Solar Spectral Flux Radiometer (SSFR) for SEAC^{4}RS:
Instrument Description and Science Goals

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Short summary: During the SEAC^{4}RS experiment, we will deploy the Solar Spectral Flux Radiometer (SSFR) onboard the NASA ER-2 and the NASA/University of North Dakota DC-8 aircraft. A similar radiometer within the HIAPER Atmospheric Radiation Package (PI: Samuel Hall) will fly on the NCAR GV aircraft. These radiometers measure solar spectral irradiance from the upper and the lower hemisphere over a wavelength range from 350 nm (the near-UV) to 2150 nm (the near-infrared). We will acquire data to assess the shortwave radiative properties of cloud-aerosol layers such as radiative forcing and absorption, and to develop new spectral remote sensing techniques for these layers. Past experiments and the ensuing studies have suggested the relationship between heterogeneous scenes and the spectral signature of clouds, aerosols, and the surface, and the SEAC^{4}RS experiment will provide excellent conditions for studying the radiative properties of such scenes. The long-term goal of our research is to improve out knowledge of cloud-aerosol radiative processes and their influence on climate and to facilitate the remote sensing of these from space.

SSFR: The Solar Spectral Flux Radiometer is a moderate resolution flux (irradiance) spectrometer with 8-12 nm spectral resolution, simultaneous zenith and nadir viewing. It has a radiometric accuracy of 3% and a precision of 0.5%. The instrument is calibrated before and after every experiment, using a NIST-traceable lamp. During field experiments, the stability of the calibration is monitored before and after each flight using portable field calibrators. Each SSFR consists of 2 light collectors, which are either fix-mounted to the aircraft fuselage, or on a stabilizing platform which counteracts the movements of the aircraft. During SEAC^{4}RS, one of the SSFR systems will be horizontally stabilized. Through fiber optic cables, the light collectors are connected to 2 identical pairs of spectrometers, which cover the wavelength range from (a) 350 nm-1000 nm (Zeiss grating spectrometer with Silicon linear diode array) and (b) 950 nm - 2150 nm (Zeiss grating spectrometer with InGaAs linear diode array). Each spectrometer pair

- Wavelength range: 350 nm to 2150 nm
- Spectral resolution: ~ 8-12 nm
- Simultaneous zenith and nadir viewing
- Hemispheric field-of-view
- Accuracy: ~ 3%; Precision: 0.5%
- Measured quantities: Upwelling and down-welling spectral irradiance (W m^{-2} nm^{-1})

covers about 95% of the incoming solar incident irradiance spectrum. The SSFR is a well-characterized sensor with a long flight heritage. It was deployed in numerous missions: FIRE III Arctic Cloud Experiment (FIRE-ACE), 1998; ERAST/ARM UAV Kauai Experiment, 1999; DOE Atmospheric Radiation Measurement (ARM) Enhanced Shortwave Experiment (ARESEII), 2000; Puerto Rico Dust Experiment (PRIDE), 2000; Southern African Regional Science Initiative (SAFARI), 2000; the Asian Pacific Regional Aerosol Characterization Experiment (ACE-Asia), 2001; the Cirrus Regional Study of Tropical Anvils and Cirrus Layers - Florida Area Cirrus Experiment (CRYSTAL-FACE), 2002; the ARM UAV Fall 2002 Experiment; the 2003 DOE ARM Aerosol IOP, the Intercontinental Chemical Transport Experiment – North America (INTEX-NA), 2004; the Mixed – Phase Arctic Cloud Experiment (MPACE), 2004; the Megacity Initiative: Local and Global Research Observations (MILAGRO), 2006; the Gulf of Mexico Atmospheric Composition and Climate Study (GoMACCS), 2006; the PACific Dust Experiment (PACDEX), 2007; the Tropical Composition, Cloud and Climate Coupling (TC^4) mission, 2007; the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS), 2008; the Aerosol, Radiation, and Cloud Processes affecting Arctic Climate (ARCPAC) experiment, 2008, and the CalNex experiment in 2010. It was deployed on numerous aircraft, the ground and research vessels.

Selected Goals:

(1) Provide spectral irradiance data as input for deriving cloud and aerosol radiative effects

(2) Derive

- cloud/aerosol radiative forcing and absorption, as well as heating rates, for homogeneous scenes (directly) and inhomogeneous scenes (indirectly through 3D radiative transfer calculations and input data from imagers such as MAS and radars/lidars)
- cloud optical thickness and effective radius, liquid/ice water path
- aerosol single scattering albedo and asymmetry parameter (with AATS-14/HSRL) (clear-sky scenes)

(3) Based on collected data set, explore new spectral retrievals that rely on the increased information content in spectral data, and on the relationship between spatial structure and spectral signature in the measured irradiances. Explore the combined effects of heterogeneous clouds and aerosol on spectral albedo, radiative forcing, absorption, and heating rates. Link the findings to the spectral radiance observed by imagers onboard the ER-2.

(4) Explore the impact of absorbing and scattering aerosol layers on (space-borne) cloud retrievals, and examine biases introduced in the derived radiative forcing and absorption.

(5) Explore the variability of spectral surface albedo due to the variable chlorophyll concentration in the Pacific Ocean. Provide spectral land surface albedo as boundary condition for 1D and 3D radiative transfer calculations and for space-borne and airborne remote sensing.