

IMPACT ASSESSMENT OF THUNDERSTORMS IN PORTUGAL IN THE 2003-2011 PERIOD: OVERALL CHARACTERIZATION AND ANALYSIS OF A NOTEWORTHY CASE STUDY IN LISBON

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I. INTRODUCTION

The research on severe storms impacts requires the availability of data with high spatial and temporal resolution taking into account that convective phenomena are mainly controlled by local or mesoscale processes. With regard the detection of ground effects of thunderstorms (e.g. hail, downbursts, heavy rainfall and lightning), the observations made by conventional weather stations are generally insufficient since the density of observation sites and the temporal frequency of records are not suitable to provide an adequate detection of the associated phenomena. Therefore, the production of databases by gathering and compiling press news, reports, photos, videos and descriptions from eyewitnesses may contribute to fill the lack of information about damages caused by storms, providing important details and evidences related with its intensity, spatial incidence and evolution. The creation of the European Severe Weather Database (Dotzek et al, 2009) exemplifies how this crucial need was recognized by several national meteorological organizations. Moreover, disasters associated to natural hazards have been gaining increasing scientific interest in the last decades due to their significant socioeconomic and environmental impacts (e.g. Guzzetti and Tonelli, 2004; Llasat et al 2009; Pereira et al, 2012; Papagiannaki et al, 2013). Some of these scientific studies have been devoted on severe storms, addressing tornados, hail and/or lightning damage, as are the case of Elsom (2001) for the United Kingdom, Collino et al (2009) for the Po Valley region (Italy), Tuovinen et al (2009) and Rauhala (2012) for Finland and Papagiannaki et al (2013) for Greece. In all these investigations is pointed out the relevance of gathering information from different eventually available sources, namely reports from meteorological journals, news media and voluntary observers.

The present study is focused on the assessment of material and human damage caused by thunderstorms in Portugal. A systematic search over the 2003-2011 period on the web archived material by 19 mass media national sources, complemented by the available online published news from 47 regional newspapers, allowed to gather information related with the impacts of thunderstorms in Portugal, including accidents affecting living beings (people or animal deaths, injured) and occurrences of material damages in several structures (e.g. buildings, vehicles, social equipments) or forested (wildfires) and agricultural areas. All selected occurrences in this (MsAccess) database are related with lightning and hail damage. In Fig. 1 is shown the location of all head offices of media sources used in this survey. The study period starts in 2003 because is the first year with available data on lightning activity, collected by

the Portuguese lightning network, providing instrumental observations of cloud-to-ground discharges to check the origin of the accidents. Temporal and spatial variability of the occurrences are analysed applying GIS (geographical information system) tools. A total of 234 accidents were registered in the database, occurring in 111 days with thunderstorm damage (DTD), which means an average frequency of 12 DTD/year. Hail related occurrences accounts for 30% of the total of the accidents, being 70% caused by lightning. The case study of the severe hailstorm occurred in the Lisbon area in the 29th April 2011 was selected to carry out a detailed survey of the produced damages during this extreme event. This case illustrates the complex diversity of impacts triggered by a severe hailstorm in this urban area resulting in a very harmful and costly natural disaster, responsible for inundations in several locations and disruptions on public and private services.

II. PRESENTATION OF RESEARCH

As it was stated in the previous section, the present research encompasses two sequential studies. Firstly, a database of accidents caused by lightning (CGD) and hail in mainland Portugal was produced, covering the 2003-2009 period. This study period was established in the frame of a contracted research (RAIDEN Project) devoted for the study of lightning activity in Portugal, whose objectives and first results were divulged respectively in Fragoso et al (2011) and Santos et al (2012); Secondly, a high-impact hailstorm event was selected from the database of accidents to carry out a case study dedicated to the assessment of the associated impacts.

The database of thunderstorm related occurrences was constructed searching and collecting news from all available online media sources in mainland Portugal, including newspapers and other periodicals, TV and radio channels with archived material accessible via internet. This systematic compilation covered a total of 19 national media sources and 47 regional publications, whose head offices location is illustrated in Fig.1. The published material was carefully analysed in order to identify occurrences undoubtedly related with CGD and hail impacts. Only occurrences mentioned at least by three different sources were selected, a validation procedure to avoid not confirmed or insufficiently described accidents. Additionally, all reported occurrences were cross-checked with observations of CGD from the Portuguese lightning network, allowing a verification of causality relationship between ground effects and proximity of thunderstorm activity.

