GACP 2nd Year Report (FY 2000)

Evaluation of uncertainties in satellite retrievals of aerosol using in-situ measurements at the surface

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Project Objective

Derivation of aerosol radiative forcing from satellite observations requires assumptions about the chemical, microphysical, and optical properties of the particles because not all the necessary information can be determined from satellites. We will assemble the extensive data sets of in-situ, tropospheric aerosol properties (in particular, single-scattering albedo, Ångström exponent, and hemispheric backscatter fraction) that have been obtained by our team of investigators and others, and work with the NASA aerosol climatology processing facility to test the sensitivity of candidate satellite data retrieval algorithms to observed variations of aerosol properties. The desired outcome of our investigation is a quantitative estimate of the uncertainty in the satellite-derived aerosol climatologies attributable to assumptions about aerosol properties used in the retrieval algorithms.

2nd Year Progress

During the second year of the GACP project, work continued on improving software to scrutinize NOAA's aerosol data sets and flag suspect data. Suspect data is investigated to determine if it should be removed from the clean data set. During this year, clean data sets have been assembled for the Point Barrow (Alaska) and Southern Great Plains (Oklahoma) monitoring stations. Statistical distributions of aerosol properties have been determined from the Bondville, (Illinois), Sable Island (Nova Scotia, Canada), Point Barrow (Alaska), and South

Great Plains (Oklahoma) data sets (Figure 1). These statistical distributions are computed on an hourly, daily, monthly, and quarterly basis to determine if there are cycles in aerosol properties on these time scales (Figure 2, Figure 3, Figure 4). Statistics based on the clean data set at Sable Island have been submitted to NASA's aerosol climatology processing facility and work has begun on developing algorithms to determine how the observed distribution relates to uncertainty in satellite retrievals. Software has been developed to determine statistics for the aerosol hydroscopic growth data. This is necessary information for relating NOAA's in-situ measurements, which are made at low relative humidity, to satellite measurements made at ambient relative humidity. Statistical relationship between various aerosol parameters, such as scattering coefficient versus single-scattering albedo, has been investigated (Figure 5). Systematic relationships between single-scattering albedo and aerosol loading, such as that show in Figure 5, suggest the possibility of systematic biases in retrieval algorithms that assume a constant single-scattering albedo.

Third Year Statement of Work

1. Construct clean aerosol data sets for the Mauna Loa (Hawaii), and Cheeka Peak (Washington) stations.
2. Incorporate observations from the University of Illinois measurements of aerosol hygroscopic grown into the Bondville, Illinois data set.
3. Determine how aerosol properties vary with air mass origin.
4. Work with NASA aerosol climatology processing facility to develop sensitivity tests of satellite parameterizations.
5. Submit paper for the aerosol special issue of Journal of the Atmospheric Sciences by December 15, 2000. This paper will focus on the daily, season, geographical, and air mass type variability of aerosol properties, utilizing measurements made at Bondville, Illinois; Lamont, Oklahoma; Sable Island, Nova Scotia; and Barrow, Alaska. The paper will present the seasonal statistics for each site, summarize the differences observed among the sites and explore how air mass type and origin relate to the measured aerosol properties.
6. Write manuscript documenting the uncertainties of satellite retrievals to the observed variability of aerosol properties.

