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EVALUATION OF ESTOFEX FORECASTS

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(Dated: 15 September 2009)

I. INTRODUCTION

The European Storm Forecast Experiment (ESTOFEX) was started in 2002 by a group of meteorology students (see http://www.estofex.org/). Its primary goals are to forecast the occurrence of lightning and severe thunderstorm (hail, convective winds, tornadoes.) Although there have been changes over the years in the format of the forecasts, in general, the lightning forecasts have consisted of a line enclosing the area where lightning is expected. The severe thunderstorm forecasts have three levels (1, 2, and 3) of expected coverage and intensity (Fig. 1.)

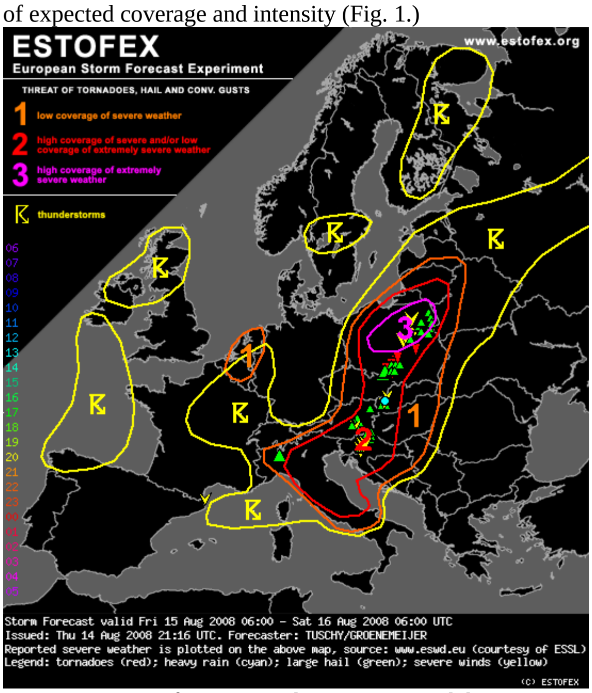

FIG. 1: ESTOFEX forecast issued 14 Aug 2008, valid starting 0600 UTC 15 Aug 2008. Yellow lines indicate regions of expected lightning coverage. Orange, red, and purple lines enclose areas of levels 1, 2, and 3. Observed severe weather reports are shown by symbols.

Evaluation of forecasts is an important part of the process of improving the forecasts. Besides providing information for the forecasters and users of the forecasts, the ESTOFEX forecasts provide an excellent opportunity to explore the use of relatively new techniques to evaluate and display forecast information.

II. FORECAST AND OBSERVATIONAL DATA

Forecasts are typically issued once per day, usually in the evening, and are valid for a 24-hour period beginning the next morning at 0600 UTC. (Since the forecasters work on a volunteer basis, occasionally forecasts are not issued.) On relatively rare occurrences, updates are issued later. For our purposes, we will consider only the first forecast issued for the day, in order to limit the impacts of additional information being available for the forecasters. We have evaluated three years of forecasts, starting 30 April 2006.

One of the primary requirements for effective forecast evaluation is to match the forecasts and observations. Since the lightning data are gridded, we have put the forecasts and observations on to a grid, so that the events (lightning or severe thunderstorms) are dichotomous and the forecasts are either dichotomous for lightning or ordered (lightning, level 1, 2, or 3) for severe thunderstorms.

Lightning data come from two different sources. Until the end of 2007, the data come from the UK Met Office arrival time difference system. We were provided with information on a 0.5x0.5 degree latitude-longitude grid every half hour from that system. The information consisted of a scaled value (not total flashes) describing the number of flashes in the time period on the grid.

Since the beginning of 2008, lightning data come from EUCLID. The format and area of coverage is somewhat different. The spatial grid is 0.25x0.25 degrees, but the temporal resolution is one hour and only part of the ESTOFEX domain is covered.

In order to make the comparison consistent over time, we have put both datasets on a consistent space-time grid (0.5x0.5 degrees, one-hour) using the EUCLID domain (Fig. 2). One or more flashes during the 24-hour period for the forecasts are counted as a "yes" event for lightning on that grid.

Severe thunderstorm data come from the European Severe Weather Database (ESWD-http://essl.org/ESWD/) (Dotzek et al. 2009). A significant problem that had to be resolved was the lack of spatial coverage of the ESWD (see parts of the Iberian peninsula and the Balkans in Fig. 2). We can determine, a priori, whether the absence of a report is because no weather event occurred or because the reporting system failed to collect the report. (Note that the more mature reporting system in the US makes the latter less common.) We decided to only use those points where severe weather was reported at least once as verification locations for the severe thunderstorm forecasts.

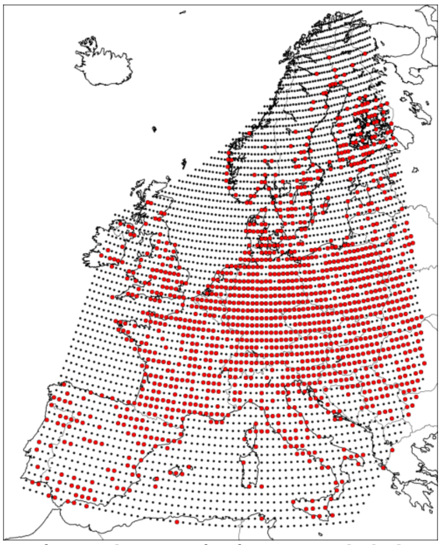

FIG. 2: Verification locations for forecasts. Black dots represent lightning verification locations. Red dots are those locations where severe thunderstorms were reported at least once during the verification period.

III. RESULTS AND CONCLUSIONS

Roebber (2009) introduced a graphical display that is useful for visualizing the performance of dichotomous forecasts of dichotomous events. As such, it is a natural choice for looking at ESTOFEX's lightning forecasts. Plotting the probability of detection (fraction of "yes" events correctly forecasts) versus the frequency of hits (fraction of correct "yes" forecasts) is ideal for considering changes in forecast performance over time (Fig. 3). By computing those quantities over periods of 91 consecutive forecasts, we can see something that resembles a seasonal average, but without restricting our attention to traditional seasons. Clearly, there is a strong seasonal signal, with the forecasts being better in the summer than in the winter. There is significant interannual variability. Peak performance is seen in the second year, at least in terms of the critical success index (CSI).

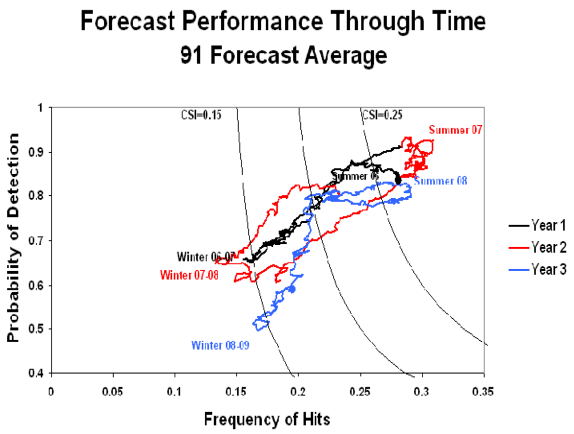

FIG. 3. Running 91-forecast average of probability of detection and frequency of hits for lightning forecasts. Thin black curves represent constant critical success index (CSI=correct forecasts of "yes" events divided by sum of correct forecasts of "yes" events, false alarms, and missed events). Colored lines represent different years of the 3-year evaluation period (red-first year, blue-second year, black-third year.) Perfect forecasts would be located at (1,1).

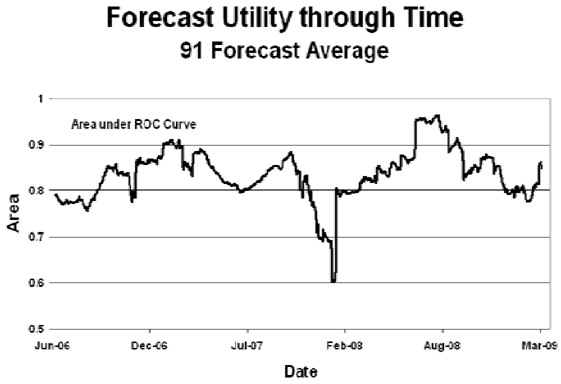

FIG. 4. Area under the curve (AUC) for ROCs as a function of date for 91-forecast running average of severe thunderstorms. Date represents center of the 91-forecast average.

Mason (1982) brought the Relative Operating Characteristics (ROC) curve to the meteorological community. It is intended to look at forecast performance when there are forecasts that have a series of ordered levels. Obviously, this is a natural choice for considering the ESTOFEX severe thunderstorm forecasts. It is created by taking each possible forecast level, creating a 2x2 contingency table from it, and then plotting the probability of detection versus the probability of false detection (fraction of "no" forecasts that have "yes" events). The area under a curve (AUC) generated by connecting points at the different forecast levels is a measure of forecast skill and is the Mann-Whitney test statistic. A value of 0.5 represents no skill and a value of ~0.7 is generally considered to be associated with useful forecasts.

Again, calculating values from a set of 91 consecutive forecasts is useful for seeing the long-term changes in forecast performance. In contrast to the lightning forecasts, in general there is a long-term increase in forecast performance, but the seasonal signal is not very consistent (Fig. 4). The average forecast is useful, in terms of the AUC, almost all of the time. Despite the 91-forecast averaging, small sample size issues still exist. The abrupt change in January 2008 results from a single high-quality forecast of many events becoming a part of the averaging window following a quiet period of a couple of months.

The ESTOFEX forecasts are of a reasonably good quality and there is evidence (for which this preprint is too short) that differences in forecaster performance are on the order of, or smaller than variability in forecast difficulty.

IV. ACKNOWLEDGMENTS

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NEW CAPABILITIES OF THE EUROPEAN SEVERE WEATHER DATABASE

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I. INTRODUCTION

The European Severe Weather Database (ESWD) is a database of severe weather reports for Europe and the Mediterranean Region (Dotzek et al., 2009). The database, which currently contains about 25,000 reports, has recently undergone several enhancements, both of a fundamental and of a technical nature. These enhancements both accommodate the cooperation of ESSL with partner organizations, and an improved quality control of the data.

The new ESWD version 3 has been developed by ESSL, and this upgrade was partly funded by the German Weather Service (DWD). Interaction with the database may take place through three interfaces, each of which can be customized.

The first interface is the Internet website, available at www.eswd.eu (Fig. 1). For different user groups, accounts with different options and privileges can be created. The Internet interface allows users to perform mutations (submit, edit, delete), to query the database, and download data in several formats, given that the user's has been given these permissions. The data formats are

- ESWD 1.40 format (ESSL, 2006; Groenemeijer, 2004)
- ESWD 1.40-csv format (ESSL, 2009)
- an HTML table
- a simple graphic map

The first two are UTF-8 encoded human-readable text.

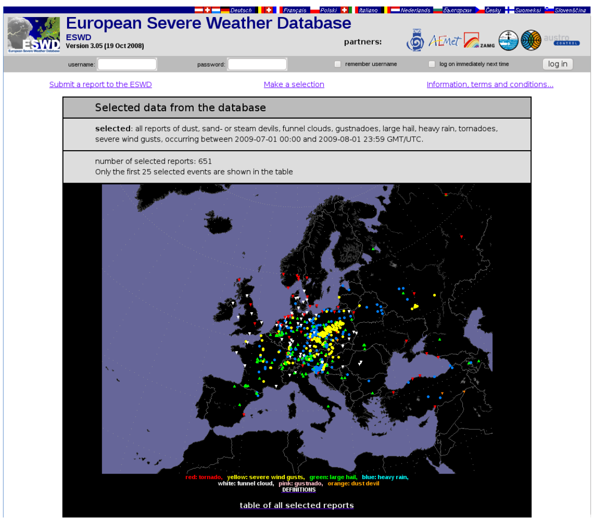

FIG. 1: The web interface to the ESWD database.

