A two-habit ice cloud optical property parameterization for GCM application

Bingqi Yi, Ping Yang
Texas A&M University
College Station, TX

Patrick Minnis, Norman Loeb, Seiji Kato
NASA Langley Research Center
Hampton, VA

Abstract
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We present a novel ice cloud optical property parameterization based on a two-habit ice cloud model that has been proved to be optimal for remote sensing applications. The two-habit ice model is developed with state-of-the-art numerical methods for light scattering property calculations involving individual columns and column aggregates with the habit fractions constrained by in-situ measurements from various field campaigns. Band-averaged bulk ice cloud optical properties including the single-scattering albedo, the mass extinction/absorption coefficients, and the asymmetry factor are parameterized as functions of the effective particle diameter for the spectral bands involved in the broadband radiative transfer models. Compared with other parameterization schemes, the two-habit scheme generally has lower asymmetry factor values (around 0.75 at the visible wavelengths). The two-habit parameterization scheme was widely tested with the broadband radiative transfer models (i.e. Rapid Radiative Transfer Model, GCM version) and global circulation models (GCMs, i.e. Community Atmosphere Model, version 5). Global ice cloud radiative effects at the top of the atmosphere are also analyzed from the GCM simulation using the two-habit parameterization scheme in comparison with CERES satellite observations.