Calculating the scattering properties of fine-grained particulates of planetary surfaces

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Abstract. Determining the compositions of fine particulates, such as the regoliths of the Moon and near Earth asteroids, has been a problematic task in infrared remote sensing. Difficulty in modeling the scattering properties arises due to the multiple scattering, absorption, and transmission of light that occurs when regolith particles have diameters on the order of the wavelength of light being used by an instrument. Radiative transfer models have been used to calculate the emissivity of closely-packed, fine particles with some success, but these models cannot fully describe the behavior of emissivity spectra[1,2]. Although the radiative transfer models have been adjusted to account for closely-packed particles, the physics of radiative transfer only holds for truly well-separated particles. The closely packed nature of planetary regolith particulates may be the fundamental cause of inadequate modeling by various radiative transfer models. Considering this, our study takes an approach in which we calculate the scattering properties from a cluster composed of many closely packed particles. Scattering by each individual particle is calculated by exactly solving Maxwell's equations at every light and particle interface using the publicly available Multiple Sphere T-Matrix (MSTM) code[3]. Then, the cluster-averaged scattering properties of a single volume are input into equations of emissivity in Hapke [1996] and Conel [1969]. This approach allows us to correctly calculate the near-field scattering properties of regolith particles to generate a cluster-averaged single scattering albedo. Previous works have shown that this method can generate more accurate emissivity spectra[4,5,6]. Following their example, we generated a cluster containing 150 closely-packed spheres of olivine composition with 10 μm diameters. We also performed calculations for a cluster composed of 10 spheres with diameter of 100 μm. Within a wavenumber range of 100 – 2000 cm^{-1} (5-100 μm), optical constants of olivine and corresponding scale factors were assigned to the clusters. Using these inputs, we executed the MSTM code on NASA's Pleiades supercomputer located at Ames Research Center. Our work compares the quality of the exact calculation method to those derived from Mie theory coupled with Hapke [1996] and Conel [1969] emissivity models. Furthermore, we will compare our model results with laboratory measurements to validate the accuracy of this model, then explore the effects of cluster size, particle size distribution, compositional heterogeneity, and particle shape.

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