MINIMUM TEMPERATURE AS AN INDICATOR OF HAILSTORM SEVERITY IN A SCENARIO OF GLOBAL CLIMATE CHANGE

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I. INTRODUCTION

Hailstorms lead to substantial damage in numerous areas of the world. Nevertheless, the limited spatial extension of this type of precipitation, its ephemeral character, and the difficulty in obtaining measurements, limit the availability of ample data bases. Due to the importance of these events as severe atmospheric phenomena, it is important to be able to determine how Global Climate Change can affect the intensity and frequency of these events.

In order to solve the problem of the lack of databases, information about hail fall estimates gathered by agriculture insurance companies and informers are usually used. In diverse studies, this information has been used to characterize not only the events, but also their seasonal evolution (Vinet, 2001; Dessens, 1995). The problem with employing this type of data is that in some instances the information is partial and incomplete.

Another available method for the characterization of hailstorms is the use of hailpads, which give information that is exact and objective. In the last few years, tools have been developed that allow us to identify severe phenomena via teledetection (Llasat, et al., 2003).

II. PRESENTATION OF RESEARCH

The objective of this study is to determine the existence of relationships between characteristics of hail fall and meteorological parameters that are easily available, which can be used to predict the future evolution of hailstorms.

For this study, data was used from hailpad networks in three regions with high frequency of hailstorms: the Ebro Valley in Spain, the Atlantic Area of France, and Mendoza in Argentina. Each hail event was characterized objectively using hailpads, and obtaining a high number of variables (TABLE I).

Similarly, for each of the areas of study, and for each of the hail events shown, the following temperature values were calculated: maximum daily temperature, minimum nighttime temperature for the night before a hailstorm, average daily temperature, and the temperature at dew point. From this data, we evaluated the capacity of these different temperatures to predict some of the parameters that are characteristic of the intensity of hail fall. In order to do so, we obtained correlations between the temperatures and parameters that characterize hail fall and applied the Pearson test.

Variable	Acronym
Number of plates impacted	Placas
Number ot total impacts	N_total
Total hail mass	M_total
Total kinetic energy	E_total
Average number of impacts	N_med
Average hail mass	M_med
Average kinetic energy	E_med
Average hail diameter	D_med
Maximum number of impacts	N_máx
Maximum ice mass	M_máx
Maximum kinetic energy	E_máx
Maximum diameter	D_máx

TABLE I: Parameters that characterize hail.

III. RESULTS AND CONCLUSIONS

The analysis of results shows significant Pearson correlations between some of the hailpad variables and meteorological variables. These correlations are greater when larger databases are available, such as in the case of France and the Ebro Valley.

The results show that the minimum nocturnal temperature emerges as the greatest indicator of hail characteristics, since it is a temperature that presents the greatest number of correlations, and with a greater significance.

If we focus on the minimum temperature, the variable that presents the greatest correlation is the D_max registered in each event. In FIG. 1, we see the distribution of D_max in relation to the minimum temperature in the case of Bordeaux (France). Despite the dispersion that applies in some cases, a clear positive correlation is observed, and, as such, warmer nights would correspond with a greater diameter of hail precipitation.

With these results, a hypothetical future increase in minimum temperature of 1ºC would produce an increase of 1.3 mm in D_max in the case of Bordeaux (FIG. 1), which show similar results to those found in the Ebro Valley.

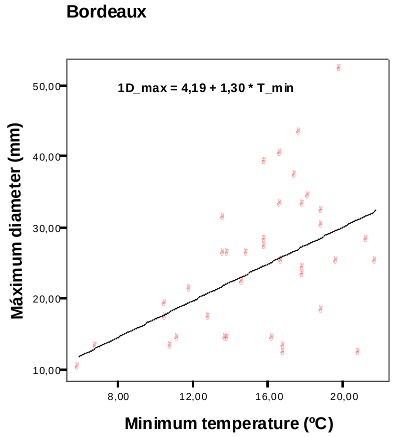

FIG. 1: Correlations between maximum diameter and minimum temperature.

