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3.8 AIRBORNE SUNPHOTOMETER AND SOLAR SPECTRAL FLUX RADIOMETER MEASUREMENTS DURING INTEX/ITCT 2004

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1. INTRODUCTION

During the period 12 July – 8 August 2004, the NASA Ames 14-channel Airborne Tracking Sunphotometer (AATS-14) and Solar Spectral Flux Radiometer (SSFR) were operated aboard a Jetstream 31 (J31) aircraft and acquired measurements during nineteen science flights (~53 flight hours) over the Gulf of Maine in support of the INTEX-NA (INtercontinental chemical Transport EXperiment-North America) and ITCT (Intercontinental Transport and Chemical Transformation of anthropogenic pollution) field studies. This paper presents example results from analyses of those data sets.

AATS-14 measures the direct solar beam transmission at fourteen discrete wavelengths (354-2138 nm), and provides instantaneous measurements of aerosol optical depth (AOD) spectra and water vapor column content, in addition to vertical profiles of aerosol extinction and water vapor density during suitable aircraft ascents and descents. SSFR consists of separate nadir and zenith viewing hemispheric FOV sensors that yield measurements of up- and downwelling solar irradiance at a spectral resolution of ~8-12 nm over the wavelength range 300-1700 nm.

The objectives of the J31-based measurements during INTEX/ITCT were to provide AOD data for the evaluation of MODIS (MODerate-resolution Imaging Spectroradiometer) and MISR (Multi-angle Imaging Spectro-Radiometer) AOD retrievals, quantify sea surface spectral albedo (which can contribute the largest uncertainty to satellite aerosol retrievals when AOD is small), test closure (consistency) among suborbital results, test chemical-transport models using AOD profiles, and assess regional radiative forcing by combining satellite and suborbital results. Specific J31 flight patterns were designed to achieve these objectives. They included a mixture of vertical profiles (spiral and ramped ascents and descents) and constant altitude horizontal transects at a variety of altitudes. Flight plans often included profiles above the NOAA Ship Ronald H. Brown and, in a few cases, coordination with other mission aircraft – namely, the NOAA DC-3 and the NASA DC-8. Most flight plans included a near sea surface horizontal transect in a region of minimal cloud cover during or near the time of an AQUA (MODIS) and/or TERRA (MODIS and MISR) satellite overpass.

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2. SATELLITE VALIDATION

During INTEX/ITCT, thirteen J31 flights included segments that were temporally and/or spatially near-coincident with a Terra or an Aqua satellite overpass. The Terra overpasses included four MISR-J31 coincidences, three of which were MISR local mode (high spatial resolution retrieval) events. Generally, retrievals of spatially coincident AOD from both MODIS and MISR during Terra overpass were not possible due to the effect of sun glint on the MODIS measurements. However, temporally and spatially coincident AATS-14, MODIS, and MISR AOD measurements were acquired during one overpass. Figure 1 shows an example that compares AOD results from AATS-14 and MODIS, with emphasis on the spatial and temporal variability measured by AATS-14 along the J31 flight paths within the satellite sensor suborbital retrieval boxes.

3. AEROSOL EFFECTS ON RADIATIVE FLUXES

When the J31 flies a horizontal leg spanning an AOD gradient, the simultaneous measurements of AOD spectra by AATS-14 and radiative flux spectra by SSFR allow derivation of the direct aerosol radiative forcing and an estimation of the aerosol absorbing fraction. During INTEX/ITCT, we observed a total of sixteen AOD horizontal gradients during ten research flights. More than half the AOD gradients were greater than 0.1 at 499 nm and extended over distances less than 40 km. Figure 2 shows an example of downwelling flux changes in the wavelength band 350-1700 nm for an AOD gradient observed on 21 July 2005. Figure 3 shows an example from another day, 23 July 2005, in this case examining not only downwelling flux but also net (downwelling minus upwelling) flux, in the two broad

