Abstract submitted to Fifth International Aerosol Conference
Edinburgh, Scotland, 14-18 September 1998

RADIATIVE FLUX CHANGES BY AEROSOLS FROM NORTH AMERICA, EUROPE, AND AFRICA OVER THE ATLANTIC OCEAN: MEASUREMENTS AND CALCULATIONS FROM TARFOX AND ACE-2

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KEYWORDS

Radiative Flux, Aerosol, Climate, Forcing, Optical Depth, Single-scatter Albedo, Closure

Aerosol effects on atmospheric radiative fluxes provide a forcing function that can change the climate in potentially significant ways. This aerosol radiative forcing is a major source of uncertainty in understanding the observed climate change of the past century and in predicting future climate. To help reduce this uncertainty, the International Global Atmospheric Chemistry Project (IGAC) has endorsed a series of multiplatform aerosol field campaigns. The Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX)and the second Aerosol Characterization Experiment (ACE-2) were the first IGAC campaigns to address the impact of anthropogenic aerosols.

Both TARFOX and ACE-2 gathered extensive data sets on aerosol properties and radiative effects. TARFOX focused on the urban-industrial haze plume flowing from the eastern United States over the western Atlantic Ocean, whereas ACE-2 studied aerosols carried over the eastern Atlantic from both European urban/industrial and African mineral sources. These aerosols often have a marked influence on the top-of-atmosphere radiances measured by satellites, as illustrated in Figure 1. Shown there are contours of aerosol optical depth derived from radiances measured by the AVHRR sensor on the NOAA-11 satellite. The contours readily show that aerosols originating in North America, Europe, and Africa impact the radiative properties of air over the North Atlantic. However, the accurate derivation of flux changes, or radiative forcing, from the satellite-measured radiances or retrieved optical depths remains a difficult challenge.

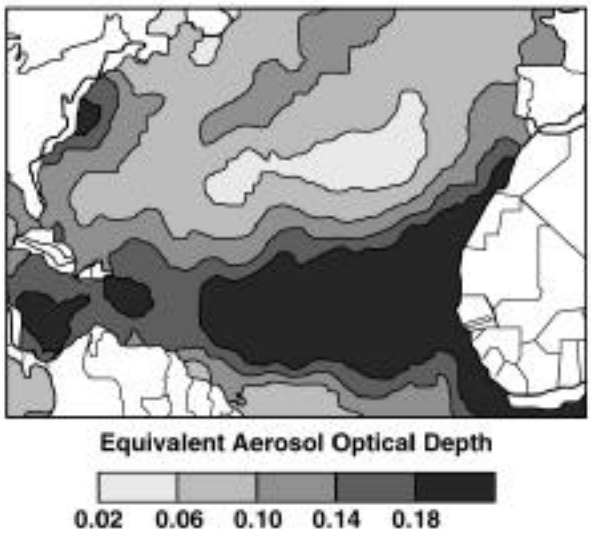

Figure 1. June/July/August map of aerosol optical depth derived from NOAA/AVHRR satellite reflectance data over the oceans (Husar et al., *J. Geophys. Res.*, *102*, 16,889-16,909, 1997)

To provide data useful for addressing this challenge, TARFOX included measurements of aerosol-induced flux changes, made simultaneously with measurements of the chemical, physical, and optical properties of the aerosols causing those changes. In particular, radiative flux and aerosol microphysical measurements were made from the UK Meteorological Office Meteorological Research Flight C-130 while measurements of optical depth spectra, aerosol composition, and other properties were made from the University of Washington C-131A and the Pelican (modified Cessna) of the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS). The resulting over-determined data sets permit tests of the consistency, or closure, between measured flux changes and those calculated from the aerosol measurements. Such a comparison is shown in Figure 2. The agreement between measured and calculated flux changes demonstrates closure (i.e., consistency) among the TARFOX-derived aerosol properties, modeling techniques, and radiative flux measurements.

Note that agreement between calculated and measured downward flux changes is best when the aerosols are modeled as moderately absorbing (i.e., having midvisible single-scatter albedos between about 0.90 and 0.95). These single-scatter albedo values are in accord with independent measurements of the TARFOX aerosol.

In ACE-2 we made measurements of optical depth and extinction spectra for both boundary-layer urban-marine aerosols and free-tropospheric African dust aerosols, using sunphotometers on the R/V Vodyanitskiy and the CIRPAS Pelican (e.g., Livingston et al., this session; Schmid et al., this session). The methods used to compute the flux changes in Figure 2, which use optical depth spectra together with aerosol composition information, are being applied to the analogous data sets acquired in ACE-2. Computed effects of these ACE-2 urban-marine and African dust aerosols on upwelling and downwelling fluxes will be presented and compared to the TARFOX results.

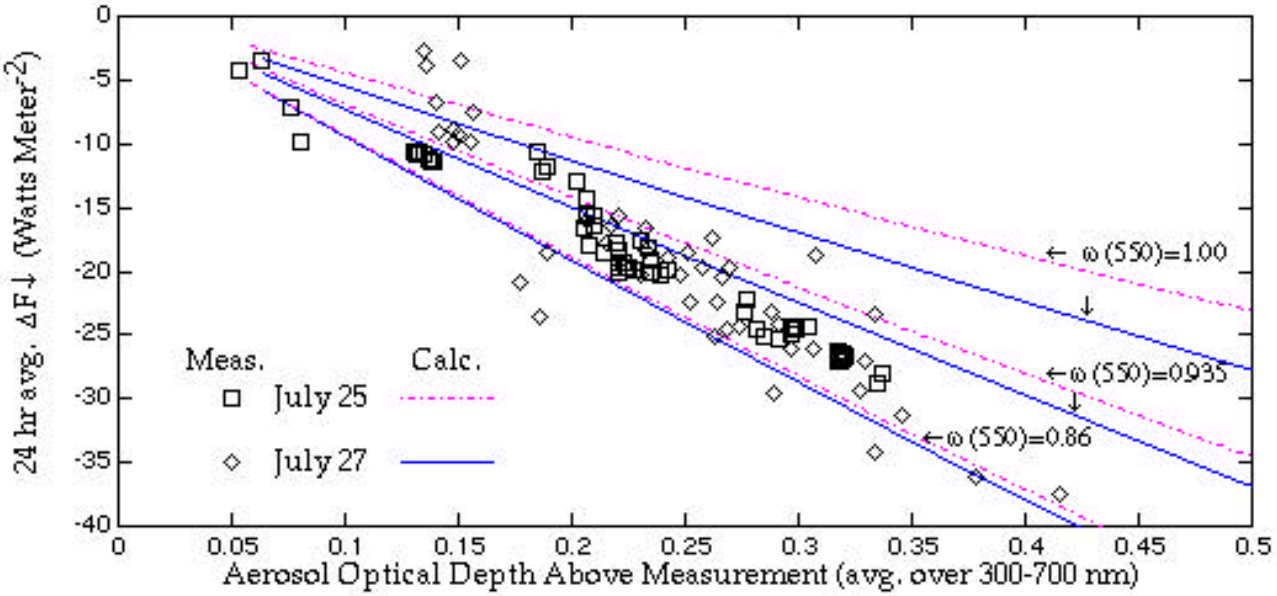

Figure 2. Comparison between aerosol-induced changes in shortwave downward flux determined from C-130 measurements (data points) and calculations (curves) for size distributions retrieved from sunphotometer optical depth spectra for two days. All results are for 24-h average flux changes.