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Precipitation forecast post-processing: blending deterministic NWPs with machine learning

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Direct model output forecasts by Numerical Weather Prediction models (NWPs) present some limitations caused by errors mostly due to sensitivity to initial conditions, sensitivity to boundary conditions and deficiencies in parametrization schemes (i.e. orography).
These sources of error are unavoidable, and atmosphere chaotic dynamics makes prediction errors to spread rapidly in time in the course of the forecast, inducing both systematic and random errors.
Nonetheless, in the last 50 years NWPs had a significant decrease in the impact of these source of errors, even in the long-term forecast, thanks for instance to an ever-increasing computational capability, but still their relevance is not neglectable.
Moreover, different NWPs present specific different pros and cons which are findable empirically. For instance, in the case of precipitation forecast in the north-west Italy, low spatial resolution models (e.g. ECMWF-IFS) tend to be more reliable in terms of space and time in predicting the average precipitation, while high resolution models (e.g. COSMO-2I) tend to forecasts the maximum precipitation better. Research purposes apart, actual limitations must be seen in an operational context, where weather forecasts' skillfulness and associated uncertainty are information of the utmost importance to the forecaster and in general to the user of a certain forecasts system.
In order to tackle the limitations of NWPs and the need of an uncertainty-quantified meteorological forecast, we propose a machine learning based multimodel post-processing technique for precipitation forecast. We focus on precipitation since it is the most important variable in the issue of spatially localized weather alert notice by the Italian Civil Protection' system and at the same time it is one of the most challenging variables to forecast.

We use different Convolutional Neural Networks (CNNs) to obtain both deterministic and probabilistic forecast grids over 24h up to 48h focusing in the North-West Italy, using different high and low resolution deterministic NWPs as input and using high resolution rain-gauge corrected radar observations as ground truth for the training. We use constrainted linear regressions as a mean of deterministic benchmark, and ECMWF-EPS as a mean of probabilistic benchmark. The test phase show decent improvements in terms of RMSE for every season.