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# Optical properties of inhomogeneous mineral dust aerosols: merits and shortcomings of effective medium approximations

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The optical properties of mineral dust particles are influenced by a number of different morphological properties, such as irregularity, small-scale surface roughness, and inhomogeneity. In the present study the focus is on the effect of inhomogeneous mineral composition. In order to isolate this from other morphological features, spherical model particles with multiple, randomly placed inclusions are considered. The host particle has a generic refractive index of 1.6 (typical for calcite or dolomite at visible wavelengths), while the inclusions are assumed to be hematite with a refractive index of 3.102+0.0925i. Two hematite volume fractions are considered, 1 % and 4 %. For each volume fraction, three different topologies are investigated, where the hematite mass is distributed among 1, 30, and 100 inclusions. Calculations are performed for 161 equidistant sizes between 80 nm and 2.8 $\mu$m. The wavelength is 550 nm. Finally, each calculation is repeated for 10 stochastic realisations of the randomly placed hematite inclusions. Thus computations for a total of 9660 individual particles are performed. The calculations took four months of wall-clock time on an HP Cluster Platform 3000 with SL230s Gen8 computing nodes, where three nodes with 16 cores each were used for the computations.

The motivation for performing such extensive and time-consuming computations was to test the validity of different effective medium approximations (EMA) over an extensive range of sizes, volume fractions, and topologies. The main question is if it is possible to find an effective refractive index so that the optical properties of inhomogeneous particles can be reproduced with homogeneous particles, and if this can be achieved not just for a few selected cases, but over the entire size range. Another question is how sensitive the optical properties are to the topology of the inhomogeneous hematite inclusions. It is found that all elements of the Mueller matrix are highly sensitive to topology. None of the tested EMA approaches reproduces the Mueller matrix of inhomogeneous particles over the entire range of sizes and volume fractions. Not even a best-fit approach of the refractive index was successful in this regard. The extinction efficiency and asymmetry parameter show only a weak dependency on topology. On the other hand, the single scattering albedo is strongly sensitive to topology. None of the EMA approaches succeeds in reproducing the single scattering albedo of inhomogeneous spheres over the entire range of sizes and volume fractions.