NCAR CCD Actinic Flux Spectroradiometers (CAFS)

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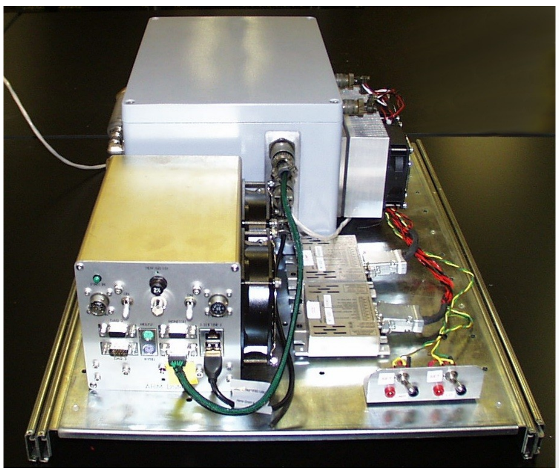


Photochemical reactions provide the driving force for much of the chemistry in the atmosphere. Even in the high solar zenith angles of the Arctic, the photochemistry can rival that of the tropics due to the high surface albedo. Thus, during ARCTAS, the *in situ* photolysis frequencies will be a key to understanding the complex atmospheric chemistry. In particular, the chemical evolution in pollution plumes as they are transported to and from the Arctic, the tropospheric oxidant chemistry, and the effects of Arctic haze, boreal fire emissions, and surface deposited black carbon are all closely linked to the light environment.

The CCD Actinic Flux Spectroradiometers (CAFS) developed in the NCAR/ARIM laboratory will be deployed on the NASA DC-8 for the 2008 winter and summer ARCTAS deployments. The up and downwelling instruments combine to measure the total UV and visible actinic flux from which *in situ* photolysis frequencies of important atmospheric constituents are calculated (see list below).

The system employs a Zeiss MCS (Multi Channel Spectrometer) monolithic monochromator equipped with a Hamamatsu S 7301-906 windowless back-thinned blue enhanced 534 pixel cooled CCD detector. The combination of the monochromator, slit size and CCD provides a wavelength range of 280-680 nm with an effective ~1.8 nm Full Width at Half Maximum (FWHM) resolution with a 20 micron entrance slit. The CCD temperature is controlled at –1.0° C by a piezoelectric cooler and control electronics. The system exhibits excellent sensitivity from the ultraviolet into the visible, which allows short full spectral acquisition times. Additionally the system shows exceptional stability. Autonomous data acquisition and instrument control are provided by small, lightweight, and low-power PC-104+ computers.

Single monochromator systems traditionally have had difficulties measuring ultraviolet radiation due to stray light contamination of the UV-B signal. This monolithic monochromator/CCD combination minimizes the stray light by careful optical design and the use of a windowless CCD, eliminating a scattering source at the detector. Cutoff filters are used to enhance the stray light rejection by elimination of some of the visible radiation. Testing of the system in ambient solar radiation has demonstrated spectral acquisition times of 200 ms which will make possible for up to 5 Hz spectral data on the aircraft, making studies of cloud and aerosol radiation field perturbations and fast photochemistry possible. However, the scans are typically averaged to increase precision, resulting in 5 second total scan times.

The absolute spectral sensitivity of the instruments is calibrated in the laboratory with 1000 watt NIST traceable tungsten-halogen lamps with an uncertainty of 3-4% depending on the wavelength. In addition, the actinic flux optical collectors are characterized for angular and azimuthal response. Spectral sensitivity and wavelength assignment calibrations will be performed in the field using secondary QTH calibration lamps and Hg line sources in a field calibration unit that attaches directly to the optical collector assembly of the actinic flux instruments. Final primary calibrations will be performed in the laboratory after the mission.

Similar CAFS systems have been deployed on the NASA WB-57 for four AVE missions in 2004-2006. A prototype system was flown on the NASA DC-8 during INTEX-NA in June-August 2004 and again on the PAVE mission in 2005. The response of the system to a field calibration source demonstrated a repeatability of 1.7±0.5% from 280-500 nm over 18 field calibrations.

Wavelength range: 280-680 nm
Wavelength resolution: ~1.8 nm FWHM at 297 nm
Precision: 1-2 % depending on wavelength
Accuracy: 5% in UV-B, 3% in UV-A/VIS limited by NIST standards
Detection limit: ~0.04 mW/m2/nm at 300 nm
Data Rate: 0.2 Hz
Weight: <18 kg per instrument
Power: <15 amps of 28 volt DC per instrument
Rack Height: 20 cm
Location of optical collectors on NASA DC-8: Zenith 1 and Nadir 7 ports
Photolysis Frequency Species: O_3, NO_2, CH_2O, HONO, HNO_3, N_2O_5, HO_2NO_2, PAN, H_2O_2, CH_3OOH, CH_3ONO_2, $CH_3CH_2ONO_2$, CH_3COCH_3 , CH_3CHO, CH_3CH_2CHO, CHOCHO, CH_3COCHO, $CH_3CH_2CH_2CHO$, and $CH_3COCH_2CH_3$.