As a meteorological interpretation of these results, it should be noted that the minimum temperature characterizes the atmospheric boundary layer at night, in such a way that it reaches the saturation point. So, nights with an elevated nighttime temperature would present a greater dewpoint temperature during the following daytime hours and as such, greater specific humidity (Sánchez et al., 2008).

Similarly, we know that the minimum nighttime temperature influences the convective inhibition that is produced during the day, in a way that if it is elevated, the convective inhibition will be reduced to the first hours of the morning. For these reasons, the minimum temperature presents adequate characteristics to place oneself as a good predictor of convection severity.

Thus, we should point out that, although by itself, the total variability registered in the hailstone diameter database cannot be explained, the advantage of being a simple parameter is resolved explicitly in the equations that govern atmosphere and, as such, can predict trends.

As seen below, once the most representative meteorological variable is selected, we moved on to the study of trends analysis of the cited variable for the period from 1973-2008, as well as the analysis of hailstone diameter trends for the period from 1989-2008. The trends have been obtained from adjustments in linear correlations.

With the objective of confirming the highlighted results, the evolution of minimum nighttime temperatures was obtained for the areas of study during the last 35 years. In order to do this, we used temperature averages for minimum temperatures by taking into account the five months in which hailstorms were produced in the different areas (FIG. 2). In FIG. 2, an increase is shown in minimum nighttime temperature, which varies between 2ºC in Bordeaux and approximately 1ºC in the case of the Ebro Valley and Mendoza. Kukla and Karl (1993) have already shown an increase in minimum temperatures close to 1ºC.

Increases corresponding to these results were found in the series of maximum diameter.

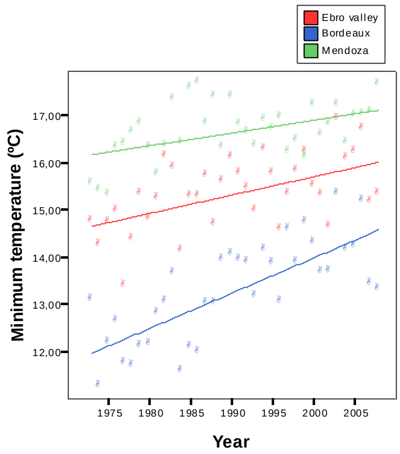

FIG. 2: Evolution of minimum temperature in the areas of study.

These results verify the reliability of minimum temperature as a predictor of severity of hail fall, as evaluated using diameter. Thus, we can predict that if the trend of minimum temperatures is positive, as seen in the great majority of models that evaluate Climate Change (IPPC, 2007), this will be accompanied by an increase in the severity of hail fall, especially in the most extreme cases. Dessens (1995) has already noted an increase in the number of severe storms as a result of Climate Change.

IV. ACKNOWLEDGMENTS

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V. REFERENCES

Dessens, J., 1995: Severe convective weather in the context of a night-time global warming, *Geophys. Res.* Lett., 22, 1241-1244.

IPCC, 2007: "IPCC Fourth Assessment Report: Climate Change 2007 (AR4)". Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press. Retrieved 2011-06-14

Llasat, M.C., Rigo, T., and Barriendos, M., 2003: The 'Montserrat-2000' flash-flood event in comparison with spring floods in the Northeast of the Iberian Peninsula since the 14th century. *Int. J. Climatol*., 23, 453-469

Kukla, G., Karl, T.R., 1993: Nighttime warming and the greenhouse effect, *Environ. Sci. Technol*., 27, 1468-1474.

Sánchez J.L., López L., Bustos C., Marcos J.L. and García-Ortega E., 2008: Short-term forecast of thunderstorms in Argentina. *Atmos. Res*., 88, 36-45.

Vinet, F., 2001: Climatology of hail in France. *Atmos. Res*. 56, 309-323.