongest since 1990 according to data collected by the ADV-TP. In similar situations (Ramis et al., 1997; Pascual, 2002 and Ceperuelo et al., 2006) it has been observed that the convection began outside the area and entered through the

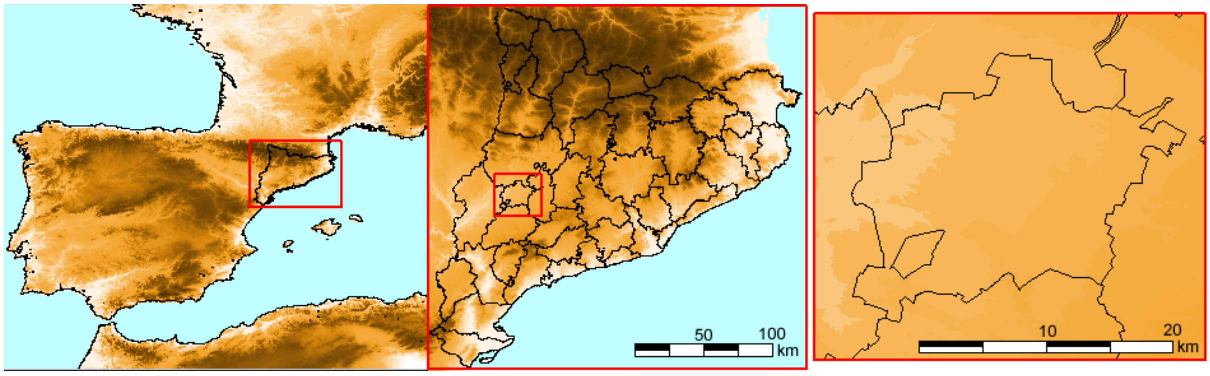

Figure 1. Location of the study area: Iberian Peninsula (left), Catalonia (middle) and Pla d'Urgell area (right).

Table 1. Surface of damaged fruit in the Lleida area (in ha) and percentage of affected surface for each crop. Source: DAR (*Departament d'Agricultura, Alimentació i Acció Rural*) (Department of Agriculture, Food and Rural action).

Municipality or *comarca*	Apples (ha)	Average % (ha)	Pears (ha)	Average % (ha)	Peaches (ha)	Average % (ha)
Pla d'Urgell	207	More than 50%	63	More than 50%	4	More than 50%
Agramunt, Castellserà, La Fuliola, Puigverd d'Agramunt and Tornabous	117	More than 50%	3	More than 50%	2	More than 50%
Juneda, Puiggròs, Borges Blanques	43	More than 50%	11	More than 50%	4	More than 50%
Soses, Alcarràs, Lleida, Montoliu, Alamús, Sudanell	235	More than 50%	85	More than 50%	115	More than 50%
TOTAL	602		162		125	

southwest of Lleida. The presence of a trough at high levels associated to a low pressure system in the north of the Iberian Peninsula is a recurring situation in hailstorms in Lleida (over 38% of days according to the climatology of Pascual, 2002). On September 17 the formation of a mesoscale convective system began in the southwest of the Iberian Range at 09:00 U.T. and moved to the northeast. Convective centers were reactivated upon their arrival in Catalonia (14:00 U.T.). The most intense part of the episode took place in the area of the Pla d'Urgell (Figure 1) between 14:54 U.T. and 15:00 U.T. The meteorological analysis of the episode is described in detail in the second part of this work (Pineda et al., 2009).

This hailstorm was particularly virulent and extensive. Six people visited the primary care center in Mollerussa with minor bruises. In addition, some street furniture and vehicles were affected; some of them were virtually destroyed. According to the report of the *Departament d'Agricultura, Alimentació i Acció Rural* (DAR) (Department of Agriculture, Food and Rural action), the most affected crops were late varieties of apples, pears and peaches. The corn production was less affected by the damages to the crops because the cob was already formed and the grain was in drying phase. As shown in Table 1, there were 889 ha of damaged fruit.

One source of information for the weather service is contributors and amateur meteorologists, and in other situations, the people affected. The difficulty of handling this type of information is a matter of many studies (e. g. Llasat-Botija et al., 2007; Delitala, 2005). These authors have focused on the perception that people have of such situations and their possible bias, mainly due to the influence of the media and historical memory of other episodes. The main objective of this work, besides characterization of the type of precipitation and its distribution, is to make a first evaluation of the reliability of the information provided by witnesses in order to improve its quality. For this reason, a comparative study between this data and the records from the registers from the hailpad network has been carried out.

This study followed the dictates of the publication *"El manual d'estil"* ("The style manual") of the *Servei Meteorològic de Catalunya* (Meteorological Service of Catalonia) (SMC, 2008), which defines graupel as "precipitation of rounded, half transparent ice grains, less than 10 mm in diameter, and hailstones are equal to or greater than 10 mm in diameter".

