European Conference on Severe Storms 2015
14–18 September 2015, Wiener Neustadt, Austria
ECSS2015-77-1

Discriminating downburst-producing and hail-bearing thunderstorms using total lightning and weather radar observations

Tomeu Rigo (1), Montse Aran (1), Joan Bech (2), Carme Farnell (1), Jordi Mateo (1), Nicolau Pineda (1), Ricard Ripoll (1), and Aleix Serra (1)

(1) Meteorological Service of Catalonia, Barcelona, Spain (tomeur@meteo.cat), (2) Department of Astronomy and Meteorology. University of Barcelona. Barcelona, Spain (joan.bech@ub.edu)

The starting point of the present work has been the generation of a database of severe weather events occurred in Catalonia (NE Iberian Peninsula). We have selected three types of severe phenomena: tornadoes and funnel clouds; hail with diameter exceeding 2 cm; and, finally, wind gusts associated with thunderstorms, with speeds over 20 m/s. A preliminary database was generated using the information from two existing public databases: SINOBAS (http://sinobas.aemet.es/), and the ESWD (http://www.eswd.eu/) managed by the AEMET, the Spanish Meteorological Agency and ESSL, respectively. This initial database has episodes between 2001 and 2015, but the density of cases per year is clearly lower for the first seven years. In any case, displaying all the data in a map allows the identification of some areas more prone to be affected by the different type of severe phenomena. In this sense, and according to these databases, the Lleida plain (W Catalonia) is more prone to be affected by hail cases, the Southern Coast shows frequent wind episodes registered there, the Central Depression presented a high density of both types (hail and wind phenomena), and a similar situation is observed in the Central Coast. However, the identification of the cases has been made by visual identification of the phenomena. This means that regions with little population density are not included as areas prone to be affected by severe weather. For this reason, it has been proposed that the end goal of the work is the generation of a definitive database, generated by means of automatic algorithms applied on weather observations and products.

As it is indicated in the same databases, some quality controls have been applied to their records. This means that not all the registers have the same validity. With the purpose to verify, correct, or remove the records, we have used different sources of information available in the Meteorological Service of Catalonia (SMC): 170 Automatic Weather Stations network of the SMC that provides local observations of strong wind gusts; a network of 50 hail-pads covers part of the Lleida plain, giving information about hail size; the surveillance network of SMC composed by 170 spotters, which provide information of the severe weather phenomena on real time; finally, social media (twitter and facebook, mainly) have become a prolific source of information, providing geo-located pictures and comments. Thus, by combining all the previous sources, it is possible to improve the quality of the selected episodes included in the preliminary database.

The fields included in this database are: location (name of the point, plus longitude and latitude), date, time, and type of phenomenon (including, if available, the maximum register of hail, wind or tornado intensity). In this sense, we have divided the registers in three categories: firstly, those cases that not need any type of modification (all fields are correct); secondly, registers that need slight changes in one or more fields (mainly, in time, coordinates, or intensity of the phenomenon); finally, we have the cases that are not valid, because the event is non-convective (for verifying this point, the SMC radar network animations have been used), the date is not correct or in the given location didn't happen anything during the episode.

Once it has corrected the registers of the database, the new version has been used in order to make a simple analysis of different questions. The first one is referred to the quality of the spotter's network: are they capable to identify most of the events with severe weather phenomena? It is important to comment that their main mission is not to provide information about this type of episodes, but most of them do it frequently. We have divided the analysis in two parts: identification of hail and convective winds. In the case of hail, the results are satisfactory, with the information of more than the 50% of the events. This is a good result, because large hail generally occurs in small areas (less than 25 km2). On the contrary, the results for strong winds are not as good as for the previous phenomenon, with more or less 25% of cases identified. However, it is also important to highlight that the area affected is even more reduced (generally, less than 4 km2).

