GACP Progress Report

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TITLE: Determination of Regional Aerosol Radiative Forcing from Remote Sensing Data and Model Simulations

3rd Year Progress Report:

The objectives of this project are: (a) to determine the downwelling irradiance at the surface for comparison with those derived from coordinated satellites, and (b) to retrieve aerosol optical thickness and other microphysical parameters from surface remote sensing to compare with spaceborne / airborne retrievals for better understanding of clear-sky and aerosol characteristics, in turn, direct radiative forcing. To achieve these goals, our approach is to mobilize an evolving suite of surface remote sensing instruments, SMART (Surface Measurements for Atmospheric Radiative Transfer), to collocate with satellite nadir overpass at targeted areas (*cf.* summary for major deployment).

This year, we focused our efforts on processing and analyzing data sets acquired from two recent field campaigns of PRIDE (i.e., Puerto Rico Dust Experiment, June-July 2000 for Saharan dust transported from Africa across the Atlantic Ocean into the Caribbean) and SAFARI (i.e., Southern Africa Fire-Atmosphere Research Initiative, August-September 2000 of biomass burning aerosol and industrial pollution) for remote sensing and retrieval of atmospheric parameters and surface radiation budget for publications. One of the highlight for this study, among others, is shown in Fig. 1 for the comparison of surface radiative forcing by dust and biomass burning aerosols. Cloud-free data, based on sun photometer and / or shadow-band radiometer observations, are used. The slopes ($\Delta F / \Delta \tau$) of each slice of air masses (lines in the upper-right figure) depict the proportion of solar radiative heating / cooling rates, ($\partial T/\partial t = -[1/\rho C_p]\, \partial F_{net}/\partial z \propto \Delta F_{down}/\Delta\tau$). Clearly, these values are well defined in SAFARI data. Since it is difficult to eliminate completely cloud contamination in PRIDE data due to daily convective activities, the results are highly variable. We currently explore the separation method of direct / diffuse radiation for PRIDE data sets in removing cloud contamination effectively. In addition, preliminary results from ACE-Asia (Asian dust effects at source regions) show smaller magnitudes of surface radiative forcing (~ 10 W m^{-2}, instantaneous) than those found in SAFARI data. Aerosol types with dominant characteristics in absorption and / or scattering are essential.

