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Consistent radiative transfer modeling of active and passive observations of precipitation

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Spaceborne platforms such as the Tropical Rainfall Measurement Mission (TRMM) and the Global Precipitation Measurement (GPM) mission exploit a combination of active and passive sensors to provide a greater understanding of the three-dimensional structure of precipitation. While “operationalized” retrieval algorithms require fast forward models, the ability to perform higher fidelity simulations is necessary in order to understand the physics of remote sensing problems by testing assumptions and developing parameterizations for the fast models. To ensure proper synergy between active and passive modeling, forward models must be consistent when modeling the responses of radars and radiometers. This work presents a self-consistent transfer model for simulating radar reflectivities and millimeter wave brightness temperatures for precipitating scenes.

To accomplish this, we extended the Atmospheric Radiative Transfer Simulator (ARTS) version 2.3 to solve the radiative transfer equation for active sensors and multiple scattering conditions. Early versions of ARTS (1.1) included a passive Monte Carlo solver, and ARTS is capable of handling atmospheres of up to three dimensions with ellipsoidal planetary geometries. The modular nature of ARTS facilitates extensibility, and the well-developed ray-tracing tools are suited for implementation of Monte Carlo algorithms. Finally, since ARTS handles the full Stokes vector, co- and cross-polarized reflectivity products are possible for scenarios that include nonspherical particles, with or without preferential alignment.

The accuracy of the forward model will be demonstrated with precipitation events observed by TRMM and GPM, and the effects of multiple scattering will be detailed. The three-dimensional nature of the radiative transfer model will be useful for understanding the effects of nonuniform beamfill and multiple scattering for spatially heterogeneous precipitation events. The targets of this forward model are GPM (the Dual-wavelength Precipitation Radar (DPR) and GPM Microwave Imager (GMI)).