Modeling of spectral snow emissivity over the entire longwave band

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Surface emissivity is defined as the ratio of actual surface emission to the blackbody radiation at the same temperature. It can vary with frequency and with the viewing solid angle. While there have been extensive measurements of surface spectral emissivity for a variety of surface types, such as the Spectral Library for the Advanced Spaceborne Thermal Emission and Reflection Radiometer [1], such measurements only cover the middle IR (> 650 cm^{-1}). There have been no systematic compilations of far-IR (< 650 cm^{-1}) spectral emissivity of surface types nor any systematic measurements of far-IR emissivity of snow or ice surfaces. Snow surface spectral emissivity is an important parameter for the energy budget and climate over high-elevation polar continents where the dry and cold atmosphere is not opaque in the far IR [2,3].

We modeled the spectral emissivity of snow surfaces for different snow grain sizes using the refractive indices of ice [4] and the Mie theory [5]. Wald [6] pointed out that the single-scattering albedo and the asymmetry parameter computed by the Mie theory cannot be directly used in radiative transfer models of closely packed grains. A "static structure factor correction" proposed by Mishchenko [7] and Mishchenko and Macke [8], which is based on solving Maxwell's equations and statistical mechanics for dense packing, is used to modify the optical properties derived from the Mie scattering theory. The corrected single-scattering parameters are then fed into the Hapke emissivity model [9] to simulate snow emissivity at all spectral frequencies in the longwave. The modeled snow spectral emissivities agree reasonably well with measurements by Hori *et al.* [10] in the middle-IR for different viewing angles and different snow grain sizes, validating our snow spectral emissivity model in the mid-IR. The modeled snow far-IR spectral emissivities are then used to do sensitivity tests of their effect on TOA and surface energy budget during a winter month over the Antarctic Plateau. Details are described in Chen *et al*. [2]. Following this study, spectral emissivities of more surface types are then simulated in Huang *et al*. [11].

References

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