Plinius Conference Abstracts
Vol. 18, Plinius18-45, 2024, updated on 13 Dec 2024
https://doi.org/10.5194/egusphere-plinius18-45
18th Plinius Conference on Mediterranean Risks


# Combined exploitation of deterministic and AI-based tools for severe weather prediction

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Mediterranean coastal regions are regularly affected by sudden heavy precipitation events leading to very dangerous flash floods. The structures responsible for extreme precipitation episodes are typically intense and small-sized quasi-stationary V-shaped mesoscale convective systems, repeatedly affecting the same area for several hours. Severe rainfall prediction, being the result of many mutually interacting multiscale processes, not yet completely understood and modeled, is still a major challenge for numerical weather prediction (NWP) systems. Furthermore, the intrinsic uncertainty related to deep moist convection and the large sensitivity of precipitation to uncertainties in the initial and boundary condition decrease the skill of numerical models, even at high horizontal resolution and short forecast times. In recent times, artificial intelligence (AI) emerged as a powerful tool for handling vast amounts of data and extracting patterns and relationships that might be challenging to identify through traditional fully-deterministic algorithms.

In the framework of the AIxtreme (Physics-based AI for predicting extreme weather and space weather events) project, a suite of AI-based techniques is being developed to calibrate numerical models based on the physics of the atmosphere, with the aim of anticipating the occurrence of extreme weather events and supporting decisions of civil protection agencies.

Thanks to the combined exploitation of deterministic weather prediction models and efficient data-driven AI-based algorithms, operational weather forecasts with improved accuracy in relation to key meteorological observables such as wind, temperature and precipitation, are expected to become available. A first significant result of the project is the development of a deep learning framework, named FlashNet, able to forecast able to forecast lightning flashes up to 48 h ahead in terms of probability of occurrence. FlashNet is capable to find an optimal mapping of meteorological features predicted two days ahead by the state-of-the-art numerical weather prediction model by the European Centre for Medium-range Weather Forecasts (ECMWF) into lightning flash occurrence. The prediction skill of the resulting AI-enhanced algorithm turns out to be significantly higher than that of the fully deterministic algorithm employed in the ECMWF model. A remarkable Recall peak of about 95% within the 0-24 h forecast interval is obtained. This performance surpasses the 85% achieved by the ECMWF model at the same Precision of the AI algorithm.