The second interface is secure ftp-transfer of csv-formatted data. This (more complex) solution has been implemented for the German Weather Service (DWD). Benefits are that the DWD can combine the data in new ways with other datasets that they own, and can edit the German subset of DWD data on their system, rather than having to log in to an external system.

A third way of accessing the ESWD is through the upload of data in the ESWD 1.40 format over passord-secured web-CGI. This upload feature was developed as part of a project called RegioExAKT in collaboration with Skywarn Germany, one of ESSL's partners. Their system transfers SMS messages from certified storm spotters who have observed a severe weather event to a central computer. The interface with the ESWD allows these reports to appear in the ESWD, and thereby on the Internet, in near-real time.

II. ESWD PARTNERS

Partners of the ESWD database can be grouped into four categories.

1. national (hydro-)meteorological institutes (NHMSs) and the ESSL
2. voluntary observer networks (VONs), using an internal quality control mechanism (such as spotter certification)
3. general public or individual observers

The ESWD currently has partners in each of those groups. Current NHMS partners in the ESWD project are the respective weather services of Austria, Bulgaria, Finland, Germany and Spain. Current VONs include Skywarn Germany, Skywarn Poland, Skywarn Slovenia, Skywarn CzechoSlovak, Keraunos (France), Skywarn Austria.

NHMSs and VONs each have specific roles within the ESWD network, that are outlined below.

III. QUALITY CONTROL

With the new version of the ESWD in October 2008, a quadrinomial classification describing the state of quality control of reports, has come into use. It was developed in response to problems with the former system that only differentiated between two quality levels. That system proved to be too coarse in practice: many reports that could not be fully verified could not be assigned the higher quality level, even when, for example, photographs supporting the report were available.

The new classification differentiates between the following levels:

- as received, **QC0**
- plausibility checked, **QC0+**
- confirmed by reliable sources, **QC1**
- fully verified, **QC2**

Severe weather reports can enter the ESWD from the three different groups of partners. Each of these groups has permission to perform quality control up to a certain level.

Data originating from the “general public” will automatically be assigned the lowest quality level, QC0, or "as received". This means that no quality control has been performed. Data of this quality is in principle not suitable for scientific use. Hence it is very important that the quality level of such data be upgraded as soon as possible. Ideally after an severe weather episode, all QC0 reports either should be raised to QC0+ or higher status, or be deleted within a few days to weeks.

The VONs, NHMSs and the ESWD management at ESSL have the possibility filter out implausible reports and upgrade the quality level of the remaining reports to QC0+. In practice, they do that by logging on the database with their customized account that will enable them to perform such changes. Naturally, this is just an intermediate step, as QC0+ reports still have not undergone a serious effort to verify their quality. Needless to say, reports that originate from a partner organization, will skip this step, and immediately enter the database with QC0+ or higher status.

NHMSs and the ESSL, and VONs that have passed an initial trial period, can perform the next step of verification to QC1. Reports that are confirmed by *reliable sources* may be assigned the QC1 status. For example, QC1 can be selected when photo and/or video material is available with a trustworthy specification of location and time, or when printed media feature detailed reports that quote and name eyewitnesses. Voluntary observers (storm spotters) that operate within a network with an internal quality control procedure also qualify as reliable sources. In an QC1 report, some details may be missing or uncertain.

QC2 is reserved for the reports that have been fully verified. These data should be complete and correct. This status can only be given by the NHMS in the respective country, and by ESSL. In case of differing assessments of ESSL and the NHMS regarding the details of an individual report, the quality level QC2 will not be assigned.

IV. DATA CONTAINED IN THE DATABASE

The number of events contained in the database currently comprises almost 25,000 reports and gradually increases. Fig. 2 shows that the bulk of reports originate from the period 2006-present, i.e. after the ESSL was funded and commenced the management of the database.

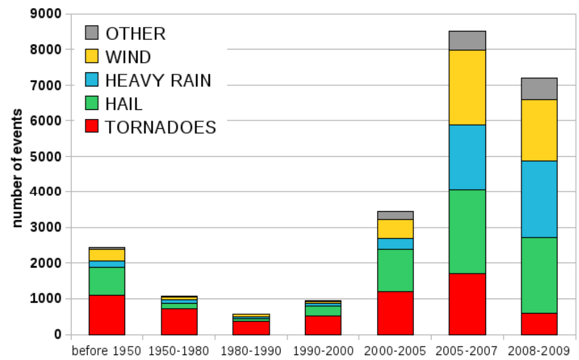

FIG. 2: Distribution of event types over the years.

Four event types form the lion's share of the reports, to wit wind, heavy rain, hail and tornadoes. There are some tendencies of the relative event type frequency through the years. From Fig. 2. it can be seen that the number of reports of heavy precipitation and wind gusts has increased strongly since the year 2000, and that older data is dominated by tornado and large hail reports.

Fig 3. shows a portion of the area covered by ESWD, giving an impression of the distribution of events. It can be seen that parts of central Europe has a very high coverage of events, but that areas like Romania, Bulgaria, Finland, central Russia and Greece also see a relatively high coverage.

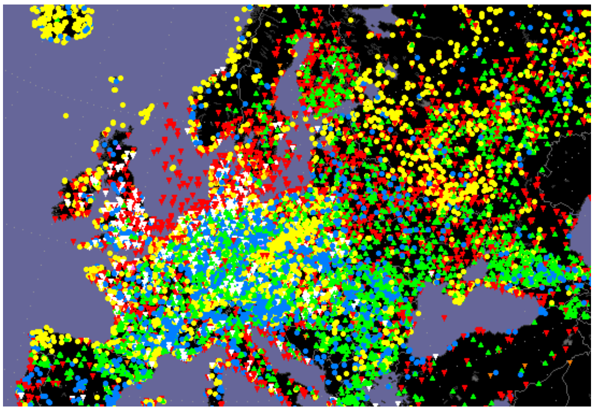

FIG. 3: Spatial distribution of events across part of the area covered by the ESWD. Different symbols represent different event types.

V. CONCLUSIONS

The ESWD database is a core activity of the European Severe Storms Laboratory, which is maintained with the help of a rapidly growing number of partners, that include several national (hydro-)meteorological institutes. New technical developments enable better interaction with the partner organizations and a new quality control scheme has been implemented. The fraction of data that has reached a higher quality level has since grown significantly.

The ESWD as a data source has in its short lifetime been used by several researchers including groups at NSSL, EUMETSAT and the DWD. The dataset has been used for climatological studies of several kinds, and by groups who seek to find ways to detect severe weather in an automatized way using satellite and or radar data, thereby needing ground-truth observations.

ACKNOWLEDGMENTS

The authors thank all partner organizations for the cooperation, and all researchers that have used ESWD data for their interest in the data. We also thank Bernold Feuerstein and Alois Holzer for their critical input to discussions about the ESWD's development.

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All references can be downloaded from ESSL's website (http://www.essl.org).

Reporting on severe storms in Early Modern Time in the Netherlands and in the Eastern Alpine Region

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(Dated: September 17, 2009)

I. INTRODUCTION

In my contribution, I focus on pictorial (e.g., drawings by Herman Saftleven) and written representations of strong winds in the Netherlands and in the Eastern Alpine region in Early Modern Time. Two hazards serve as case studies: First of all, I will talk about the strong wind of 1674. It started in Paris, tore over Antwerp and Utrecht and destroyed great parts of these cities. Second, I will speak about the strong wind, which damaged houses of Abtenau (Salzburg) in July 1796. These strong winds shall illustrate my cultural historical approach. The focus is on how the contemporaries perceived, interpreted, managed and memorized strong winds.

II. METHODOLOGY

The methodological triangle *perception, interpretation, and management* used in Hauer (2009) is generalized to a fourth category, called *memory*. Figure 1 visualizes the analyzing square; the arrows show the constellation of the conditions. If a natural hazard occurs, the contemporaries try to interpret it (a). It is possible to manage a natural hazard materially without doing etiology (c) It is doubtful, if this is possible on a mental level. If something horrible is perceived, it often stays in the long term memory. The category interpretation is a preliminary stage of the category management. As soon as contemporaries had a plausible interpretation of the natural hazard, they could concentrate on management (b).

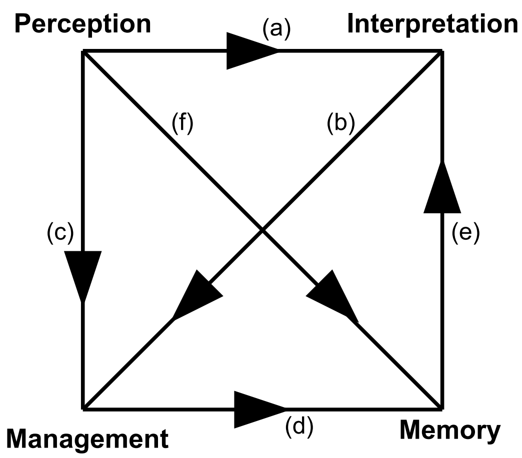

FIG. 1: Analyzing square. (a)–(f) denote the relations among the four methodological categories (see text). Arrows denote the presupposition-relations among them.

If the calamity is intensively analyzed, it stays in the memory (d). However, also the process of interpreting, the seeking/searching for a cause is remembered.

III. IMPORTANT SOURCES FOR A CULTURAL HISTORICAL APPROACH

A. Perception: An eyewitness account on the storm of 1674

Dutch original:	Free translation:
Uytrecht den 2 Augusti. Gister Avont ten half achten ontstond hier een schrickelick Onweer, dat tot half negen toe duurde; doch het slimste was gedaen in een Quartieruurs: den Hemel stont gedurigh in licht en Vlam, en 't was schrickelijck den Donder en vreesselijcke Winden te hooren, dat verselt wierdt met het nederstorten van Schoorsteinen, Daecken, Gevels en Toornen, dat ieder een ongemeene verbaestheyt aenbracht, en dat heeft veele van een Aertbevingh doen spreecken [...] Oprechte Haerlemse Saterdaegse Courant of 4 August 1674.	Utrecht, 2nd August. Yesterday night at half past seven a terrible thunderstorm occurred here, which lasted until half past eight; but the greatest horror lasted only fifteen minutes: the sky lit up continuously, it was terrifying to listen to the awesome thunder and violent winds, accompanied by falling chimneys, roofs, gables, and turrets, making all who witnessed it sorely astounded, and many people spoke of an earthquake [...] Oprechte Haerlemse Saterdaegse Courant of 4 August 1674.

B. Interpretation: A broadsheet on the storm of 1674

SIR,
I Cannot refrain writing to you, to give you to understand the Wonderful and Miraculous Judgment of the Almighty and Angry God, whose hand of late hath been very heavy upon our Netherlands, and especially against that Flourishing and Renowned City (though now a City in heaps) UTRECHT; the wounds yet being fresh which we received by the Conquests of the French, by whom we were brought low and impoverished. Weh ad hopes to have had some time of refreshing; but we have received the contrary: For the Great GOD is yet pouring out his Vials of Wrath upon us. [...]

