FORM A: GACP ACCOMPLISHMENT REPORT

Principal Investigator: John A. Ogren, NOAA/CMDL

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

ABSTRACT: 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 propose to assemble the extensive data sets of in-situ, tropospheric aerosol properties (in particular, single-scattering albedo, hemispheric backscatter fraction, and Ångström exponent) 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.

Each satellite retrieval of aerosol properties uses different assumptions, either because of different primary observations or different algorithms. These assumptions comprise an "aerosol model", which specifies the unknown aerosol properties needed to calculate the retrieved quantities. In general, the aerosol model specifies the aerosol size distribution and refractive index. Some retrievals may use different aerosol models, depending on geographical region or on the satellite-based observations themselves. In all cases, the aerosol properties specified in the aerosol model can be compared with in-situ measurements of those properties. However, combined observations of aerosol size distribution and refractive index are rare, making it difficult to compare the models directly with measurements.

Our approach begins with a candidate aerosol model, which could be part of a currently operational retrieval algorithm, a planned operational algorithm, or a new algorithm proposed by other members of the NASA Aerosol Radiative Forcing Science Team. Guided by in-situ observations of aerosol size distribution and chemical composition, we will develop a set of perturbed versions of the candidate aerosol model that yield similar frequency distributions of aerosol properties, such as single-scattering albedo, as actually observed. These perturbed versions of the aerosol model can then be used by the NASA aerosol climatology processing facility to evaluate the distribution of retrieved aerosol properties that is consistent with estimated variations in the retrieval algorithm's aerosol model. The statistical nature of our approach requires large data sets that adequately represent the variability of atmospheric aerosols on time scales ranging from diurnal to multi-year. Surface-based measurements from NOAA's worldwide aerosol monitoring network, with sites spanning conditions from polluted continental, to clean marine, to the free troposphere, are one of the few sources of data appropriate for this approach.

GOALS: Our long-term research goal is to characterize means, variability, and trends of climate-forcing properties of different types of aerosols, and to understand the factors that control these properties. Our research goal is aimed at addressing the following questions:

1) What are the sign, magnitude, and spatial distribution of climate forcing by anthropogenic aerosols?
2) What is the uncertainty in the forcing estimate, and what are the causes of this uncertainty?
3) How has the forcing (and its spatial distribution) changed in the past and how will it change in the future?

On-going field research at the Climate Monitoring and Diagnostic Laboratory (CMDL) address these questions by developing sampling procedures, instrumental methods, and establishing ground-based stations to obtain measurements of the relevant aerosol properties.

OBJECTIVES: The role of anthropogenic aerosol particles on radiative forcing of climate is a key issue being addressed by the NASA Global Aerosol Climatology Project (GACP). Improved understanding of how aerosols affect climate will rely largely on satellite mapping of aerosol optical depth. Satellite retrieval algorithms require knowledge of aerosol properties that are not directly measured. Therefore, for satellites to provide accurate global maps of aerosol optical depth, aerosol properties must be accurately parameterized in satellite retrieval algorithms.

Measurements of aerosol properties began at CMDL in the mid-1970s with stations at Point Barrow (Alaska), Mauna Loa (Hawaii), American Samoa, and the South Pole. Since 1992, CMDL has been expanding its aerosol measurement program to include monitoring stations designed to obtain representative regions measurements of aerosol properties in areas directly impacted by human activities. Our research objective is to use data obtained from ground-based sampling stations to address the following questions:

1) What are the values and uncertainties of climatically relevant aerosol properties as determined over this network of aerosol monitoring stations?
2) What variability do aerosol properties exhibit as a function of season, geographical location, and air mass type?
3) What are the uncertainties in the satellite retrievals of aerosol radiative properties based on measurements of aerosol properties from our sampling sites?

APPROACH: Data from our sampling stations and from other aerosol measurement programs is to be assembled into a data set with common file formats. Rigorous error checking and quality assurance procedures will be applied to all the aerosol measurements to construct a clean data set for each sampling station. The clean data sets will be used to derive aerosol properties and investigate their seasonal and geographical variation. The relationships between aerosol properties and atmospheric flow patterns will be determined by using twice daily, 10-day back-trajectories to each station. The trajectories will be grouped into typical transport regimes (cluster) according to transport speed and direction. For each of the resultant clusters, the characteristic values and variability of the important aerosol properties needed in satellite retrieval algorithms will be determined. Working with the NASA aerosol climatology processing facility and the NASA Aerosol Radiative Forcing Science Team, our measurements of aerosol properties will be integrated with satellite retrievals. Using our ground-based measurements of aerosol properties as a guide, a range of aerosol models for a given algorithm and retrieval will be constructed that approximates the statistical distributions observed at our surface sites. The ‘perturbed’ aerosol models will then be used by the climatology processing facility to estimate a distribution of aerosol properties for a given satellite retrieval. The distribution of aerosol properties can be used to evaluate the uncertainty in derived aerosol products due to observed values and variability of aerosol parameters used in the retrieval.

TASKS COMPLETED:

1. Developed software to scrutinize the aerosol data sets and flag suspect data.
2. Improved IDL software code to make it easier to investigate and edit suspect data.
3. Developed quality assurance web pages that provide yearly validation reports, list any anomalous data, and give comments concerning the data (for an example see, http://www.cmdl.noaa.gov/aero/net/wsa/datacheck_wsa.html)
4. Completed editing of NOAA's Sable Island (Nova Scotia, Canada) and Bondville (Illinois) data sets and assembled clean data sets for these sampling stations.

