Toward a dedicated warning system of severe storms in Italy: the PRETEMP project

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PRETEMP group

Volunteer group of 12 students and young meteorologists (Fig.1), inspired by the ESTOFEX initiative (Brooks et al, 2011). Main activities:

1. Every day **severe weather outlooks** specific for Italy since 2015 (Fig.2);
2. Collection of **severe storm reports** from Italy since 2018.

Italy is a country with very **complex orography** mostly surrounded by the sea

⬇

A **national dedicated warning** system may allow to capture local mesoscale features, important for severe storm development, better than an outlook on a continental scale.

***Fig.1**: Part of PRETEMP group in Venice, 2019. From the left to the right: Mattia Nordio, Federico Pavan, Luca Valentini, Nicola Carlon, Simone Buttura, Francesco De Martin, Sebastiano Carpentari.*

Damage path reconstruction of Italian tornadoes

Carried on using both **damages photos and satellite images**. The procedure applied is afterwards summarized:

1) Day of the event: landmarks of damage reports are searched in social media/news articles and are localized in Google Earth. The storm motion, extrapolated via weather radar, can help to understand the trajectory.
2) Following couple of days: other documented Damage Indicators (D.I.s) are searched via Google Earth and Street View, and new reports are collected. Intensity rating is worked on in parallel, with experts (civil engineers, ESSL).
3) Following weeks and months (or years!): Sentinel-2A satellite images can be used for finding forest or agricultural damages as well as tarped roofs. Google Earth updates can show areas never documented and new D.I.s.

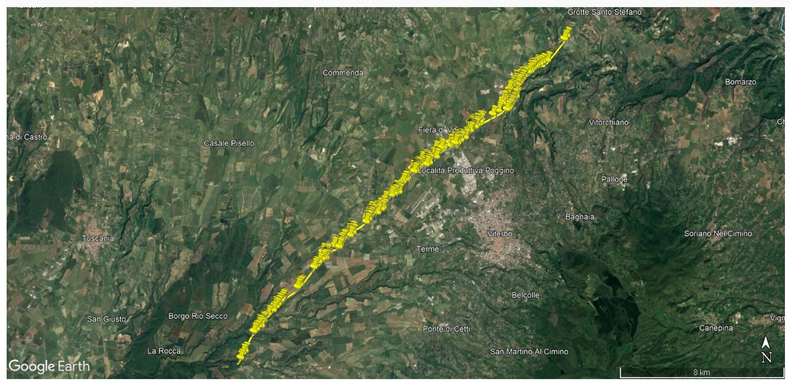

***Fig.6**: Damage path reconstruction (pins = D.I.s) of a tornado occurred near Viterbo on 30 August 2020 . The tornado was ranked as F2, according to the Fujita scale.*

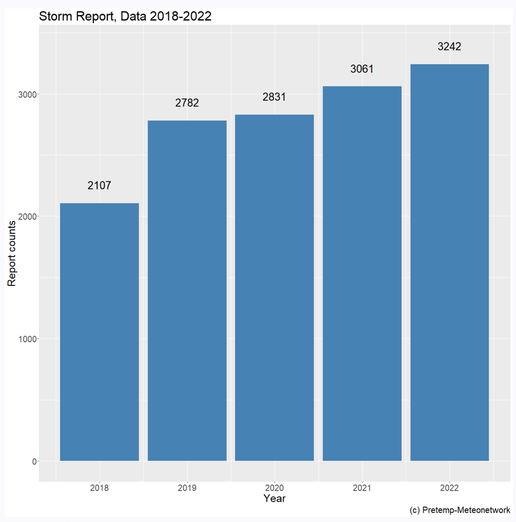

***Fig.7**: Number of collected reports by years*

Acronyms

BSS: Brier Skill Score
CSI: Critical Success Index
ESSL: European Severe Storm Laboratory
ESTOFEX: European STOrm Forecast EXeriment
ESWD: European Severe Weather Database
SPC: Storm Prediction Centre
NOAA: National Oceanic and Atmospheric Administration

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Hitchens, N. M., Brooks, H. E., & Kay, M. P. (2013). Objective limits on forecasting skill of rare events. *Weather and forecasting*, *28*(2), 525-534.
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PRETEMP Forecast

- **Four levels of severity** (Fig.2 and 3);
- Each level is associated to a specific **probability threshold**;
- The definition of "generic", "severe" and "extremely severe thunderstorms" is made with respect to the four main phenomena associated with severe storms (heavy rain, hail, wind gusts and tornadoes, example in Fig. 4).

