Simulations of Multi-stream Polarimetric Microwave Radiance using the UMRT Model based on DDSCAT Nonspherical Hydrometeor Database

Kun Zhang and Albin Gasiewski
CET, University of Colorado at Boulder, CO, USA

A database of simulated pristine ice crystals and snow aggregates with different sizes and geometries released by NASA/GSFC becomes publicly accessible for nonspherical hydrometeor single-scattering properties computed by Discrete Dipole Approximation Scattering (DDSCAT). Simulations of 89- and 165.5 GHz microwave radiances at nadir view for a single hypothetical snow layer were performed by the database authors and huge radiance differences (e.g. > 20 K) when comparing with Mie spheres were illustrated. These preliminary results motivated us to perform an extended study of multi-stream and coupled dual polarization microwave radiance simulations using the full Stokes matrix of ice crystals and snow aggregates in the database for frequency bands from 10 GHz to 874 GHz.

The existing Unified Microwave Radiative Transfer (UMRT) model developed by *Tian and Gasiewski* was used to perform the desired simulations for it takes advantage of the symmetry of the reduced Mie phase matrix for dual-polarization (*v*,*h*) radiances to realize unconditional numerical stability and high computational efficiency for all matrix operations required by the discrete-ordinate eigenanalysis (DOE) method. In this study, the UMRT model incorporated DDSCAT-based single-scattering parameters (e.g. extinction, absorption cross sections and full Stokes matrix) and maintained the properties of unconditional numerical stability, efficiency, and accuracy due to the fact that the required transition matrix symmetry holds for the discretized phase matrix of randomly oriented hydrometeors in the DDSCAT database. Both analytic proof and numerical validation of the transition matrix symmetry were shown in this paper. Further, gamma functions of snow and ice Particle Size Distributions (PSDs) fitted to the observation data were used to derive the bulk scattering phase matrix of polydispersions of snow and ice particles. The hydrometeors of liquid water, rain and graupel were assumed to be spherical and follow the decaying exponential functions of PSDs. By randomizing the intercept parameter in the gamma functions of PSDs and constraining the total ice concentration, a series of random samples of phase matrix of snow and ice particles were created for the simulations of the multi-layer top-of-atmosphere microwave radiance based on the atmosphere and precipitation states of hurricane Sandy simulated by WRF model. Evaluations of the DDSCAT-based nonspherical snow and ice particle scattering models in the multi-stream polarimetric radiance simulations were performed by comparing with Mie spherical scattering model. Statistical brightness temperature variances with respect to stream elevation angles, frequencies and polarizations were summarized in this paper to provide a quantitative reference for precipitation remote sensing observations and 3D inhomogeneous UMRT model development.