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Probabilistic forecasting of extreme weather events based on extreme value theory

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Extreme events in weather and climate such as high wind gusts, heavy precipitation or extreme temperatures are commonly associated with high impacts on both environment and society. Forecasting extreme weather events is difficult, and very high-resolution models are needed to describe explicitly extreme weather phenomena. A prediction system for such events should therefore preferably be probabilistic in nature. Probabilistic forecasts and state estimations are nowadays common in the numerical weather prediction community. In this work, we develop a new probabilistic framework based on extreme value theory that aims to provide early warnings up to several days in advance.

We consider pairs (X, Y) of extreme events where X represents a deterministic forecast, and Y the observation variable (for instance wind speed). More specifically two problems are addressed:

1. Given a high forecast $X = x_0$, what is the probability that $Y > y$? In other words: *provide inference on the conditional probability*:
$$\Pr\{Y > y | X = x_0\}.$$
2. Given a probabilistic model for Problem 1, what is the impact on the verification analysis of extreme events.

These problems can be solved with bivariate extremes (Coles, 2001), and the verification analysis in (Ferro, 2007).

We apply the Ramos and Ledford (2009) parametric model for bivariate tail estimation of the pair (X, Y). The model accommodates different types of extremal dependence and asymmetry within a parsimonious representation. Results are presented using the ensemble reforecast system of the European Centre of Weather Forecasts (Hagedorn, 2008).

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