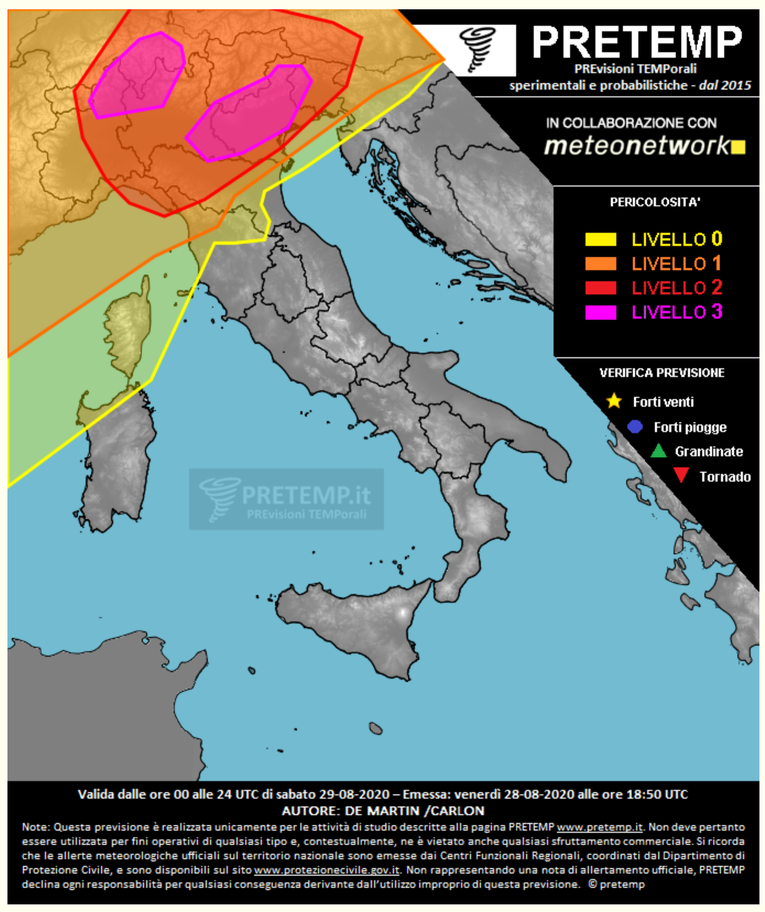

***Fig.2**: PRETEMP forecast for the 29 August 2020 event, when a severe weather outbreak affected Northern Italy, with multiple downbursts, damaging hailstorms and two tornadoes. It was correctly predicted, with a level 3 in the area most affected by the severe storms.*

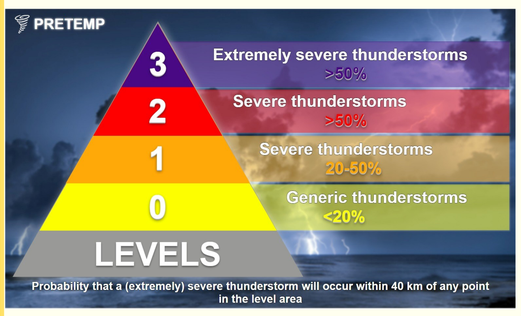

***Fig.3**: Levels of the PRETEMP forecast, courtesy of Giorgio Rotunno*

***Fig.4**: Expected hail size for each forecast levels (yellow, level 0, orange and red levels 1 and 2, purple level 3). Courtesy of Giorgio Rotunno.*

Climatology of storm reports in Italy

- Example of **citizen science applied to severe weather:** reports are collected by many volunteers and local meteorological associations in the Storm Report Database (*www.meteonetwork.it/tt/stormreport*).
- Storm reports are automatically **submitted to the ESWD** since 2019.