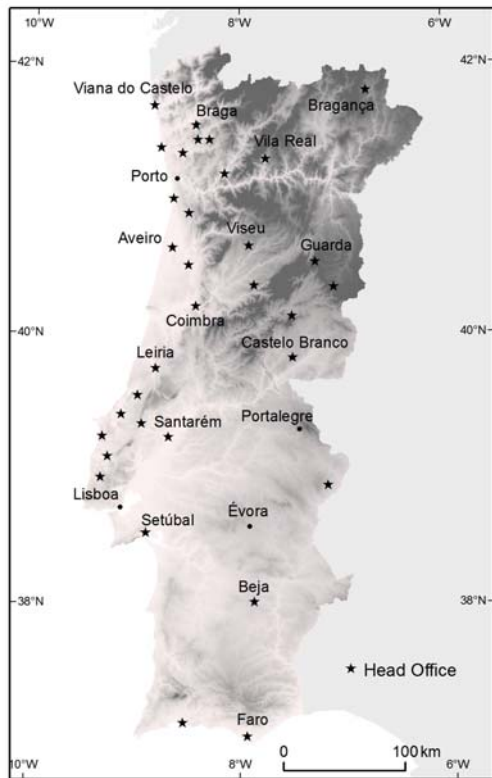


FIG. 1: Location of the head offices of media sources (e.g. newspapers, journals, TV and radio press with online publishing) used to collect information on thunderstorm-related accidents, including lightning and hail damage.

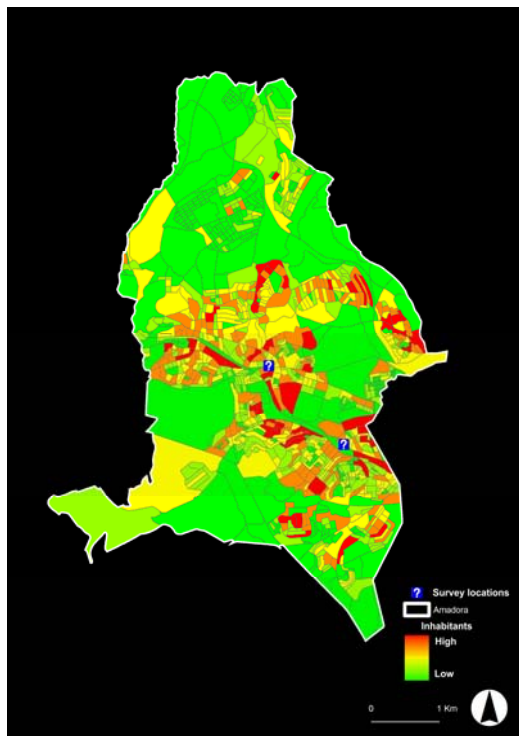


FIG. 2: Amadora's population distribution and location of the two major spots severely affected by the 29th April 2011 hailstorm.

The hailstorm event occurred on the 29th April 2011 in the Lisbon area affected all the north bank of the Tagus River in Lisbon, but with particular intensity the municipality of Amadora. In that day, more than half of the eight hundred incoming calls requesting support to the District Civil Protection Operational Command came from that municipality. In order to establish the damages scope related to the hailstorm, an inquiry was launched to commercial and industrial units located in two of the most affected areas, according to the reports and the Municipal and Civil Protection officers. Those areas were hardly affected by hailstones accumulation, flood and clogging. Seventh six personal questioners were carried out, representing more than 13% of the economic units located in the area (Figure 2).

III. RESULTS AND CONCLUSIONS

The data analysis shows that thunderstorms have a no negligible social and economic impact. The results will be presented in two sections. The first related to the accidents database from 2003 to 2011 analysis and the second related to the hailstorm occurred on 29th April 2011.

Thunderstorms 2003-2011

From 2003 to 2011 we could identify trough media collection, 163 incidents related to lighting and 71 incidents related to hail in mainland Portugal.

Damages associated with lighting and hailstorms are quiet different. While hailstorm damages are mainly related to crops destruction and traffic interruption, lighting damages are related with wildfires and electric supply disruption.