FUTURE PLANS:

1. Construct clean aerosol data sets for the Point Barrow (Alaska), Mauna Loa (Hawaii), Southern Great Plains (Oklahoma), and Cheeka Peak (Washington) stations.
2. Incorporate observations from the University of Illinois measurement program into the Bondville, Illinois data set.
3. Determine the values and uncertainties for the important aerosol properties from the clean data sets.
4. Determine how the aerosol properties vary with season, geographical location, and air mass origin.
5. Submit clean data sets to the NASA aerosol climatology processing facility.
6. Work with NASA aerosol climatology processing facility to develop sensitivity tests of satellite parameterizations.
7. Begin work on a peer-reviewed paper relating to the seasonal and site to site variability of aerosol properties.

RESULTS: An inventory of the available data was produced for each sampling station. Figure 1 presents an example of the type and amount of data available from a sampling station. The inventory for each sampling station is available in the aerosol section on CMDL's web site (http://www.cmdl.noaa.gov/aero/net/index.html). Additional results are expected in the near future as the clean data sets are analyzed to determine seasonal and site to site variability of aerosol properties and work begins with NASA aerosol climatology processing facility to develop sensitivity test of satellite parameterizations

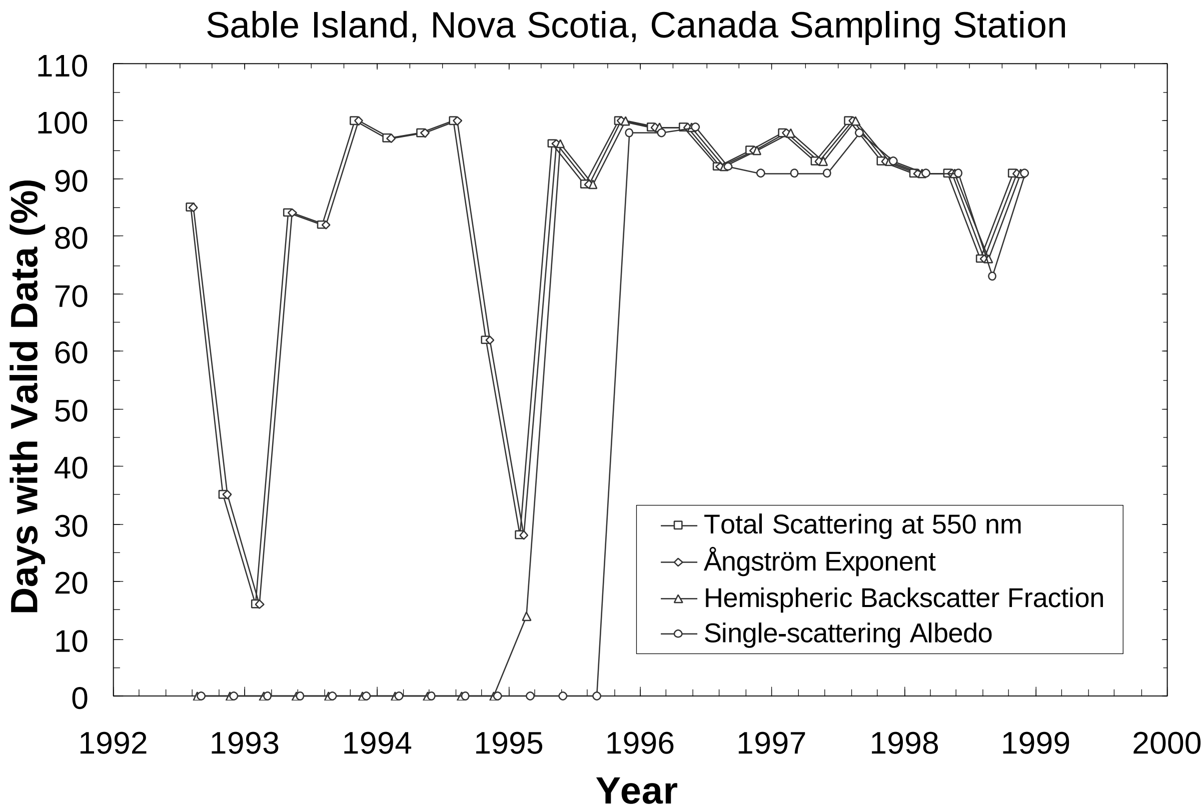

Figure 1. The percentage of days with valid aerosol data necessary to obtain four important aerosol parameters. The total scattering coefficient at 550 nm is the most basic parameter measured and requires only a single wavelength nephelometer. Determination of the Ångström exponent requires measurement of the total scattering coefficient with a multiple wavelength nephelometer. Calculation of the hemispheric backscatter fraction requires measurement of both the total scattering coefficient and the backwards scattering coefficient. Measurement of the absorption coefficient, along with the total scattering coefficient is required to determine the single-scattering albedo. The addition of the hemispheric backscatter fraction and single-scattering albedo parameters in 1995 is due to the installation of new instrumentation.

FORM C: FUTURE PLANS

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