The major hail days of 1988-2010 in Southwestern France

C. Berthet[1] , J. Dessens[1], JL. Sanchez[2]
[1]*Anelfa, 52 rue Alfred Duméril, 31400 Toulouse, France*
[2]*Laboratory of Atmospheric Physic,IMA. University of León, 24071 León, Spain*
(Dated: 26 August 2011)

I. INTRODUCTION

In every country of the world where hail may damage crops and property, severe hailfalls are concentrated over a very few days during each thunderstorm season. In order to improve the forecast and the prevention of hail in these situations, it is useful to know the meteorological conditions which have favoured them in the past.

Until now, a major hail day in a region was just a day with strong hailfalls on precious crops or larges cities. This fact may introduce a bias in the analysis of the meteorological conditions leading to severe hail, some hail days being possibly outclassed by hailfalls occurring in vulnerable areas, and other more or less occulted. The situation is now different in countries where hailpad networks have been set up, as it is the case in France where the Association Nationale d'Etude et de Lutte contre les Fléaux Atmosphériques (ANELFA) has developed hailpad networks in relation with its hail prevention program.

The purpose of the present paper is to compute the main daily hail parameters measured during the 1988-2010 period in the two best documented regions of Southwestern France, then to rank the days by hail frequency and intensity, and finally to examine the environmental conditions for the major days compared to the ordinary ones.

II. HAIL DAY CLASSIFICATION

The ANELFA hailpad system has been described in several papers, most of them referenced in Berthet et al. (2011). The hailpad networks were developed from 1988 in two areas of Southwestern France along the Atlantic and the Pyrenees, then, some years later, in the Central and Mediterranean basins. The hail climatology proposed in Berthet et al. (2011) is based on the examination of the yearly and monthly values, in each region, of three parameters: the point hailfall frequency, F, the mean kinetic energy per hailfall, Eh, and the mean kinetic energy per station, Es. When the daily values of these parameters are examined, it appears that the data samples in the Central and Mediterranean regions are not sufficiently representative for a day time scale study during the first part of the period, due to a slow development of the networks. For this reason, this paper only examines the data in the two Southwestern areas (Fig. 1). From the results presented in Berthet et al. (2011), the two areas were not combined, because their hail climatology is rather different, which will be confirmed by the present study.

The results presented in this paper are then relative to the following areas and parameters:

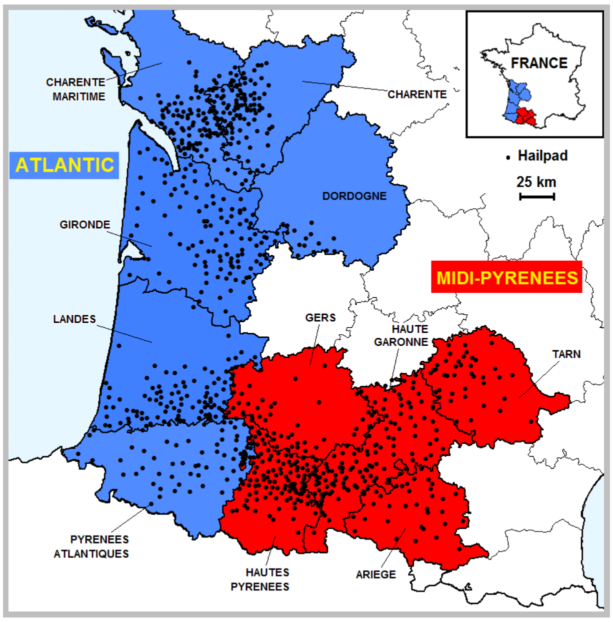

Fig.1: Regions under study, with hailpad locations.

Atlantic area: 31,000 km², 1988-2011, 473 stations (mean annual number), 483 hail days (at least one hailpad impacted), 1972 hailfalls.

Midi-Pyrenees: 20,000 km², 1988-2011, 299 stations, 582 hail days, 2885 hailfalls.

Fd (%), daily frequency:
(100 x number of hailfalls) / (number of stations).

Eh (J/m²), mean daily intensity:
(total kinetic energy) / (number of hailfalls).

Es (J/m²), mean daily amount:
(total kinetic energy) / (number of stations).

The three parameters are not independent since Es = (Fd x Eh) / 100. Table 1 gives the day-by-day correlations of these parameters in the two regions.

	Fd and Eh	Fd ans Es	Eh and Es
Atlantic	0.20	0.77	0.51
Midi-Pyrenees	0.31	0.83	0.51

Table 1: Day-by-day correlation coefficients between hailfall parameters.

In order to focus on the major days, Fig. 2 ranks the days with Fd > 2% (upper curve), with Eh > 50 J/m² (middle curve), and with Es > 1 J/m² (lower curve). The pyramids give the rank for the Atlantic region (western area, left curve) and for Midi-Pyrenees (eastern area, right curve). The figure also gives the dates of the outliers in the three categories, and the number of hailfalls measured on these days. The asymmetry observed between the curves relative to each parameter confirms that hail is more frequent and more severe in Midi-Pyrenees (Berthet et al. 2011).