Seasonal Cycles of Aerosol Properties for North American Monitoring Sites

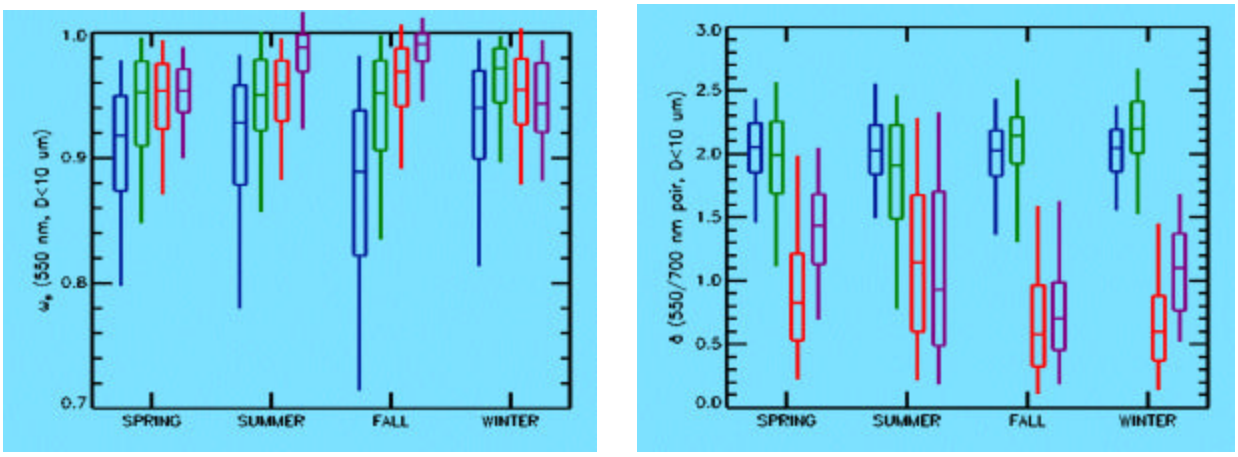

Figure 1 The single-scattering albedo and Ångström exponent for North American monitoring sites located at Bondville, Illinois (blue); Lamont, Oklahoma (green); Sable Island, Canada (red); Barrow, Alaska (purple). The box-and-whiskers denote the 5, 25, 50, 75, and 95 percentiles. The continental sites have scattering coefficients that are dominated by submicrometer aerosols, while at sites impacted by sea-salt aerosols, the supermicrometer fraction typically dominates. The aerosol single-scattering albedo is typically lower at the continental sites than at the more remote sites; however, during the winter the sites are similar. The natural variability of these aerosol parameters contributes to the uncertainty in satellite retrieved aerosol optical depth.

Daily Cycle in Single-scattering Albedo at Bondville

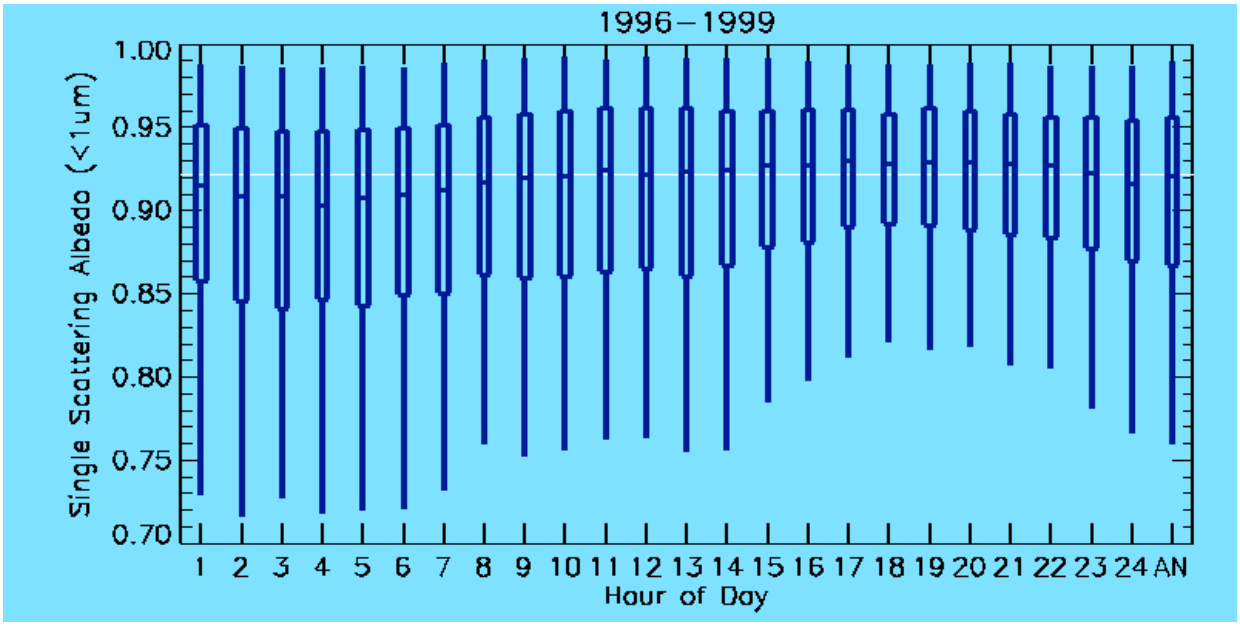

Figure 2 Daily cycle in single-scattering albedo at Bondville, Illinois. The box and whiskers denote the 5, 25, 50, 75, and 95 percentiles. The statistics are based on the hourly averaged data for all valid measurements obtained from the start of 1996 until the end of 1999. The x-axis denotes the GMT hour of the day, with the last box-and-whisker denoting the percentile for the entire period. A cycle in single-scattering albedo is evident with a peak around noon (local time).