C. Management: Letter to the Hofkammer concerning the storm of 1796

German original:	Free translation:
Durch das unterm 31 Julii abhie(r) zwischen 7 und 8 Uhr Abends alda unter heftigem Windstoß ausgebrochen ganz ausserordentliche Hagelwetter, wobey die Schlossen in der Grösse denen welchen Nüssen gleich so schnell, häufig und tief fielen, daß man nicht einmal so viel Zeit gewann in den Häusern die Fenster halvieren zu können wurden in der hochfürstlichen Pfleg, Jäger und Gerichtsdiener Häusern, so wie in all andern Häusern dieß Markt und auch auf dem Gau die Fenster dergestalt beschädigt und zu Grund gerichtet, daß der alhierige Glasermeister sich bey nahe außer Stande gesetzt findet die erforderliche Zahl Gläser zu schleuniger Wiederherstellung in der fast aller Orten eingeschlagener Fenster wegen allzu weiter Entfernung der Glashütte und beschwerlicher Zufuhr beizuschaffen.	There was a severe hailstorm on July 31 between 7 and 8 in the evening. The hailstones were the size of nuts, and coming down so quickly that it was impossible to close the windows. The Pfleg, Jäger and Gerichtsdiener houses as well as all the other houses in the surrounding area were damaged so severely and there was such a long distance between the glass-works and the damaged houses that the local glazier nearly felt it was impossible to rebuilt all the windows in time.

D. Management: Drawings of the storm of 1674 by the contemporary artist Herman Saftleven

The artist Herman Saftleven (1609-1685) lived in Utrecht in 1674. The collapsed nave of the Dome impressed Saftleven deeply; he made 16 drawings of the collapsed nave from different angles (see, e.g., Figure 2). Saftleven sold the drawings to the city council, together with six other drawings, for 250 guilders in 1682.

E. Memory: A book on the storm of 1674

The Dutch author Thea Beckman (1923-2004) wrote a children's book on the storm of 1674.

IV. WEATHER CONDITIONS IN 1674 AND 1796

The weather conditions in the Netherlands were extreme in 1673/74. The winter was long and cold. The inland waterways, the large rivers and the Ijsselmeer froze over twice. Frost set in in the mid of November in 1673. Lakes and rivers were still frozen over in early April 1674. The spring was short and intense, the summer cool and humid, with numerous thunderstorms. There were also a lot of thunderstorms in summer 1796 in Salzburg.

FIG. 2: Destroyed dome of Utrecht (drawing by Herman Saftleven; Archief Utrecht).

V. CONCLUDING REMARKS: WHY CHOOSE A CULTURAL HISTORICAL APPROACH?

The newer cultural historical research tries not only to mention but also to combine different approaches from various disciplines to create a more comprehensive reconstruction of historical incidents. This is only partly possible in socio-historical descriptions; the dimensions of incidents can be represented only partly by facts such as the year, the location and the number of possible victims. Similar limitations are apparent with a natural scientific approach which typically concentrates on weather and climate, because it tends to ignore the human dimension of how people cope with disasters. However, the newer cultural historical research focuses on the human dimension, on how people perceive, interpret, manage and memorize natural hazards. It gives us an insight into how the contemporaries dealt with calamities.

VI. ACKNOWLEDGMENTS

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Building a database of severe weather phenomena: Severe hail in Finland

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I. INTRODUCTION

Building a database is the starting point of studying severe weather phenomena, giving better knowledge of the temporal and spatial occurrences of the phenomena. This knowledge, in turn, can lead to clues about the relevant physical processes, help the forecasting process, and allow for an analysis of risk to vulnerable populations and infrastructure.

In this presentation, we show how Finland's severe hail database was constructed. We also introduce an approach to monitor the radar-derived hail-detection algorithm running in real time and to contact local businesses via e-mail to obtain hail observations. As a result of employing this approach, a large increase in the number of severe-hail reports occurred, suggesting a large underreporting problem based on traditional approaches to collecting observations of hail. For the first time, we are closer to understanding the frequency of hail in Finland. A similar, but much larger, experiment called the Severe Hazards Analysis and Verification Experiment (SHAVE) was introduced in the United States (Smith et al. 2006; Ortega et al. 2009).

II. SEVERE-HAIL DATABASE SOURCES

A climatology of severe hail in Finland covered the 77-years 1930–2006 (Tuovinen et al. 2009). There was no earlier database existing for Finland. Several approaches were used to create the database—microfilms of old newspapers and Internet databases of major newspapers were the main source. Storm spotters have provided hail observations since 2004. Since summer 2006, the public has been asked to send their severe-hail observations to FMI's Web page. Even synoptic weather observation data, insurance companies and annual yearbooks were checked for possible hail reports. It is worth mentioning, that the insurance sector, unlike in many countries, does not collect or maintain any kind of statistics of the hail reports.

As a part of the database, a hail-reporting system was set up on the FMI Web page during summer 2006. This kind of collection mode is essential for growing the database in the future. Making the form easy, understandable, and quick was essential for ensuring the public's help. Although a few bogus reports have been received, these reports have been easily identified. Nevertheless, every severe-hail report is verified by weather-radar data and a severe-hail case filing follows closely the requirements used in the United States with 15 km or 20 minutes separation between two different cases (Schaefer et al. 2004). We have excluded all the graupel observations from the statistics, which usually dominate the earliest part of the hail season.

Last, the FMI Web page was renewed during 2008. One improvement to draw increased public attention was a colored text box on the front page that includes a short message. During days with lots of hail, the text box read "Did you run into a hailstorm? The FMI collects hail reports of at least 2 cm. Report your observation to us." with a link to the hail-reporting system. Now anyone can send observations via Internet with possible photos included.

III. ENLARGING THE SEVERE-HAIL DATABASE BY USING RADAR DATA

During the summers of 2008 and 2009, an experiment was conducted with the help of an experimental hail algorithm (measuring the height difference between the 0°C isotherm and the top of the 45-dB*Z* radar reflectivity factor contour, available on all 8 Finnish Doppler radars with 5-minute time steps). The algorithm is based on the methods of Waldvogel et al. (1979) and Holleman et al. (2000), and the details are explained in Saltikoff et al. (2009, submitted to *Journal of Applied Meteorology and Climatology*). Each time the hail probability from the algorithm exceeded at least 80% for 15–20 minutes within a convective cell (found to be a relatively good indicator for marginally severe or severe-hail cases), the first author would pinpoint the exact location and the closest business of any kind to the possible hail cell (e.g. Eniro maps with overlaying location of business and contact information on the map; http://kartat.eniro.fi/). The next step was to contact these possible observers by sending e-mails to local businesses, libraries, village associations or emergency personnel, asking if hail was observed and, if so, what was the diameter of the hailstones. Most of the e-mails were sent to local summer cottage renters, as these kinds of businesses are scattered all over the country. Twice we ran into a situation where no e-mail receiver could be found from the suspected hail area. In those two cases, we called to local citizens who were able to confirm the severe hail observation. Each contact had to be made within four or five days from the event so that the event was still fresh in people's memories. The hail algorithm has a 5-day archive, which is most suitable for this process.

There were several motivations for this approach. First, our intention was to identify the skill of the hail algorithm in detecting hail, and, further, to compare different probabilities from the algorithm output to observed hail sizes. Second, the total number of hail cases and hail days in Finland is unknown, so a more vigorous approach was needed to identify potential days when hail fell in Finland. Third, we wanted to see the effectiveness of the new approach and compare the numbers to the hail climatology study (Tuovinen et al. 2009).

The response rate was high considering that the e-mail receiver was randomly picked: 76% responded of the 125 e-mails sent during 2008 and 72% responded of the 109 e-mails sent during 2009. Of course some of replies were negative hail reports (13% or 12 of 95 in 2008, and 17% or 13 of 78 in 2009) and some were small-hail reports as the contacted observer was not in the region of maximum hail or severe-hail did not fall at all. Even most negative hail observers stated that large raindrops (possibly indicating melting hail) did occur. Only a minority of replies confirmed the occurrence of severe hail. Also, it was nice to notice that the tone of answers was positive, encouraging us to keep the research going.

Period	HD	SHD	HR	SHR	CSHR
1930–2006	-	5*	-	10*	240
2004-2006	20**	7**	61**	12**	240
2008	43	20	184	49	318
2009	33	10	140	31	349

TABLE 1: Annual statistics of hail from Finland on different periods. HD is the number of hail days, SHD is the number of severe-hail days, HR is the number of hail reports, SHR is the number of severe-hail reports, and CSHR is the cumulative number of severe-hail reports. * represents a 77-year average, and ** represents 3-year average

Table 1 shows how much the hail algorithm helped us to obtain new reports. The number of hail days (HD), severe-hail days (SHD), hail reports (HR) and cumulative severe-hail reports (CSHR) are presented. A clear increase in all numbers can be seen. The number of HD and HR reports has increased because of more storm spotters reporting (increase from 50 to 100), more people sending images of hail to newspapers and our contacting hail-favoured areas seen by the hail algorithm. Because summer in Finland lasts between 100 and 140 days, hail occurs every third or fourth day on average. Summers 2008 and 2009 did not have a lot of convective storms; there were less than half of the cloud-to-ground lightning strikes compared to the 25-year average (Tuomi and Mäkelä, 2003). The biggest difference between the severe-hail climatology from 1930–2006 and the last two seasons are the SHD (severe-hail day; at least one severe hail report in Finland) and SHR. Both values are approximately four times larger. Otherwise no conclusions can be drawn. One can carefully state that the new approach for collecting hail data has lessened the under-reporting in SHD and SHR, but HD and HR are likely still under-reported. As of this writing (September 2009), the severe-hail database of Finland has 349 reports, with 109 reports from the last three summers.

We are encouraged to learn that other countries have been inspired by our study. For example, recently we learned that Romania has started to build their own hail database.

IV. ACKNOWLEDGMENTS

The authors would like to thank all the randomly contacted people who contributed to the hail observations and the growing community of storm spotters in Finland. Schultz is partially funded by Vaisala Oyj.

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THE USE OF A HAILPAD NETWORK IN A METEOROLOGICAL SERVICE. A COMPARATIVE STUDY WITH OBSERVATIONAL DATA: 17TH SEPTEMBER 2007.

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(Dated: 15 September 2009)

I. INTRODUCTION

One of the biggest arable lands in Catalonia (northeast of Spain) is the plain of Lleida (fig. 1) with about 200.000 hectares of crops. At 17th September 2009, a storm heavily affected 889 hectares of fruit trees, the main production of the area. From 1990 the Associació de Defensa Vegetal - Terres de Ponent (ADV-TP), a local organisation for crop protection, is working to collect information of hail events and damages. In 2001 they built a hailpad network in this arable land with 170 hailpads distributed every each 16 square kilometres (Fraile et al. 1992). Thanks to this network different studies have been carried out (Aran and Peña, 2009; Mateo et al., 2009) at the Meteorological Service of Catalonia (SMC).

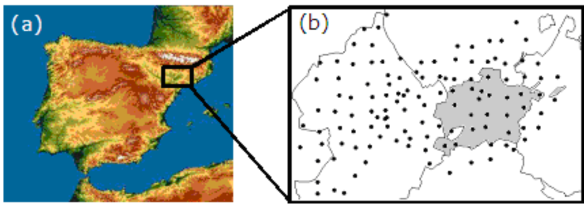

FIG. 1: (a) Iberian Peninsula (b) Hailpad network in the plain of Lleida. The area affected by the hail storm, El Pla d'Urgell, shaded.

