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Improving GCM aerosol climatology using satellite and ground-based measurements

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Abstract

A physically based aerosol climatology is essential to address the questions of global climate changes. In this study, we use available satellite and ground-based measurements, i.e., MODIS, MISR, POLDER, AVHRR, and AERONET data, to characterize and validate the geographic distribution and seasonal variability of the GISS ModelE [*Schmidt et al*., 2005] aerosol optical depth (AOD) and particle size via Ångström exponent (A). Our analysis of satellite and ground-based observations shows that there is considerable "diversity" in observed global distributions of AOD, and in particular, the Ångström exponent. Given the uncertainties associated with satellite retrieval results, both the global optical depth and the Ångström exponent distributions of GCM aerosols are qualitatively reasonable. The Ångström exponent of the GISS GCM aerosol is clearly biased low compared to satellite data, implying that the GCM aerosol climatology sizes might be overestimated. We have also compared the GISS ModelE aerosol single scattering albedo climatology versus TOMS Aerosol Index (AI) and AERONET data. This inter-comparison study points to the need to readjust the size specification of different aerosol species in the GCM to produce agreement between the model derived aerosol climatology and those retrieved from satellite and ground-based measurements, and requires improvement of the chemical transport model simulations upon which the GCM aerosol climatology is based. On the other hand, the existing diversity among different satellite products indicates an urgent need for improved retrieval of tropospheric aerosol radiative properties from satellite measurements.

Results and Analyses

a: Aerosol optical depth and Angstrom Exponent

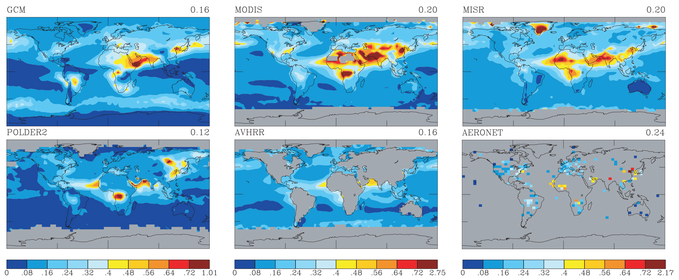


Figure 1. Qualitative agreement for the overall seasonal mean in Summer (JJA) aerosol optical depth at 0.55 μm complied from different datasets. Numbers at top right corner represent the area weighted global means.

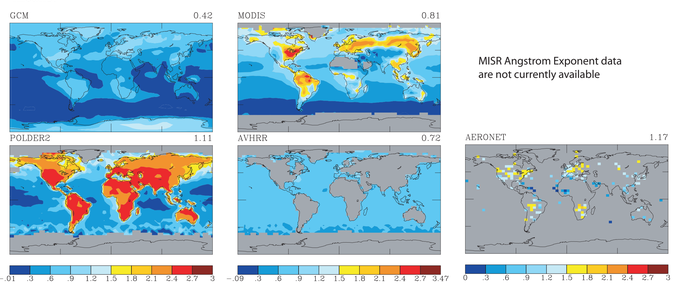


Figure 2. GCM underestimate of the overall seasonal mean in Summer (JJA) Ångström exponent compiled from different datasets. Numbers at top right corner represent the area weighted global means.

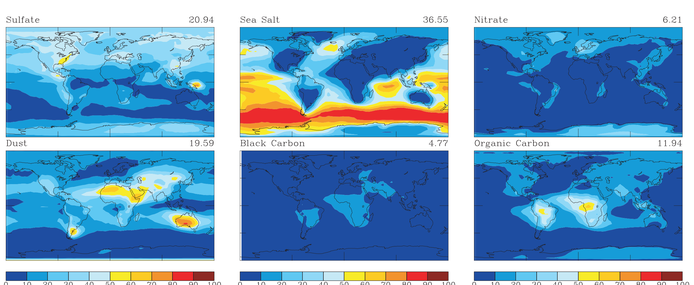


Figure 3. Fractional distribution of principle species (per cent) of GISS annual - mean aerosol climatology.

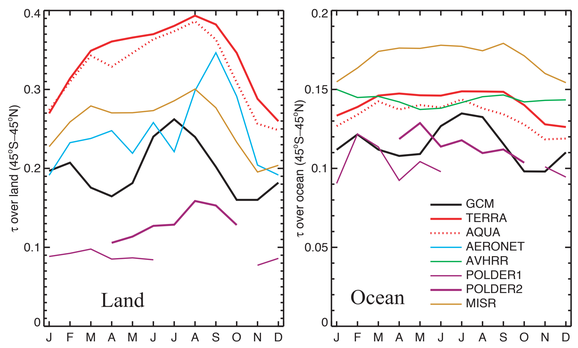


Figure 4. Seasonal dependence of area weighted overall monthly mean aerosol optical depth from different data sources. Data over land (left panel) and over ocean (right panel) have been averaged over 45 degree South and North latitudinal band and over available data of the respective instrument.

