Performance of idealized snow particle models for simulating W-band reflectivity and implications for global snowfall retrievals

Norman B. Wood*[1] and Tristan S. L'Ecuyer[2]

[1] Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin, Madison, WI, USA

[2] Department of Atmospheric and Oceanic Sciences, University of Wisconsin, Madison, WI, USA

At millimeter wavelengths, it is expected that the scattering properties of snow particles are not strongly sensitive to the fine structure of the spatial distribution of particle mass, but will be sensitive to the larger-scale structure. The objective of a particle model used for such scattering calculations, then, is to reasonably capture the gross features of the spatial distribution of mass, but not to attempt to replicate particular fine features.

A method for generating realistic, physically consistent snow microphysical and scattering models will be described. Microphysical models are developed which describe snow particle mass and horizontally-projected area, Ap, as functions of particle size. These models are used to partially constrain discrete dipole models for calculating 94 GHz (W-band) scattering properties. Discrete dipole approximation calculations are then performed for a range of different idealized particle habits which meet the constraints on mass and Ap. The idealized habits are chosen to represent the gross features of a variety of planar and spatial shapes. This method allows uncertainties in the microphysical properties to be propagated as uncertainties in simulated reflectivities. These reflectivity uncertainties are substantial contributors to the error covariance matrices needed for retrievals of snowfall rate using W-band reflectivity observations.

The models are evaluated using observations from the Canadian CloudSat CALIPSO Validation Project. Observed snow size distributions from twelve snow events are used with the modeled scattering properties to produce synthetic reflectivities for each habit, and these synthetic reflectivities are compared against coincident 94 GHz reflectivity observations. The various habits produce biases versus the observed reflectivities ranging from -3.1 to +11.7 dBZe. The minimum absolute bias of 0.03 dBZe is produced by a spatial particle with a vertical aspect ratio of 0.5, suggesting this habit is a reasonable approximation for the snow particles occurring during these snowfall events, for the purposes of simulating 94 GHz reflectivities.

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