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.

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