# Introducing the SAS-He and SAS-Ze!

## ARM Climate Research Facility's newest solar spectral radiation instruments

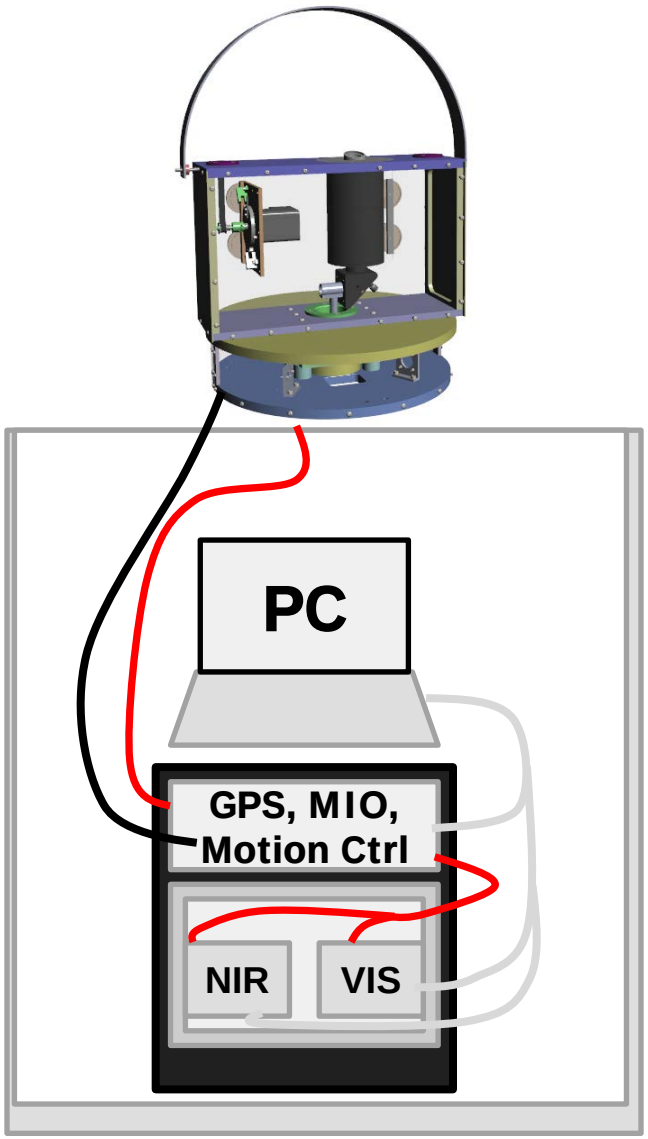
**ARRA-funded instrument effort:**

PNNL: **Connor Flynn**, J. Barnard, D. Hopkins, E. Kassianov, A. Mendoza, D. Nelson, R. Norheim

NOAA/ESRL/CU: P. Disterhoft, P. Kiedron, J. Michalsky

Pacific Northwest
NATIONAL LABORATORY

# 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:

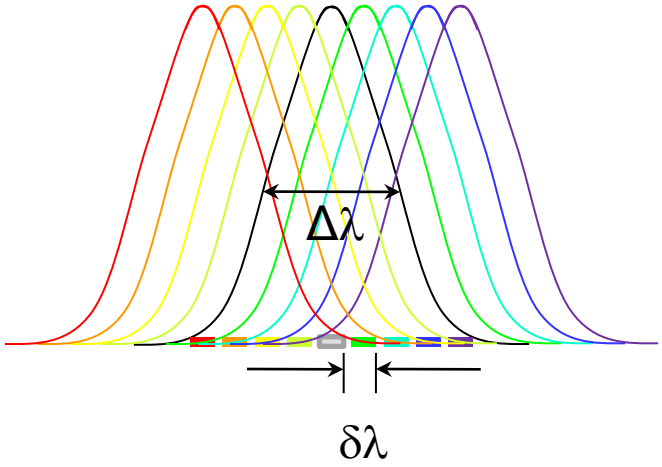
- External sky collection optics
- Instrument rack inside climate-controlled building.
- Fiber-optic from collection optics to instrument rack.
- Connection through electronic shutter to a “Y” fiber leading to two array detectors spanning UV/VIS and near-IR

Pacific Northwest
NATIONAL LABORATORY

# 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 Δnm = 0.5 nm

NIR: InGaAs CMOS/NMOS array
Avantes AvaSpec-NIR256-1.7
- •Spectral range: 900-1700 nm
- •Rayleigh resolution = 6 nm FWHM
- •Pixel spacing Δnm = 3.3 nm




- Non-chilled detectors protected within a moderately cooled temperature-controlled housing. Reduced noise characteristics while retaining beneficial responsivity overlap.