In this study, some advantages and limitations of using a hailpad network for the analysis of the spatial distribution of hail fall and its characteristics are presented. The analysis is based on the 17th September 2007 hailstorm. The synoptic and mesoscale characteristics of this event are analysed by Pineda et al. (2009). The second section shows a summary of the climatology of the last years of the hailpad database in the plain of Lleida and the main characteristics of the hail fall for this event. In the third section, some details of the planning for the ground survey carried out only few days after the hailstorm and the result derived from are presented. In the fourth section, there is the comparative study between the ground survey and the hailpad information of this event. In the fifth section, it is shown the usefulness of using radar product to analyse hail storm such as probability of hail (POH) and also its limitations. Finally, the last section includes the main conclusions.

II. HAILPAD DATA

The hailpad database used is from 2001 to 2007 with a total of 82 hail events. According to this data, April is the month with bigger areas affected by hail however the diameter is lower than 2 cm. In May, June and July the diameter can achieve 4 cm. September is a month characterised by a lower number of hail events and by hail with a diameter lower than 2 cm. According to this, the 17th September of 2007 was an extraordinary episode, the hail surpassed 5 cm and the number of hailpads affected were 81 when the average is 10 hailpads per event.

It can be seen in figure 2 the area with higher diameter is in south, whereas the maximum intensity is displaced to the north. This dissociation was also found by Fraile et al. (1992).

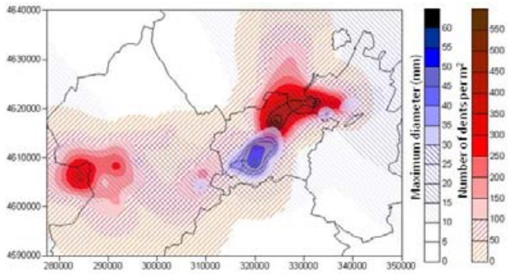

FIG. 2: Maximum diameter (blue scale) and number of dents per square metres (in red) in the plain of Lleida in the 17th of September of 2007 hail episode.

III. GROUND SURVEY

To obtain observational data from spotters or witnesses of the heavy storm, a ground survey was done. The proceeding followed was: (i) Identifying the affected area by means of mass media. (ii) Contacting to the affected people by telephone to have a previous report. (iii) Planning the visit starting from the inner part with big damages and ending to the external areas where the impact was low. (iv) Visiting the area and carrying out some interviews to obtain more detailed information (evolution of the storm, type of precipitation, size and intensity of the hail, other phenomena, description of the damages) and in some cases taking photos or collecting useful debris. In total, 11 interviews were done. From this information, a map with 5 zones defined according to a degree of affectation was elaborated, ranged from 0, no damages, to 5, big diameter or high intensity with important damages (Fig. 3).

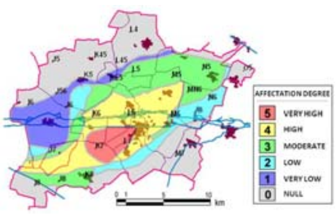

FIG. 3: Map of the degree of affection according to the information obtained from the ground survey in El Pla d'Urgell .

IV. COMPARATIVE ANALYSIS WITH HAILPAD NETWORK

In order to compare the quantitative information given by hailpads with the qualitative information of the ground survey it was used the ANELFA scale (Dessens et al., 2007) to categorize the qualitative information of the 5 zones (Fig. 3). Also, for each of the 5 zones it was chosen two of the closest hailpads. In figure 4, it is shown as an example, the comparison of the range of diameters observed with the ones marked in a hailpad.

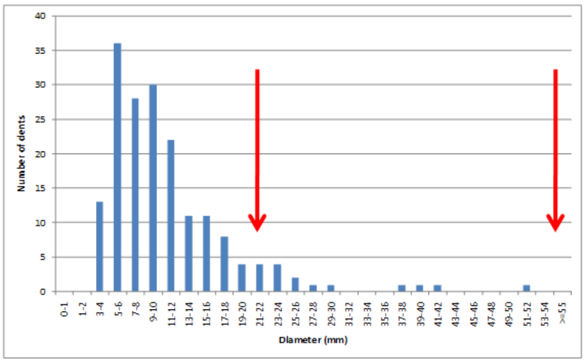

FIG. 4: Representation of the number of dents per diameter (mm) for the hailpad K6. The red arrows point at the maximum and minimum diameter observed by a witness of that area.

To evaluate the goodness of the visual observation with the closest hailpad, for each zone it was build a table of 3 factors (maximum size, range of diameters and intensity): 1-very good coincidence, 2-not bad and 3-low coincidence.

Variable	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Maximum diameter	2	1	1	1	1
Range of diameter	3	2	1	3	1
Intensity	3	2	1	1	2

TABLE I: Degree of coincidence (1-very good coincidence, 2-not bad and 3-low coincidence) for the observed maximum diameter, range of them and intensity of the hail fall in each area.

It can be seen in table I how spotters seem to put more attention when the event is important and the information given is closer to the obtained by a hailpad. In some hailpads, the maximum diameter recorded doesn't correspond to the observed one.

V. PROBABILITY OF HAIL

At the SMC since 2004 it is operating a probability of hail (POH) radar product (Aran et al., 2007). In the analyzed event the area with a probability of hail greater than 30% totally coincides with the area of the heaviest hail fall in El Pla d'Urgell (Fig. 5). The area of maximum diameter and higher intensity agrees with the maximum probability (higher than 90%). Although, the POH product is useful to determine the area affected by hail it doesn't give clear information about the size and intensity of the hail fall.

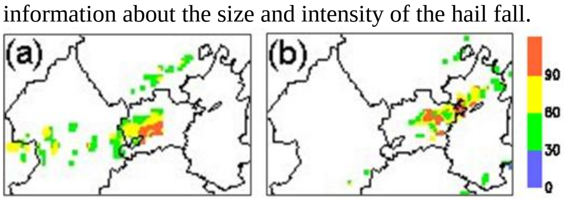

FIG. 5: Hourly composite map of the probability of hail radar product for the 17th September 2009: (a) 14 UTC and (b) 15 UTC.

VI. CONCLUSIONS

From the comparative analysis it can be concluded that the ground observers tend to perceive only the bigger hail stones in detriment of smaller ones even if the intensity is high. Also, it is important to point out a hailpad network doesn't give all the information about the hailstorm: bigger diameters are likely not to be recorded or in some events different storms can contribute to dent the same hailpad in the same day.

The main advantage of using POH product in surveillance is that it shows the probability of hail fall in a vast region. The cost of support a hailpad network with a high density of hailpad like the ADV-TP one is high and it cannot cover big extensions like the ones covered by a radar network. Another advantage of using POH product is that this information is available every 6 minutes with a delay of 15 minutes for processing the product. The main limitation of using POH is that no information about size and density intensity can be inferred.

The information given by spotters is very useful if it is taken following some basic recommendations such as to use common objects as references to describe it or taking photos, timing of the event, reporting other characteristic of the storm ... It is necessary to train spotters or give them some advise if not their information will be useless.

VII. ACKNOWLEDGMENTS

The authors would like to thank the volunteers and spotters of El Pla d'Urgell who participate in the ground survey, and also all the volunteers who contribute to the collection of the hailpads. Without their information this work wouldn't be carried out. Especially thanks to L. López for her comments and suggestions that have helped to improve this work.

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THE DEADLY EF-4 TORNADO OF AUGUST 3, 2008, IN NORTHERN FRANCE

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I. INTRODUCTION

A strong tornado hit seven cities of northern France in the late evening of Sunday, 3 August 2008, causing severe damage along its 19 km path from Pont-sur-Sambre to Boussois. Three people were killed in the collapse of their house and 18 were injured. More than 1000 houses were damaged and several thousand of trees were uprooted or fallen down.

The authors led a damage survey in the hours that followed the disaster, then investigated this case, in order to determine precisely the characteristics of this tornado and to better understand the conditions that led to its formation.

II. DAMAGE SURVEY

The site investigation shows that the tornado first touchdown occurred in a corn field at 20.28 UTC with an EF-1 intensity. During the first 3 minutes of its development, it produced two suction vortices, with a maximum wind speed estimated at 45 m/s. Few houses suffered minor damage and large branches of hard wood were broken.

Only 2 minutes later, the tornado reached an EF-2 intensity (many uprooted trees and several damaged houses), then, at 20.31 UTC, an EF-4 intensity, causing the total destruction of one solidly built house (FR12 DOD10, see Fig.1). Many trees were uprooted and some of them were completely debarked (TH DOD5).

FIG. 1: total destruction of a solidly built house in Boussières-sur-Sambre (FR12 DOD10 ; EF-4).

Keeping its EF-4 intensity during 2.5 km (until 20.33 UTC), with a maximum wind speed estimated at 85 m/s, the tornado crossed the *Fayt Wood*, uprooting and debarking all the trees on its 150 meters wide path. Then, it hit the city of Hautmont, where 3 people were killed by the total destruction of their house. Hundreds of houses were severely damaged all around the tornado path (sometimes as far as 500 meters from it), some of them were demolished down to the foundations in the central part of the path. Many cars were thrown to significant distances, and one was lifted up to the first floor of a severely damaged house. Some trees were ejected to more than 500 meters. Little objects, like photographs or chequebooks, were thrown to more than 30 km.

A few minutes later, the tornado weakened to EF-2 intensity, causing significant damage on the boroughs of Maubeuge. The bell-tower of a church collapsed. Many other infrastructures (factories, hospitals, the city-hall, the zoo) sustained moderate damage. Hundreds of trees were knocked down at the Public Garden and all around.

About 12 km after its touchdown, the tornado weakened to EF-1 intensity. It hit the Military Cemetery of Assevent, where large branches of hard wood were broken. Many little trees were also uprooted. Finally, at 20.40 UTC, the tornado weakened to EF-0 intensity on a 50 meters wide path. Two minutes later, it caused little damage on trees again, then it dissipated at 20.42 UTC near the Belgian border.

The damage survey reveals that this tornado case is of greatest interest, because it hit a wide variety of terrains with a wide variety of intensities (see Fig.2), from corn fields and woods to highly populated areas, from a narrow EF-0 vortex to a 150 m wide severe EF-4 tornado.

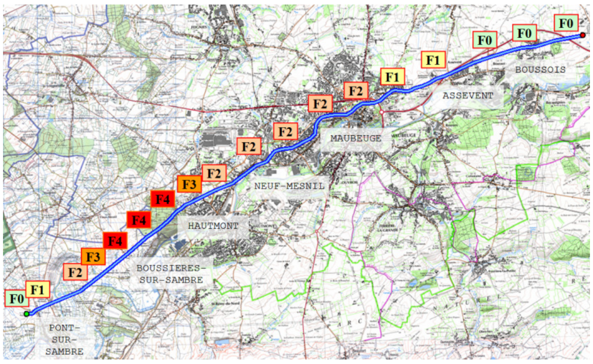

FIG. 2: the 19 km path of the "Hautmont tornado", from Pont-sur-Sambre (SW) to Boussois (NE) with EF-scale intensities and cities names.

III. RADAR ECHO FEATURES

High resolution radar data show that the tornado was generated by a supercell that formed about 45 minutes earlier. Main radar signatures include a persistent rear inflow notch, a tornado vortex signature on Doppler radar and a discrete hook echo. This supercell was characterized by a 20° deviation to the right of the mean wind, and by a double heavy precipitation core, the first one imbedded in the forward front downdraft (F.F.D.) and the second one in the rear front downdraft (R.F.D.). Both produced heavy rain, but a major axis of 30 to 80 mm hourly rain accumulation is noticeable about 4 kilometres north of the tornado path, i.e. under the F.F.D..

