YEARLY FLUCTUATION OF HAIL PRECIPITATION IN FRANCE

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I. INTRODUCTION

Former studies on long-term fluctuations of hail in different countries in the world are based on subjective observations of hailfalls and on crop damage insurance data (Genève, 1961; Changnon, 1977; Xie et al., 2008). It is only a few decades ago that physical data became available, with the development of hailpads and other measuring systems. Unfortunately, most of the field projects involving hailpads have not lasted long enough to constitute consequent data series. In order to control its hail prevention project with silver iodide ground generators, the Association Nationale d'Etude et de Lutte contre les Fléaux Atmosphériques (ANELFA) has installed hailpad networks in four of the most hailed regions of France. This paper presents a first survey of the data collected during 21 years of continuous measurements.

II. HAILPAD DATA

At each hailpad station, during a hailfall, the hailstones impact a polystyrene plate which is processed semi-automatically (Dessens et al., 2001). The networks are displayed in 4 main areas: Atlantic (31,000 km²), Pyrenean (20,000 km²), Central (7,000 km²) and Mediterranean (8,500 km²). These networks have been in operation since 1988, 1988, 1990 and 1994 respectively (Dessens et al., 2007). The first two networks are much more developed than the other two, so that their data allow the examination of the yearly fluctuations, while in the Central and Mediterranean areas, only the mean values of the hailfall characteristics can be considered for now. During the 21 years of the 1988-2008 measurement period, the total point hailfall number in the four networks is 4,975 for a yearly mean value of 915 hailpad stations.

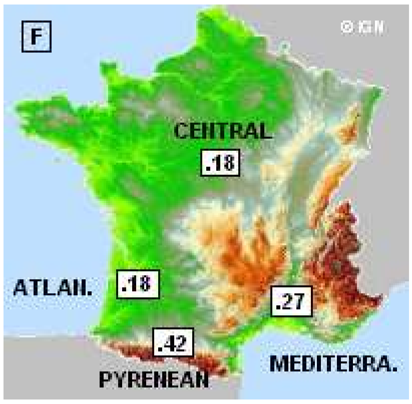
In this paper, the total kinetic energy of the hailstones larger than 0.5 cm of a point hailfall will be the parameter under study, but the results do not change significantly when the mass is considered instead of the kinetic energy.

III. REGIONAL VARIATIONS

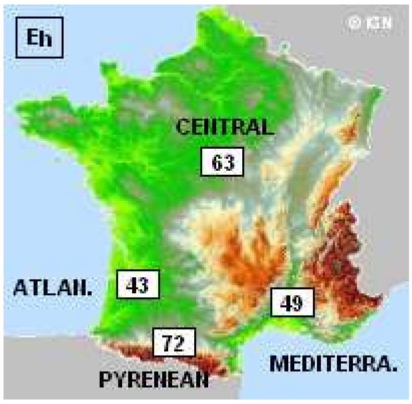
In order to examine the spatial variations of hail, the following parameters are examined for each hail season:

- frequency, F
  F = number of impacted pads / number of stations,
- energy per hailfall, Eh
  Eh = total energy of the year / number of impacted pads,
- energy per station, Es
  Es = total energy of the year / number of stations

The mean values of the yearly parameters are given on FIG.1 for the various regions.



F→ Frequency per station, per year.



Eh (J.m^{-2}) → Energy per hailfall.

Es (J.m^{-2}) → Energy per station, per year.

FIG.1: Mean regional values of F, Eh and Es in France.

The frequency has its highest values near the Pyrenees (mountain range effect and proximity of the summer Iberian low). The energy per hailfall is maximum in the same region, but it is also high in the central area. The spatial variations of Eh confirm that continental storms are more intense than maritime ones, probably due to differences in convection intensity and in atmospheric nuclei content. The variations of the third parameter, Es = F x Eh, is evidently also maximum in the Pyrenean region.

IV. YEARLY FLUCTUATIONS

Yearly values of F and Eh for the whole of France can be estimated by combining the four areas together (FIG.2). F and Eh have a very poor year-to-year correlation (coefficient r = 0.14), which means that, when there are more storms, they are not necessary more severe.

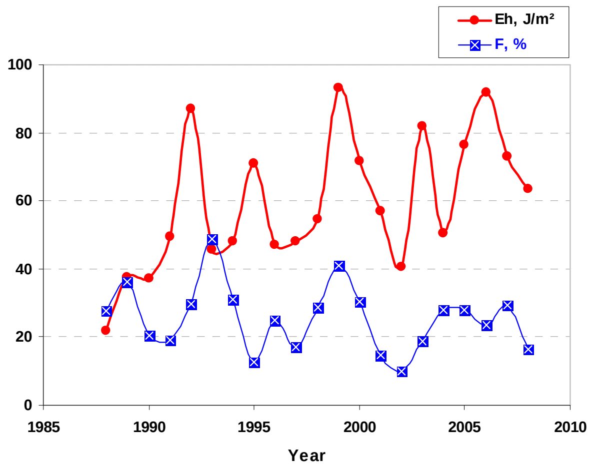


FIG.2: Yearly variations of hail frequency, F, and hailfall energy, Eh, in France

The yearly variations of F shown on FIG.2 suggest that, for the frequency, hail years are more or less organized in a succession of three years with high values followed by three years of low values. With this series of 21 years, it is only possible to have a first look at the autocorrelations between successive years. For the two parameters, the correlations are negative (significant at the 0.5 level) for the pairs (year, year + 3), and negative (significant at the 0.1 level) for the pairs (year, year + 6). One can then suggest that there may be a 6 year periodicity in the frequency of hailfalls in France. Many more years and physical support are necessary to confirm this observation already suggested by insurance data.

Moreover, it is of interest to notice that the yearly values of F are well correlated with the loss-to-risk ratio, R, of the insurance data published by the “Association Internationale des Assureurs Grêle” (AIAG, Zurich). For the 19 years of the 1988-2006 period, the correlation coefficient is r = 0.74, corresponding to a 0.01 significance level. The correlation of R with F is lower, which means that for the insurance companies the number of hailfalls is more important then their intensity.

V. CONCLUSION

With this first 21-year series of continuous measurements in several hailed regions, a physical climatology of hail is developing in France. Some interesting preliminary results are already suggested, like the effect of the air mass origin on the hail intensity or the hail frequency oscillations. A good knowledge of hail climatology would be of interest for the severe storm scientific community, for the insurance industry, and for the general public. Our first results, and the hypothesis that severe convective phenomena may increase in the future, should initiate the organization of a European hailpad network under the ESSL coordination.

VI. REFERENCES

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