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Rigorous light-scattering simulations of space-weathering effects on reflectance spectra

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We present a multi-scale light-scattering model that is capable of simulating the reflectance spectra of a regolith layer. In particular, the model can be applied to a case where the regolith grains have varying amounts of nanophase inclusions due to space weathering of the material. As different simulation tools are employed for different size scales of the target geometry (roughly, nano-, micro-, and millimeter scales), the particle size effects, the surface reflections, and the volume scattering can all be properly accounted for. Our results with olivine grains and nanophase iron inclusions verify the role of the nanoinclusions in the reflectance spectra of space-weathered materials. Together with the simulation results, we give simplified explanations for the space-weathering effects based on light scattering, namely the decrease of albedo, the general increase of the red spectral slope, and the dampening of the spectral bands. We also consider the so-called ultraviolet bluing effect and show how the change in the spectral slope over the ultraviolet-visual wavelengths is due to the decrease of reflectance in the visual wavelengths rather than the increase of reflectance in the ultraviolet part.