Probabilistic Quantitative Precipitation Estimation With Space-Based Radars

Pierre Kirstetter, Nana Liu

University of Oklahoma

Progress in precipitation estimation is critical to advance weather and water studies and to characterize extreme events and associated natural hazards from local to global scales. Spaceborne weather radars on the Global Precipitation Measurement (GPM) and CloudSat satellites uniquely capture precipitation characteristics globally, serving as cornerstones for the global understanding of water fluxes. While Quantitative Precipitation Estimation (QPE) from these sensors is currently deterministic, applications and the comprehension of hydrometeorological processes require more than a single "best estimate" to effectively manage the intermittent, highly skewed distribution that characterizes precipitation.

To advance the quantitative interpretation of spaceborne radar observations of precipitation, we propose the explicit estimation of uncertainty and extremes through probabilistic approaches. Probabilistic QPE leverages the Ground Validation Multi-Radar/Multi-Sensor (GV-MRMS; S-band) to demonstrate GPM Dual-frequency Precipitation Radar (DPR and Combined algorithm; Ku-Ka-band) and CloudSat (W-band) retrievals of QPE uncertainty and extremes. Probability distributions of precipitation rates are established using models quantifying the relation between sensor measurements, algorithm states, and the corresponding GV-MRMS reference precipitation.

This approach integrates sources of error in spaceborne radar QPE and provides a framework for in-depth diagnostic of radar algorithms, especially when instruments sample raining scenes or processes challenging the algorithms' assumptions. For practical applications, probabilistic QPE mitigates systematic biases from deterministic retrievals, quantifies uncertainty, and advances the monitoring of precipitation extremes through remote sensing. Probabilistic QPE opens perspectives for improved understanding of precipitation and its parameterization in spaceborne retrievals, estimation of precipitation at multiple scales, hydrological prediction, and risk monitoring.