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# Machine and Deep Learning algorithms to improve weather forecasts over a complex orography Mediterranean region

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The rapid development of artificial intelligence algorithms has generated considerable interest in the scientific community. The number of scientific articles relating to applying these algorithms for weather forecasting has increased dramatically in the last few years. In addition, the recent operational launch of products such as GraphCast has put this area of research even more in the spotlight. This work uses different Machine Learning and Deep Learning algorithms, namely ANN (Artificial Neural Network), RF (Random Forest) and GNN (Graph Neural Network), with the aim to improve the short-term (1-day lead time) forecasts provided by a physically-based forecasting system. Specifically, the CeSMMA laboratory, since January 2020, has been producing daily forecasts accessible via the https://cesmma.unical.it/cwfv2/ webpage related to a large portion of southern Italy. The NWP (Numerical Weather Prediction) system is based on the WRF (Weather Research and Forecasting) model, with boundary and initial conditions provided by the GFS (Global Forecasting System) model. The AI algorithms post-process the NWP output, applying correction factors achieved by a two-year training considering the observations of the dense regional monitoring network composed of ca. 150 rain gauges.

The results show that the AI is able to improve daily rainfall forecasts compared to ground-based observations. Specifically, the ANN reduces the average MSE (Mean Square Error) by approximately 29% and the RF by 21% with respect to the WRF forecast for the whole study area (about 15'000 $km^2$). Moreover, the GNN applied to a smaller area (considering only 22 rain gauges) further reduces the MSE by 35% during the heaviest rainfall months.

In addition to improving the performance of the forecast, the AI-based post-processing provides reasonable precipitation spatial patterns, reproducing the main physical phenomena such as the orographic enhancement since it is not a surrogate model and benefits from the original physically-based forecasts.

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