After this introduction, the hailpad network is presented in section 2. Section 3 sets out the fieldwork from its inset

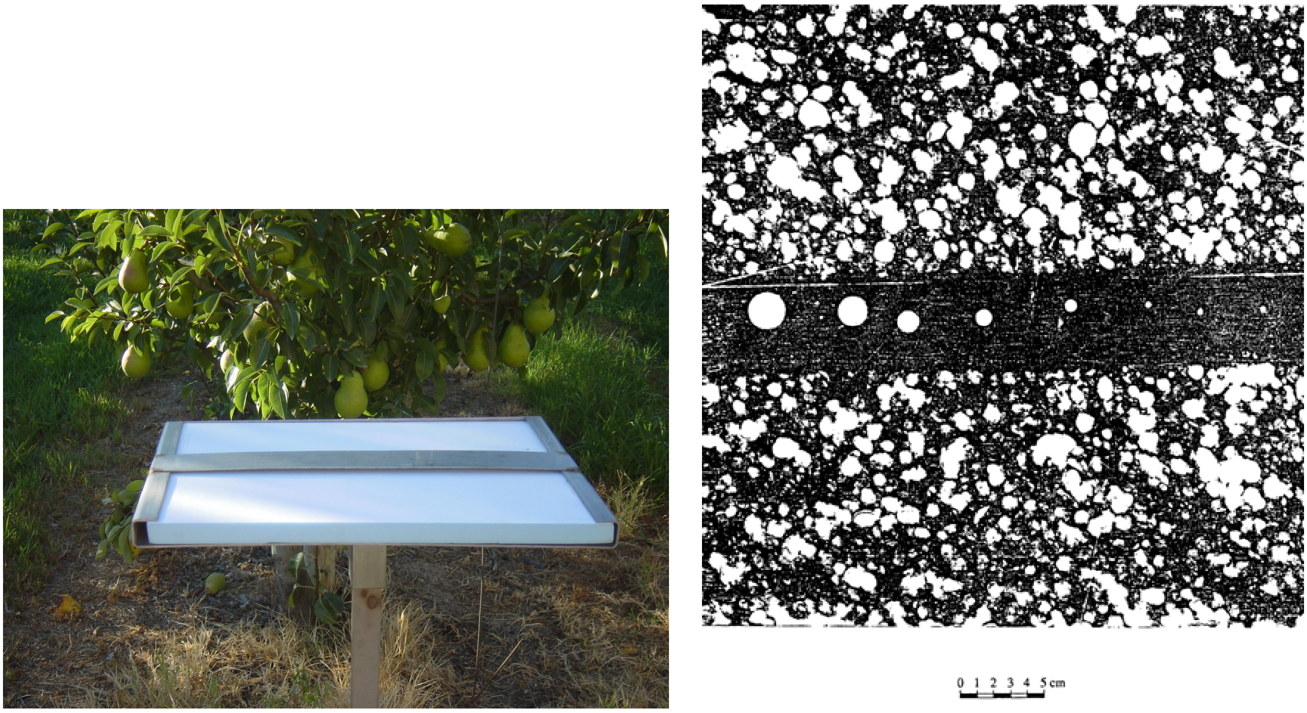

Figure 2. (a) Hailpad used in the ADV-TP. Source: M. Torà. (b) Plate with impacts painted in black, prepared for analysis. The central strip presents the impacts done in laboratory to do the calibration. Source: Atmospheric Physics Group, *Universidad de León*.

until the determination of the affected areas. In section 4 there is a comparative study between the field data and what was measured in the hailpads. In section 5, some indications for improving the information gathering provided by observers are proposed. Finally, the conclusions of the study are presented in section 6.

2 Hailpad network

The data from the hailpad network of the ADV-TP were used to objectively analyze the hailstorm. This section first presents the characteristics of the hailpad network, then analyzes the results obtained and, finally, compares them with the statistics elaborated in the period 1990-2007.

2.1 Characteristics of the hailpad network

A hailpad consists of a 30x40x3 cm polystyrene plate with a layer of white exterior paint to prevent spoilage due to weather and solar radiation (Fraile et al., 1992; Schleusener and Jennings, 2006). This plate is positioned approximately 1.5 m above ground (Figure 2a). A portion of the plate is protected from impacts with an iron strip used to make the calibration. After one episode of hail or graupel, the damaged plates are sent to be analyzed and replaced with new plates. In the case of the ADV-TP, the plates are analyzed in the laboratory of the Atmospheric Physics Group of the *Universidad de León* (University of León). In the laboratory, the impacted plates are painted with black graphic paint (Figure 2b) to facilitate the measurement of the size and depth of the marks. Other parameters, such as diameter, energy, mass, etc, of the graupel or hail are obtained from this operation (Palencia et al., 2007).

In the Lleida plain, the ADV-TP created a network of hailpads with a density of 4 x 4 km. This pattern of a hailpad each 16 km^2 means a total of 170 hailpads distributed in the control area (Figure 3). This hailpad distribution and quantity responds to three criteria (Fraile et al., 1992):

- Average surface affected by hail in the ten years prior to the installation of the network.
- Need to obtain 10 affected hailpads in each significant hailstorm to be able to carry out its study and comparison.
- Network maintenance criteria.

2.2 Analysis of the data from the hailpads in the Pla d'Urgell

This study is focused on the Pla d'Urgell area, where there are 18 hailpads (Figure 3). The figures of several variables are obtained from these hailpads, which let us know the characteristics of the hailstone: diameter, number of impacts per m^2; this refers to the intensity of the hailstorm, mass and energy (Table 2). To estimate the energy (Lozowski and Strong, 1978), the final fall speed of a hailstone is approximated on the basis of its diameter (Fraile et al., 1992).

