Nowcasting-Nets: Representation Learning for Satellite-based Precipitation Nowcasting using Convolutional and Recurrent Neural Networks

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Abstract**—**Accurate and timely estimation of precipitation is critical for issuing hazard warnings (e.g., for flash floods or landslides). Current remotely sensed precipitation products have a few hours of latency, associated with the acquisition and processing of satellite data. By applying a robust nowcasting system to these products, it is (in principle) possible to reduce this latency and improve their applicability, value, and impact. However, the development of such a system is complicated by the chaotic nature of the atmosphere, and the consequent rapid changes that can occur in the structures of precipitation systems. In this work, we develop two approaches (hereafter referred to as Nowcasting-Nets) that use Recurrent and Convolutional deep neural network structures to address the challenge of precipitation nowcasting. A total of five models are trained using Global Precipitation Measurement (GPM) Integrated Multi-satellitE Retrievals for GPM (IMERG) precipitation data over the Eastern Contiguous United States (CONUS) and then tested against independent data for the Eastern and Western CONUS. The models were designed to provide forecasts with a lead time of up to 1.5 hours and, by using a feedback loop approach, the ability of the models to extend the forecast time to 4.5 hours was also investigated. Performance of the models was compared against the Random Forest (RF) and Linear Regression (LR) machine learning methods, a persistence benchmark (BM) that uses the most recent observation as the forecast, and also Optical Flow (OF). Independent IMERG observations were used as a reference, and experiments were conducted to examine both overall statistics and case studies involving specific precipitation events. Overall, the forecasts provided by the Nowcasting-Net models are superior, with the Convolutional Nowcasting Network (CNC) achieving 42%, 24%, 18%, and 16% improvement on the test set MSE over the BM, LR, RF, and OF models, respectively, for the Eastern CONUS. Results of further testing over the Western CONUS (which was not part of the training data) are encouraging and indicate the ability of the proposed models to learn the dynamics of precipitation systems without having explicit access to motion vectors and other auxiliary features, and to then generalize to different hydro-geo-climatic conditions.

Index Terms—Deep Learning; Deep Neural Networks; Precipitation Nowcasting; IMERG; GPM; UNET; ConvLSTM

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