The Effect of Non-sphericity on GOES-8 Dust Aerosol Retrievals During PRIDE

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Overview
Integrating more than 10 aerosol characterization measurements and 3 different radiative models, this study quantitatively explores the dust non-sphericity issues ... With the change of the solar zenith angle, the GOES satellite provides observations over a wide range of scattering angles in a short time period – an opportunity to explore the non-sphericity effect on dust retrievals.

Area of Study
Characterize Aerosols from in situ Measurements for GOES-8 Dust Retrievals
Aerosol Volume Size Distribution
- Measured dust size distribution (from 3 different sizes) and aerosol light scattering/extinction coefficients (from 3 nephelometers) are combined together to infer the aerosol effective refractive index, and constrain aerosol properties in the retrievals. Inferred refractive index for dust particles is 1.53±0.0015, and single scattering albedo is about 0.97~0.98.

Introduction
- Dust affects visibility, human health, and the Earth energy budget. However, modeling of dust distribution and quantification of its radiative effects are difficult, simply because ground-based measurements for dust aerosols are limited in both space and time.

Area of Study
- The satellite measurements have been considered as one of the best tools to characterize the high spatio-temporal variations of aerosols.
- However, the current dust retrievals from satellite measurements have large uncertainties, mainly because dust particles are non-spherical, and their phase functions cannot be calculated/trusted properly. It has been shown theoretically that such uncertainties can be easily larger than 2.
- In the context of practical applications, few quantitative evaluations of non-spherical effect on satellite retrievals have been made, either due to the lack of in situ aerosol characterization measurements, or because most measurements lack the capability to monitor the same dust layer from different angles with high temporal resolutions.

Objectives
Will consideration of non-spherical effects improve the satellite retrievals, if all the required data to characterize aerosol optical properties are given in the same temporal-spatial domain?

Results Using Different Phase Functions
Retrievals using spherical phase function generally agrees with SP AOT (fig. a). But the retrieval errors have distinct pattern as a function of scattering angles (fig. b). We found that considering the mixture of spherical and non-spherical particles produces the best retrievals (fig. c).

Quantitative Analysis of Non-spherical effect

<table>
<thead>
<tr>
<th>Phase Function</th>
<th>All-angle</th>
<th>45°~30°</th>
<th>30°~15°</th>
<th>15°~150°</th>
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</thead>
<tbody>
<tr>
<td>Spherical</td>
<td>0.55</td>
<td>0.79</td>
<td>1.4%</td>
<td>10%</td>
</tr>
<tr>
<td>Non-Spherical</td>
<td>0.55</td>
<td>0.98</td>
<td>33%</td>
<td>41%</td>
</tr>
<tr>
<td>Mixture</td>
<td>0.25</td>
<td>0.35</td>
<td>1%</td>
<td>14%</td>
</tr>
</tbody>
</table>

References

Acknowledgements
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Summary
Using SEM data and T-matrix calculations, the computed non-spherical phase function agrees well with synthetic phase function derived from independent measurements [Liu et al., 2003].

Applying purely non-spherical phase functions into the satellite retrieval algorithms only shows slightly improvement at certain scattering angles. However, using composite phase function by considering both spherical and non-spherical particles greatly improves the retrievals.

Further efforts are needed to combine the use of multi-angle, multi-channel, and polarization data sets to retrieve the morphologies of particles and to apply them in satellite retrievals.