NORTH ATLANTIC AEROSOL PROPERTIES AND DIRECT RADIATIVE EFFECTS: KEY RESULTS FROM TARFOX AND ACE-2

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Abstract

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. However, the accurate derivation of flux changes, or radiative forcing, from the satellite-measured radiances or retrieved optical depths remains a difficult challenge. In this paper we summarize key initial results from TARFOX and ACE-2, with a focus on those results that allow an improved assessment of the flux changes caused by North Atlantic aerosols at middle latitudes. We then compute aerosol-induced radiative flux changes over the midlatitude North Atlantic Ocean by combining AVHRR-derived fields of aerosol optical depth (AOD) with a TARFOX-derived aerosol microphysical model. The microphysical model has been shown to give computed radiative flux sensitivities (dF/dAOD) that agree with (1) values measured in TARFOX and (2) preliminary values computed for the polluted marine boundary layer aerosol in ACE 2.

We exclude African dust from our calculations, primarily by restricting calculations to latitudes north of 25 N. We compute the net flux change for cloud-free and cloud-containing conditions for the winter, spring, summer and fall seasons as well as the annual average. The local, cloud-free effects using the TARFOX derived aerosol properties range from –9 W/m^2 near the eastern US coastline in the summer to –1 W/m^2 in the mid-Atlantic during winter. The North Atlantic cloud-free regional averages range from –1.7 W/m^2 in the winter to – 5.1 W/m^2 in the summer. The cloud-free regional annual average is –3.5 W/m^2. The effect of changing the aerosol single-scattering albedo from the TARFOX-derived value of 0.9 (moderately absorbing) to 1.0 (no absorption) is to increase the flux change by about 30%. We used the ISCCP cloud data to compute the effect of clouds in the

region. Including the cloudiness reduced the regional annual net flux change to –0.8 W/m^2 for the TARFOX aerosol and –1.1 W/m^2 for the non-absorbing aerosol.