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A hybrid approach to predict and explain extreme precipitation events over Northern Italy

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The prediction of extreme precipitation events is one of the main objectives of operational weather services. Numerical weather prediction models have continuously improved, providing uncertainty estimation with dynamical ensembles. However, explicit forecasting of these events is still challenging due to the limited predictability of precipitation fields. Greater availability of machine learning modules paves the way to a hybrid-forecast approach, with the optimal combination of physical models, event statistics, and user-oriented post-processing. In this contribution, we describe a specific warning chain, called MaLCoX (Machine Learning model predicting Conditions for eXtreme precipitation), specialised in recognizing synoptic conditions leading to precipitation extremes and subsequently classifying them into predefined categories. The application, running in test at ARPAE Emilia-Romagna, focuses on northern and central Italy, taken as a testbed region. The application leverages a hierarchy of predictors, large-scale (non-local predictors), synoptic-scale (local predictors) and direct (precipitation) to improve the prediction of exceeding precipitation thresholds, maximising the predictability of the different scales of motion at increasingly longer time horizons. A practical approach that can be extended to other geographical areas and over long time intervals seamlessly. The system has been trained with the ARCIS gridded high-resolution precipitation dataset as the target truth for precipitation and with the last 20 years of the ECMWF reforecast dataset as input predictors. We show that the optimal blend of larger-scale information with direct model output improves the probabilistic forecast accuracy of extremes in the medium-range. In addition, with specific methods, we provide a useful diagnostic of the physical processes that make a weather event extreme.