Spectrally and microphysically consistent ice particle model for application in the terrestrial troposphere

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Suspended ice particles in the terrestrial atmosphere mostly occur in the troposphere as ice clouds. The size and shape of ice cloud particles are diverse and thus their corresponding single scattering properties (e.g. single scattering albedo and phase function) since the single scattering properties are highly dependent on the particle shape, size, and internal structure. The reflection and emission by clouds are determined by the geometric structure of clouds as well as scattering properties of such diverse populations of particles.

For applications such as remote sensing and climate modeling, ice cloud particle models that represent this diverse population are indispensable. Aircraft measurements show that natural clouds cannot be modeled with particles of a single fixed shape because of the complex relation between independently measured particle volume (i.e. ice water content) and particle size. Also, multi-spectral satellite measurements indicate that the retrieved cloud optical thickness from the shortwave technique and the longwave technique are not always consistent and depend on ice particle models. These findings are strong drives for the development of a simple ice particle model that is microphysically and spectrally consistent w.r.t. these measurements.

In this study, we introduce a two-habit model that consists of roughened hexagonal column particles and ensemble of distorted column-aggregate particles. An aggregate particle consists of 20 randomly distorted hexagonal column particles. The mixing ratio of single column particles (habit 1) and the ensemble of aggregate particles (habit 2) are adjusted so that the model is consistent with the in-situ aircraft measurements. We also present the results of validation efforts on the spectral consistency to compare with other ice particle models, including the models used in the production of the Moderate-resolution Imaging Spectroradiometer (MODIS) Collection 6 cloud products and the Cloud and the Earth's Radiant Energy System (CERES) products.

Preferred mode of presentation: Oral/Poster