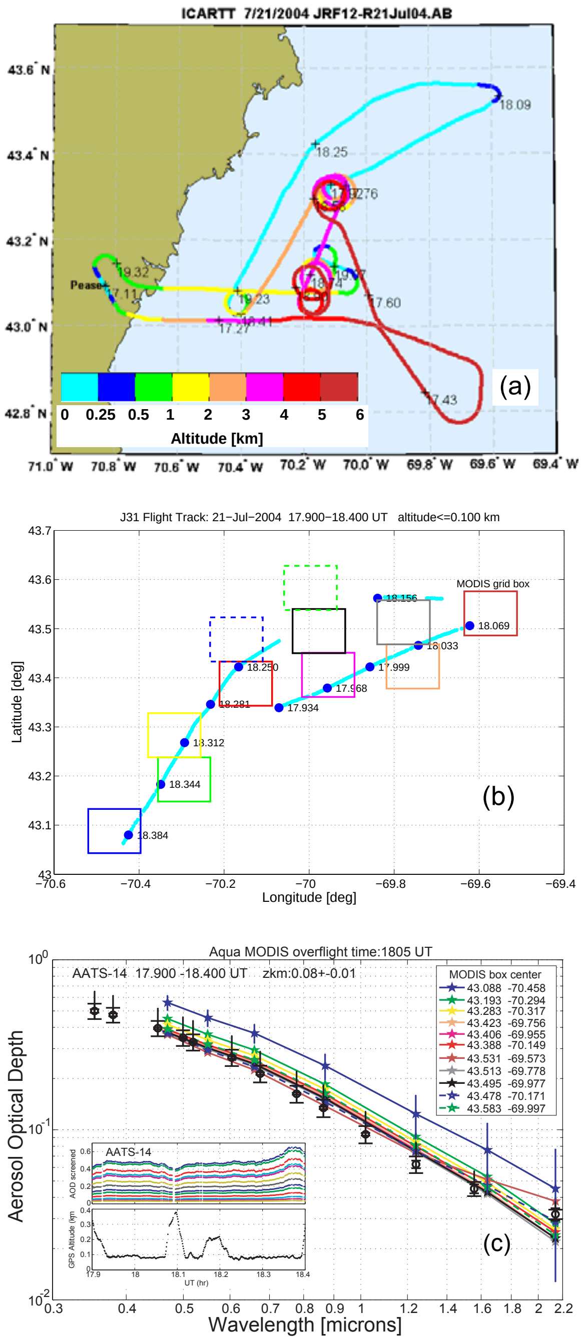

Figure 1. AATS-14 and MODIS AOD results from the Aqua overflight, 1805 UT, 21 July 2004. **(a)** J31 track for entire flight. **(b)** J31 flight segments when cloud-free AATS-14 AOD measurements were acquired at minimal altitude (~75 m); boxes show MODIS nominal 10-km by 10-km retrieval frames (uncorrected for horizontal stretching). **(c)** Comparison of AATS-14 and MODIS AOD retrievals. MODIS retrievals are color coded to match colors of boxes in (b). The likely cause of the large MODIS AODs in blue is cloud contamination, resulting from smoke over clouds impairing the cloud mask.

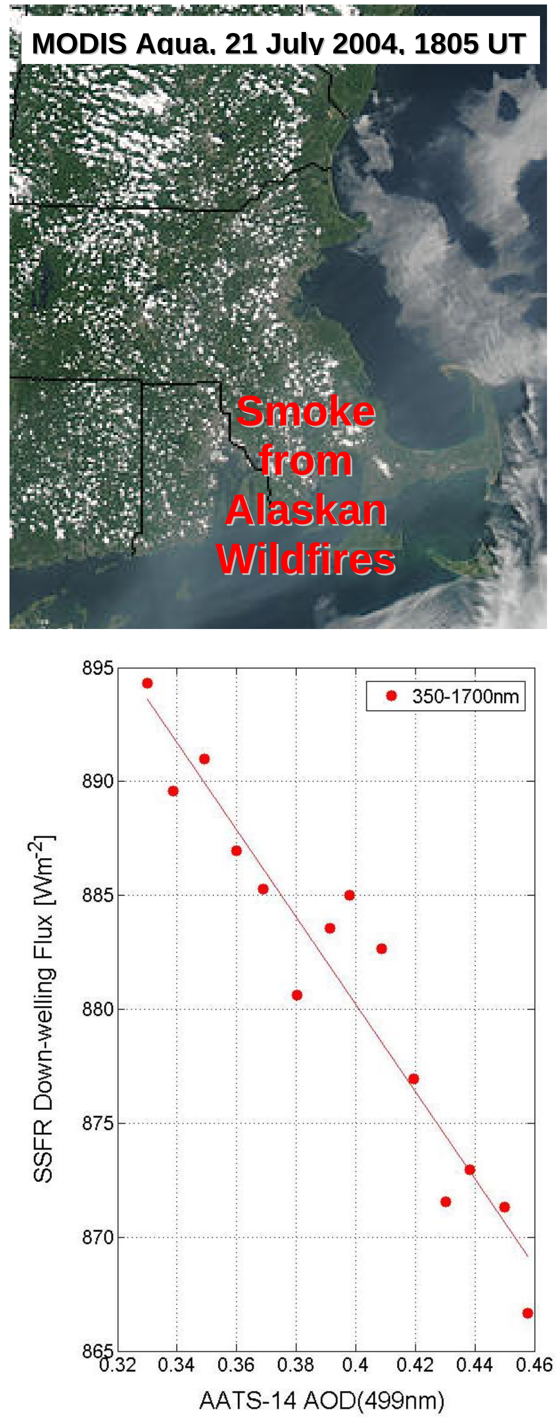

Figure 2. An example of radiative flux changes measured when underflying an AOD gradient. **Top frame:** MODIS Aqua image, 21 July 2004, 1805 UT, showing haze identified as smoke from Alaskan wildfires. **Bottom frame**: Downwelling flux plotted vs. midvisible AOD.

