Exploring radar observables for ice water content retrieval using an ice crystal scattering database

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An ice crystal (dendrites, plates and columns) scattering database at radar wavelengths (W-, Ka-, Ku- and X-bands) is created to facilitate radar retrievals and cloud model evaluations of ice cloud properties. The ice crystals in the database are modeled as clusters of closely-packed tiny spheres with various shapes, maximum dimensions, thicknesses and masses to represent the complexity of real ice crystals and to cover the spread of the mass-dimensional relationships found in the literature. Single scattering properties from different incident angles, including backscattering cross sections at *hh*- and *vv*-polarizations and amplitude scattering matrix elements in the forward scattering direction, of the ice crystals are calculated with the Generalized Multi-particle Mie-method (GMM). Radar observables, such as effective radar reflectivity factors at *hh*- and *vv*-polarizations (Z_{hh} and Z_{vv}), differential reflectivity (Z_{dr}), specific differential phase (K_{DP}) and specific attenuation at *h*- and *v*-polarizations (A_h and A_v), are created from the database using gamma size distributions with various parameters. The relationships between ice water content (*IWC*) and the radar observables listed above are investigated. For the same ice water content, the radar reflectivity factors at *hh*- and *vv*-polarizations vary over 10 dB when different particle size distributions are used. The differential reflectivity (Z_{dr}) at side incidence is about 4-6 dB for dendrites and plates, and about 1-3 dB for columns, and does not change with ice water content. The specific differential phase (K_{DP}) increases almost linearly with ice water content. The specific attenuation at *h*- and *v*-polarizations is too small to observe. Thus, the specific differential phase (K_{DP}) shows the greatest promise in retrieving ice water content.