A systematic comparison of the optical properties of spheroids and super-ellipsoids with implications in optical modeling of dust aerosols

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Atmospheric dust particles are known to have diverse irregular morphologies. In order to account for the non-sphericity, the spheroidal model with a distribution of aspect ratios has been extensively used for modeling the optical properties of dust aerosols. The spheroidal model is superior to the spherical shape assumption but still has shortcomings. For example, the aspect ratio distribution is unrealistic or even suffer spectral inconsistency. Due to additional degrees of morphology freedom, the super-ellipsoidal model can mimic the aspect ratio, roundness and concavity characteristics of realistic dust aerosols. Note that the super-ellipsoids are non-spherical at the aspect ratio of unity. This study presents a comprehensive comparison of the optical properties of spheroids and super-ellipsoids. The invariant imbedding T-matrix method (II-TM) [1–3] is employed to compute the single-scattering properties of super-ellipsoids with a number of roundness/concavity parameters. Then we assess the applicability of spheroidal model and super-ellipsoidal model for simulating the optical properties of different dust samples from the Amsterdam-Granada Light Scattering Database [4]. It is found that extreme aspect ratios for spheroids in reproducing the measurements are unnecessary if super-ellipsoids are employed. Specifically, we will highlight the use of a newly defined shape index (SI) of super-ellipsoids ($SI = 3V / [4\pi(S/\pi)^{3/2}]$, where V is the volume and S is the average projected area, $SI = 1$ for a sphere) in conjunction with the aspect ratio to characterize the non-sphericity of aerosol samples. Different non-spherical particles with close shape index are found to have strong optical similarity.

References

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