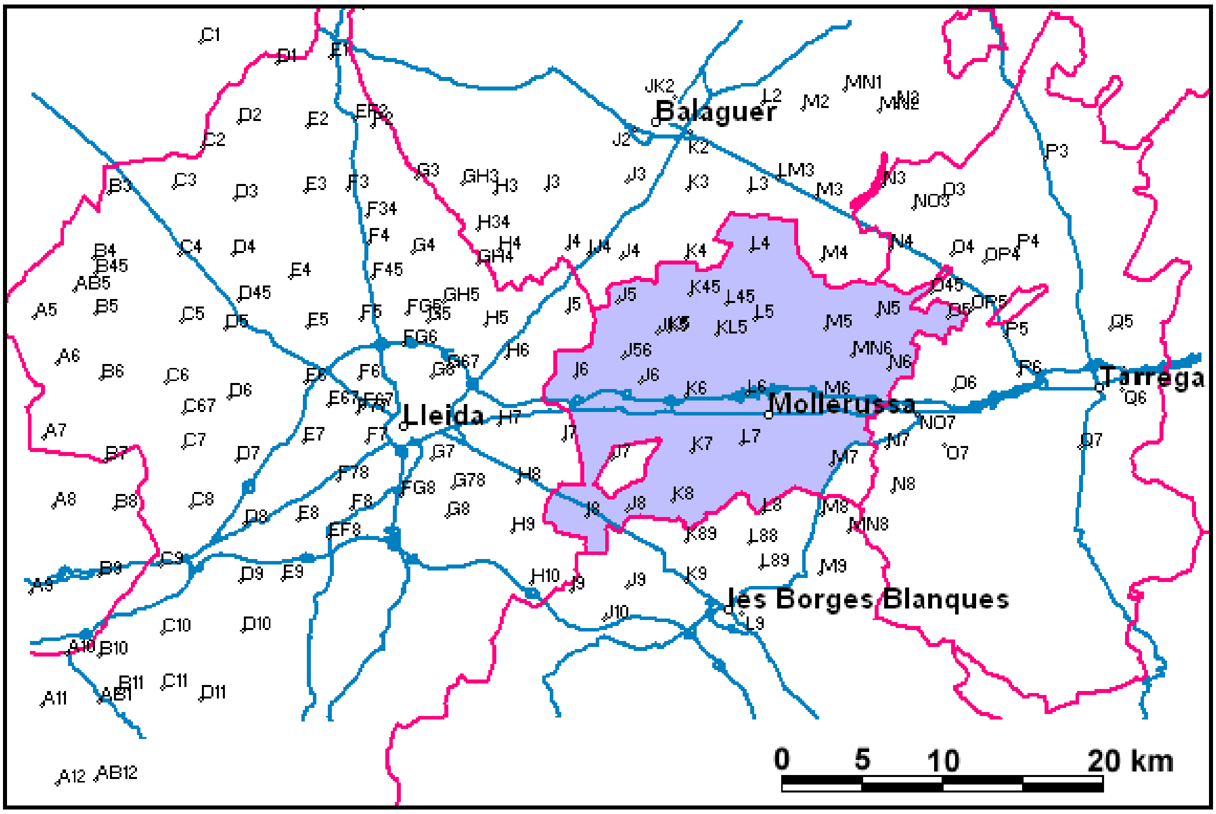

Figure 3. Hailpad network of the ADV-TP: consists in 170 hailpads distributed in the different comarques (administrative divisions) (boundaries in pink) of Segrià (Lleida), La Noguera (Balaguer), Pla d'Urgell (Mollerussa), l'Urgell (Tàrrega) and Les Garrigues (Les Borgues Blanques). The Pla d'Urgell, where 18 hailpads of the network are located, is highlighted in purple. The network of main roads in the area are in blue.

Table 2. Hailpad code, maximum diameter (mm), impacts (number m^{-2}), mass (kg m^{-2}) and energy (J m^{-2}) of the impacts per each hailpad of the Pla d'Urgell.

Code	Maximum diameter (mm)	Average diameter (mm)	Impacts (number m^{-2})	Mass (kg m^{-2})	Energy (J m^{-2})
K7	56.45	14.29	914	4.377	1566.9
K6	52.81	12.15	1581	3.397	946.6
L6	48.86	10.84	1486	2.429	670.3
J7	41.10	11.84	771	1.733	465.4
L7	33.71	11.80	571	1.042	216.2
L5	28.08	10.27	5152	4.015	527.2
N5	25.53	9.83	914	0.683	94.9
J8	21.50	8.97	286	0.198	29.2
J6	20.77	7.90	391	0.143	15.7
M5	20.26	10.71	1762	1.391	164.3
M4	19.17	9.55	4143	2.321	247.4
MN6	18.76	9.11	524	0.283	31.3
I8	18.25	8.18	581	0.245	27.2
J56	16.94	6.84	1133	0.241	20.0
O5	15.86	11.06	67	0.050	5.5
M6	13.41	8.13	152	0.049	4.0
K5	11.14	6.71	219	0.036	2.3
N6	13.56	7.23	314	0.076	6.1
J5	9.76	7.32	67	0.015	1.0

