Modeling Ice Crystals and Aggregates and their Radar Scattering Characteristics

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Botta et al. (2011 JGR, http://dx.doi.org/10.1029/2011JD015909) show that modeling aggregates using spherical and spheroidal particles with a dielectric constant based on mixtures of ice and air can lead to large uncertainties. This indicates that a new method is necessary. Botta et al. (2011) generate aggregates composed of collections of stellar crystals, each of which is constructed using a collection of tiny spheres. They apply the Generalized Multi-particle Mie-method (GMM), a method for calculating the scattering properties of a cluster of spheres, on these generated aggregates to calculate their backscattering cross sections at X-, Ka- and W-band. For example, at Ka-band (8.4 mm wavelength) the spheroid that best represents the aspect ratio of the model aggregates underestimates the radar cross section at vertical incidence by several dB beginning around 4 mm (maximum dimension) and exceeds 20 dB at larger sizes. This underestimation starts at sizes smaller than 2 mm at side incidence.

The method of using tiny spheres to model ice crystals and computing their scattering characteristics with the GMM method is extended to dendrites, plates and columns. The generated database illustrates a wide variability (10 to 15 dB) in the radar cross sections for a given maximum dimension, which results from the variability in the mass and shape of the crystals. The mass and shape are affected by the crystal thickness and, for dendrites, by the planar structure. This sensitivity of the radar cross section to the characteristics of the ice crystal population provides an opportunity to evaluate ice microphysics model parameterizations through forward modeling of the radar reflectivity and comparing with measurements. The forward modeling of radar reflectivity is a strong function of the model assumed ice characteristics.