Learning More About Ice Crystals in Relation to Remote Sensing with an Optimal Estimation Algorithm

The natural variability of ice crystal mass, area, and other assumed parametric relationships that together characterize the essential properties of the non-spherical nature of ice crystals cause uncertainties in the interpretation of remote sensing data from ice and mixed phase cloud environments. Interpretations of remote sensing measurements collected in sample volumes containing ice-phase hydrometeors are very sensitive to assumptions regarding the distributions of mass with ice crystal dimension, otherwise known as mass-dimensional (m-D) relationships. The uncertainties from these assumptions extend to backscattered cross-sections and radar forward modeled reflectivity factors. An optimal estimation (OE) algorithm (MZ) was developed to quantify the optimal m-D relationships and uncertainties in the retrieved relations, as well as the radar forward model. The MZ algorithm minimizes the difference between observed radar reflectivity and in situ particle size distribution (PSD) calculated reflectivity, to output optimal m-D relationships per PSD. Using data collected during the Tropical Composition, Cloud and Climate Coupling Experiment (TC4), the MZ algorithm was compared with a similar OE algorithm and results from several previous studies to establish validity of the methodology. Results show that both parameters in the m-D relationship increase with temperature. The methodology of the MZ algorithm was also applied to data collected during the Storm Peak Laboratory Cloud Property Validation Experiment (StormVEx), which is comprised of a unique dataset and interesting results relating to enhanced radar backscattering and radar depolarization ratio.

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