ST-AR (STORM - ARCHIVE): A PROJECT DEVELOPED TO ASSESS THE GROUND EFFECTS OF SEVERE CONVECTIVE STORMS IN THE PO VALLEY

Elena Collino[1], Paolo Bonelli[2] , Luciano Gilli[3]

1 Institute CESI RICERCA, V.Rubattino 54, Italy, elena.collino@cesiricerca.it
2 Institute CESI RICERCA, V.Rubattino 54, Italy, paolo.bonelli@cesiricerca.it
3 Envitech Ambiente e Tecnologie srl, V. Bonomelli 1/f, 28100 Novara, luciano.gilli@envitech-ambiente.it
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I. INTRODUCTION

Summer convective thunderstorms cause heavy damages in the Po Valley every year. Although events are often localised and short in time, their effects on the ground, i.e. hail, downburst, heavy rainfall and lightnings are very important, particularly in a densely populated region like Northern Italy.

Moreover, after the storm, it's very important to establish if the event was exceptional, especially to determine if the damages were caused by human negligence or by the "extraordinary" strength of the storm. This subject mainly interests electric power enterprises and local authorities. For this reason, it is necessary to provide both effective warning systems (nowcasting), before the storm, and an objective analysis system afterwards.

Furthermore, a climatic knowledge of local severe storm is also necessary in order to better design open-air infrastructures, like overhead lines, stronger roofs etc. Anyway, in order to assess this kind of risk, it is essential to collect storm data and set up some analysis method of them.

Schiesser et al. [Sch94] in their "Study of mesoscale structure of severe precipitation systems in Switzerland" already stressed the importance of a knowledge base, describing the mesoscale structure and organization of the storms. They collected news from media and insurance companies in order to describe the damages caused by severe storms in Switzerland.

Both in Europe and in the USA there are different types of storm data banks, but it's known that is not easy to find a common collecting and analysis method, essentially because of the different resolution data availability.

Due to the small scale of the local convective storms, remote sensing data are necessary, in particular radar, lightning location system (LLS) and Meteosat radiometric data. Since standard WMO ground stations in Po Valley region are not enough, the information about storm ground effects need to be searched in metadata, like local newspapers. In fact this kind of media quite often reports information about severe storms, their main damages, time and involved municipal territory.

In this work (*), the authors collected, organized and analysed many different data regarding more then 150 single convective storms of the 2003 and 2004 summer in the Po Valley. The first part of this presentation illustrates the structure of the database. The second part describes the analysis method used to select the most important variables (radar, Meteosat…) related to the severity of the storm and to assess, for particular types of events (hail, downburst and flood) the probability that they will occur in the storm.

II. PRESENTATION OF RESEARCH

For this research, radar data from the Swiss Radar of Monte Lema, recorded every five minutes, were used to estimate the rain rate on the ground [Jos97]. 3-D radar data were also collected in order to analyse the vertical structure of the convective cell every fifteen minutes. In particular, different parameters, like the maximum value of vertical reflectivity, the height of this maximum, the reflectivity at the top of the cloud, the height of the top, the number of vertical levels with reflectivity greater than 44 dBz, were calculated for each radar pixel.

IR10.8 Meteosat 7 images, available every thirty minutes, were calibrated and corrected to estimate brightness temperature at the top of the cloud. Positive and negative lightnings and their current, obtained from CESI-SIRF (Italian system of lightnings detection), were collected. All data have been georeferenced. Plots of all previous data were created to represent the time - spatial pattern of convective cells.

Furthermore maps of geopotential and temperature at standard vertical level were made in order to describe the general circulation. Finally, articles from different local newspapers were collected in order to extract some key information like type of event (hail, downburst, small flood), location and start time.

All these types of data were organized in a public database, that is also available at the following web page (http://star.ricercadisistema.it/). In the on-line database, it is also possible to use easy interactive queries that can extract data on spatial, time, or threshold values base.

Once the database was developed, the attention was driven to evaluate the existing correlation between the type of event and the other collected data. A statistic method, based on instrumental data, was then devised to define a model for the probability that a type of event (hail, downburst or floods) will happen.