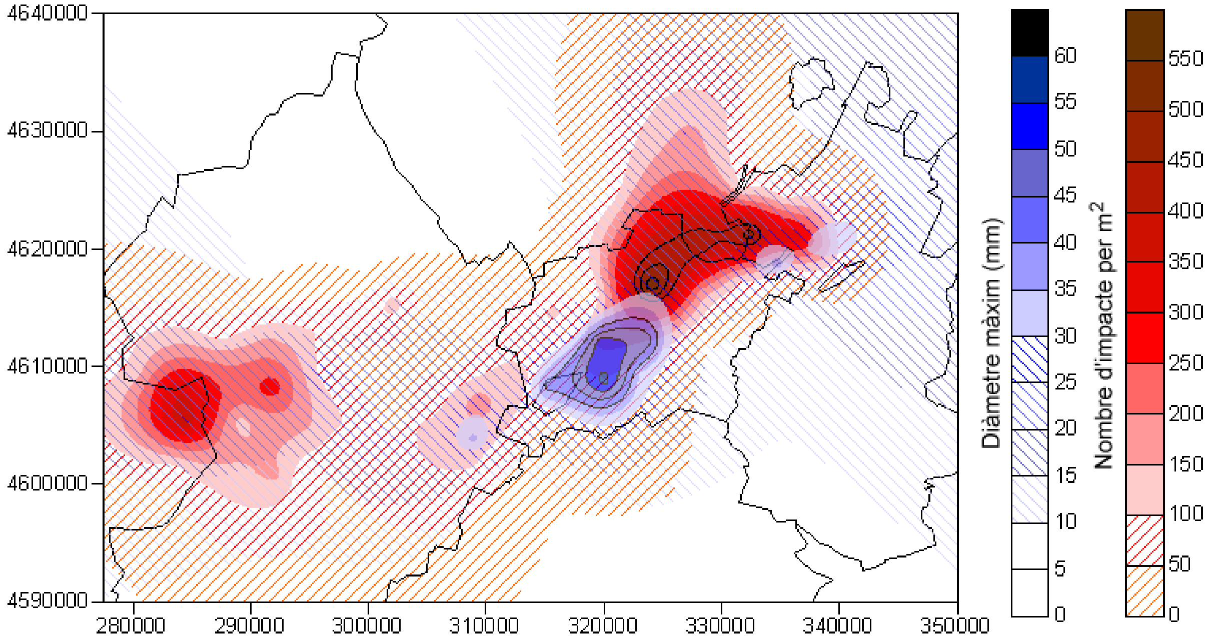

Figure 4. Spatial distribution of the maximum diameter of the graupel (in mm and scale in blue) and the number of impacts per m^2 (scale in red).

Figure 4 shows the distribution of the maximum diameter and the number of impacts in the Pla d'Urgell area. Regarding the maximum diameters, the largest were recorded in the southern region. However, the smallest diameter was recorded in the northwest. Nevertheless, if the distribution of the average diameter is analyzed (not shown), the hailpad with a larger average is located in the northwest. In this area, the hailpad did not register an outstanding maximum diameter but the diameter distribution is around the average values. Regarding intensity, the highest was registered in the hailpad located in the north. In contrast, the lowest values, corresponding to the less affected areas, are recorded in the boundaries of the area, both to the west and to the east. This spatial dissociation between the maximum diameter and intensity is similar to that presented in the work of Fraile et al. (1992) for the area of León and Zamora.

In the spatial distribution of mass and energy (not shown) it was observed that the areas with higher values for these variables corresponded to the locations where higher values were recorded both for maximum diameter and for number of impacts. This is because both mass and energy depend on the diameter and number of impacts.

One factor that has to be taken into consideration when analyzing hailpads is the fact that when large diameters are recorded, the number of small hail impacts are underestimated, since the latter can be covered by those of larger diameter (Dessens et al., 2007). On the other hand, there is also an underestimation in the case of large diameter hailstones, as the probability of impact on the hailpad is very small (Smith and Waldvogel, 1989; Bardsley, 1990; Fraile et al., 1999).

2.3 Climatology of the hailstorms

In the Lleida plain, September is not very affected by hailstorms, as the average of this phenomenon during the period between 1995 and 2007 is one day (the yearly average is 12 days). The month with a higher frequency of hailstorms or graupel storms is May, which has three days, followed by April, with two days. In 2007 there were 17 days of hailstorms: 8 in April, 4 in May and 1 in September.

Generally, hailstorms in September cover a small area, with an average of seven hailpads affected. Until 2007, the maximum number of hailpads impacted in September was 26 (2002). Regarding absolute values, the average of impacted hailpads per hailstorm day was 12, and the maximum of hailpads in a single day was 41, which occurred twice - once on 17 April 2008.

On 17 September, 81 hailpads were affected, which means 30% of the affected hailpads in 2007. Thus, in a single day there were as many hailpads affected as in May and June 2007, which is a sign of the magnitude of the range of the hailstorm. Regarding the size of the hail, in September it is usually small; 70% are cases of graupel. During the day analyzed, the hailstones collected were larger than 5 cm in diameter (Figure 5a).

3 Fieldwork

To complement the information provided by hailpads, it is important to have more information about the meteorological phenomenon, which can be obtained in different ways.

Figure 5. (a) Hailstone of 5 cm in diameter from 17 September 2009. Source: F. Farnell. (b) Expanded polystyrene plates from factory premises in the area. Source: Comolsa, S.A..

Table 3. Degree of impact according to measurement and intensity.

Category	Measure	Intensity	Degree of impact
5	Chicken eggs	High	Very high
4	Cherry to chicken egg	High - very high	High
3	Cherries and walnuts	High	Moderate
2	Chickpeas and hazelnuts	Low	Low
1	Lentils, peas and chickpeas	Low	Very low
0	Not affected	Not affected	Nil

First of all, a network of observers or contributors might be used, that need to be close enough in proximity to cover the whole area of study, as Sánchez et al. (1996) did. If the contributors are not located close enough to each other, data from insurance companies could be used, as they provide information about large hail that provoked damages (Dessens, 1986). If the necessary resources are available, and they are protected by the data privacy law, it is possible to call the people affected by a hailstorm, according to the radar images, in real time (Smith et al., 2006).