The second question to be answered is: what are the most common meteorological characteristics associated to severe weather events in Catalonia. The first results can be summarized in the following points. In the case of hail, two predominant synoptic charts have been observed: on one hand, the passage of a mid-level trough (from

W to E) in the 60% of events. Furthermore, in a 35 % of the cases it was not a deep trough. Moreover, the local convergences at surface level are the main trigger of the convection. On the other hand, the observation of a ridge at mid-troposphere over the Iberian Peninsula has occurred in the 25% of events. Besides, these events were marked by a short wave crossing through N Catalonia, and the triggering of the convection in the mountainous areas. Thermodynamically, the hail events were marked by values of LI bellow -3°C, thermal gradients between 850 and 500 hPa over 28°C, and low values of CAPE. Because the number of collected events of non-tornadic convective winds was still not large enough, this category has not been analysed. Finally, for tornadic events, we have observed three main synoptic patterns: the omega configuration; the observation of a depression at NE of Europe, with a cut-off low over the Iberian Peninsula; and, finally, the presence of a secondary low near the Catalan coast. In this kind of events, the sRH(0-3km) showed high values in more or less the 50% of the cases, while the EHI and CAPE not shown a representatively of the situation. More information about thermodynamic characteristics of tornadic storms in Catalonia can be found in Rodriguez and Bech (2015).

The key point of the work is the identification of patterns of features using remote sensing data that can help to the identification automatically of this type of events. In the first step of this point, we have selected lightning and satellite data. In the case of lightning data, Metzger and Nuss (2013) had developed a method to categorize hail-producing and downburst-producing thunderstorms by means of different type of data: radar parameters, sounding derived indices, and, mainly, the presence of "lightning jumps" (LJ), i.e. sudden increases in lightning flash observations, either in cloud-to-ground or intra-cloud data. The SMC operates a Total Lightning Location System that allows monitoring those lightning jumps, mainly associated to intra-cloud lightning, but also to cloud-to-ground flashes (see Pineda et al, 2012, for more details about the lightning network).

For this study, the identification of the track of the thunderstorm which produced each phenomenon has been made using radar data and the Rigo et al (2010) technique, with slight modifications (the main one, the use of PPIs instead of CAPPIs). Once the area of analysis has been selected, the lightning data observed during the period associated with the thunderstorm in that region have been analysed, by means of the identification of high increases in the flash rates (for both types of lightning, intra-cloud or cloud-to-ground). Every lightning jump detected has been included in a data base, introducing if it was occurred before (between 1 hour and 10 minutes before the phenomenon happened), in time with the phenomenon (between 10 minutes before and 10 minutes after), or after (between 10 minutes and 1 hour after the phenomenon).

General results for all type of events (72) show that a LJ occurred in practically 80% of them before the phenomenon. This percentage decreases to 50% approximately for the observation in time with the phenomenon, and to 28% after the phenomenon had occurred. Considering different types of phenomena, we can deduce that in the case of hail, 95% of cases a LJ was observed before the hailfall. In the case of strong winds and tornadoes, the percentages decrease to 75% and 60%, respectively, and considering only of the situation before the phenomenon. The other percentages are considerably lower.

In the case of the satellite data, we have centred in the searching of the V-Shape pattern in infrared imagery, using the model presented by Brunner et al (2007). The method has consisted in identifying cold cloud top points with warmer points placed at a short distance of the first ones. The results, in this case, were obtained for a reduced set (49 events). This pattern was identified in a distance shorter than 30 km to the point of observation of the phenomena in 85% of events. The percentages were higher in the cases of hail and strong winds, while for the tornadoes the results are not good as for the rest of types.

References

Brunner, J. C., S. A. Ackerman, A. S. Bachmeier, and R. M. Rabin, 2007: A Quantitative Analysis of the Enhanced-V Feature in Relation to Severe Weather. Wea. Forecasting, 22, 853-872.

Metzger, E. and W. A. Nuss, 2013: The Relationship between Total Cloud Lightning Behavior and Radar-Derived Thunderstorm Structure. Wea. Forecasting, 28, 237–253.

Pineda, N., J. Montanyà, and O. A. van der Velde, (2012). Characteristics of lightning related to wildfire ignitions in Catalonia. Atmos. Res., 135–136, 380-387

Rigo, T., N. Pineda, and J. Bech, 2010: Analysis of warm season thunderstorms using an object-oriented tracking method based on radar and total lightning data. Natural Hazards and Earth System Science, 10.9, 1881-1893.

Rodriguez, O. and J. Bech, 2015: Sounding-derived parameters associated to tornadic storms in Catalonia. Proceedings on the 8th European Conference on Severe Storms, held in Wiener Neustadt (Austria).