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Comment on acp-2022-633

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Referee comment on "Single-scattering properties of ellipsoidal dust aerosols constrained by measured dust shape distributions" by Yue Huang et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-633-RC1, 2022

This paper investigated the single-scattering properties and lidar observables of tri-axial ellipsoids at short wavelengths using a shape distribution from observations. The novelty of this paper is that the aspect ratio distributions were constrained by observations. The influences of model shapes were illustrated by comparing to spheroidal and spherical models, and the impacts of smaller-scale surface textures were also discussed. The ellipsoidal dust models were found to be substantially superior to spherical models and better than spheroid models in many ways except at the backscattering angle which might be caused by the inaccuracy of computation methods and smaller-scale textures. The tri-axial ellipsoidal dust models were believed helpful in improving climate models and remote sensing retrievals. This paper was well written and organized.

I have a few comments:

1) The database used and the calculation details should be more specific. It could be better to state which method (the Lorenz-Mie theory, the T-matrix method, the DDA, the IGOM) was used at what size parameter range. In particular, what is the aspect ratio range of particles in available databases? It looks that the aspect ratio range from observations is much larger than those of spheroid and tri-axial ellipsoid models. Since the database was developed a long time ago, I am wondering whether the database was updated.

2) The spheroidal model developed by Dubovik was used for comparison. Is it possible to update this model by using new shape distribution compiled from the observation? In this case, it will be easier to understand impact of tri-axial ellipsoids.

3) Line 49-52 “These problematic dust shape assumptions of aerosol models and retrieval

algorithms generate biases in dust single-scattering properties… To facilitate accounting for more realistic dust shape in aerosol models…". I suggest the authors add a few sentences to review the progress in studying the impact of dust asphericity. Other different dust models are also developed in the community to overcome the shortcoming of spheroidal dust models. For example, superspheroid (or superellipsoid) models (Lin et al. JGR, 126, e2020JD033310.https://doi.org/10.1029/2020JD033310, 2018) showed their significant superiority in simulating optical properties of dust comparing to spherical and spheroidal models. The model was also further used to study lidar observations (Kong et al. JGR, 127, e2021JD035629. https://doi.org/10.1029/2021JD035629,2022).

4) Besides, Line 149-150 "we for the first time (to our knowledge) account for the observation constrains on dust shape in obtaining dust single-scattering properties". I would like to mention the following papers. Bi et al. (Applied Optics, 48(1), 114–126, 2009; https://doi.org/10.1364/AO.48.000114) utilized the ratios of the three axes of ellipsoids obtained by Ghobrial & Sharief (IEEE Transactions on Antennas and Propagation, 35(4), 418–425, 1987) in simulating the single-scattering properties of triaxial ellipsoidal dust particles. Actually, the above study provided the technique readiness for the development of a tri-axial ellipsoidal database, which was used in this study.

5) Line 159-160 "LWR … commonly referred to as the aspect ratio … Fig. 1". However, in Figure 1c, the aspect ratio (commonly referred to) should be because the LWR=1 for oblate spheroid in this figure. A little bit confusion.

6) Line 207 "…, we used Monte-Carlo sampling to randomly generate a large number…". It is difficult to understand this procedure. Why did the authors use a Monte-Carlo method instead of directly multiplying the two probabilities from Eqs. (9) and (10).

7) Line 328-329 "First, most aerosol models underestimate the extinction efficiency (Qext) and mass extinction efficiency (MEE) by 20% to 180% …" The authors summed the extinction cross sections of all the 121 ellipsoid models and then divided by the projected area of the volume-equivalent sphere in Eqs. (11) and (18). Therefore, the extinction efficiency could be larger than 2 such that the difference of Qext in Fig. 2a-b was mostly caused by the definition in Eq. (11). I suggest the authors recalculate these two parameters by the projected area of the ensemble of 121 particles. The difference is expected to be smaller. Otherwise, more related discussion is necessary to clarify the understanding of the extinction efficiency, although different definitions (if used consistently) have no impact in the final calculation (e.g., the extinction coefficient).

8) The hexahedral dust optical model was compared in this study. The first paper that proposed the hexahedral dust model is Bi et al (Applied Optics, 49, 334-342. https://doi.org/10.1364/AO.49.000334, 2010).