Such resources where not available for this work. To get complementary information, we proceeded as follows: (i) The affected area was determined from the meteorological data taken from the media information. (ii) The places to be visited where selected, starting with the most affected and ending with the least damaged. (iii) We set up visits with the affected people via phone. (iv) Finally, the field visit was carried out, with face-to-face interviews with the witnesses.

During those visits, we obtained the description of the events by people who were directly affected: evolution of the storm, kind of precipitation, maximum size of the hailstones, variety of diameters, intensity of the hailstorm, other relevant meteors observed during the hailstorm and damages. Additionally, some material of interest was compiled, such as photographs or material affected by the impacts (Figure 5b).

In all, 11 interviews with affected people were conducted, who provided information about practically the entire region. On the other hand, other visits were made to obtain additional information. This field study was carried out a few days after the hailstorm.

As an example, one of the descriptions given by an interviewed farmer (Miralcamp) is the following: "Very large hail fell near the Range, the size of chicken eggs. At the be-

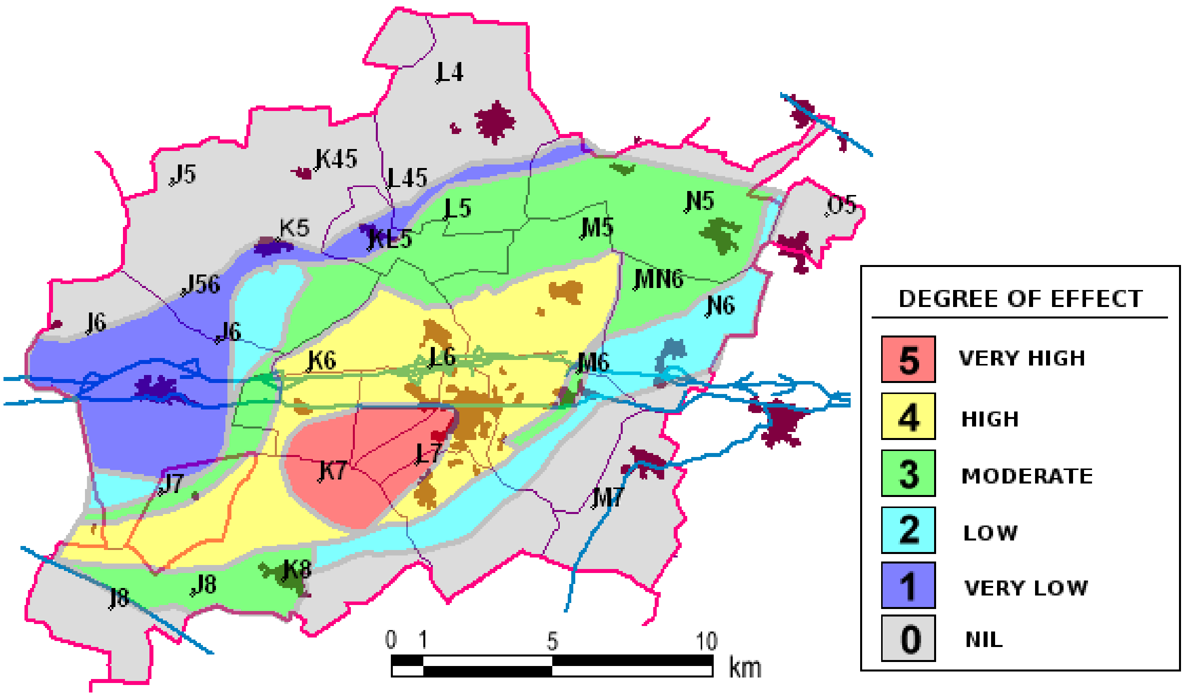

Figure 6. Areas affected by the hailstorm determined by the fieldwork in the Pla d'Urgell area. Code of the area hailpads (Table 1). Municipality boundaries (purple), main roads (blue) and main population centers (brown).

ginning they were dry hailstones, this is to say, without rain. After a few hailstones fell, they were mixed with rain and thanks to that the hail did not hit so hard." And about intensity (el Poal): "There were no damages in town. But a lot of it fell near Sarcènit and with a strong intensity."

Table 3 describes the scale used by the ADV-TP, which incorporates the degree of impact during this episode. Figure 6 shows the spacial distribution of the degrees of impact according to the above-mentioned observations.

4 Comparative study between hailpads and observations

Once the areas were established according to the degree of impact (section 3), a comparison between data from hailpads and observers was performed. To make a comparative study, a diameter for each of the reference objects used by the observers of the ADV-TP network was established.

The comparative study was focused on three variables: the maximum size of the hailstones, the range of diameters recorded and the intensity of the hailstorm. To compare both the data of the maximum size and the range of diameters, it is necessary to know the size of the reference objects used by the observers of the ADV-TP network (see Table 4). To be able to compare the intensity data, the description of the observer was contrasted with the number of impacts recorded in the nearest hailpad (see Annex).

Table 4. Equivalence in mm of the object used to describe the graupel and hail.

Descriptive object	Representative measurement (mm)
Chicken egg	40 - 50
Walnut	30
Cherry	15 - 20
Chickpea	15
Hazelnut	10
Lentil	6
Pea	5
Rice	5

The next step was to make a qualitative assignment of a number from one to three depending on the degree of concordance (1: exact, 2: approximate concordance, 3: low concordance) for the variables of maximum size, range of diameters and intensity. When applying this equivalence, an average number for each analyzed variable and each area was obtained (Table 5). The analysis of these equivalences shows that the maximum degree of concordance between visual observations and hailpads occurs in the area where the degree of impact is low (zone 5) for all variables. Therefore, it is easier for an observer to describe a usual episode (low intensity and small graupel) than to describe an unusual one.

