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Nowcasting of extreme precipitation events: performance assessment of Generative Deep Learning methods

Gabriele Franch, Elena Tomasi, Rishabh Umesh Wanjari, and Marco Cristoforetti
Fondazione Bruno Kessler, Data Science for Industry and Physics, Trento, Italy

Radar-based precipitation nowcasting is one of the most prominent applications of deep learning (DL) in weather forecasting. The accurate forecast of extreme precipitation events remains a significant challenge for deep learning models, primarily due to their complex dynamics and the scarcity of data on such events. In this work we present the application of the latest state-of-the-art generative architectures for radar-based nowcasting, focusing on extreme event forecasting performance. We analyze a declination for the nowcasting task of all the three main current architectural approaches for generative modeling, namely: Generative Adversarial Networks (DGMRs), Latent Diffusion (LDCast), and our novel proposed Transformer architecture (GPTCast). These models are trained on a comprehensive 1-km scale, 5-minute timestep radar precipitation dataset that integrates multiple radar data sources from the US, Germany, the UK, and France. To ensure a robust evaluation and to test the generalization ability of the models, we concentrate on a collection of out-of-domain extreme precipitation events over the Italian peninsula extracted from the last 5 years. This focus allows us to assess the improvements these techniques offer compared to extrapolation methods, evaluating continuous (MSE, MAE) and categorical scores (CSI, POD, FAR), ensemble reliability, uncertainty quantification, and warning lead time. Finally, we analyze the computational requirements of these new techniques and highlight the caveats that must be considered when operational usage of these methods is envisaged.