PROBABILISTIC SEVERE WEATHER FORECASTING AT THE EUROPEAN STORM FORECAST EXPERIMENT

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1. INTRODUCTION

The European Storm Forecast Experiment (ESTOFEX) issues *Storm Forecasts* that provide an assessment of the severe convective storm risk, that is the threat of large hail, convective wind gusts, tornadoes and recently, excessive precipitation across Europe (Dahl et al., 2004). These risk estimates are communicated in a forecast text, and more precisely in a map that assigns *threat levels* to specific areas in Europe. Four threat levels are used, three of which are numbered on the forecast maps: 1, 2 and 3. Level 0 is implied where no level 1, 2 or 3 is indicated. The assigned threat level is determined by a meteorologist who weighs several types of information including data from global and regional numerical models, and observational data from satellites, radiosondes, and surface networks.

The threat level system as it was used until 1 May 2009 described the number of severe events to be expected within a 200 km x 200 km area for each threat level area, but this proved to be a difficult criterion for forecasters to work with. To users, it was not easy either to derive the probability of experiencing severe weather within a particular threat level. Still forecast verification could be carried out, for some methods do not require the risk level to be specified, enabling Brooks et al. (2008) to present verification results of ESTOFEX forecasts without having to use the troublesome criteria.

The wish to develop an straightforward and usable definitions of the probability of severe weather in each threat level remained a goal of the team. In what follows, the method of deriving those will be explained.

II. METHOD

In making the transition from a qualitative to a quantitative forecast scheme, it was decided not to discard the old threat levels, but rather to quantitatively define the threat levels that were already used. To find the corresponding probability values, an *a posteriori* analysis of the average frequency of severe weather in the threat areas was performed. Such an exercise would ideally make use of a dataset that contains all severe weather events that occurred, and the size of the area affected by each event. Naturally, such a dataset does not exist. The dataset that comes closest to this is the severe weather database ESWD (Dotzek et al., 2009), managed by the European Severe Storms Laboratory. This dataset however, contains severe weather events as points in space and time. The size of the area affected by the event is normally not available. This implies that “the probability of a person within an threat level area to experience severe weather”, which is arguably the most elementary quantity to forecast, cannot be verified using the dataset.

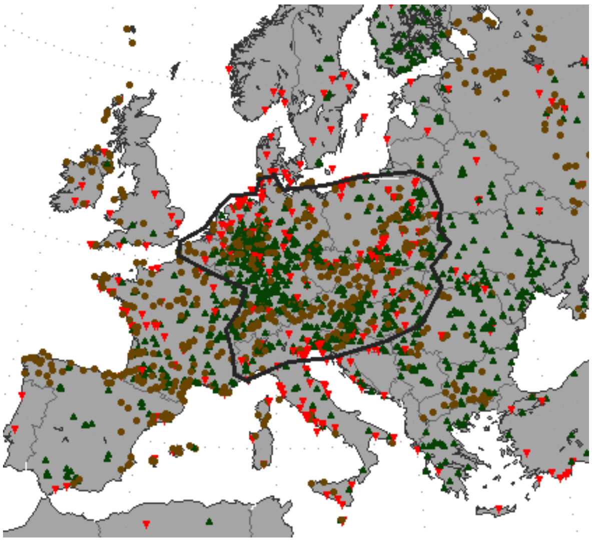

FIG 1: Severe weather events in the period considered, 1 May 2008 – 30 April 2009. Triangles pointing upward: large hail, pointing downward: tornadoes, circles: wind gusts. The dark contour denotes the area across which the analysis has been performed.

The obvious solution to this conundrum is to specify an arbitrary area of vicinity. We have chosen a circle of 40 km, which is comparable with the 25 nautical miles radius used by the U.S. Storm Prediction Center to facilitate future comparisons. The predictand of the forecasts was formally defined as:

“The probability that one or more severe weather events occur within a circle with radius 40 km of a point”

	severe weather	**extremely severe weather**
hail	≥ 2 cm	≥ 5 cm
tornado	any	≥ F2
wind gust	≥ 25 m/s	≥ 32 m/s

TABLE. 1: Fraction of rectangles contained within each threat level area that was labelled “severe” and “extremely severe”, respectively.