More than 14 000 reports since 2018, with a continuous increase over the years (Fig. 7). Some results:

1. The more frequent hazard is hail (6502 reports, Fig. 8)
2. The highest frequency of severe storms is observed in the **North-East of Italy** (Fig. 9).
3. **890 reports of very large hail** (diameter ≥ 4 cm, Fig. 10). The most relevant event was observed in Pescara on July 10, 2019 (hail size of 14 cm).

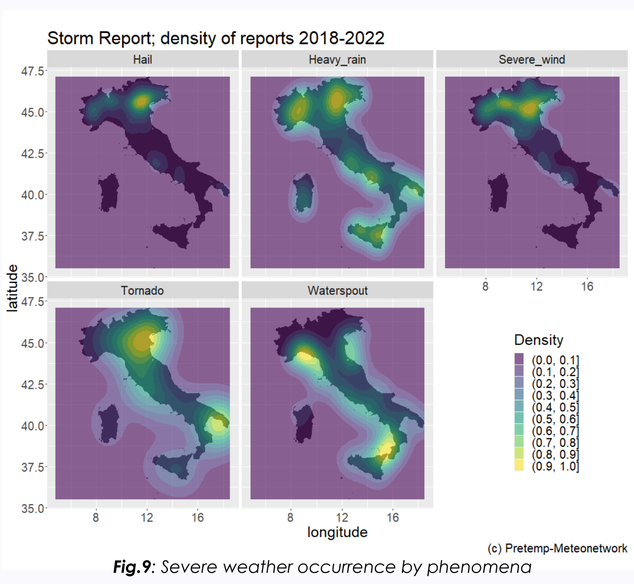

***Fig.9**: Severe weather occurrence by phenomena*

Forecast verification

PRETEMP is testing two methods used at SPC to assess its outlooks (applied in the 29 August 2020 case in Fig. 5).

Dichotomous method

$$Skill = \frac{CSI_{outlook} - CSI_{min}}{CSI_{max} - CSI_{min}}$$

Hitchens et al (2013)

$CSI_{outlook}$ CSI of the forecast;
CSI_{max} CSI of the Practically Perfect (PP) forecast;
CSI_{min} CSI of the "man who know nothing of the subject" (Peirce, 1884).

Probabilistic method

$$BSS = \frac{\sum_c (p_c - o_c)^2}{\sum_c (p_{clim} - o_c)^2}$$

Herman et al (2018)

p probability threshold of the forecast;
P_{clim} climatological probability;
o_c=1 if a report is close to the grid point;
o_c= 0 otherwise;

- **Both have downsides** (Skill does not consider probabilistic thresholds, while climatology used in the BSS is not robust)
- A combination of the two may give an acceptable assessment of the forecast.

