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GPM Dual-frequency Precipitation Radar Estimation of Precipitation Rate: A Deep Learning Approach

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The Global Precipitation Measurement (GPM) satellite mission is expected to provide the next generation of global precipitation products through advanced observations from the GPM Microwave Imager and Dual-frequency Precipitation Radar (DPR). Compared to its predecessor, a key advancement of GPM is the extended capability to observe light rain, solid precipitation and insights of microphysical properties of precipitation. In this study, a novel machine learning approach consisting of two deep neural networks (DNNs) is developed to improve precipitation rate estimation by building a relation between spaceborne radar measurements and rain gauge observations using ground radar to bridge the gap between the spaceborne radar and the rain gauge. The first DNN model is trained from gauge measurements to ground radar rainfall estimation, while the second model is trained from ground radar rainfall estimation to spaceborne radar rainfall estimation. Using the two DNN models, the entire system can generate a rainfall product by linking spaceborne radar observations to ground rain gauge measurements via ground radar observations.

In this paper, the architecture of the hybrid two-stage machine learning system for precipitation rate estimation will be detailed. For illustration purpose, the ground radar neural network is trained using WSR-88D radar (i.e. KMLB radar) data collected in Melbourne, Florida during the storm events in 2014. In particular, radar reflectivity observations at the gauge locations are used for training purpose. The trained model is applied to areal radar observations to produce improved rainfall estimates for ground-based radar. Subsequently, the GPM overpasses at this ground validation site, as well as rainfall estimates derived from ground radar were used for training the satellite radar neural networks. The training and estimation processes are similar for GPM Ku and Ka band. The machine learning-based precipitation products are evaluated using rain gauge observations. In addition, standard precipitation products generated by GPM science team will be used for cross-validation purposes.