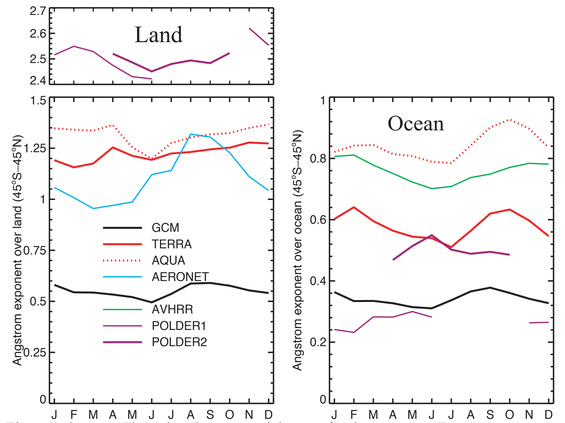


Figure 5. Same as Fig. 4, but the averaged data are for the Angstrom Exponent.

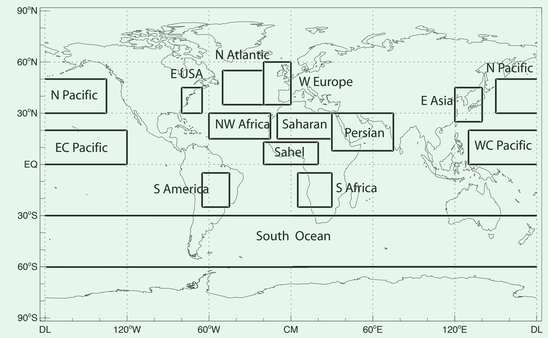
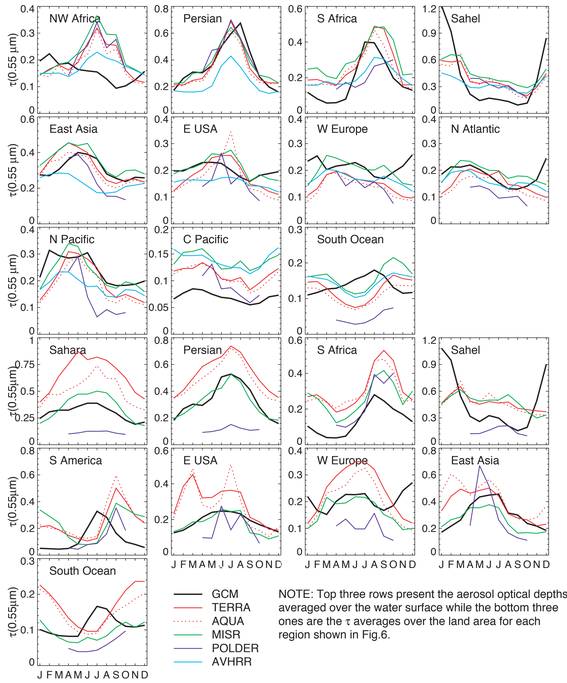


Figure 6. Regions selected for comparisons of GCM aerosol climatology with satellite retrievals.



NOTE: Top three rows present the aerosol optical depths averaged over the water surface while the bottom three ones are the τ averages over the land area for each region shown in Fig.6.

Figure 7. Regional analysis of overall monthly mean aerosol optical depth averaged over the various aerosol regimes shown in Fig.6. Averages are computed over water surfaces (top three rows) and land areas (bottom three rows) if the designated area contains both land and water masses.