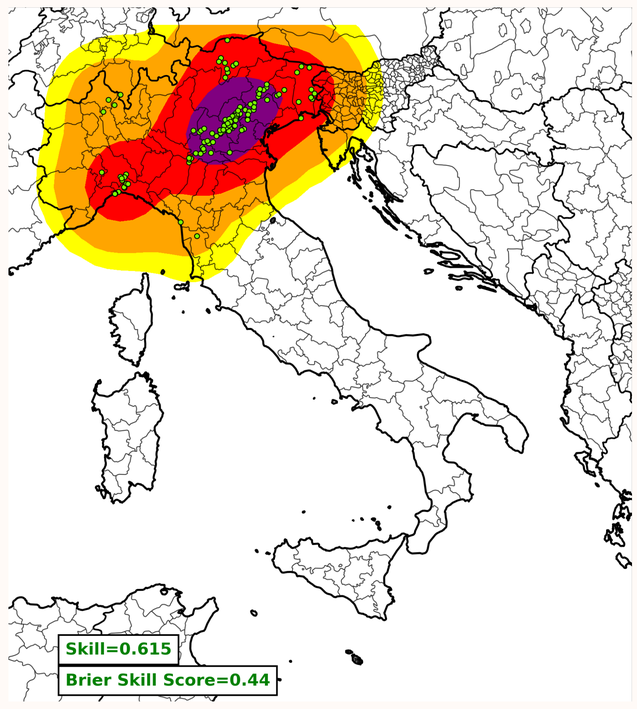

***Fig.5**: PP Forecast of 29 August 2020 and skill scores computed, the green dots are the storm reports.*

Pratically Perfect (PP) Forecast

The PP Forecast is the outlook that "a forecaster would make given a perfect knowledge of the reported events beforehand" (Hitchens et al, 2013).

The storm reports are smoothed using a **gaussian** with a standard deviation of 60 km (Fig.5).

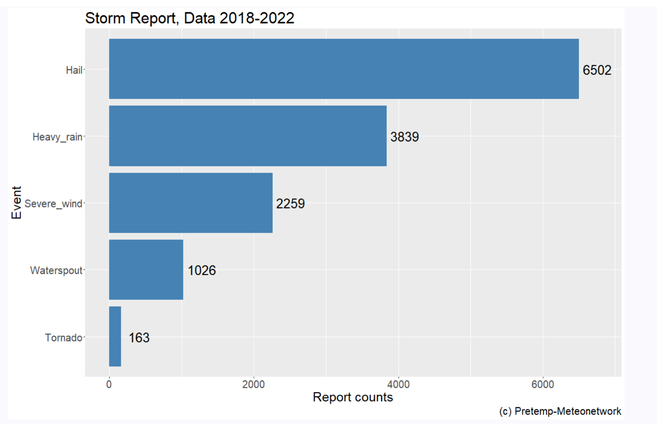

***Fig.8**: Number of reports by severe weather evernt*

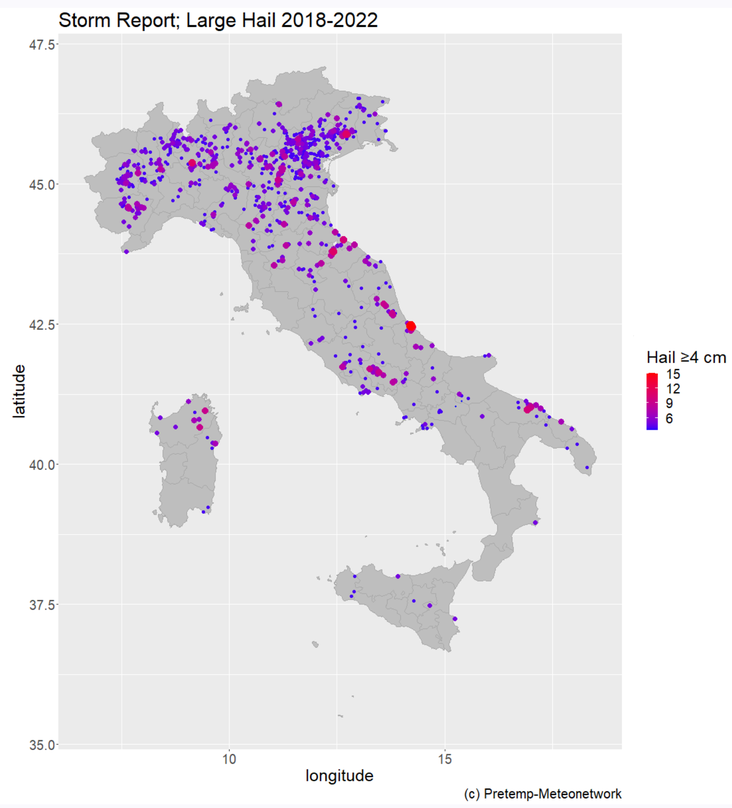

***Fig.10**: Distribution of large hail reports with diameter greater than or equal to 4 cm*