Determination of Infrared Radiative Properties of Ice Clouds and Their Parameterizations for Climate Models

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A composite methodology to determine infrared radiative properties of ice clouds is developed based on the finite-difference time domain technique. It is shown that both the anomalous diffraction theory and the geometric optics method underestimate the emissivity of cirrus clouds, while the Mie theory using equivalent spheres to nonspherical ice crystals tends to overestimate the absorption efficiency. An accurate parameterization of the infrared radiative properties of cirrus clouds is developed based on the improved single-scattering calculations, which is well suited for incorporation in climate models to study the climate effects of cirrus clouds. Furthermore, understanding of absorption and scattering by nonspherical ice crystals in the infrared is a necessary step to explain the observed relationship between the solar albedo and infrared emissivity of cirrus clouds.