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Simulation of optical properties of non-spherical desert dust particles in the terrestrial infrared with an asymptotic approximation approach

L. Klüser (1), C. Di Biagio (2), and P.D. Kleiber (3)

(1) German Aerospace Center (DLR), German Remote Sensing Data Center (DFD), Wessling, Germany (lars.klueser@dlr.de), (2) LISA, UMR CNRS 7583, Université Paris Est Créteil et Université Paris Diderot, Institut Pierre Simon Laplace, Créteil, France, (3) Department of Physics and Astronomy, University of Iowa, Iowa City

The use of classical Lorentz-Mie theory for modeling desert dust extinction spectra causes problems due to a systematic blue shift of the extinction peak position and a poor representation of the spectral shape around extinction peaks. The combination of asymptotical solutions for small and large particles is able to provide high resolution spectra of optical properties. This asymptotic approximation approach combines Rayleigh-limit approximations for small non-spherical particles (i.e. the continuous distribution of ellipsoids approach and a similar approach for disks) with the asymptotic geometric optics solution for large particles.
Extinction spectra have been simulated assuming random orientation of non-spherical (ellipsoidal respective disk-like) particles for seven single mineralogical components of desert dust in two different size distribution regimes as well as for bulk dust samples from desert environments. The simulations have been compared with the independent measurements of dust extinction as well as with Lorentz-Mie simulations of the spectra.
It has been shown that the asymptotic approximation approach improves the spectral extinction pattern compared to pure Lorentz-Mie calculations. Also the bulk dust results obtained from averaged optical constants yield more realistic results than results from a posteriori averaging of optical properties. The improvement is seen in a significant increase of the spectral correlation coefficient between simulations and measurements in the atmospheric windows compared to Lorentz-Mie theory (R^2>0.9 in most cases) as well as a better representation of the peak positions.
Spectral unmixing of bulk dust measurements, based on simulations of single component spectra with appropriate particle size distributions, has been performed with simulations using Lorentz-Mie theory and the asymptotic approximation approach. The latter resulted in better representation of the original spectra compared to the results obtained with Mie simulations.
Like Lorentz-Mie theory and also T-matrix solutions the asymptotic approximation approach fully describes the spectral variation of extinction efficiency, single scattering albedo, asymmetry parameter and the scattering phase function and can be applied to any spectral resolution and arbitrary particle size distributions. As it does not require iteratively building series of Bessel functions, it is much faster than Lorentz-Mie theory and thus can be used to simulate large amounts of different particles with high spectral resolution.