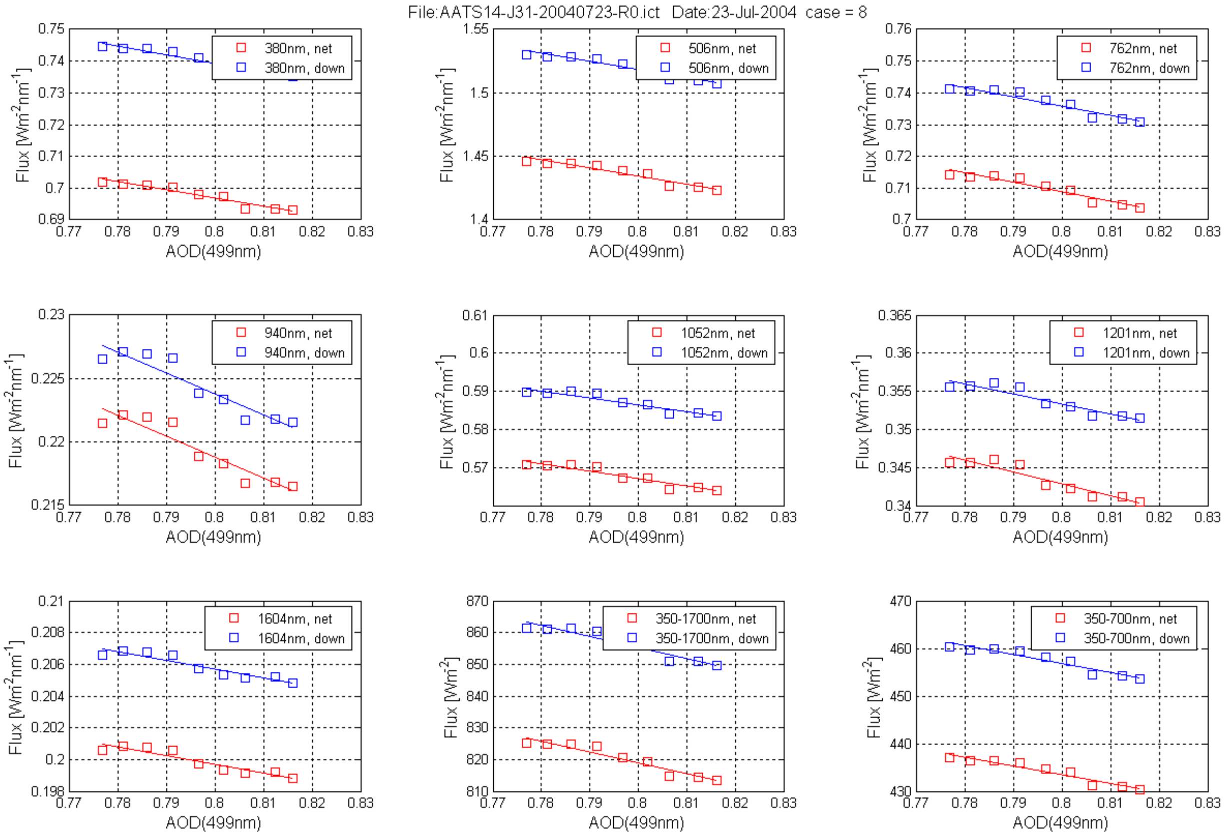

Figure 3. Radiative fluxes (narrowband and broadband, net and downwelling) plotted vs midvisible AOD, all as measured when underflying an AOD gradient on 23 July 2004.

bands (350-700 and 350-1700 nm), and also specific SSFR wavelengths ranging from 380 nm to 1604 nm (chosen to match AATS-14 wavelengths).

Preliminary analysis of these gradients revealed cases when a reduction in mid-visible AOD of 0.1 was accompanied by a reduction in downwelling irradiance of more than 9 Wm^{-2} for SSFR flux measurements integrated from 350 to 700 nm. We will examine the implications of such a reduction for instantaneous radiative forcing efficiency and compare the result with values previously reported from ground-based measurements during the Asian Pacific Regional Aerosol Characterization Experiment (ACE-Asia) and Indian Ocean Experiment (INDOEX) field campaigns.

4. FUTURE WORK

Preliminary analysis indicates that the primary contributors to the AODs measured by AATS-14 during INTEX/ITCT were not only the expected anthropogenic aerosol from nearby East Coast sources but, at certain times, smoke that originated from Alaskan and Canadian forest fires. At the time of this writing, there is no evidence that the J31 sensors obtained any measurements through dust transported from Asia or Africa. Previously, however, AATS-14 and SSFR measured Asian dust outflow during the spring 2001 ACE-Asia and the spring 2004 Extended MODIS-λ Validation Experiment (EVE) field campaigns. With the experience gained in ACE-Asia, EVE, and INTEX/ITCT, we have proposed participation in the upcoming INTEX-B campaign that will include a measurement component to study Asian outflow as it crosses the vicinity of the U.S. West Coast.

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