The tornado touched the ground during the mature stage of the supercell storm, about 10 minutes after the beginning of the maximum F.F.D. rain intensity phase. In the meantime, radars show a sudden acceleration of the R.F.D. circulation, which began to wrap the mesocyclone about 3 minutes before the tornado touchdown. The R.F.D. development is particularly obvious during the 15 minutes of the tornadic stage. So, in this case, the evolution from a non-tornadic to a tornadic supercell may be related to the transition from a classic stage to a high precipitation stage supercell. In this respect, the role of the F.F.D. rain core intensification may have been significant in the minutes that preceded the tornado formation.

IV. SYNOPTIC AND MESOSCALE PATTERN

From a synoptic point of view, this tornadic supercell was generated during a prefrontal convective event. The cell formed in a moderately unstable but highly sheared environment, characterized by a coupling between a low-level jet and a highly divergent jet-stream left exit region. The LLJ was associated with a rapidly moving baroclinic mesoscale wave, just ahead of a deepening mid-level trough in-phase with a rapidly moving upper-level PV anomaly. This synoptic pattern is known to be severe weather conducive, by forcing deep convection and by insuring high deep shear and high storm-relative helicity values.

A reconstructed vertical profile for the city of Hautmont at 22.30 UTC, based on surface observations from nearby meteorological stations, on proximity soundings and on numerical simulations, shows interesting features. Indeed, the low level environment was characterized by a warm and moist air advection (high dew points), producing low LCLs and low LFCs (about 400 m AGL), with a highly accelerating and veering wind profile. Wind speeds in the upper-level WSW flow were in excess of 45 m/s, with favourable mid- and upper-level storm relative winds from 8 to 20 m/s (Kerr and Darkow, 1996). In the meantime, a discrete mid-level layer of drier air was present around the 700 hPa level, resulting in an effective downdraft production. Nonetheless, vertical profiles were over-all dominated by a well saturated air mass, generating a quite weak DCAPE (200 J/kg) and high values of K Index (34). Instability parameters show a moderately unstable profile, with a CAPE of 700 J/kg (EL at 285 hPa), a MULI of -2,6°K and a Significant Severe Parameter of 12,927. On the other hand, shear parameters show very high values : 0-1 km SRH (607 m²/s²), 0-3 km SRH (692 m²/s²) and Low Level Shear (22 m/s) reach critical values. All these parameters produce a vertical profile which is tornado and supercell conducive (EHI of 2.94 and SCP of 10.5).

It is worthy to note that high resolution numerical models succeeded in forecasting this event, despite its mesoscale component characteristics. The Tornado and Severe Storms French Observatory forecasters tested for this case, with the contribution of Avel Olejnikov, a 2.8 km horizontal resolution WRF model grid centred on northern France, nested on a 7.5 km grid covering whole France, nested itself on the GFS 1° model (2 August 18h UTC initialisation, i.e. 24 hours before the tornadic event). Results based on a 3D-Var assimilation show an impressive precise result (see Fig.3). Nonetheless, GFS- and NMM-based routine forecasts which are produced daily by the French Observatory (Keraunos) highlighted this tornado risk on northern France for the August, 3, 2008 evening, about 12 hours before the event. Estofex forecasters produced nearly the same prediction as Keraunos forecasters : that shows that moderate resolution models are partly sufficient to point out tornado risk areas with a valuable efficiency.

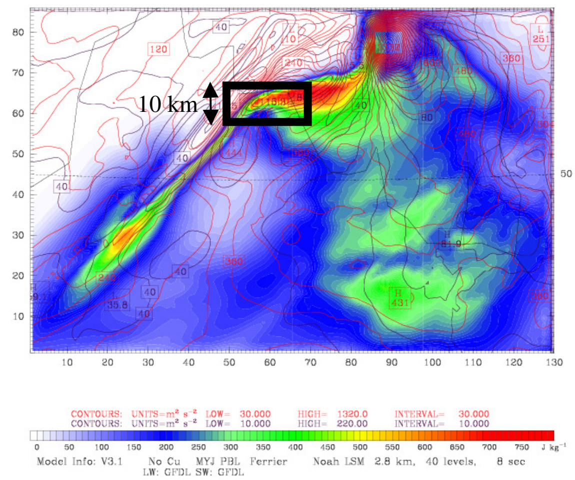

FIG. 3: 27h forecast of CAPE (shaded), 0-3km SRH (red lines) and BRN (black lines) for August, 3, at 21h UTC (2.8 km resolution WRF field). The area hit by the tornado is outlined in black.

V. RESULTS AND CONCLUSIONS

The tragic events of August, 3, 2008, in northern France, are related to a severe supercell-induced tornado, that hit seven cities on a 19 km long and 150 m wide path. Site investigation shows that the vortex reached an EF-4 intensity and had a translation speed of about 80 km/h.

This tornado confirm that the Nord – Pas de Calais French region counts among the European regions which are the most frequently hit by severe tornadoes (Dessens and Snow, 1989). Indeed, in this 12,400 km² area, we count no less than 2 EF-3 (1965, 1998), 2 EF-4 (1967, 2008) and 1 EF-5 (1967) tornadoes on the modern period. That means that the tornado risk in this area could be considered as significant.

Furthermore, despite a quite original synoptic configuration in comparison to usual tornadic synoptic patterns in France, this case proves the liability and the legitimacy of convective forecasts experiments that are led in France (Keraunos) or in Germany (Estofex) in order to improve severe storms prediction.

VI. AKNOWLEDGMENTS

The authors would like to thank Avel Olejnikov for his contribution to the high-resolution modelling of this severe convective event, and Dr. Jean Dessens for his review.

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THE INTERNATIONAL CENTRE FOR WATERSPOUT RESEARCH

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I. INTRODUCTION

Running a routine search for media material on waterspouts, international reports will be noticed every few days throughout the summer and fall season. In the Great Lakes area between Canada and USA, two waterspout outbreaks occurred on August 6 and 30, 2009 (Fig. 1). "Waterspout" is the historical label for a tornado over water/on the sea. Although there has been criticism about a name linking a meteorological phenomenon with its geographic frame, the traditional term is firmly rooted in common knowledge, used worldwide, and therefore cannot be abolished or changed easily.

With the classical work of Wegener (1917), Rossmann (1961), and Golden (1974a,b, 1977) , scientific research expanded internationally (Szilagyi, 1994, 2004, 2009; Reynolds, 1999; Dotzek, 2001, 2003; Tyrrell, 2001; Sioutas, 2003; Keul et al., 2009).

FIG. 1: Waterspout near small boat, Lake Erie, August 6, 2009 (photo Robert LaPlante).

First systematic case collections (e.g. TorDACH) led to the European Severe Weather Database (ESWD) in operation since 2000 where waterspout reports can be entered on-line. More recently some research initiatives have been focused on Mediterranean waterspouts concerning investigation of favour meteorological conditions and forecasting (Gaya et al., 2001; Giaiotti et al., 2007; Sioutas and Keul, 2007; Sioutas et al., 2008; Keul et al., 2009).

A first analysis of central-eastern Mediterranean waterspout cases was based on investigating typical synoptic features and conventional thermodynamic elements (Sioutas and Keul, 2007). Based on a data sample comprised of 28 reported waterspout cases from three sea regions, the Adriatic, the Ionian and the Aegean, the frequency of four basic synoptic types associated with waterspout events–south-west flow, long-wave trough, closed low and short-wave trough–was identified as well as the role of upper and lower level jets for increased wind shear. Out of a number of thermodynamic instability indices studied, KI and TT were good predictors.

FIG. 2: Central-Eastern Mediterranean waterspout locations (Keul et al., 2009).

An effort was made to develop a waterspout prognosis tool applied to a sample of 110 central-eastern Mediterranean waterspout cases (Fig. 2), from 96 days occurred in the period 2002-2006, by testing of the Szilagyi waterspout nomogram (Fig. 3). The results were very encouraged, indicating that the nomogram could be used as a valid waterspout prognostic tool for the Aegean, Ionian, and Adriatic Seas (Keul et al., 2009). Consideration should also be given to using the Szilagyi nomogram over the remainder of the Mediterranean and other European waters.

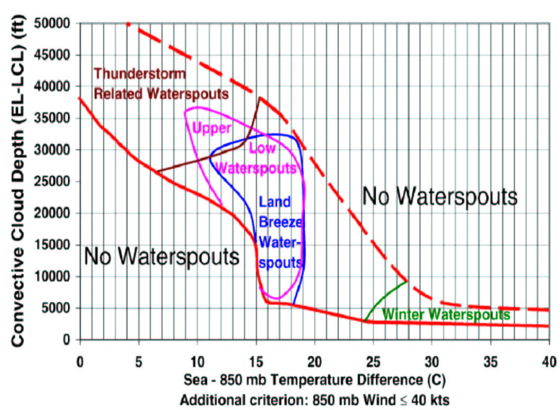

FIG. 3: The Szilagyi Waterspout Nomogram (2005).

The Szilagyi waterspout nomogram was initiated in 1994 and continues to the present was empirically derived from a number of 172 waterspout events and tested by the Meteorological Service of Canada for the Great Lakes. It uses tephigram values, lake surface water and 850 hPa temperatures, to numerically define four waterspout types and their occurrence (Szilagyi, 2005). As a further improvement to the performance of the nomogram, a "fine tuning" could be considered.

II. PRESENTATION OF PROJECT

In 2008, the three authors decided that an international network would make sense–an independent, private organization comprised of individuals worldwide, interested in the field of waterspout research and its operational applications.

For this reason, the International Centre for Waterspout Research (ICWR), was founded. The second author suggested its title. The organizational goals are as follows:

1. Foster the advancement of scientific research and applications related to waterspout occurrence and prognosis.
2. Provide an international forum for the exchange of information and ideas among researchers, operational meteorologists, storm chasers and other weather observers.
3. This forum will also facilitate the reporting of waterspouts from around the world and help in the organizing and establishment of a global waterspout data base.
4. Promote, educate, and communicate ICWR outcomes to other interested institutions, the media and the marine community.

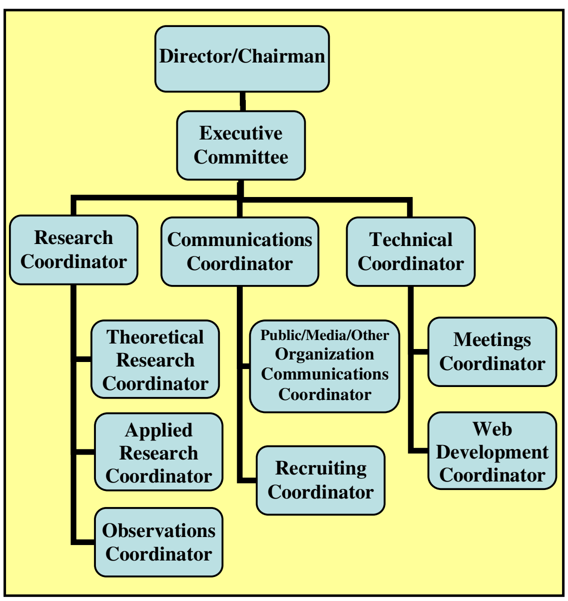

FIG. 4: ICWR organizational chart.

The current status of the ICWR is embryonic–three members from Canada and Europe, in contact via teleconference meetings, and a first small network of interested researchers. In Figure 4, the ICWR organizational chart is displayed.

III. CONCLUSIONS

Affiliations with other scientific bodies are underway. An ICWR web page is planned for 2009. With ICWR evolving and an expanding membership, its main projects will gradually materialize: Developing a global waterspout data base, a global waterspout reporting system, a digital waterspout publication library, a global waterspout climatology and fostering/collaborating new research papers and projects.

