ABSTRACT:

Estimating the Concentration of Large Raindrops from Polarimetric Radar and Disdrometer Observations

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Estimation of rainfall integral parameters, including radar observables, and empirical relations between them are sensitive to the truncation of the drop size distribution (DSD), particularly at the large drop end. The sensitivity of rainfall integral parameters to the maximum drop diameter (D_{max}) is exacerbated at C-band since resonance effects are pronounced for large drops in excess of 5 mm diameter (D). Due to sampling limitations, it is often difficult to reliably estimate D_{max} with disdrometers. The resulting uncertainties in D_{max} potentially increase errors in radar retrieval methods, particularly at C-band, that rely on disdrometer observations for DSD input to radar models. In fact, D_{max} is typically an assumed DSD parameter in the development of radar retrieval methods. Because of these very uncertainties, it is difficult to independently confirm disdrometer estimates of D_{max} with polarimetric radar observations.

A couple of approaches can be taken to reduce uncertainty in large drop measurement. Longer integration times can be used for the collection of larger disdrometer samples. However, integration periods must be consistent with a radar resolution volume (RRV) and the temporal and spatial scales of the physical processes affecting the DSD therein. Multiple co-located disdrometers can be combined into a network to increase the sample size within a RRV. However, over a reasonable integration period, a single disdrometer sample volume is many orders of magnitudes less than a RRV so it is not practical to devise a network of disdrometers that has an equivalent volume to a typical RRV. Since knowledge of DSD heterogeneity and large drop occurrence in time and space is lacking, the specific accuracy or even general representativeness of disdrometer based D_{max} and large drop concentration estimates within a RRV are currently unknown.

To address this complex issue, we begin with a simpler question. Is the frequency of occurrence of large rain drops (D > 5 mm) in disdrometer observations, either stand alone or networked, generally representative and consistent with polarimetric radar observations? We first show from simulations that the concentration of large (D > 5 mm) rain drops (N_{T5}) can be estimated from polarimetric observations of specific differential phase (K_{dp}) and differential reflectivity (Z_{dr}), $N_{T5}=F(K_{dp},Z_{dr})$, or horizontal reflectivity (Z_h) and Z_{dr}, $N_{T5}=(Z_h,Z_{dr})$. We assess the error associated with polarimetric retrieval of N_{T5}, including sensitivity to D_{max} parameterization assumptions and measurement error in the radar simulations. Polarimetric measurements at S-band and C-band will then be used to retrieve estimates of N_{T5} and compared to disdrometer estimates of N_{T5}. After careful consideration of retrieval error, we will check consistency between disdrometer and polarimetric radar estimates of N_{T5} and the frequency of occurrence of large rain drops in a variety of precipitating regimes using data from NASA's Global Precipitation Measurement (GPM) Ground Validation (GV) program, including field campaigns such as MC3E (Oklahoma) and IFloodS (Iowa) and extended measurements over Huntsville, Alabama and NASA Wallops Flight Facility in coastal Virginia.