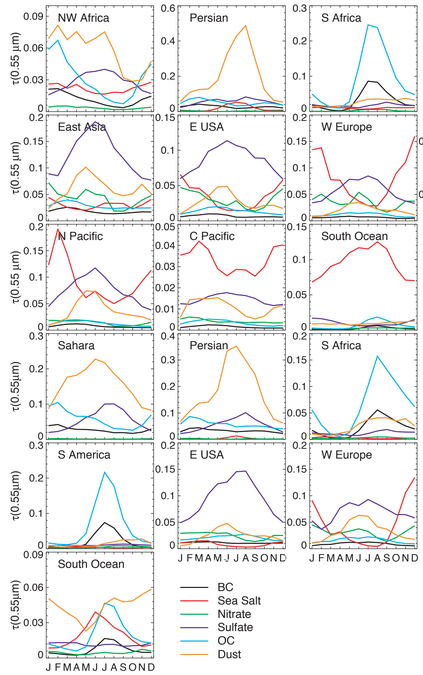
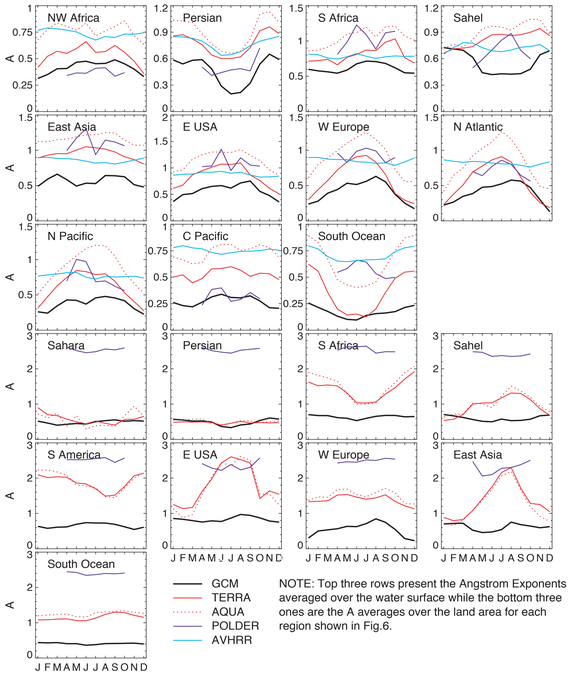


Figure 8. Relative contributions of each principle aerosol component considered in the GCM to the total aerosol optical depth depicted by the thick black curves in Fig.7.



NOTE: Top three rows present the Angstrom Exponents averaged over the water surface while the bottom three ones are the A averages over the land area for each region shown in Fig.6.

Figure 9. As in Fig. 7, but for seasonal dependence of overall monthly mean Angstrom Exponent at different places shown in Fig.6.

b: Aerosol single scattering albedo

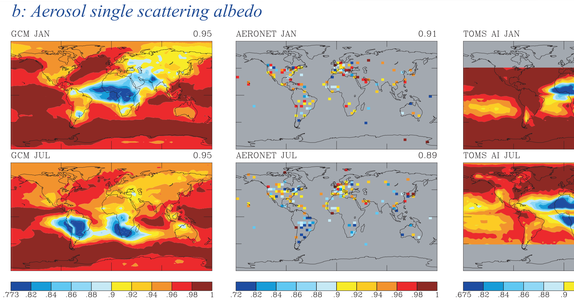


Figure 11. January and July monthly-mean single scattering albedo for the GISS ModelE aerosol climatology for 1990 (left panels). TOMS Aerosol Index (AI) (right panels) has been re-scaled as (1 - 0.1 x AI) to roughly resemble the GCM single scattering albedo. Aerosol single scattering albedo measured locally at AERONET network sites is shown in the center panels. Numbers appearing in the upper right corners are area weighted global mean values.

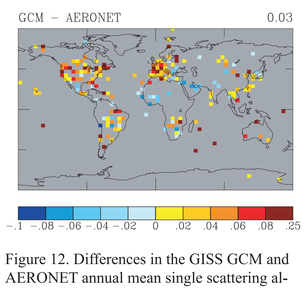


Figure 12. Differences in the GISS GCM and AERONET annual mean single scattering albedo. The single scattering albedo is reported at 0.55 μm for the GCM, while the selected AERONET wavelength is 0.44 μm. The number in the upper-right corner represents area weighted global mean.

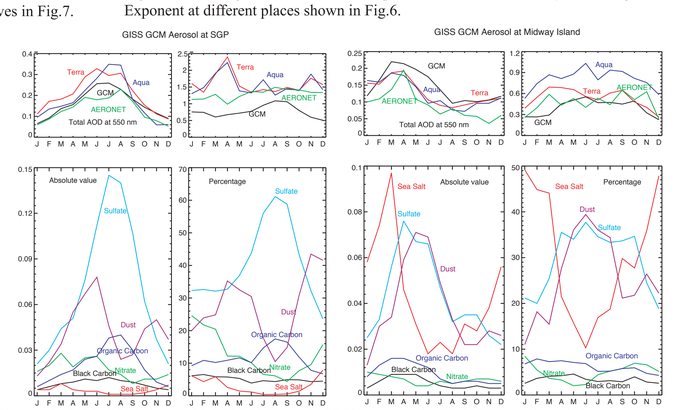


Figure 10. GISS GCM along with MODIS Terra, MODIS Aqua, and AERONET at selected sites.

Schmidt. G. A., et al. (2005), Present day atmospheric simulations using GISS ModelE: Comparison to in-situ, satellite and reanalysis data, *J. Climate*, in press.