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

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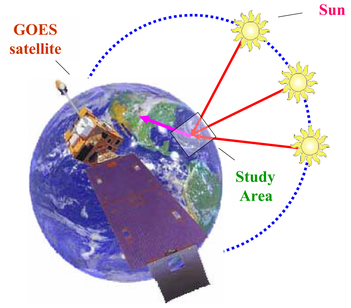
Overview

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.*

Introduction

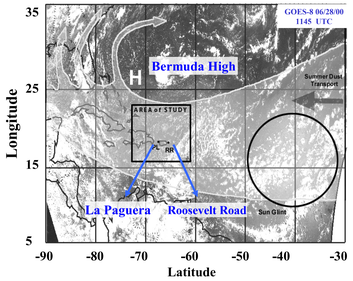
- Dust affects visibility, human health, and the Earth energy budget. However, modeling of dust distribution and quantification of its radiative effects are difficult, simply because ground-based measurements for dust aerosols are limited in both space and time.
- The satellite measurements have been considered as one of the best tools to characterize the high spatial-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 can not be calculated/treated 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 satellite 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?

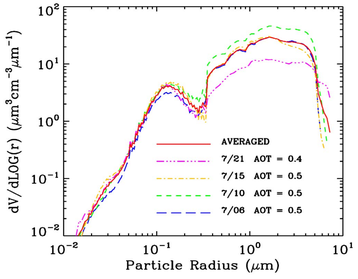
Area of Study

We use the *in situ* datasets collected during Puerto Rico Dust Experiment (PRIDE), June 28 ~ July 24, 2000. The following figure shows GOES8 ch1 image on June 28, 2000 at 1145UTC composite with a conceptual model showing how dust from Africa can be transported to continental United States. Also shown are two Sunphotometer (SP) locations. On this day, the dust aerosol optical thickness (AOT) is about 0.5, as reported by both Sunphotometers.



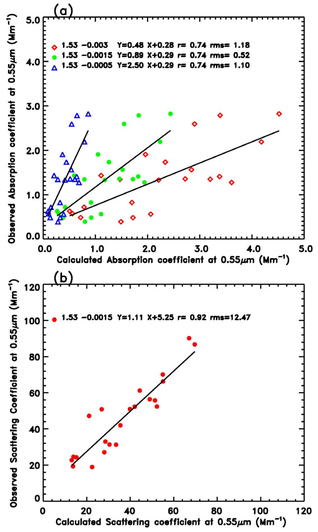
Characterize Aerosols from *in situ* Measurements for GOES-8 Dust Retrievals

Aerosol Volume Size Distribution



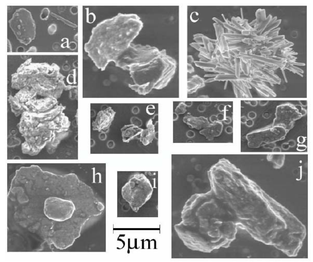
Measured dust size distribution (from 3 different sizers) and aerosol light scattering/extinction coefficients (from 3 Nephelometers) are combined together to infer the aerosol effective refractive index, and constrain aerosol properties in the retrievals. Inferred refractive index for dust particles is 1.53-0.0015i, and single scattering albedo is about 0.97~0.98.

Aerosol Refractive Index

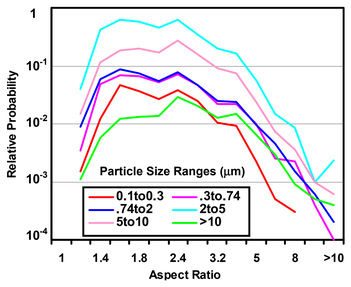


Dust samples were collected from the aircraft and then analyzed through the scanning electronic monograph (SEM). A statistical mode for dust morphologies is created based on the SEM analysis of 60, 500 particles. The model uses 6 size intervals and 15 aspect ratios (1.2~10) to describe the dust size and shape. In this study, we assume dust particles are oblate spheroid. The aerosol optical properties are then computed through the T-matrix calculations.

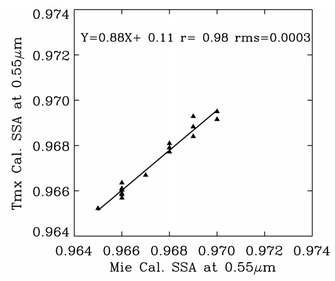
Dust Morphology (SEM images)



Dust Morphology Model



Spherical vs. Non-spherical Single Scattering Albedo Comparison



Results Using Different Phase Functions

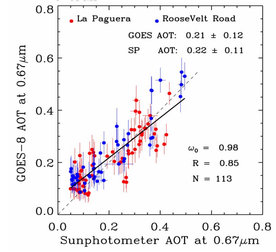
Retrievals using spherical phase function generally agrees with SP AOT (fig. a). But the retrieval errors have distinct pattern as a function of scattering angles (fig. b). We found that considering the mixture of spherical and non-spherical particles produces the best retrievals (fig. e).

Quantitative Analysis of Non-spherical effect

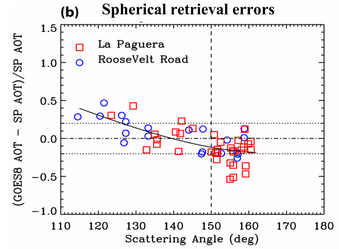
Phase Function	110°~150°	150°~165°	All angle	
	γ*	γ	ε*	|ε|*
Spherical	0.65	-0.89	-6%	18%
Non-Spherical	-0.50	0.98	31%	41%
Mixture	0.37	0.35	5%	14%

(*ε: relative errors; |ε|, absolute errors; γ: ε / |ε|)

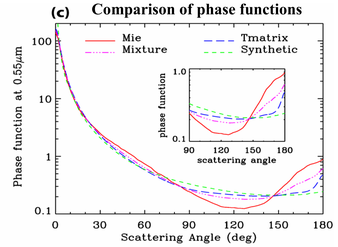
(a) GOES8 AOT vs. SP AOT



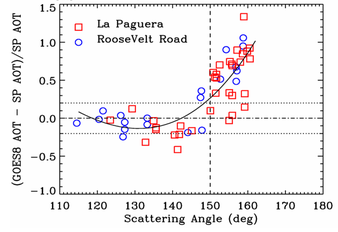
(b) Spherical retrieval errors



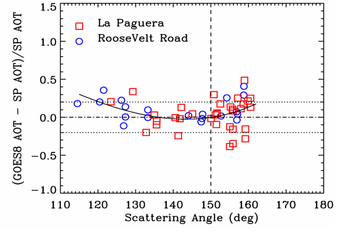
(c) Comparison of phase functions



(d) Non-Spherical retrieval errors



(e) Mixture retrieval errors



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.

References

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