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Keynote: Precipitation nowcasting: from Lagrangian models to advanced ML approaches

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Precipitation nowcasting is the task of predicting rainfall over very short time scales (from a few minutes to a few hours), particularly important for applications in flood management, aviation, and emergency response. Unlike traditional weather models that rely on longer-term atmospheric dynamics, nowcasting focuses on extrapolating current weather observations, such as radar data, to provide highly localized and timely forecasts. The accuracy of such predictions is crucial for mitigating the impacts of severe weather events like flash floods, regional flooding, and intense thunderstorms.

A simple yet effective method to perform precipitation nowcasting is the Lagrangian model, where the precipitation features are followed along their trajectories, assuming their movement is governed by the prevailing winds. This approach can be enhanced by estimating the increase or decrease of precipitation intensity e.g., to describe convective growth or orographic blockage. A common approach is to apply regression techniques to relate the historical behavior of rainfall intensification to various factors such as temperature, humidity, or wind patterns. Alternatively, precipitation tendencies could be extracted from NWP forecasts.

Just as any other forecasting technique, the skill of precipitation nowcasting was found to depend on multiple factors such as the meteorological conditions, geographical location, spatial and temporal scales. Hence, the nowcasting community rapidly acknowledged the importance of estimating predictive uncertainty. A common approach is based on stochastic simulation, in which correlated noise fields are used to perturb a deterministic nowcast. Substantial research efforts have been made to make the perturbation fields as realistic as possible and consistent with the nowcast uncertainty. An alternative approach is to apply generative ML models such as GANs or diffusion models to create realistic spatio-temporal structures.

In the outlook we describe the integration of precipitation nowcasting and forecasting into a unified discipline. Machine learning models are capable of handling both large-scale and fine-grained temporal and spatial data. Hence, the same methodologies and architectures can now seamlessly support both forecast horizons.

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