FORM A: GACP PROGRESS REPORT

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TITLE: Defining a Climatology and the Effects of Absorbing Aerosols: Models and Measurements

ABSTRACT: It is crucial to quantify the amount of absorbing aerosol present in the atmosphere because it may lower the single scatter albedo of otherwise mainly scattering aerosol. These absorbing aerosols consist primarily of dust, smoke from biomass burning, and carbonaceous aerosol associated with fossil fuel burning. These aerosols also may act as cloud condensation nuclei, thereby increasing reflection of solar radiation by clouds. In order to estimate the indirect effect, the quantification of the fraction of absorbing, carbonaceous aerosol relative to natural organic aerosol is needed. In this proposal we plan to use our global aerosol model in combination with meteorological fields that have been nudged towards observed or analyzed fields to enable us to compare predicted absorbing aerosols with observed aerosols as derived from the TOMS instrument (Herman et al., 1997). The TOMS instrument is only able to record absorbing aerosol above about 2 km. We intend to use the model/data comparison to improve estimates for the source strengths of aerosol, fill in the gap in data below 2 km, and to improve the aerosol model itself. Other sources of data (i.e. ground-based and aircraft) will also be used to evaluate the model. The technique developed for determining this absorbing aerosol climatology will be applied to develop sources for the entire record of the TOMS data. Furthermore, we will carry out studies with a coupled aerosol/climate model in order to understand whether and to what extent absorbing aerosols warm the atmosphere.

As science team leader, we are also conducting a model/data intercomparison. The goal of this part of the project is to identify uncertainties through comparison of the models with each other and to quantify the differences between models and satellite-derived optical depths.

GOALS: The goal of this research project is to quantify the direct and indirect forcing by anthropogenic aerosols, particularly those from biomass burning, and to understand their climate impact. We will also summarize recent literature to understand work related to the radiative effects of aerosols and evaluate model capability to assess the climate forcing by anthropogenic aerosols.

OBJECTIVES: One of the largest sources of uncertainty in estimates of the climate impact of biomass aerosols is the magnitude of the total source strength of aerosols from biomass burning. Our present ability to test the model's representation of biomass aerosols and their source strength is unsatisfactory. In Liousse et al. (1996) we found reasonable agreement between our predicted aerosol concentrations and measurement of absorbing aerosols at Amsterdam Island, but our concentrations at the South Pole were underestimated for the time period October - February. Tegen et al. (1997) showed that the optical depths from our smoke aerosols were considerably smaller than those measured locally at several sites in South America (possibly due to an overestimate of the grid-averaged optical depth by a localized measurement); but the model-predicted optical depths were higher than measured off the Western South Atlantic. Another example of the uncertainty in biomass-burning source strengths derives from the comparison of model-predicted CO concentrations and measurements. Saylor and Easter (1996) compared model-predicted CO (which is primarily from biomass burning in Africa and South America) with data from the MAPS instrument and found that their inventory for burning may be substantially under predicted.

Quantifying the radiative forcing by anthropogenic aerosols is one of the most important tasks in the assessment of climate change since this radiative forcing is one of the most uncertain factors affecting climate. The NASA Aerosol Climatology Project has the potential to significantly increase our understanding of the effects of aerosols on climate over the historical past by defining a climatology of aerosols through model/satellite intercomparison and through comparison of a variety of historical data sets. One purpose of our project is to help coordinate the activities of the NASA Aerosol Program science team members and to act as Coordinating Lead Author for Chapter 5 of the forthcoming IPCC Third Assessment Report.

SECOND YEAR PROGRESS REPORT

We have developed estimates of the temperature change expected from including biomass and fossil fuel black carbon in a climate model. We are proceeding to analyze these results to understand whether the inclusion of black carbon in the model can significantly alter cloud cover and/or the vertical temperature structure in the atmosphere. In particular, we have compared the model-predicted temperature difference anomalies for the surface and mid-troposphere and the column black carbon concentration. Absorption by black carbon appears to significantly alter the vertical structure of temperature. The change in vertical structure appears to depend on the vertical structure of the distribution of aerosol. Thus, biomass aerosols, injected into the model near 500 mb tend to cool the surface while warming the mid troposphere, and fossil fuel black carbon, injected into the model boundary layer, tends to warm the surface relative to the mid troposphere. We are in the process of generating climate model results for the temperature structure in the absence of any absorbing aerosols. These will be used to gauge the statistical significance of the change associated with absorbing aerosols. We hope to use these results to examine further the appropriate vertical distribution of absorbing aerosol. This should aid us in interpreting the TOMs data which are sensitive to the vertical structure of absorbing aerosols.

We have also completed our analysis of the sources of aerosols from biomass burning based on estimates of burned area and frequency of detection of burning from AVHRR and written an initial report (Penner et al. 2000).

We also conducted a model intercomparison exercise where, for the first time, models for dust, sea salt, organic carbon and black carbon as well as for sulfate, were compared. We have compared the data from the models to both ground based data and to satellite-derived optical depths. We have drafted an initial report of our findings. We are now writing several different reports examining the results of this intercomparison.

We have obtained the IMPACT model which uses the DAO meterological fields as input. We have modified this model to treat dust and organic and black carbon aerosols as well as biomass aerosols. We have obtained meteorological data for 1991 and 1992 and are in the process of beginning a simulation for this specific time period before trying out the entire time period which we plan to analyze.

THIRD YEAR STATEMENT OF WORK:

We expect to complete the write-up of our model intercomparison exercise and update the write-up of the model intercomparison for the chapter on aerosols for the IPCC Third Assessment Report. For this work, we will expand the present analysis to include satellite data analyzed by Nakajima and co-workers, and also a new analysis to be provided by Mischenko and co-workers. In addition, we will write-up our analysis of the effects of absorbing aerosol on vertical temperature structure. We will also write-up our work to refine the estimates of the total biomass burning source which are based on satellite estimates of burned area. As noted above, we have obtained the IMPACT model which uses the Goddard Data Assimilation fields for predicting trace species. We intend to use this model to carry out simulations of biomass burning aerosols to compare with the measured aerosols from TOMs. We will examine these results to improve our specified sources of aerosols from biomass burning and to help build a climatology of aerosols from biomass burning.

We will complete our analysis of the effect of absorbing aerosols on the vertical structure of temperature and write up the results. We will complete our analysis of model intercomparison and write up the results.

FORM D: GACP BIBLIOGRAPHY

Name:

Institution:

BIBLIOGRAPHY:

Papers, reports, and presentations refer to those published during GACP by the principal investigator, co-investigators, and other researchers supported by your agency for aerosol research. Include those in progress or planned.

a. List of publications (including books, book chapters, and refereed papers), using AMS bibliographic citation form.

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