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A13: Effects of dust non-sphericity on atmospheric modelling

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Motivation

- Mineral dust particles have complex morphology and minerology which leads to uncertainty in scattering properties and hence, in radiative flux and satellite retrieval.
- Efforts have been made for accurate representation of dust shape in remote-sensing application but impact of dust shape on atmospheric models has received insufficient attention.

Research Objectives

1. Investigate the impact of the most representative shape i.e. spheroid, on the 3-D CTM GEOS-Chem computed Aerosol optical depth (AOD) and surface area for heterogeneous chemistry.
2. Study the change in the phase function, scattered intensity and scattering weights (AMF) due to particle shape using a VLIDORT based radiative transfer model.

Results (ΔQ_{ext} vs. Size Parameter and wavelength)

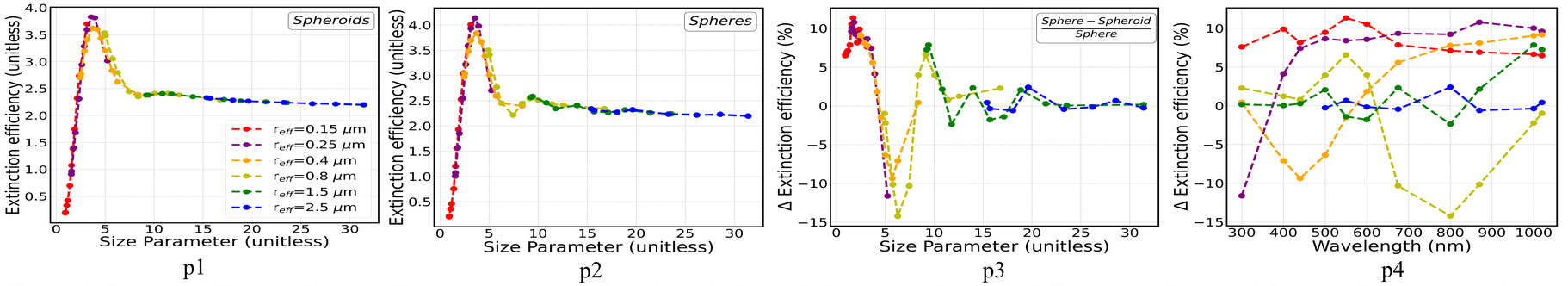


Figure 1: Extinction efficiency (Q_{ext}) vs. Size parameter (x_{eff}) for spheroids (panel 1), for spheres (panel 2); Δ Extinction efficiency (ΔQ_{ext}) vs. Size parameter (x_{eff}) (panel 3); Δ Extinction efficiency (Δ Q_{ext}) vs. wavelength (panel 4). ***Key take away:*** *1) The extinction efficiency for spheroid particles exhibits a broader and shallower resonance peak than for spherical particles, reflecting the broader distribution of aspect ratios for spheroid particles. 2) Large differences (> 10%) come in the sub-micron size range.*

Results (Δ Surface area)

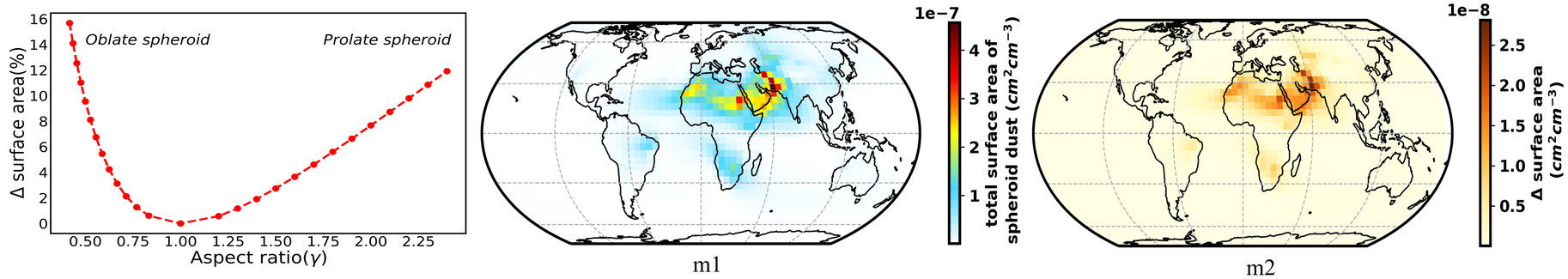
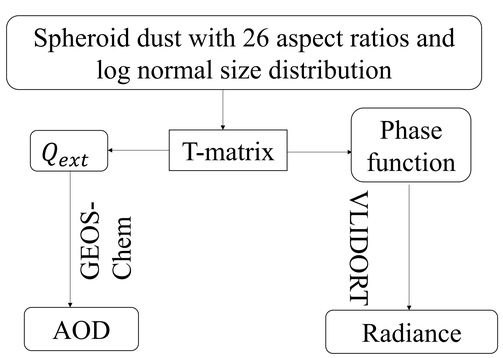


Figure 2: Deviation of the surface areas of spheroid shape dust particles from spherical shape with respect to the aspect ratios (plot), Modeled monthly mean total surface area of dust particles in the troposphere for September 2016, assuming the spheroid shape for the dust particles (map 1) ,absolute difference in the surface area when deviating from spherical shape (map 2). ***Key take away****: The relative difference in surface area is about 6%.*

Methodology



- Q_{ext} and Phase function are compared for spheroid and spherical dust.
- Surface area change ∝ f (aspect ratio). Calculated total surface area change for spheroid particles averaged over 26 aspect ratios.

Results (Phase function)

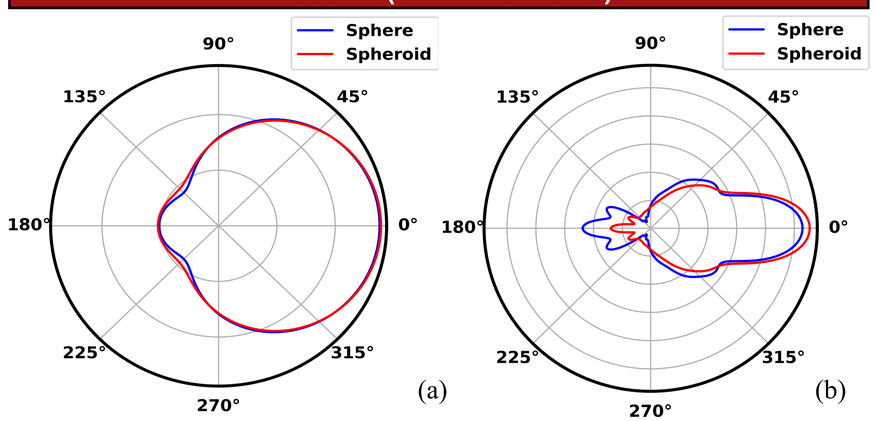


Figure 3: Phase function of spheres (blue curve) and ensembled averaged phase function of spheroid shape dust particles (red Curve) for (a) size parameter (x_{eff}) 1.7 (b) size parameter (x_{eff}) 6.38.

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Conclusions

- We find that assuming spherical dust particles can introduce size-dependent and wavelength-dependent errors up to 18% in dust AOD.
- The impact of particle shape on heterogeneous chemistry is affected by increased surface area of non-spherical dust particles changes.
- Comparison of the phase function of spheroid and spherical dust reveals differences of up to a factor of two in backward scattering.
- We find that use of spherical particles can underestimate scattered radiance in the forward direction by up to 30% and overestimate scattering in the backward direction by up to 31 %