4STAR sky-scanning retrievals of aerosol intensive optical properties from multiple field campaigns with detailed comparisons of SSA reported during SEAC4RS

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Abstract

The 4STAR (Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research) instrument combines airborne sun tracking capabilities of the Ames Airborne Tracking Sun Photometer (AATS-14) with AERONET-like sky-scanning capability and adds state-of-the-art fiber-coupled grating spectrometry to yield hyperspectral measurements of direct solar irradiance and angularly resolved sky radiance. The combination of sun-tracking and sky-scanning capability enables retrievals of wavelength-dependent aerosol optical depth (AOD), mode-resolved aerosol size distribution (SD), backscattering, and complex refractive index, and thus also the scattering phase function, asymmetry parameter, single-scattering albedo (SSA), and absorption aerosol optical thickness (AAOT).

From 2012 to 2014 4STAR participated in four major field campaigns: the U.S. Dept. of Energy’s TCAP I & II campaigns, and NASA’s SEAC4RS and ARISCE campaigns. Establishing a strong performance record, 4STAR operated successfully on all flights conducted during each of these campaigns. Sky radiance data from scans in either constant azimuth (principal plane) or constant zenith angle (azimuthal) were interspersed with direct beam measurements during level legs. DURING SEAC4RS and ARISCE, 4STAR airborne measurements were augmented with flight-level albedo data from the collocated Shortwave Spectral Flux Radiometer (SSFR) providing improved specification of below-aircraft radiative conditions for the retrieval. Calibrated radiances and retrieved products will be presented with particular emphasis on comparisons between ambient SSA retrievals SEAC4RS and comparisons between 4STAR and AERONET.

What is 4STAR?

**Spectrometer**

- **AERONET-like**
  - phase function
  - size mode distributions
  - nAOD, fAOD
  - single-scattering albedo
  - asymmetry parameter
  - shape, hence aerosol type

**Sky-Scanning**

- Immerse H2O, O3...
- Provide NO2
- Improve AOD

**Sun-Tracking** = Atmospheric Research!

- Sun & Sky
- Collectors fiber optic cable
- Slip Ring
- Optical Entrance
- Fiber Optics Rotating Joint
- Azimuth Motor
- Elevation Motor
- Motor
- Feedback Devices
- Aircraft Skin


What is next for 4STAR?

- Current AITT funding to improve calibration stability and implement mechanical/optical improvements
- Selected for KORUS-AQ 2016
- Selected for ORACLES 2016-2020
- Explore new calibration approach to eliminate relative bias errors between direct beam and sky radiance measurements.
- Implement vectorized radiative transfer code to speed sky scan retrieval for N-wavelengths.
- Hyperspectral cloud-properties retrievals in development (demonstrated in NAAMES)
- Build more 4STARS!

Goal: airborne profiles of trace gas + aerosol type via Aeronet-like retrievals

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