Central coastal region, Lisbon and Alentejo were the regions with the highest incidence of lighting storms. Major damages associated to lighting along the period were wildfires (51 incidents), power supply interruptions (33), building and collective equipment's damages (32), communications disruptions (9) and, unfortunately, 4 killed and 11 wounded persons.

The northern and northeast plateaus were the regions with highest incidence of hailstorms. Major damages were related to crops destruction (42), road accidents (13) or road interruption (7), and 2 wounded persons.

The economic value of damages could not be seriously evaluated due to the absence of more detailed information about the incidents.

29th April 2011 hailstorm

On 29th April 2011 a hailstorm came over the Lisbon region, causing a chaotic situation all over the region in that late afternoon. On that day more than 800 emergency calls was received from 16 municipalities of Lisbon region, namely 90 from Sintra, 73 from Oeiras, 70 from Lisbon and 445 from Amadora. In fact, Amadora was the municipality most affected by the storm, with hailstone accumulation, flood and clogging that special affect high risk areas (Figure 3).

The inquiry conducted almost two years after the hailstorm, shows that it was not forgotten. Indeed, 91% of the inquired remember clearly that day and 69% of the questioned said they had been affected by the hailstorm of 29th April.

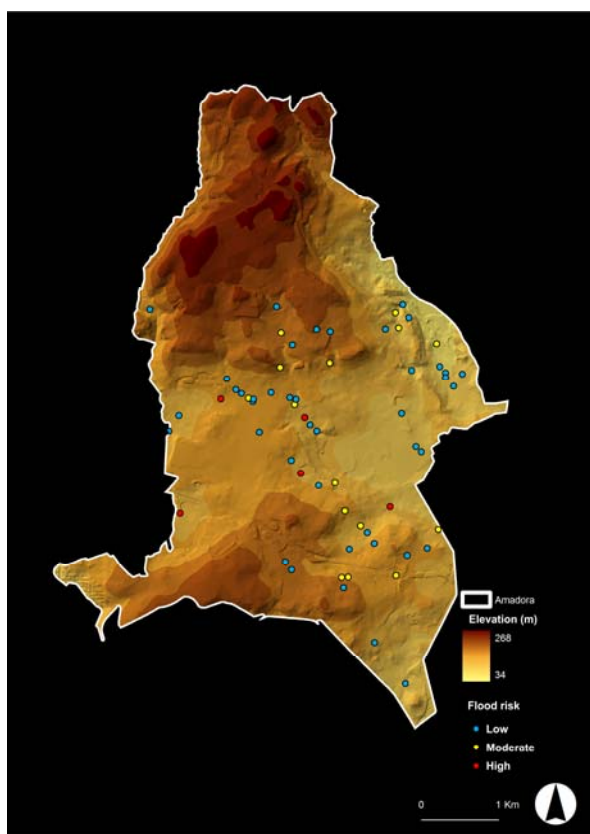


FIG. 3: Amadora's elevation and flood risk (low, moderate, high)

Flood, water infiltration and energy supply interruption was the main damage that was pointed by the respondents.

Questioned about the value of the material losses, almost half declared less than 500€ 35% a value between 500€ and €1000€, but 12.5% mentioned losses exceeding 5000€ and we know that one optical shop closed definitively. On the other hand, the affected units were closed for a period from one hour to more than one day. A quarter of the affected units were only closed for one hour, but another quarter for more than six hours and 12% for more than one day.

Fortunately, there was only one injured during the storm. The major health problems affected the emergency personnel with hypothermia symptoms due to the rapidly temperature drop and the contact with hailstones for a long period during the removing work.

The main emergency contact was the fire department, both directly and through the national emergency number (112). The opinion expressed about the efficiency of the emergency service was neither good nor bad. The majority of the questioned marked with 3 in a scale of 5. In fact, the surprise and the unusual atmospheric phenomena put major problems to the emergency actions. The hailstone accumulation on a depressed area required the use of machinery that was not at the disposal of the emergency units. On the other, that accumulation occurred on a central node of the municipal road network generating more problems to the displacement of the emergency units.

The individual prevention actions after the incident developed by respondents were insure they assets and some investment on prevention mechanisms, namely in relation with the floods.

After this episode, all agree that the population need more information about how to deal with natural hazards and more deep prevention actions, namely trough infrastructure maintenance and improvement works.

IV. ACKNOWLEDGMENTS

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