The maximum size is considered as the best variable. In the hardest-hit area, zone 1, some observers reported a

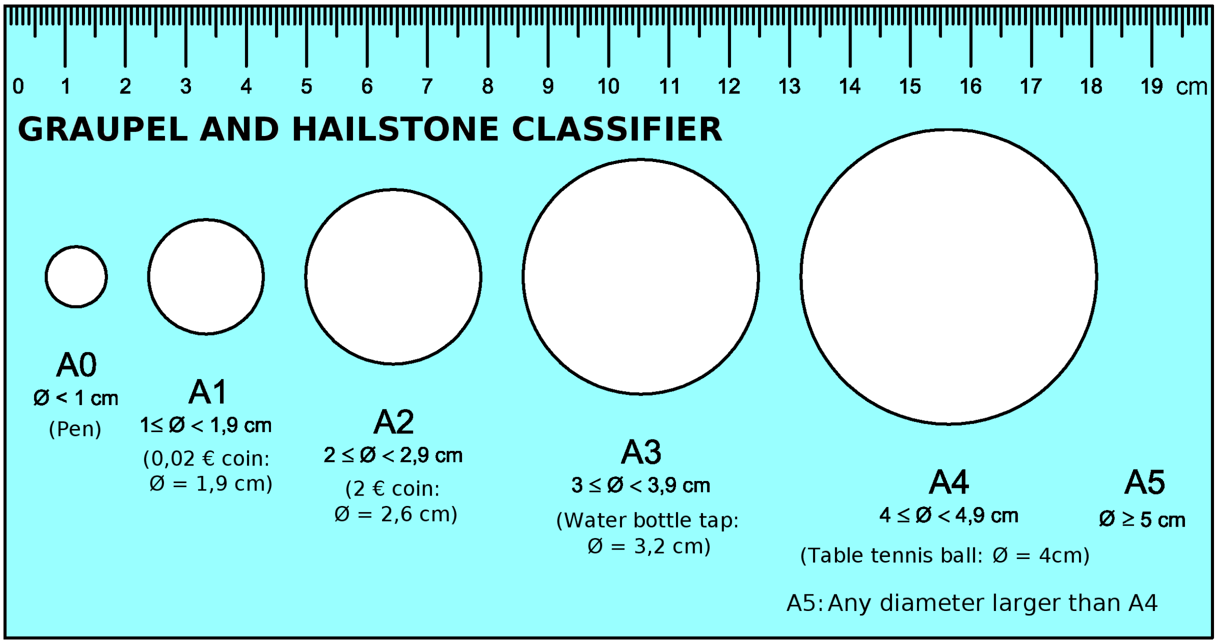

Figure 7. Ruler used to analyze the measurement of the diameter of the graupel and to classify it.

Table 5. Average scoring of the concordance between the description given by the observers and the data from the hailpad per areas. Value 1 indicates maximum concordance.

Variable	Area 1 (red)	Area 2 (yellow)	Area 3 (green)	Area 4 (light blue)	Area 5 (navy blue)	Final average scoring
Maximum average	2	1	1	1	1	1.25
Variety of diameters	3	2	1	3	1	2
Intensity	3	2	2	1	1	2

larger size than that recorded by the hailpad. It may be an exaggeration of the observer, but it also may be the case that the hailpad did not register precisely the largest diameter (Smith and Waldvogel, 1989).

Regarding diameter, it was detected that the observer mainly takes the size of the larger hailstones and tends to ignore the smaller ones. This fact is understandable because the larger hailstones produce larger damages and remain longer on the ground after falling, since the smaller hail melts faster.

Determination of the intensity (number of impacts per m^2) is the weakest point when interpreting the information obtained from observers, as it is the most subjective variable of all, since there are no standard parameters to define it.

5 Recommendations

Following the line opened by Eduard Fontserè about recommendations for rural meteorological observers (Fontserè, 1923) and due to the large amount of existing graphic documentation about this episode, it is necessary to draft a set of instructions to improve the transmission and subsequent interpretation of the information between observer and weather service.

The observer gets information from the consequences of a hailstorm on the crops on a land that they are very familiar with. Starting from this premise, we can work to achieve a more useful and accurate transmission of information, improving key aspects such as images, channels of communication and the description of the phenomenon.

The images are of great importance, as they show visually the characteristics of the hail and the damages produced by it. When making a photograph it is important to bear some characteristics in mind, such as:

- Keeping track of the date, time and location of where the photograph was taken.
- Placing reference objects of universal dimensions to compare the measurements of the hailstones.
- A ruler may also be used. Find a dark background to increase the contrast.
- If possible, take a general picture of the situation before and after the storm, with the direction of the lens indicated.

Table 6. Classification of the hailstones depending on the diameter, reference objects or consequences according to the ANELFA scale (Dessens et al., 2007). Each category has to be complemented with a + or - sign depending on whether the ground is significantly covered by graupel/hail more than 50% or less than 50%.

Category	Maximum diameter of the hailstones (cm)	Reference object	Typical associated consequences
A0	<1	Pea	Trees are left without flowers. Traffic accidents.
A1	1 - 1.9	Grapes, bullet, cherry	Vines, fruit trees and tobacco plants are affected.
A2	2 - 2.9	Pigeon's egg	Serious damages to cereals, vegetables and trees.
A3	3 - 3.9	Walnuts, table-tennis ball	Full damages in all crops, broken windows and damaged cars.
A4	4 - 4.9	Hen's egg, golf ball	Winter landsacape, dead animals, hurt people, damages to airplanes.
A5	≥5	Orange, peach, apple, tennis ball	Extremely dangerous event, unsheltered people die.

