Title: Radar and Satellite Observations of Precipitation: Space Time Variability, Cross Validation, and Fusion

Abstract:

Rainfall estimation based on onboard satellite measurements has been an important topic in satellite meteorology for decades. A number of precipitation products at multiple time and space scales have been developed based upon satellite observations. For example, NOAA Climate Prediction Center has developed a morphing technique (i.e., CMORPH) to produce global precipitation products by combining existing space based rainfall estimates. The CMORPH products are essentially derived based on geostationary satellite IR brightness temperature information and retrievals from passive microwave measurements. Although the space-based precipitation products provide an excellent tool for regional and global hydrologic and climate studies as well as improved situational awareness for operational forecasts, its accuracy is restricted due to the limitations of spatial-temporal sampling and the parametric retrieval algorithms, particularly for extreme events such as very light and/or heavy rain.

On the other hand, ground-based radar is more mature science for quantitative precipitation estimation (QPE), especially after the implementation of dual-polarization technique and further enhanced by urban scale radar networks. Therefore, ground radars are often critical for providing local scale rainfall estimation and a \heads-up" for operational forecasters to issue watches and warnings as well as validation of various space measurements and products. Since 2012, the center for Collaborative Adaptive Sensing of the Atmosphere (CASA) has been operating a high-resolution dense urban radar network in Dallas-Fort Worth (DFW) Metroplex. The CASA DFW QPE system, which is based on dual-polarization X-band CASA radars and a local S-band WSR-88DP radar, has demonstrated its excellent performance during several years of operation in a variety of precipitation regimes. The real-time CASA DFW QPE products are used extensively for localized hydrometeorological applications such as urban flash flood forecasting. It also serves as a reliable dataset for validation of global precipitation measurement (GPM) satellite precipitation products.

In this dissertation proposal, the real-time high-resolution CASA DFW QPE system is presented. The specific dual-polarization radar rainfall algorithms at S- and X-band frequencies, as well as the fusion methodology combining radar observations at different temporal resolution are detailed. Cross-comparison between radar rainfall estimates and rainfall measurements from ground rain gauges is conducted to demonstrate the excellent performance of this urban QPE system.

In addition, we introduce a neural network based system, termed as "Deep Multi-Layer Perceptron" (DMLP), to improve satellite-based rainfall estimation using DFW radar rainfall products. Particularly, the CMORPH methodology is first applied to derive combined microwave (MW) rainfall estimates and combined infrared (IR) data from multiple satellites. The combined MW and IR data then serve as input of the proposed DMLP model. The high-quality DFW rainfall products are used to train the model. In this dissertation proposal, prototype architecture of the DMLP model is detailed, and the DMLP-based rainfall products will be evaluated using existing CMORPH products and surface rainfall measurements from gauge networks.