IV. ACKNOWLEDGMENTS

The authors would like to thank all participating waterspout observers–meteorologists, officials, sailors, amateurs, tourists–with an active interest, who reported their sightings to national weather services, the ESWD and/or the authors and often took valuable photographs/videos.

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TORNADOES AND SEVERE STORMS IN SPAIN

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I. INTRODUCTION

Tornadoes and other severe winds associated to thunderstorms are relatively frequent in Spain. This was yet performed for the Balearics Islands (Gayà, 2001) and for a contiguous Spain (Gayà, 2005) and the present work is devoted to investigate how severe storm distributions have evolved through the last five centuries or more.

The complex orography of the Iberian Peninsula and the Mediterranean Sea play a determinant role in the Geographic distributions of severe weather, but the economic and societal perception seems to be an important factor in their apparent changes.

II. DATABASE

The database has been developed collecting information from different sources. In the last twenty years, many cases have been surveyed by the author or other meteorological teams.

According to its origen, the database have divided into three periods, the first one contains the most ancient times until 1825. The oldest times information is kept in archives and the notice are usually picked up by an official chronicler. Many cases are linked to magic or mythic event. some battles are 'lighted' with a religious vision and God operates through a vortex or by severe storm. All these cases are not included in this study.

On the second period (1826-1975) the information is mainly collected from journalists and are kept in newspaper archives. The most recent times (1976-nowadays) combines newspapers, tv, internet, and personal survey.

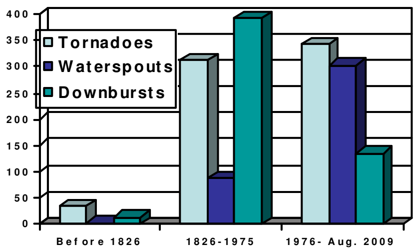

FIG. 1: Tornadoes, waterspouts, and downburst in the three selected periods.

III. TIME AND GEOGRAPHYCAL DISTRIBUTIONS

In the most recent times (1976-2009), the number of severe winds has increased to 1995 when it stabilizes and seems to have the inherent variability of rare phenomena of one year to another.
The attention paid to these phenomena and the quick diffusion of the news via television and internet, and the increase of insurance policies in an increasingly complex society, seem to be the cause of this behavior.

Much more difficult is to explain the evolution in the period from 1825 to 1975. Whether in the early years the press barely pays attention to topics other than political, the presence of remarkable events is increasing steadily. The decrease in cases since 1900 is probably due to a progressive journalistic disinterest in these subjects and progressive industrialization of the country that would become less vulnerable. However, political upheavals (World Wars and Civil Spanish War) seem to have a decisive effect on this anomalous behavior.

Adverse events in the period between 1400 and 1825 are usually described in a context where, few exceptions, the news is not the weather but the politics or military action that is told. However, some very notable cases are described by themselves, such is the 1671 tornado case, where damage was very extensive and the number of deaths so remarkable that make it one of the most notable tornadoes in the world.

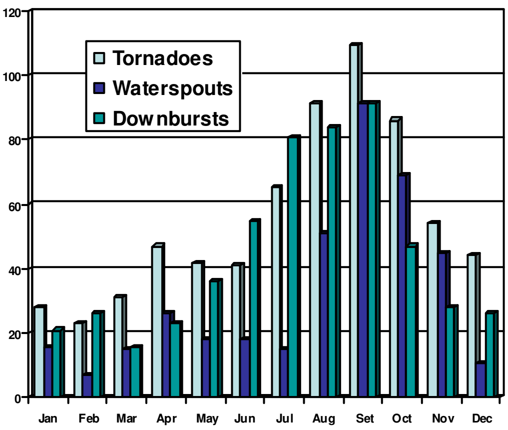

FIG. 2: Monthly distribution of tornadoes, waterspouts, and downbursts (complete database).

It is clear on the figure 2, that warm season is when all kind of severe weather can be generated.

In the most recent time period (see Fig. 3) the density distributions of tornadoes are similar to the lapse (1826-1975), with small weight differences. But in earliest period, before 1826, Southwestern part of the Iberian Peninsula and Northern Plateau (Castilia) present higher severe activity than the Mediterreanean areas. It is obvious that this 'anomalous' distribution is not due to climatic change but for the location of the ancient official chroniclers and economic and political power.

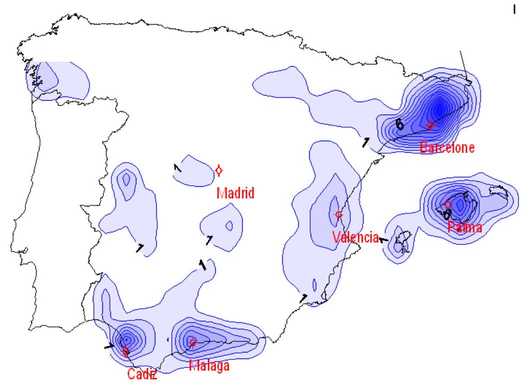

FIG. 3: Tornadic density in the most recent period (1975-August 2009).

Most of tornadoes are weak and only a small part is strong. In the complete database, only one case can be violent (Fig. 4).

Because the comments are always limited in the ancient records, the difficulty to assign an F scale is high. Then, the database probably understimates the F in the older cases, and F is overestimated in some of the recent cases if they have not surveyed.

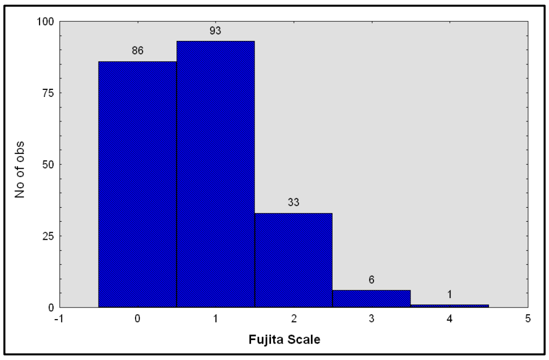

FIG. 4: F-Scale in the tornadic cases (complete database)

The strongest tornado in Spain is the event of March 1671 where it seems died more than 600 people and destroyed many houses in Cadiz. This case was preliminary studied by Sánchez-Lauhle (2005) and rated as F3. But it is plausible that this event was stronger because some documents writen by other chroniclers were not considered.

IV. CONCLUSIONS

A climatology of tornadoes, waterspouts, and downbursts in Spain is presented. It shows the spatial and temporal distribution in three periods: before 1826, 1826 to 1975, and 1975 to Agust 2009.

The spatial distribution is significantly different when taking into account the reference periods past and present. But these remarkable differences are due to other causes not attributable to climate change, but to sociological reasons. When time distributions are observed, the difference is not significative.

The downburst cases are underestimated when comparing with severe vortex in the recent times, but they are probaly overestimated when ancient times are considered.

The shape of the distributions of the maximum velocity is similar to other countries or regions, perhaps the number of events in the violent lapse is too small.

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ANCIENT NATURAL DISASTERS TRIGGERED BY SEVERE WEATHER IN SÃO PAULO, BRAZIL

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(Dated: 15 September 2009)

I. INTRODUCTION

Our lives are strongly influenced by the climate of where we live (Burroughs, 2005), so that a comprehensive knowledge of weather and climate is of great relevance to all aspects of our lives, including our integrity. Notwithstanding, because current conditions are connected to past episodes, the reconstruction of climate is of utmost importance, not only for providing an extension of knowledge back in time, but also for understanding the present climate conditions and predicting future events.

Documentary sources such as personal diaries and official reports that mentioned events such as floods, droughts or any other weather phenomena provide valuable information for past climatic reconstruction. Among the oldest are the measurements of Nile's floods (Bowden et al, 1985) and reports of the flowering of cherry trees in Japan and Korea, which date back over a thousand years. In Europe, there are records for many regions from the year 1500 approximately (Fagan, 2009). For South America, some old information comes from the time of the great discoveries, with compilation of excellent meteorological and geographic information (Silva, 2000).

In Brazil, former climate conditions are still poorly known, although the country has precious information from reports made by naturalists that crossed the country in colonial times to survey natural resources, among them Debret, Rugendas, Kidder, Saint-Hilaire and Luccock. Despite their richness, these reports were not fully analyzed in the light of the climate perspective, but they are an extraordinary source of information.

This study aimed to reconstruct the past climate conditions of the state of São Paulo, Brazil (FIG. 1), evaluating man-made documentary sources of information (i.e., before systematic observations) in view of comparing former and current conditions in the same area as well as possible similarities with other areas in the same period. Further, because the state of São Paulo has experienced quite impressive environmental changes in the last decades, the results of this study might be useful for estimating the degree of the human influence on climate.

II. MATERIAL AND METHODS

Sources of information were manuscripts, newspapers, official and particular correspondences, literary compositions, periodicals, magazines and different sorts of artistic expressions, such as paintings, drawings, maps, photographs and films collected in museums and archives. Other precious source of information comes from reports of exploratory journeys made by naturalists, which contain direct information from instrumental records, as well as indirect and more subjective information of atmospheric characteristics obtained by folklore, painting, music and other cultural manifestations. Documentation consulted (scientific registers, periodicals and bulletins) spanned a period from 1869 to 1950. However, within the documents there are mentions of phenomena back in the beginning of the Brazilian colonization by Portugal.

FIG. 1: Brazil and the state of São Paulo (in red).

All information collected was organized in a database containing for each episode reported the date and the area in which the event was registered, its characteristics and source of information.

III. RESULTS

Letters written by Jesuits at the time of the foundation of the village of São Paulo (1560) contain important information regarding weather conditions. A clear and lively description of a severe storm associated with strong winds and its damages to buildings and trees was done by the local priest, José de Anchieta, founder of the village of São Paulo, nowadays São Paulo, one of the biggest cities of the world. Anchieta also described the ways in which reconstructions were done in order to minimize damages from future extreme events. By the rich description of damages, full of details (Magazine of the Geographic and Historical Institute of São Paulo, v.46, p.72), one can hypothesize the phenomena was a tornado.

In the 18th. century, mining activities became important in the colony economy (former Brazil): westward incursions by fluvial navigation were done by explorers, in view of looking for minerals and promoting the occupation of lands. River Tietê, in particular, (FIG. 2) were an important via to reach the far west. The explorers recorded all types of environmental information in their diaries and reports, including descriptions of weather. Registers of the Baron Langsdorff expedition (1826-1827), for instance, mentioned a strong cold spell on 25 June 1826 which, in the words of the Russian Langdorff was comparable to the conditions of Siberia, even considering that the expedition members had appropriated clothes (Komissarov and Silva, 1997). Many other reports also mentioned very severe winter conditions, in phase with the Little Ice Age in Europe, demonstrating that areas of Southern Hemisphere also experienced concomitant situation.

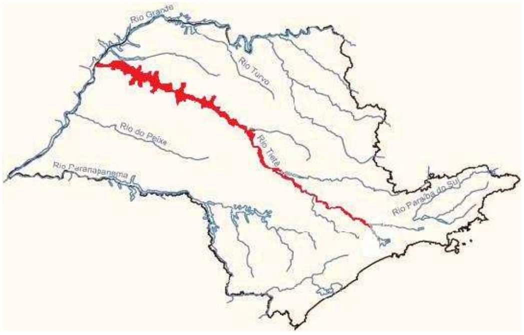

FIG. 2: River Tietê, State of São Paulo (in red).