Daily Cycle in Ångström Exponent at Bondville

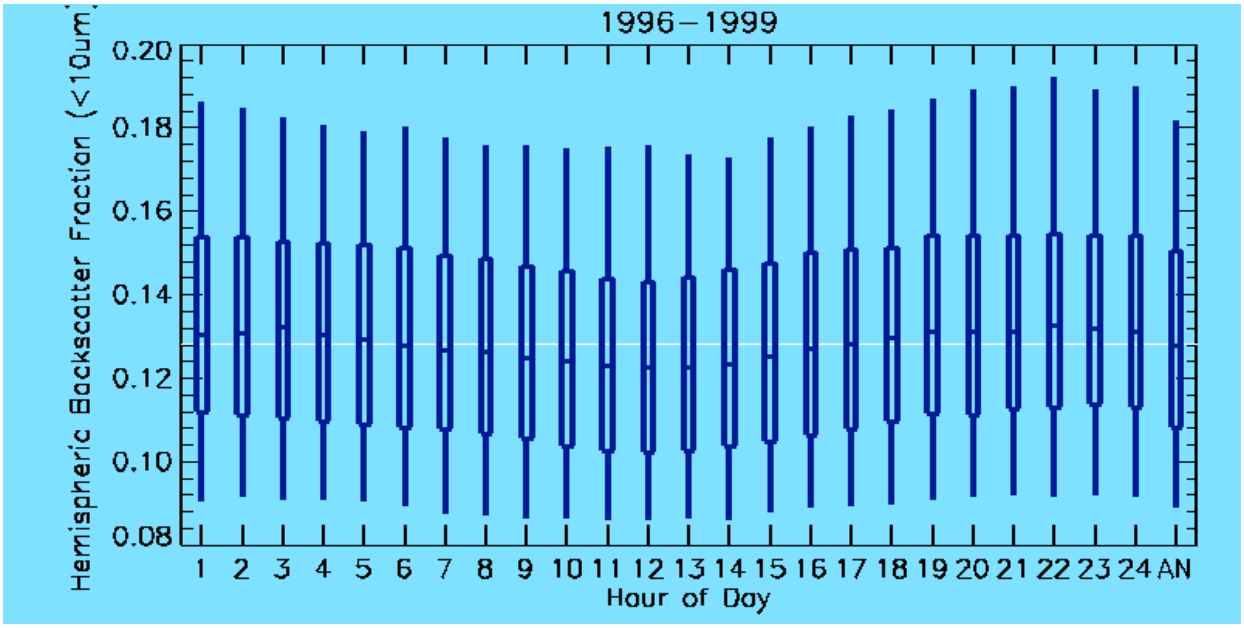

Figure 3 Daily cycle in Ångström exponent at Bondville, Illinois. The box and whiskers denote the 5, 25, 50, 75, and 95 percentiles. The statistics are based on the hourly averaged data for all valid measurements obtained from the start of 1996 until the end of 1999. The x-axis denotes the GMT hour of the day, with the last box-and-whisker denoting the percentile for the entire period. The Ångström exponent statistics does not show any daily cycle.

