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Original
Towards a machine learning based multimodel for precipitation forecast over the italian peninsula / Monaco, L., Cremonini, R., Laio, F.. - (2023). (European Geosciences Union General Assembly 2023 24–28 Apr 2023) [10.5194/egusphere-egu23-13327].

Availability:
This version is available at: 11583/2991668 since: 2024-08-12T12:14:45Z

Publisher:
Copernicus

Published
DOI:10.5194/egusphere-egu23-13327

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15 November 2026

EGU23-13327
https://doi.org/10.5194/egusphere-egu23-13327
EGU General Assembly 2023
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Towards a machine learning based multimodel for precipitation forecast over the italian peninsula

Luca Monaco et al.

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 atmospheric chaotic dynamics make prediction errors 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 sources of errors, even in the long-term forecast, thanks for instance to an ever-increasing computational capability, but their relevance is still not neglectable.
Moreover, different NWPs present specific different pros and cons which are findable empirically. For instance, in the case of precipitation forecast in north-west Italy, low-resolution models (e.g. ECMWF-IFS) are more reliable in terms of space and time in predicting the average precipitation, while high-resolution models (e.g. COSMO-2I) tend to forecast better the maximum precipitation. 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.

To tackle these limitations of NWPs and the need for 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 a Convolutional Neural Network (CNN) to obtain deterministic and probabilistic forecast grids over 24h up to 48h focusing on North-West Italy, using several high and low-resolution deterministic NWPs as input and using high-resolution rain-gauge corrected radar observations for the training. The effect of the usage of different convolutional parameters (e.g. stride, padding) is taken into account. The deterministic output grid is chosen as the grid with the lowest mean square error obtained during the training, and it is compared with the linear regression of the input NWPs and with every single model. The probabilistic output grid is generated by considering the statistical ensemble of the twenty grids with the lowest mean square error obtained during the training, and it is compared with the logistic regression of the input NWPs and with ECMWF-EPS as a benchmark, both at different precipitation thresholds.

How to cite: Monaco, L., Cremonini, R., and Laio, F.: Towards a machine learning based multimodel for precipitation forecast over the italian peninsula, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-13327, https://doi.org/10.5194/egusphere-egu23-13327, 2023.