Around 270 reports on weather and climate for Brazil and other countries were collected from the newspaper Gazeta de Campinas between 1869 and 1884, with information particularly focused on extreme episodes, in special, intense cold spells that affected coffee plantation, the main economic item of São Paulo’s economy of the time. It follows some examples:

- 3 July 1870 - the effect of a frost was so severe that local authorities considered that the economy of many farmers were completely broken.

- 6 July 1884 - two days after a great frost, a farmer realized, with deep sorrow, that an extensive part of his coffee plantation was completely ruined.

- 25 July 1884 - a coffee farmer testified that since 1855 there was no comparable frost like the one of 26 June: an eight years old coffee plantation in a supposedly safe place completely died. Also, the freezing cracked thick trees in the neighbourhood.

- 8 October 1884 - a frost episode was registered in October, an unusual time for this sort of phenomenon (spring), fact that was considered by many local farmers as a signal of God’s punishment.

Considering some Almanacs from 1872 to 1918, around 190 registers concerning atmospheric aspects were found. Information came from collaborators that gave their impressions of climate. This kind of subject was included in the physical description of the cities, related to the local population salubrity. Park (1999) quotes some attempts to explain the climatic phenomena in view of forecasting local weather:

- In threatening weather conditions birds are quitter, because before storms, the atmospheric pressure is lower, the air is less dense and the flight is more difficult.

- When good weather prevails smoke raises straight up, indicating higher-pressure, whereas less dense air associated with bad weather conditions avoids the smoke to ascend.

- Good visibility on the sea is an indicator of bad weather, since the air turbulence avoids the formation of sea misty.

- Echoes that reach longer distances and are better identified are clear signal of rainfall, because low level clouds reflect sound waves.

- Smells are more intense before rainfall, because odours are retained by higher pressures and conversely are dissipated when the pressure comes down.

Another journal, Provincia de S. Paulo (currently O Estado de S. Paulo), presented 160 news about extreme weather between 1875 and the 1879. It is worth mentioning that in the years of 1876 and 1877 there was much information on climate extremes for sectors of Brazil, Europe and United States. Examples:

- 16 July 1876 – winter conditions in cities of the province were compared to situations experienced in North Europe.

- 15 August 1876 – a number of areas of coffee plantation were affected by frosts for the first time.

- 23 August 1876 - a letter from New York was published, relating that in July temperatures reached 106 degree Fahrenheit, causing 40 to 50 daily cases of sudden headaches.

- 5 October 1876 – a report stressed that also in Europe the summer of 1876 was particularly hot and would be remembered for a long time.

- 23 December 1876 – referring again to the heat in Europe, a piece of news mentioned many cases of insolation in Spain.

- 27 May – 26 July 1877 – during this period, there were many reports about droughts in Northeast Brazil. They mentioned the aid to the victims that came from other areas of Brazil, as well as famines and epidemics in the affected area.

IV. CONCLUSIONS

Historical sources present considerable potential for studies of current and long-term physical processes, but they have been under explored for interpreting some features of the physical environment, like the atmosphere. They are also important to evaluate the magnitude of the impact of human activities on the physical environment (Hooke, 1982).

Detailed information of climatic characteristics in different periods can be defined through homogeneous and continuous registers but also from distinct data sources collected not systematically that contain information on situations and processes that are affected by the climate. Thus, valuable information can be obtained from instrumental measurements, food production variations (including agriculture, cattle and fishery) in different moments of the human evolution, diseases associated with atmospheric conditions, natural disasters, as well as impacts of long-term extremes on civilizations or social groupings, culminating in historical facts that were influenced by atmospheric conditions, such as numerous wars and their effects on the fate of the nations.

This study showed that Brazil has rich documentation of past climatic information that deserves to be properly explored. A promising aspect for future studies involves further investigation of cooler winters in the 18th century, similar to conditions experienced in Northern hemisphere.

IV. AKNOWLEDGMENTS

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SIGNATURE OF HAIL PRECIPITATION ON THE GROUND

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I. INTRODUCTION

In describing the hail climatology of one particular study zone, hailpad networks are the most widely used systems for determining the ground truth. In spite of some minor disadvantages, hailpad networks provide very detailed information on a number of hail parameters. These values may subsequently be used to construct databases integrating the parameters obtained separately by each hailpad from both a spatial and temporal perspective. These integrated parameters for one particular study zone are typical of the different areas and may be interpreted as a 'signature' of the characteristics of hailstorms in each area.

This study compares the parameters describing the characteristic features of hail precipitation in the Iberian Peninsula (Province of Zaragoza) and in Argentina (Province of Mendoza) on the basis of data from the corresponding hailpad networks. The maximum values registered have also been computed, as they may be very useful in studies on meteorological risks in engineering. The frequency histograms of the variables have also been computed for the different hailpads and in different time spans. These histograms implement the information obtained from the mean and extreme values and may be very useful in future studies relating this type of variable to thermodynamic parameters or radar variables.

II. STUDY AREAS AND DATABASES

Although different methods have been used since the 1960s to calculate parameters connected with hail, today the most widely used sensor is the hailpad. Different authors (Fraile et al., 1992) have studied the calculation of the variables related to hailstones based on impacts caused by them on the surface of the hailpad. As a result, hailpads allow us to obtain a wide range of characteristic variables of hail precipitation, such as the presence or absence of hail, maximum precipitated size, number of impacts (number of impacts per m^{-2}), total precipitated hail mass (g m^{-2}), total kinetic energy (J m^{-2}), area covered by hail, hail size histograms (N. / size range), parameters of the adjustment to the exponential distribution or gamma, amongst others.

As it is not possible to cover the whole of a geographic area with hailpads, these are usually installed over a small, localised area. The area and density of a hailpad network is established based on the characteristics of the hailstorms that affect the respective regions, as well as the limitations in terms of maintaining the network. The main limitation of these networks is the overlapping of two different hailstorms on the same pad. To avoid this, it is necessary to have an effective methodology available for checking and replacing pads on which hail has fallen during the experimental data gathering campaigns. In our case, in the study zones selected, the weather radars include an application developed by López and Sánchez (2009a) which shows directly on a screen the probability of hail on each hailpad in the network, making it possible to minimise the replacement times of the pads and avoiding overlap errors.

As already mentioned, in order to carry out this study, data was gathered and analysed on hail from the hailpad networks in the province of Zaragoza (Spain) and the province of Mendoza (Argentina). These are two geographically distant zones, but which share a common characteristic: a high frequency of storms with hail precipitation, mainly during the summer months (Sánchez et al., 2009b)

Firstly, in Spain there is a hailpad network in Zaragoza. The study zone is in the extreme north-east of the Iberian Peninsula, and covers an area of some 50,000 km^2. The network of hailpads in Zaragoza is located in the south-west of the province, in the districts of Valdejalón, the Community of Calatayud, Campo de Cariñena and Campo de Daroca, as well as the northern part of the district of Jiloca in the province of Teruel. The 100 hailpads in the network are distributed along the vertices of a grid measuring 5 x 5 km, coinciding with the UTM network. Five experimental campaigns were carried out to gather data in this area from 2003 to 2007. A total of 413 hailpads included in the study received impacts.

Secondly, the Argentinean province of Mendoza is located between 32° and 37° latitude S and 67° and 70° longitude W, to the west of Argentina on the border with Chile. In this study a network of hailpads located in the south of the province was used, with 130 pads distributed in a 5 x 5 km grid. In the areas with the highest storm frequency, the network is supported by another internal grid measuring 2.5 x 2.5 km. The network has data from three experimental campaigns carried out between 2005 and 2007. A total of 750 hailpads in the area received impacts.

III. RESULTS AND DISCUSSION

Firstly, in order to arrive at an approximation of the intensity of hail precipitation in the area of the hailpads, the descriptive statistics were calculated (maximum, minimum and mean values, and standard deviation) of the variables of the hailpads for the individual pads. The results are shown in Tables I and II.

The variables measured in the hailpads make it possible to characterise the hail precipitation in each of the networks. In terms of the variables per unit of surface, if we compare the two study areas, the maximum number of impacts is quite similar in both networks (9222 impacts m^{-2} in Zaragoza, compared to 9924 impacts m^{-2} in Mendoza); however, the maximum kinetic energy per unit of surface is more than three times higher in Argentina than in Spain.

	Nº impacts (imp m^{-2})	Mass (g m^{-2})	Kinetic energy (J m^{-2})	Maximum diameter (mm)
Maximum	9222	4007.05	819.97	43.4
Minimum	9	0.02	0.03	5.4
Mean	938	380.99	44.11	13.5
Stand.Dev.	1417	705.62	102.04	6.3

TABLE I: Characteristic values per hailpad in Zaragoza.

	Nº impacts (imp m^{-2})	Mass (g m^{-2})	Kinetic energy (J m^{-2})	Maximum diameter (mm)
Maximum	9924	8712.59	2588.32	49.5
Minimum	10	0.69	0.03	5.4
Mean	872	516.36	79.89	16.5
Stand.Dev.	1150	1044.74	231.10	7.7

TABLE II: Characteristic values per hailpad in Mendoza.

Also, in Zaragoza and with respect to the mass of ice precipitated per unit of surface, a fall of little more than 4 kg m^{-2} was recorded on a hail pad, with the mean being nearly 381 g m-2. In Mendoza these results are nearly twice as high: a maximum of 8.7 kg m^{-2}, with means of 516.36 g m^{-2}). This data may be applicable to engineering studies to calculate the maximum load to be supported by specific types of structures (roofs, canopies, etc.).

Furthermore, the maximum diameter recorded on a hailpad was 4.3 cm in Zaragoza, compared to 4.9 cm in Mendoza.

This study also estimated the mean ice mass precipitated per day, which was 6.73 10^4 tons for the network in Zaragoza, with a maximum of 5.56 10^5 tons. If we suppose that a normal storm in the area has dimensions of 20 x 10 x 10 km, or a volume of 2000 km^3, and that the normal liquid water content in a storm is 2 g m^{-3}, the liquid water contained in this volume would be 4 10^{12} g, or 4 10^6 tons. Out of these, they only precipitate a mean of some 7 10^4 tons in the form of ice, or only 1 or 2 % of the liquid water content of a storm.

The numerical data shown above in Tables I and II make it possible to understand the characteristics of the hail precipitation, although it would be necessary to know if these values are the most usual, or if otherwise they are extreme cases. As a result, the frequency histograms were calculated of the values of the hailpad variables (number, mass, energy and size) recorded on each pad and accumulated by days. For example, Figure 1 and 2 show the maximum diameter frequency histograms recorded for Zaragoza and Mendoza respectively.

For both networks, the histograms show how the values of the smallest classes of number of impacts, precipitated ice mass and kinetic energy per unit of surface are more frequent than the larger classes. The frequency histograms for both networks show that the modes are found in the values of the lowest intervals, meaning that the most frequently observed values are found within the smaller classes, with the maximum and mean values shown in tables I and II higher than the most usual values.