Table 7. Proposed scale in this study using reference objects. Each category has to be complemented with a + or - sign depending on whether the ground is significantly covered by graupel/hail more than 50% or less than 50%.

Category	Maximum diameter of the hailstones (cm)	Reference object
A0	<1	Standard pen base (BIC)
A1	1 - 1.9	0.02€ coin (1.875 cm)
A2	2 - 2.9	2€ coin (2.575 cm)
A3	3 - 3.9	Water bottle cap (plastic)
A4	4 - 4.9	Table-tennis ball (4.267 cm)
A5	≥5	Tennis ball (between 6.5 and 6.858 cm)

Reception of information from contributors in the weather services should be carried out in a more unified and standardized way. It is necessary to announce the established channel and work towards a deft, efficient and easy communication.

Related to description, as mentioned earlier, the observer usually provides the size of the largest hailstones, but it would be very useful if he or she could also provide information about the existence of hailstones of smaller sizes.

The key to a good description of the graupel and hailstones lies in the use of a classification system that is as simple and objective as possible. Today, three scales are mainly used for its classification: the Torro scale (Webb and Meaden, 1986), the GSC scale (Moisselin and Guillande, 2004) and the ANELFA scale (Dessens et al., 2007).

In this study we decided to use the ANELFA scale (Table 6), as it is also used by the ADV-TP. In it the class category is determined by the total value of the largest diameter size of the hailstone, measured in cm. In the case this measurement is not available, the class is determined from its equivalence to objects such as peas, grapes, pigeon's eggs, walnuts, chicken eggs and oranges, and the damages provoked. Finally, as in the Fujita scale (1971), the consequences and gravity of the damages are used to catalogue the hail.

Nevertheless, this scale is based on a certain degree of subjectivity, since there are different sizes of chicken eggs and grapes. To get a description that is as objective as possible, it is necessary to use reference objects of known and universal size, such as euro coins, table-tennis balls or tennis balls.

For this reason, an adaptation of the ANELFA scale with the standard correspondences with universal common objects is proposed (Table 7).

Finally, we propose providing contributors with a ruler in order to easily categorize the hailstones observed (Figure 7).

6 Conclusions

In the case of the storm that affected the Pla d'Urgell on 17 September 2007, it appears that the southwest wind in mid levels favored the shifting of the storm in that direction. The degree of effect was small when following the storm movement both right and left. Instead, the central area was more affected and was oriented from southwest to northeast. Furthermore, in the south there were impacts of higher diameter registered and in the north the intensity was higher but the hailstones were smaller in diameter.

From the comparative study we can draw that observers tend to perceive the larger hailstones rather than the smaller graupel or hailstones even if there is a larger number of the latter. However, hailpads underestimate the number of the impacts with a larger diameter. Besides, there are obvious gaps in hailpad detection of the hailstones of a very large diameter, due to the low probability of impacting on the plate or an underestimation of the number of small impacts because they are disguised by those with a larger diameter.

There is a need to standardize the data provided by observers in order to be able to properly analyze the scope of the episode and to process them together with the data obtained from hailpads. Both sources of information are complementary. For this purpose, a classification scale for graupel and hailstones in six categories, following the ANELFA scale (Dessens et al., 2007) but with equivalences with known and universal objects is proposed. The use of a ruler with the reference diameters for each category of the ANELFA scale is also proposed.

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Appendix A

The information used to carry out the comparative study, between the information obtained from the observers and the hailpads closest to the affected area is presented in the annex.

Table A1 has been elaborated to provide an overview of all the information. This table shows the following information:

- Number of the area. Degree of impact defined in Table 3 of the article.
- Municipality. Municipality of the affected area described by the observer.
- Data from the observer: type of hailstones, size, intensity, other observed phenomena, photographs, comparison with other objects and if the hailstones have been measured or not.
- Data from the hailpad. Bar chart that represents the number of impacts depending on the diameter of the graupel/hail registered in the hailpad closest to the observation point. On the chart the maximum diameter described by the observer is pointed out in red (Figure A1).
- Degree of concordance. Description of similarity of each variable: maximum size, variety of diameters and intensity of the information obtained from the hailpad and from the observer.

Table A1. Comparative study between the data from the observers and the hailpads.

Zone number	Municipality	Data from the observer							Degree of concordance		
		Type of hailstone	Size	Intensity	Other phenomena	Photo	Comparison with other objetcs	Is the size of the hailstone measured?	Maximum size	Variety of diameters registered by the hailpads	Intensity
1	Miralcamp	1st dry hailstone and later mixed with water. Hard hailstone.	Very big, like chicken eggs	High	-	Yes	No	No	Good. It was the area where a larger quantity of large sized hailstones were registered.	Bad. The observer mentions only one size.	Bad, as the number of impacts was too high.
1	Mollerussa	-	Very big, like chicken eggs	High	-	No	-	-	Bad, as the observer registered hailstones the size of chicken eggs and the hailpad showed a diameter of 33-34 mm.	Bad. The observer mentions only one size.	Bad, as the number of impacts was too high.
2	Sidamon	-	Between cherry and walnut, and some chicken eggs	High	A lot of wind	No	-	-	Good	Quite good, although there were some hailstones of a smaller size than mentioned by the observer.	Good, as it was highlighted by register in the hailpad.
2	El Palau d'Anglesola	Hard	From walnuts to chicken eggs	High	Tere was a lot of wind and even some eddies	Yes	Yes	Yes	Good (there is a discordance of only 5 mm between the described size and the registered size).	Improvable, although the observer mentions quite a wide range, he or she does not observe smaller sizes.	Bad
3	El Poal	Hard	Hazelnut or cherry	Very high	-	Yes	No	No	Good	Good, although there also were smaller hailstones.	Good
3	Ivars d'Urgell	-	Until plain walnut	High	-	Yes	Yes	Yes size).	Good (there is a discordance of only 5 mm between the described size and the registered	Good	Bad
4	Castellnou de Seana	-	Chickpea	Low	-	No	-	-	Good	Bad, since he or she did not mention smaller sizes.	Good
5	Bellvis	-	Pea	Very low	-	No	-	-	Good (there is a discordance of only 5 mm between the described size and the registered size).	Good, given the short width of sizes provided.	Good