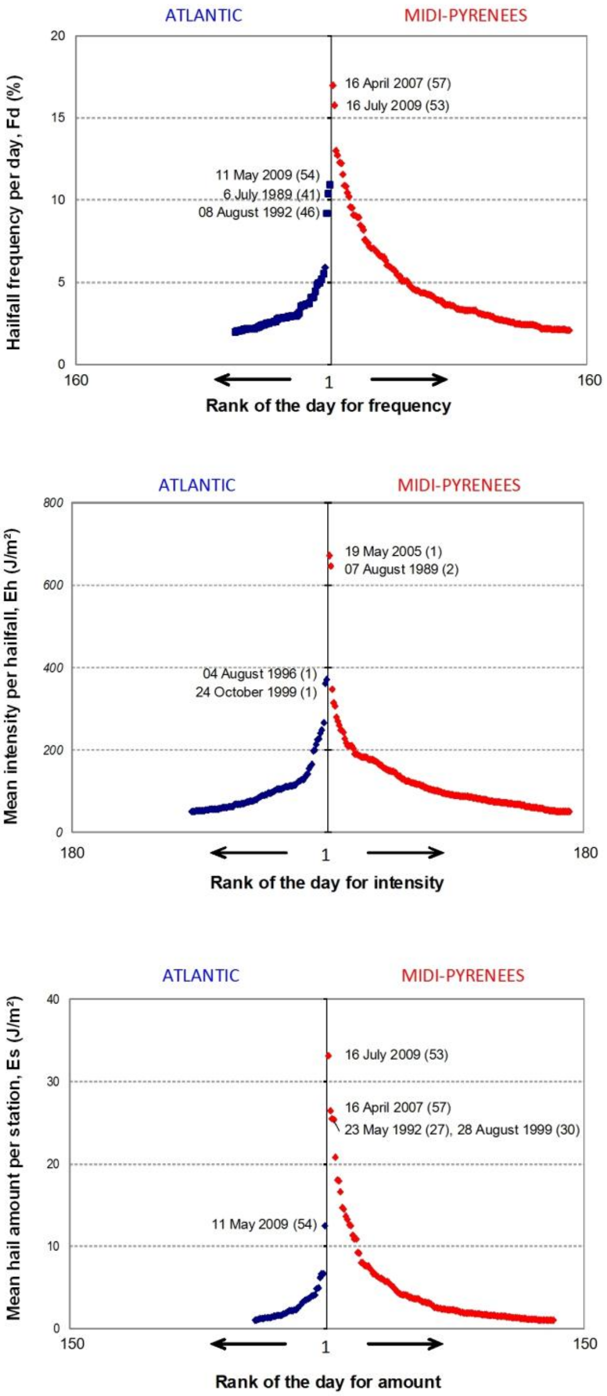

Fig. 2. hail days by region ranked by frequency Fd, energy per hailfall Eh (intensity), and energy per station, Es (amount).

The Fd and Es outlier days have three dates in common, a consequence of the high correlations between these two parameters (Table 1). Moreover, it must be noticed that the Eh top days have received only one or two hailfalls, which may reduce the significance of the ranking with this parameter.

In the next section, the meteorological conditions relative to the major days for each parameter in the two regions will be summarized. Details concerning these situations can be found in the referenced ANELFA annual reports.

III. MAJOR DAY METEOROLOGICAL CONDITIONS

Data are in blue for the Atlantic major days and in red for the Midi-Pyrenees ones. After a general description, three atmospheric characteristics computed from the radiosounding data at Bordeaux, Zaragoza or Nîmes (depending on the mean upper flow) are given for each day: the 0°C level altitude, H0°C (km), the wind velocity at the 600 hPa level, V600 (m/s), and the maximum wind velocity in the troposphere, Vmax (m/s).

a. Daily frequency, Fd

- 11 May 2009. This is a typical situation with a low on Portugal and a rapid SSW flow on the south Atlantic coast (ANELFA N° 58, 56-58). A detailed study of this major case is available on the Keraunos web site (Dumas 2010). Seven supercells travelled through the area.
  H0°C = 3.0 km, V600 = 17.0 m/s, Vmax = 38.0 m/s.

- 6 July 1989. This classical case is similar to the previous one, but in an air mass of Saharan origin with a high desert dust concentration. Two long-lived supercells travelled in parallel at 60-75 km/h (ANELFA N° 38, 36-37).
  H0°C = 4.2 km, V600 = 22.1 m/s, Vmax = 44.2 m/s

- 8 August 1992. A cold front associated to a secondary low produces in the afternoon at least 4 supercells. A Saharan dust outbreak was observed during the previous night (ANELFA N° 41, 50).
  H0°C = 4.2 km, V600 = 20.6 m/s, Vmax = 36.0 m/s.

