Response to RC2

We're grateful to the reviewers for their comments and suggestions, which significantly improved the manuscript. In the revised version, we have made the following major changes:

- Streamlined introduction and reduction of discussion on the radiative effects of dust
- Equations and quantity definitions moved to a newly introduced “Theoretical Background” section
- Minor revisions to most plots for improved clarity
- Clarifications to results and discussion in section 5
- Additions to limitations in conclusion section

Below are point-to-point responses to reviewer comments.

Comments:
1. Please capitalize the 'p' in the title “properties” to maintain consistency with the other words in the title.

Response: Done.

2. Page 6 (48): The sentence, 'If lidar backscattering is dominated by single scattering, δ is close to zero for spherical or quasi-spherical particles like smoke aerosols and water droplets,' is only partially accurate. Theoretical calculations show that even a small deviation from perfect sphericity can produce a finite depolarization ratio. Additionally, the term 'smoke aerosols' can refer to both fresh and aged soot, which may form super-aggregates with irregular shapes. Therefore, the near-zero depolarization ratio observed for soot particles may also be due to their high imaginary refractive index, which reduces their depolarizing ability. I encourage the authors to revise this statement accordingly.

Response: We have removed “or quasi-spherical” from our statement, and changed smoke to sulfate to avoid confusion over shape. Results from Bi et al. (2018) suggest, especially for larger particles, small changes from an ellipsoid aspect ratio of 1 have high depolarization ratio.

Lei Bi, Wushao Lin, Dong Liu, and Kejun Zhang, "Assessing the depolarization capabilities of nonspherical particles in a super-ellipsoidal shape space," Opt. Express **26**, 1726-1742 (2018)

3. Page 16 (48): The term 'scattering phase matrix P' is somewhat unusual. Most textbooks refer to this simply as the 'scattering matrix,' which includes the phase function as its first element. Please review this usage.

Response: We have reworded it to 'scattering matrix' throughout the text.

4. Page 19 (48): The statement 'Fig. 4 can serve as a benchmark for future studies on

mineral dust scattering properties' is somewhat surprising. To me, this appears to be a basic phase function calculation without a clear or coherent explanation. Similar plots are widely available in the literature. Furthermore, the graphs represent scattering calculations at different size parameters, which are dimensionless quantities. From the figure, what I observe is that larger particles (with higher size parameters) exhibit stronger forward scattering, which is expected, as scattering in the forward direction is roughly proportional to the particle diameter to the fourth power (D^4)-a well-known behavior in the scientific community.

Response: This is in regards to a benchmark comparison for future theoretical shape models, given the shapes are tied to physical observations and the lack of single particle lab measurements of lidar properties. The statement was adjusted to improve clarity.

5. In line 405, page 23 (of 48): A space is needed after “P11(π)”.

Response: Thank you for the correction.

6. Line 514, page 29 (48): The expression for the size parameter is written incorrectly-specifically, the factor of 2 is missing.

Response: This was previously defined in the paper with the factor of 2, so we have removed the second incorrect definition.

7. In the caption of Fig. 7, please correct the sentence: 'The color of each dot corresponds to the imaginary of the imaginary index.

Response: Fixed.