Using Ground-based Radar Observations to Estimate Precipitation Variability across GPM Satellite Radar Field-of-Views

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One assumption often made in radar meteorology is that the hydrometeors are uniformly distributed throughout the radar pulse volume. By making this assumption, the radar measurements can be converted into pulse volume averaged meteorological quantities (e.g., radar reflectivity factor, rain rate). But as the radar pulse volume increases, the precipitation spatial variability increases within the pulse volume which invalidates the uniformity assumption leading to representativeness errors in the measured quantities, leading to uncertainties in the estimated meteorology quantities.

The horizontal extent of the Dual-frequency Precipitation Radar (DPR) pulse volume on the NASA/JAXA Global Precipitation Measurement (GPM) mission core satellite is approximately 5 km diameter at nadir. Precipitation variability across this instantaneous field-of-view (FOV) leads to non-uniform beam filling (NUBF) that effect radar measurements and, as discussed above, impacts retrieved precipitation rainfall estimates. To statistically quantify the sub-FOV variability, this study used high-resolution ground-based polarimetric scanning radar observations to investigate precipitation variability across simulated DPR FOVs. This study’s statistical analysis used a neighborhood of 3x3 FOVs. The mean and variance were estimated for the central FOV and the mean was estimated for each of the surrounding eight neighbors. To determine precipitation regime dependence and to relate statistical results to DPR measurements, statistical relations were evaluated relating the central FOV variance with the surrounding 3x3 mean FOV values.

This study used NASA S-band Polarimetric scanning radar (NPOL) observations from the GPM Integrated Precipitation and Hydrology Experiment (IPHEx) held in the southern Appalachian Mountains in May-June 2014. Statistical analysis found a linear relationship between the variability over the 3x3 domain with the sub-FOV variability. This results suggests a down-scaling of variability where the variability over a 15x15 km domain can be projected down to estimate the variability at the 5x5 domain. This result supports using precipitation variability estimated from neighboring FOVs to estimate unresolved sub-FOV variability, or NUBF effects, in satellite-based rainfall retrieval algorithms.