- 16 April 2007. This is the most atypical case of the study for two reasons. First, the meteorological situation is what the meteorologists from the Toulouse region call an "east return" (related to a through on the Mediterranean sea), often producing much rain or snow, but not hail. Second, the hail generating supercell occurred by night, between 0 to 5TU, and travelled from east to west on a distance of 250 km (ANELFA N° 56, 52-53).
  H0°C = 2.9 km, V600 = 9.0 m/s, Vmax = 30.3 m/s

- 16 July 2009. A cold front progressing in the late afternoon in an exceptionally warm air mass (36°C or more) produces many cells, one developing as a supercell along the Pyrenees (ANELFA N° 58, 66-67).
  H0°C = 4.0 km, V600 = 16.4 m/s, Vmax = 44.2 m/s.

b. Energy per hailfall, Eh

When going back to the original data, the 3 outliers with one hailpad impacted are found not to be representative of serious situations (two of them being perhaps data errors). Only one case is a major hail day well highlighted by the ranking:

- 7 August 1989. A violent hail and wind producing supercell travelled at 60 km/h on a 180 km path through the Atlantic and Midi-Pyrenees areas, but only two hailpads were impacted, one of them with an exceptional intensity (Blagnac, 1230 J/m²). This supercell was associated to an ordinary cold front and a strong jet stream (ANELFA N° 38, 38-39).
  H0°C = 3.0 km, V600 = 20.6 m/s, Vmax = 48.0 m/s.

c. Energy per station, Es

- 11 May 2009. See case N° 1 for Fd, Atlantic.
- 16 July 2009. See case N° 2 for Fd, Midi-Pyrenees.
- 16 April 2007. See case N° 1 for Fd, Midi-Pyrenees.
- 23 May 1992. Several ordinary storms are observed in a general southern flux, but one evolved as a supercell producing hailstones larger than 4 cm diameter (ANELFA N° 41, 26-27 and 39).
  H0°C = 2.8 km, V600 = 12.8 m/s, Vmax = 21.1 m/s
- 28 August 1999. A mesocyclonic convective system developed in the morning on the Pays Basque, then rapidly moved to the Midi-Pyrenees region and produced 3 intense supercells in the late morning and the early afternoon, which is a rare situation (ANELFA N° 48, 35-36).
  H0°C = 3.6 km, V600 = 13.9 m/s, Vmax = 20.8 m/s.

IV. COMMENTS AND SUMMARY

In this study made at the time scale of the day, the processing of a 23-year data sample in two regions of Southwestern France highlights some major days with mean hailfall parameters far above their other daily values. These events deserve a special attention in order to better understand the hail formation processes, and to improve the forecast.

As expected, all the hail days emerging from the classification have in common the observation of one or several supercells. In the Atlantic area, the big hail day of the period is 11 May 2009, and this extreme supercell situation (7 supercells in the afternoon) has been the subject of a model forecast which partially explains the exceptionality of this day. In the Midi-Pyrenees region, two days are put forward by the classification: 16 April 2007, a very atypical situation with a night supercell storm moving in the direction opposite to the regular one, and 16 July 2009, a more classical one for the region.

A reanalysis like that presented by Dumas (2010) for 11 May 2009 needs to be made for all the major events, as well as a comparison with the atmospheric patterns corresponding to the main hailstorm days in the Ebro Valley, Spain, just on the other side of the Pyrenees (Garcia-Ortega et al. 2011). For now, this preliminary study is a little disappointing because neither the synoptical situations nor the local conditions appear to be very different for these major days. In the Atlantic region, 2 major hail days on a total of 4 occurred during a Saharan dust outbreak, and again, the question arises of whether thermodynamics is sufficient to explain strong hail formation, or whether the atmospheric aerosol content plays a major role.

The mean hail amount per station, Es, is the most representative parameter for most of the economic purposes. It may be noticed that the 3 record days for this parameter occurred in 2009, but apart from this remark, nothing special reinforces the hypothesis of a global warming effect.

A last remark concerns the hail prevention project by silver iodide ground seeding in the two studied areas. The most recent evaluation of this project indicates a 48% reduction in hail kinetic energy when the seeding is correctly made in time and quantity (Dessens et al. 2009). The main daily values of Es for the major days show that, even with such an important decrease in this parameter, the major days still remain damaging hail days.

V. REFERENCES

Berthet C., Dessens J., Sanchez J.L., 2011: Regional and yearly variations of hail frequency and intensity in France. *Atmos. Res.*, 100, 391-400.

Dessens J., Berthet C., Sanchez J.L., 2009: Seeding optimization for hail prevention with ground generators. *J. Weather Modif.*, 41, 104-111.

Dumas D., 2010: L’épisode supercellulaire du 11 mai 2009: Apports et limites du modèle WRF à haute résolution en situation convective extrême. http://www.keraunos.org/recherche_etude_episode_supercellulaire_11_mai_2009.pdf, 29 p.

Garcia-Ortega E., Lopez L., Sanchez J.L., 2011: Atmospheric patterns associated with hailstorm days in the Ebro Valley, Spain. *Atmos. Res.*, 100, 401-427.