Passive microwave rainfall retrievals for tropical cyclones with understanding of microphysical characteristics from cloud resolving models

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Satellite passive microwave observations have been widely used for better precipitation measurements because microwave signals are well associated with the vertically integrated quantities of various hydrometeors in the precipitation system. Understanding the relationships between hydrometeor distributions and radiometric observations is commonly achieved from a-priori information based on cloud and radiation transfer simulations. However, major difficulties in making the a-priori information reside in the simulation variabilities resulted from the assumed microphysical process and insufficient 3-dimensional (3-D) descriptions of radiative signatures as observed by satellite sensors. According to Shin and Kummerow (2003), liquid particle profiles over the precipitation fields can be constructed realistically by matching the radar reflectivity profiles from simulations and GPM dual frequency radar (DPR) observations. However, ice particle profiles produce significant discrepancies in scattering signals depending on the microphysical parameterization methods used in constructing a-priori information. It is then suggested that selecting a proper microphysics scheme showing the most similar microwave signatures for both emission and scattering to the observations can have a substantial impact on the retrieval results. Especially for heavy rainfall systems which can produce large amounts of ice particles, scattering signals should be appropriately described in the a-priori information.

In this study we firstly assessed five microphysical parameterization methods including Thompson, Morrison, WDM6, NSSL-2mom and Thompson aerosol-aware schemes in the Weather Research Forecasting (WRF) model by analyzing the emission and scattering characteristics of each scheme from the perspective of microwave observations for several tropical cyclone cases. Then, the best performed microphysics scheme among them is selected and used to retrieve rain rates. This process may reduce the uncertainties due to the incorrect assumptions on microphysical properties of precipitating clouds. Moreover, as pointed by Kim et al (2016) proper descriptions of the scattering signals along viewing directions can also affect the retrieval quality. We construct more realistic a-priori databases with the 3-D radiative transfer treatment and the best performed microphysics schemes for the GPM microwave imager (GMI). The enhanced prior knowledge is tested to measure the precipitation fields for several tropical cyclone cases.

Keywords: microwave satellite remote sensing, tropical cyclone rainfall measurements, microphysical characteristics of tropical cyclone, microphysics schemes of cloud resolving models