Introducing the SAS-He and SAS-Ze!

ARM Climate Research Facility’s newest solar spectral radiation instruments

ARRA-funded instrument effort:
NOAA/ESRL/CU: P. Disterhoft, P. Kiedron, J. Michalsky
What do the letters “S-A-S” stand for?

Shortwave Array Spectroradiometer

There are two types of SAS systems:
• SAS-Ze
• SAS-He

One of each deployed at SGP.
One of each shipping with AMF

Similar design characteristics:
► External sky collection optics
► Instrument rack inside climate-controlled building.
► Fiber-optic from collection optics to instrument rack.
► Connection through electronic shutter to a “Y” fiber leading to two array detectors spanning UV/VIS and near-IR
The array spectrometers...

**UV/VIS:** Silicon CCD array
Avantes Avaspec CCD 2048x14 ULS
- Spectral range: 340-1050 nm
- Rayleigh resolution: 2.4 nm FWHM
- Pixel spacing $\Delta \text{nm} = 0.5 \text{ nm}$

**NIR:** InGaAs CMOS/NMOS array
Avantes AvaSpec-NIR256-1.7
- Spectral range: 900-1700 nm
- Rayleigh resolution = 6 nm FWHM
- Pixel spacing $\Delta \text{nm} = 3.3 \text{ nm}$

- Non-chilled detectors protected within a moderately cooled temperature-controlled housing. Reduced noise characteristics while retaining beneficial responsivity overlap.
What do the –Ze and –He suffixes mean?

- **Zenith** radiance, 1 Hz
- **FOV**: 1 (full-angle)
- Solar zenith > 4

And the - **He** stands for “hemispheric”

- The **SAS-He** incorporates a Spectralon diffuser very similar to the MFR to obtain a hemispheric FOV
- Shadowband sequence similar to MFRSR yields:
  - direct solar irradiance
  - diffuse hemispheric irradiance
  - direct/diffuse ratio
  - Currently ~30 sec
- Bonus: spectra collected as band sweeps thru the forward scattered lobe
SAS-Ze
SAS-He optical collector

SAS-He
SAS systems collect robust metadata

- GPS location and time
- Surface atmos. pressure
- Several relevant T and RH readings
- X-Y tilt confirming level to \( \sim 0.02^\circ \) precision
- N,S,E,W, and band vertical to \( < 0.1^\circ \) accuracy
- Detection of band or motor slippage to \( < 0.1^\circ \)
- Frequent detector dark measurements
- Solar ephemeris info
Emphasis on characterization

- Mechanical backlash & repeatability, <0.01°
- Repeatability on reconnection of fibers, ~99.9%
- Wavelength registration, discharge lamps & line sources
- Instrument response function for each pixel
- Temperature sensitivity of each detector <0.1%/degC
- Polarization sensitivity of SAS-Ze
- Linearity with light levels and integration time
- SNR and NESR determinations
Where do the SAS instruments fit in?

- **SAS-He similar to MFRSR & RSS, complementary to NIMFR & Cimel.**
  - MFRSR & RSS use similar diffuser and shadowband approach
  - RSS has shorter wavelength range but finer resolution for UV.
  - NIMFR, Cimel: free of cosine correction but measure only discrete wavelengths rather than continuous spectrum.
**SAS-He science applications:**

- Radiation closure with cloud and aerosols
- Aerosol: AOD, Å, ω, g, phase function information
- Cloud: OD, $R_{\text{eff}}$, liquid/ice discrimination or partitioning
- Cloud edge studies
- Column abundances: PWV, CO$_2$, O$_3$, NO$_2$, CH$_4$, ...
- Aerosol size distributions with forward scattered lobe info

Mid-lat summer direct and diffuse irradiance, SZA=0 (from SBDART)
Mid-latitude summer atmospheric composition in optical depth (from SBDART)

- **Wavelength (nm):** 300, 450, 600, 800, 1100, 1400, 1700
- **Transmittance:** $\text{ln}(1/T)$, unitless
- **Components:**
  - Water vapor
  - CO$_2$
  - CH$_4$
  - A-band
  - O$_3$
SAS-Ze similar to NFOV, NFOV2, Cimel (sky radiances) and SWS

- NFOV, NFOV2: only 1 or 2 filter-based channels
- Cimel: several channels but discontinuous/infrequent data
- SWS: very similar, SAS better resolution below 900 nm, better SNR up to 1700 nm.
SAS-Ze science applications:
- Radiation closure with cloud and aerosols
- Cloud OD and effective radius retrievals
- Cloud edge studies
- Liquid/ice discrimination / partitioning

Applications depend on measurement sequence:

SAS systems support definable “experiments”
- Active over defined SZA ranges
- Azimuth alignment
- Band position in absolute degrees or scattering angle
- Stationary or scanning spectra acquisition
- Distinct integration times for each detector and acquisition mode
- Separate control of each shadowband
- Filename tag
Future efforts, additions, extensions

- IOP with down-looking SAS-He head.
- Direct drive of band shafts, no belt
- Shaft encoder for band position, immediate position correction.
- Implement second band, assess wide-band
- Extend wavelength range
  - Enhanced UV to ~300 nm
  - Enhanced NIR 2.1, 2.2, 2.5 micron