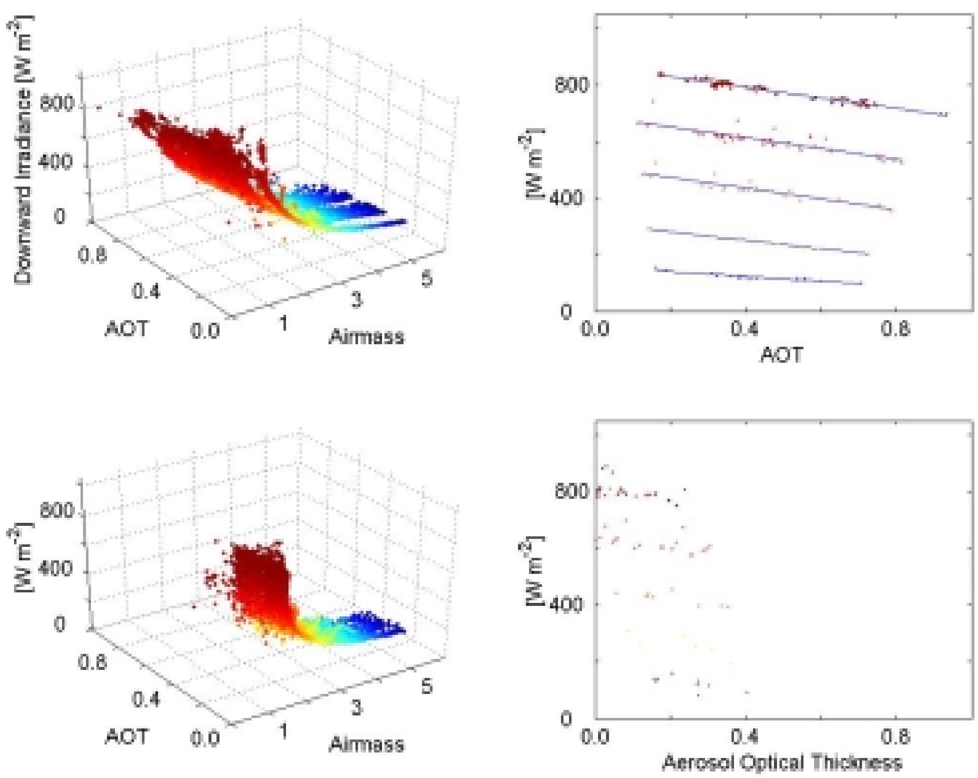

Figure 1. ***The total data (1-minute average flux) points shown in the 3-D plots are 12,892 for SAFARI (upper) and 8,619 for PRIDE (lower). For SAFARI, the values of $\Delta F/\Delta\tau$ are -187, -192, -195, -150, and –87 Wm^{-2} for five selected airmasses at 1.2, 1.5, 2, 3, and 5, respectively. For PRIDE, most data points are clustered at airmass around 1 (local solar noon and less cnvective cloud systems) and narrow range of aerosol optical thickness, which leaves insufficient data points for meaningful statistical analysis at other values of airmasses. Removing diffuse flux contributed by distant cloud fields is essential for PRIDE data analysis.***

Summary Report (FY99-01):

Figure 2. ***The SMART system: (a) many shortwave and longwave broadband radiometers, (b) shadow-band radiometer, (c) sun photometers, (d) solar spectrometers, (e) micro-pulse lidar, (f) whole-sky camera, and (g) microwave radiometer, as well as (h) meteorological probes for atmospheric pressure, temperature, humidity, wind speed/direction and (k) surface moisture content.***

The surface remote sensing instruments, SMART as shown in Fig. 2, play an important role in this study for providing vital data sets. For the past year deployments, calibrated and quality controlled data sets were posted at the web site of http://particle.gsfc.nasa.gov/SMART for community use. However, due to tightened security issues, our site is in the process of moving to the main web and currently not available. These major data sets, among others, are:

- SCSMEX, South China Sea Monsoon Experiment, March-May 1998 to study the radiative effects in maritime environment;
- PRIDE, Puerto Rico Dust Experiment, June-July 2000 to study the long-range transport of Saharan dust across the Atlantic Ocean to the Caribbean;
- SAFARI, Southern Africa Fire-Atmosphere Research Initiative, Aug.-Sept. 1999 / 2000 to study the radiative forcing by biomass burning aerosols;
- ACE-Asia, Aerosol Characterization Experiment-Asia, March-May 2001 to study regional / global climatic effects of Asia dust.

For assuring the success of this research, understanding the accuracy of downwelling irradiance measured at the surface is essential. A great deal of our effort is devoted to characterize the flux radiometers, pyrgeometers and pyranometers. The dome effect of these instruments can cause a measurement uncertainty larger than 10 W m^{-2}. Utilizing an energy balance equation and collocated pyranometer data, the thermal dome effect of pyranometers, commonly referred to as the nighttime negative outputs or the dark-offset, is described for suitable correction. The results are reported in the work of Ji and Tsay (2000) and more details to come in Tsay et al. (2001, to be submitted). This approach suggests a sound method to evaluate the uncertainty range involving long-term surface radiation measurements in climate study.

Using quality-controlled measurements of broadband and spectral irradiance, the magnitudes of radiative forcing at the surface by aerosol types are currently analyzed for SAFARI (biomass burning and industrial pollution) and PRIDE / ACE-Asia (dust). These results will be reported in three papers for suitable publications (Tsay et al. 2001a / b and Campbell et al. 2001, to be submitted). Efforts will be extended to analyze data acquired from earlier deployments (e.g., SCSMEX) of radiation measurements for maritime aerosols.

SAFARI and ACE-Asia data sets provide rich contents for analyzing and modeling the relationship between aerosol microstructure (e.g., relative humidity, size and spectra) and radiation field (e.g., reflectance and absorptance). A recent publication by Yan et al. (2001) demonstrated clearly the effect of aerosol microstructure on SeaWiFS ocean color simulations. A more thorough study synthesizing data acquired from SCAR-B, TARFOX, SAFARI, and ACE-Asia deployments is currently underway and will be reported in the work by Ji et al. (2002, to be submitted).

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