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Airborne measurements of direct aerosol radiative forcing in INTEX/ITCT, 2004

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As part of the INTEX-NA (INtercontinental chemical Transport EXperiment-North America) and ITCT (Intercontinental Transport and Chemical Transformation of anthropogenic pollution) field studies, the NASA Ames 14-channel Airborne Tracking Sunphotometer (AATS-14) and a set of Solar Spectral Flux Radiometers (SSFR) took measurements from aboard a Jetstream 31 (J31) aircraft during 19 science flights ($\sim$53 flight hours) over the Gulf of Maine during 12 July – 8 August 2004.

AATS-14 measures the direct solar beam transmission at 14 discrete wavelengths (354-2138 nm), yielding aerosol optical depth (AOD) spectra and water vapor column content. The SSFR system consists of separate nadir- and zenith-viewing hemispheric optical collectors and respective grating spectrometers that yield measurements of down- and upwelling, solar irradiances at a spectral resolution of $\sim$8-12 nm over the wavelength range 300-1700 nm. Among the overall goals of the J31-based measurements of spectral AOD and irradiances were to assess spectral direct and indirect radiative effects of aerosol particles advecting from North America over the northwestern Atlantic Ocean.

The combination of coincident and simultaneous measurements of spectral AOD using AATS-14 and spectral irradiance using SSFR in horizontal AOD gradients allows

the derivation of the direct aerosol radiative forcing. An estimate of the aerosol absorbing fraction can be obtained using a minimal amount of radiative transfer modeling. Unlike ground-based measurements of direct aerosol radiative forcing which rely upon the advection of various air masses over a measurement site during an extended period of time, the airborne horizontal gradient measurements have the advantage of being quasi-instantaneous. This means that the derivation of aerosol radiative forcing is actually representative of the aerosol type present in a given airmass rather than an ensemble of aerosol types advected over a measurement site during an extended period of time.

In INTEX/ITCT, we observed a total of 16 horizontal AOD gradients during 10 research flights. More than half of the AOD gradients were greater than 0.1 (at a wavelength of 499 nm) and extended over distances less than 40 km. In this paper we will show examples of these AOD gradients and their impact on downwelling SSFR measurements. A preliminary analysis of these gradients revealed cases when a reduction in mid-visible AOD of 0.1 was accompanied by a reduction in integrated downwelling irradiance of more than 9 Wm^{-2} for the wavelength interval between 350 and 700 nm. Such a reduction translates into an instantaneous forcing efficiency of more than 90 Wm^{-2} per unit mid-visible optical depth, which is larger than previously reported values from ground-based observations during ACE-Asia and INDOEX.