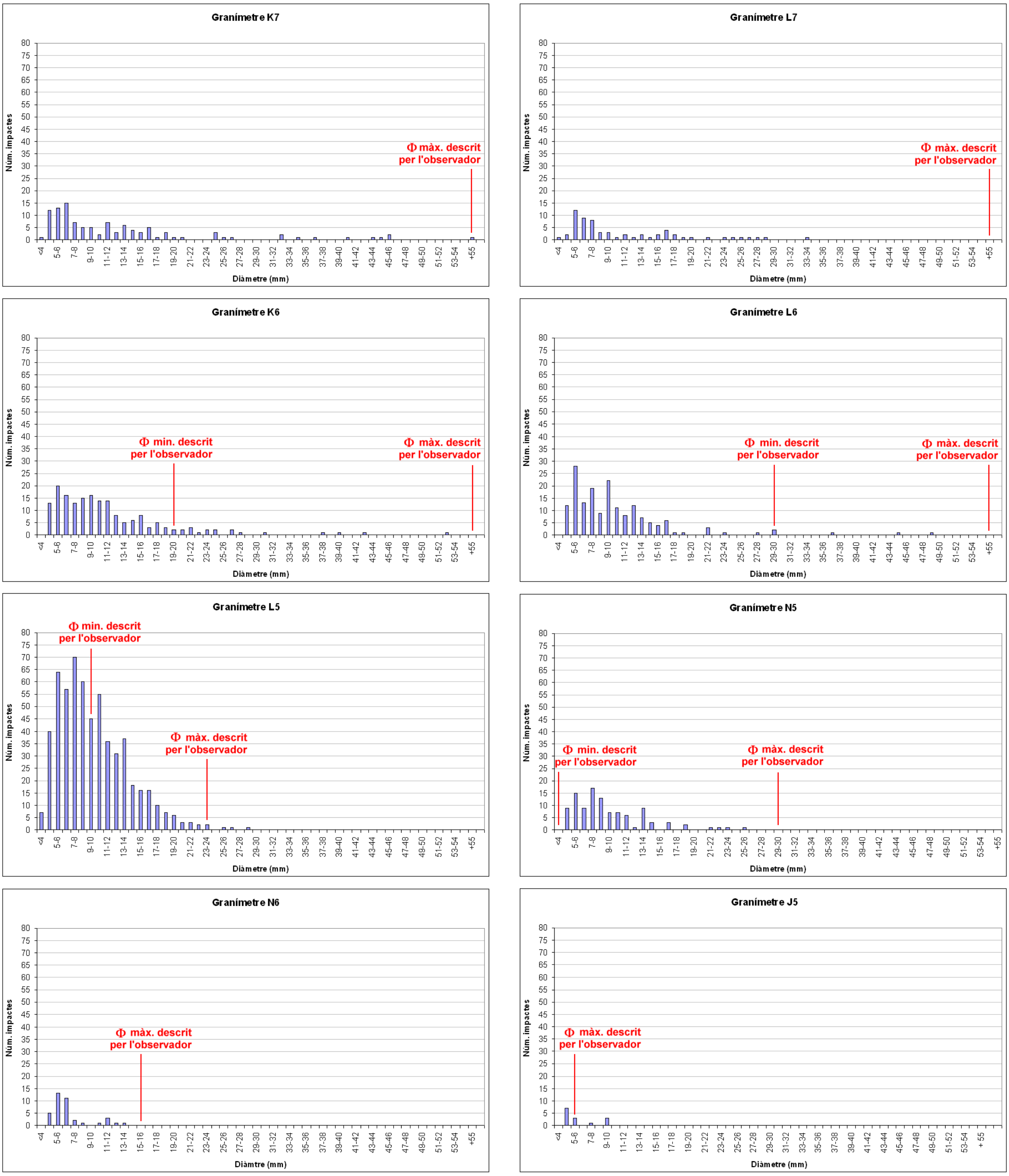

Figure A1. Hailpad data from different municipalities: (a) (1^{st} left) Miralcamp, (b) (1^{st} right) Mollerussa, (c) (2^{nd} left) Sidamon, (d) (2^{nd} right) El Palau d'Anglesola, (e) (3^{rd} left) El Poal, (f) (3^{rd} right) Ivars d'Urgell, (g) (4^{th} left) Castellnou de Seana and (h) (4^{th} right) Bellvis. These bar charts represent the number of impacts depending on the diameter of the graupel/hailstone registered by the hailpad closest to the observation point. On the chart the maximum diameter described by the observer is shown in red.

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