The procedure was repeated with *severe weather* replaced by *extremely severe weather*. For definitions of these concepts, please refer to Table 1.

Subsequently, a part of the forecast area of Estofex was selected as the domain for the analysis (see Fig. 1). Within this area, which includes the Benelux, Germany, the Alps, Hungary, the Czech Republic, Slovakia and Poland, active storm spotter networks provided a –subjectively judged– good coverage of severe weather throughout the considered period (1 May 2008 – 30 April 2009).

This area was divided into rectangular areas with a surface area corresponding to a circle with radius 40 km. Subjectively, an area across which several active storm spotters delivered data to the ESWD data was selected. Using the dataset, each rectangle could be labelled as being “non-severe”, “severe”, or “extremely severe”. This procedure to some extent mitigates the fact that the ESWD dataset only contains a part of all severe weather events that occurs in reality: if severe weather strikes a particular rectangle, one report from the area suffices to label the square as “severe”. It is thus not necessary that an observer of severe weather be present in every square kilometer.

III. RESULTS

It was found that the coverage of severe weather (i.e. the fraction of contained rectangles labelled as “severe” within each area) increases strongly with increasing threat level, which is what one would hope for. The values that were found are displayed in Fig. 2.

Using these coverages of severe and extremely severe weather, the future definitions of the threat level areas could be redefined. At the same time the definition was to be developed, there was a very strong wish of the forecasters to revise the criterion for severe weather to include *excessive precipitation*. Such a step would likely lead to higher coverages of severe weather within the risk areas. Moreover, a further slight increase of reporting efficiency was anticipated. As a consequence it was decided to define the threat levels with rather high percentages relative to the values of past severe weather coverage.

The new definitions are:

- Level 0 Lower than 5% probability of severe
- Level 1 5 - 15% probability of severe
- Level 2 > 15% probability of severe *(where level 3 does not apply)*
- Level 3 > 15% probability of extremely severe

It can be seen that level 0, 1 and 2 have been defined in terms of the coverage of severe weather, but that for level 3, the coverage of *extremely severe weather* is the defining quantity. These thresholds are high relative to the percentages that were found. For example, in the dataset the observed coverage of severe weather in level 1 was only slightly above the 5 % threshold (5.1%). The threat levels have been defined each as a range of probabilities, so that their borders correspond with lines of equal probability.

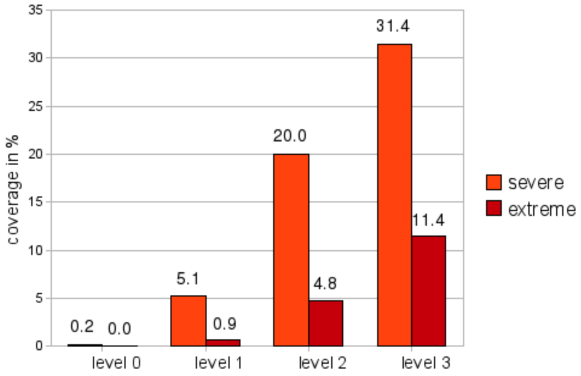

FIG. 2: Fraction of rectangles contained within each threat level area that was labelled “severe” and “extremely severe”, respectively.

IV. CONCLUSIONS AND OUTLOOK

With the presented analysis, ESTOFEX has made a first step towards quantitative forecasting. Since the presented results have become available, ESTOFEX has also changed its lightning forecasts from deterministic to probabilistic. An important new question to solve is how forecast verification can be performed using this new data. Threat levels defined by a range of probabilities may not be the easiest to work with when developing a forecast verification method. Perhaps the definitions need to be reviewed in this light.

IV. ACKNOWLEDGMENTS

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