Daily Cycle in Hemispheric Backscatter Fraction at Bondville

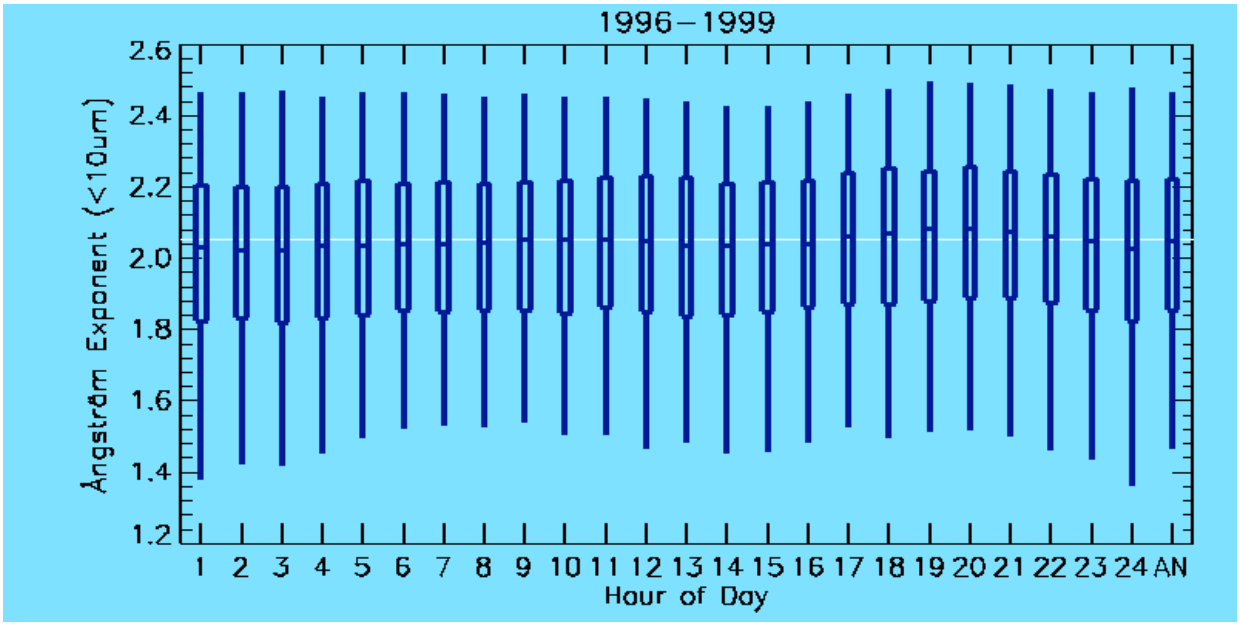

Figure 4 Daily cycle in hemispheric backscatter fraction at Bondville, Illinois. The box and whiskers denote the 5, 25, 50, 75, and 95 percentiles. The statistics are based on the hourly averaged data for all valid measurements obtained from the start of 1996 until the end of 1999. The x-axis denotes the GMT hour of the day, with the last box-and-whisker denoting the percentile for the entire period. A cycle in hemispheric backscatter fraction is evident with the highest values in the afternoon (local time).

Single-scattering Albedo versus Scattering Coefficient

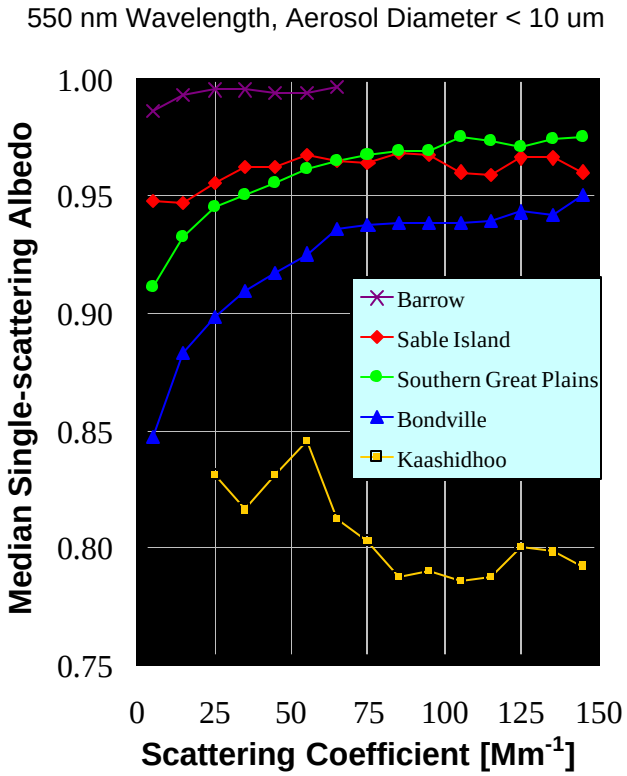

Figure 5 Median aerosol single-scattering albedo versus the total scattering coefficient for hourly averaged aerosol measurements made during INDOEX at Kaashidhoo (February & March, 1999), and the period of record measurements at Bondville, Southern Great Plains, Sable Island, and Barrow are shown in the figure. The median single-scattering albedo was calculated over 10 Mm^{-1} scattering coefficient bins. At the North America sites, periods with high scattering coefficients have high single-scattering albedo, while at Kaashidhoo, periods of high scattering coefficients have low single-scattering albedo. We speculate that regional differences in removal mechanisms for absorbing versus non-absorbing aerosols are responsible.