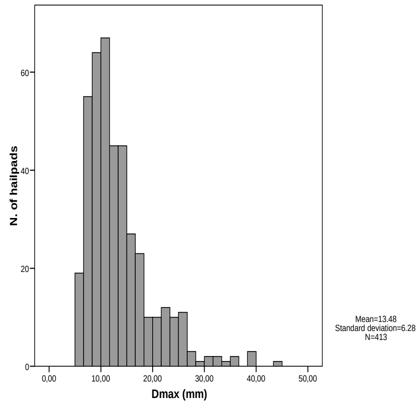

FIG. 1: Histogram of diameter frequencies in Zaragoza

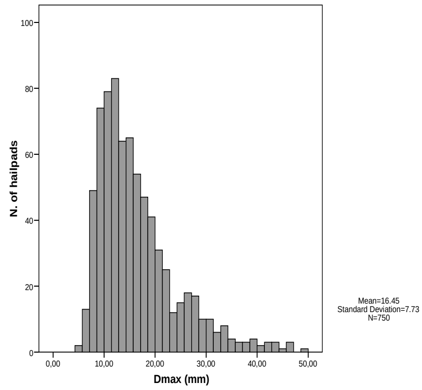

FIG. 1: Histogram of diameter frequencies in Mendoza

In terms of maximum diameter recorded on each pad, the most frequent value, the mode, is between 10 and 12 mm in Zaragoza, while the daily maximum varies between 13 and 16 mm. Unlike the previous variables, the mode of the maximum diameter is not observed in the smallest classes. The same occurs with the network in Argentina, which has a mode of between 12 and 15 mm, while the daily maximum varies between 15 and 18 mm. Finally, on representing the accumulated percentage of the frequency of the maximum diameter for each pad or for each day, it may be seen that 75% of the pads have a maximum diameter of less than 15 mm in Zaragoza, and 20 mm in Mendoza.

IV. ACKNOWLEDGMENTS

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Towards an integrated hail database: a comparative study of different sources of information in Catalonia

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(Dated: 15 September 2009)

I. INTRODUCTION

This study presents a comparative analysis of different sources of information about hail data in Catalonia (NE of Spain). In order to obtain a complete hail climatology such as that reported by Giaiotti et al. (2003), a detailed description of hail occurrence (date and time), size and density distribution, and extension of affected area in the region of interest are ideally needed. The different sources of information are listed and characterized in a first section, meanwhile in the second section are showed the results obtained using hail data reports during 2008.

II. DATA SOURCES

Five sources of information of hail observations were examined covering the year 2008. The advantages and limitations (spatial and time resolution, arriving time, size information, etc.) of the different sources are discussed in this section. The five data sources were:

1) Visual observations reports, obtained mainly from the Meteorological Service of Catalonia spotter network (Figure 1), a preliminary analysis of these sources of information indicates that the geographical distribution of the visual observation reports is very irregular and largely biased towards densely populated areas.

2) Mass media information, obtained from newspapers and Catalan public television TVC. This information is not always very precise but can be very helpful to detect the occurrence of important hailfall events and their impact.

3) Hailpad network data. This network is placed in Western Catalonia and provides the most complete description of hail characteristics, but in Catalonia it is restricted to a very small agricultural area.

4) METAR and SYNOP observations obtained from nine stations operated in Catalonia by the Spanish Meteorological Agency (AEMET). They provide high quality information with good temporal resolution but with limited spatial resolution.

5) Hail data provided by the AEMET secondary observation network operated by volunteers. This network is rather dense and allows comparisons with traditional hail day climatologies but time resolution is somewhat limited.

6) Radar-based probability of hail (POH) product (Aran et al 2007), which provides a high temporal and spatial resolution, but requires a calibration with ground information and its performance may vary with each hail event.

III. RESULTS

From the different sources described above more than 700 hail reports were obtained (Fig. 1). More than 90 days with hail data were reported; the monthly distribution is showed in Fig. 2.

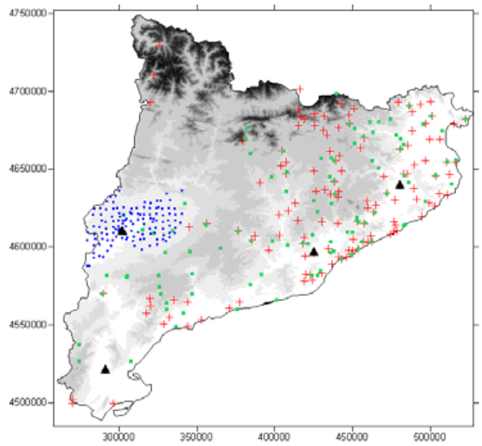

FIG. 1: Hail data report locations during 2008. Blue squares (hailpad network data), red crosses (visual reports and mass media information), black triangles (METAR and SYNOP observations) and green circles (AEMET secondary observation network).

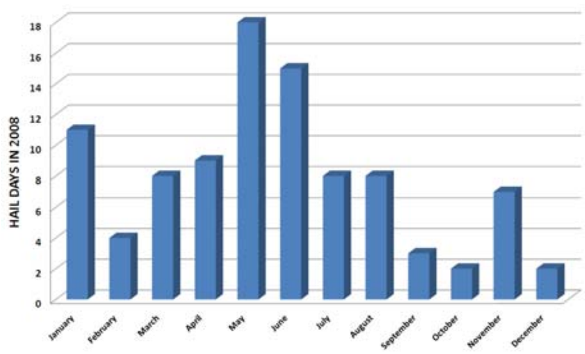

FIG. 2: Monthly distribution of hail days during 2008.

IV. ACKNOWLEDGMENTS

We thank Maite Torà for the hailpad observations, and the spotters, AEMET and the Meteorological Service of Catalonia staff who provided data for this study.

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SEVERE CONVECTIVE WEATHER CASES ON THE TERRITORY OF THE CZECH REPUBLIC – MONITORING AND DOCUMENTATION, DATABASE – CURRENT STATUS AND NEAR FUTURE

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(Dated: 15 September 2009)

I. INTRODUCTION

Documentation of severe weather phenomena (downbursts, funnel clouds and tornadoes, heavy rain or hail) in terms of CR is very closely linked to the end of 20 th century. Only a few experts from the CHMI and the Institut of Atmospheric Physiscs interested in these phenomena initially, particularly M. Setvák and M. Šálek (CHMI). Increased interest can be attributed partly to both these activities and the activities of both amateur meteorologists. (stormchasers or stormspotters). The development of technology helped significantly to these activities (f.e. PC, internet, dig. recording devices, etc.).

II. PRESENTATION OF RESEARCH

Current research strengths of convective storms in the CR is focused on events caused by damage (wind - tornadoes, down(micro)burst, large hails, or heavy rain and flash floods). These severe weather events are studied from the perspective of the causes, structure and development of life storms. The aim of this study is early detection of these events and their location – with a significant contribution of observation (stormchasing or stormspotting) and documentation of these phenomena - creating and maintaining the necessary databases (Table I).

Date	Time and duration	Location	Latitude	Longitude	F-scale	Type
27.8.2006	~ 13:10-13:25 ~ ca 15 min	Napajedla	49.16 N	17.50 E	F0	T
13.8.2006	čas neudán ~ ca 5 min	Teplice (Litvínov-Jirkov-Chomutov)	(50.63 N)	(13.78 E)		F
11.8.2006	~ 11:30-11:38 ~ ca 8 min	JZ od České Lípy	50.66 N	14.53 E		F
24.7.2006	~ ca 19:16 ???	Zliv u Českých Budějovic	(49.07 N)	(14.37 E)		F
12.7.2006	~ 16:40 ???	Vodňany - Křtětice (okr. Strakonice)	49.16 N	14.16 E	F1	(T)

TABLE I: Sample registration of severe convective events within the territory CR.

This database can help to create a vision of the occurrence of these events within a relatively small territory of the CR.

Severe weather cases may be accompanied by the occurrence of tornadoes or funnel clouds within the territory of the CR (Fig. 1).

The occurrence of severe weather cases can be analyzed during the different months of the year. (Fig.2)

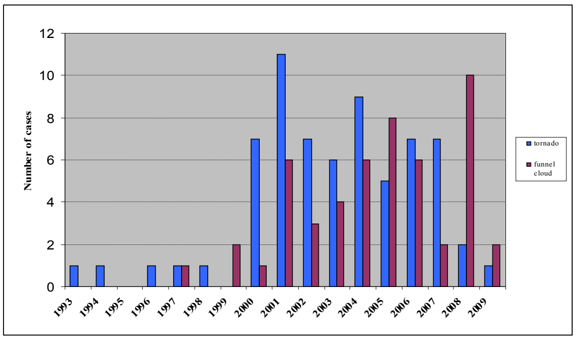

Fig. 1: Annual absolute frequency of documented cases (1993-2009)

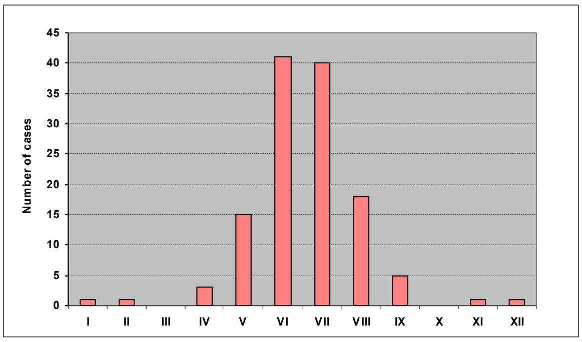

Fig. 2: Monthly absolute frequency of significant convective weather cases (1993-2009)

Another possible presentation of data from this database is a map of these cases (events) – created by GIS software ArcView (Figure 3).

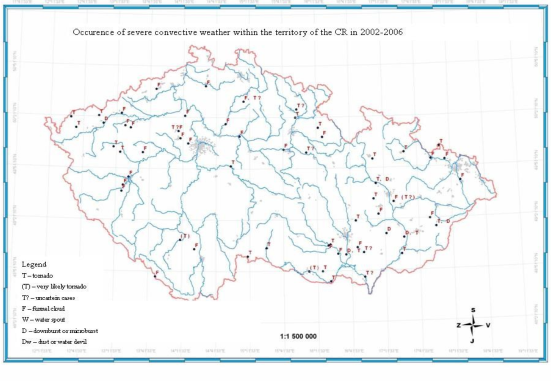

Fig. 3: Map of significant convective events in the CR in 2002-2006

III. RESULTS AND CONCLUSIONS

The database contains a number of interesting severe weather events (since 1996) from the entire Czech Republic (including some historical cases). Further details about cases can be found at the websites.

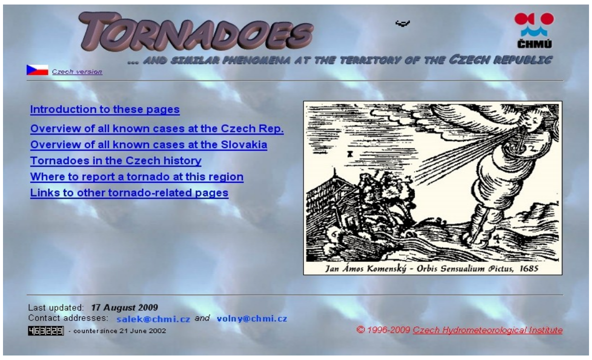

Fig. 4: Website - Tornadoes and similar phenomena at the territory of the Czech Republic

The current form of the website is already inadequate, during the year 2009 will be upgrading…will be clearer and more user-friendly.

One the latest trends in this activity is growing cooperation between the professional meteorologists and skilled weather enthusiasts from Stormchasing Amateur Society (ASS) and Skywarn Czechoslowak. We can participate in the project European Severe Storm Laboratory (ESSL) - European Severe Weather Database (ESWD).

This cooperation is likely to be a continuation of these activities and other trends in the Czech Republic.

IV. AKNOWLEDGMENTS

Interest in the issue of monitoring, documentation, records of severe weather phenomena associated with convective activity was and always is significantly from the CHMI and Institute of Atmospheric Physiscs, which in the past to provide support (particularly financial) of the GA CR (205/001451 and 205/04/0114). Thanks also belong to many stormchasers (or spotters) and enthusiasts interested in this problem (ASS, SKYWARN etc.).

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ESWD – European Severe Weather Database http://www.eesl.org/ESWD/

Amateur Stormchasing Society http://www.bourky.com