At the beginning over 150 thunderstorms were selected from the database. Every storm was defined using and all the data within an area of 20 x 20 Km around the involved city.

In order to analyse each thunderstorm, different parameters were calculated:

- duration of the precipitation in the area of 20 x 20 Km;
- duration time of maximum rate rain;
- Variation of rain rate in fifteen minute before the maximum rate;
- maximum of reflectivity in the volume;
- height of the above maximum;
- dbz at the top of the cloud;
- height of the top;

- average of dBz on the volume;
- number of levels with reflectivity greater than 0 dBz (NP0);
- number of levels with reflectivity greater than 44 dBz (NP0);
- minimum of brightness temperature at the top;
- number of positive and negative lightnings normalized for the duration.

With the above listed parameters a statistical analysis was performed to identify the most important value differences between “weak” storms, without observations of hail, downburst and small floods and that ones for which some of these observations have been done.

The plot in fig 1 shows, for example, the differences in the NP 44 distributions in the presence or absence of an important ground effect:

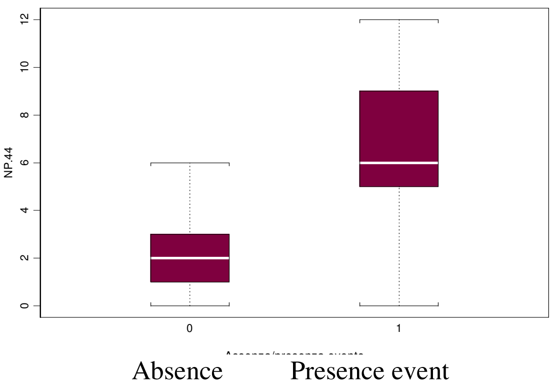

FIG. 1: distribution of NP44 for storms without (on the left) or with (on the right) hail, downburst or small floods.

The fig 1 reveals two distinctly skewed distributions, towards small values of NP44 for weak storms and towards higher values for severe storms. The solid horizontal line in the box plot is located at the median of the data, and the upper and lower ends of the box are located at the upper quartile and lower quartile of the data, respectively. Another interesting parameter is the minimum of the brightness temperature at the top of the cloud, as shown in fig 2:

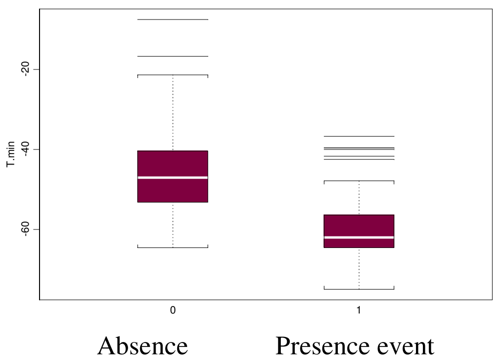

FIG. 2: distribution of minimum brightness temperature for storms without (on the left) or with (on the right) hail, downburst or small floods.

For each type of observed event hail, strong wind, small flood and for the “weak event” , a model was defined to calculate the probability of that event. The model was determined with the logistic regression, a statistical technique generally used to correlate continues variables (rain rate, duration, etc) with binary variables (hail yes or no).

Every model was based on different types of parameters between those previously described. The determination of the necessary parameters for each model was obtained by the stepwise regression technique. Tables of forecast/observation were created to calculate POD (probability of detection), CSI (critical success index) and FAR (false alarm rate) in order to test the models.

III. RESULTS AND CONCLUSIONS

The work presented in this paper underlines the key role played by storm database to analyse and guess the severity of a certain storm. The carried out statistical analysis shows that the most important parameters to distinguish severe storms are the duration of precipitation, the top brightness temperature, NP44 and the number of positive lightnings. The models developed show good critical success index, especially to predict the probability of hail, downburst and “weak storm” (without important ground effects). Another interesting result is the low false alarm rate obtained to evaluate the probability of weak thunderstorm. The results related to small flood events are instead poorly reliable, because they depend on the type of the soil and infrastructures. The work could be further developed introducing other types of data, like different MSG channels.

IV. AKNOWLEDGMENTS

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V. REFERENCES

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