Pacific Northwest
NATIONAL LABORATORY

# What do the –Zo and –Ze suffixes mean?

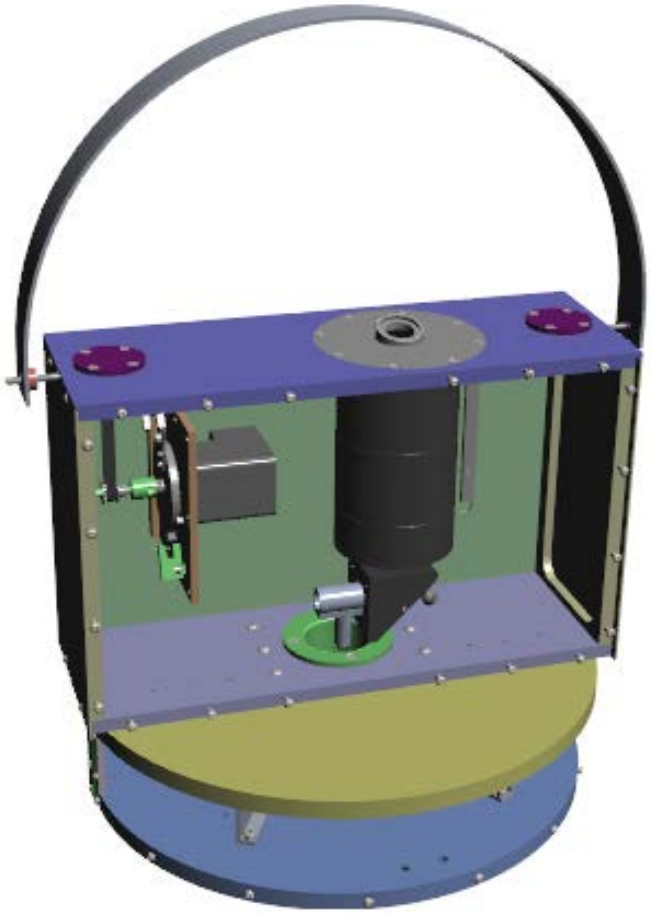
- **Zenith** radiance, 1 Hz
- FOV: 1  (full-angle)
- Solar zenith > 4

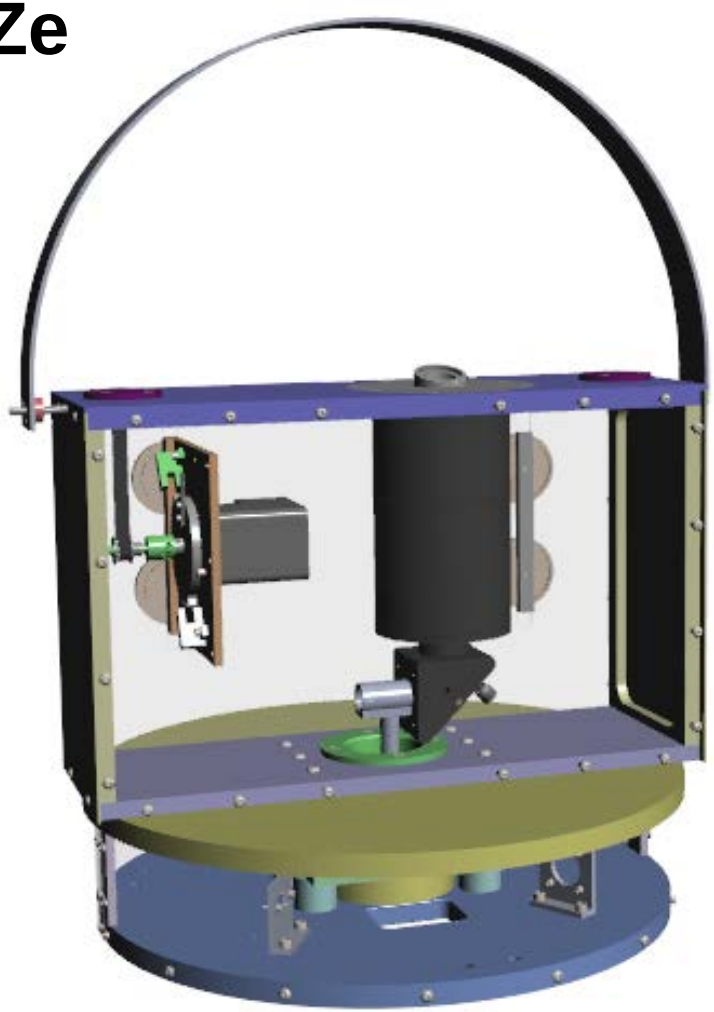
## And the –He stands for “hemispheric”

- 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

Pacific Northwest
NATIONAL LABORATORY

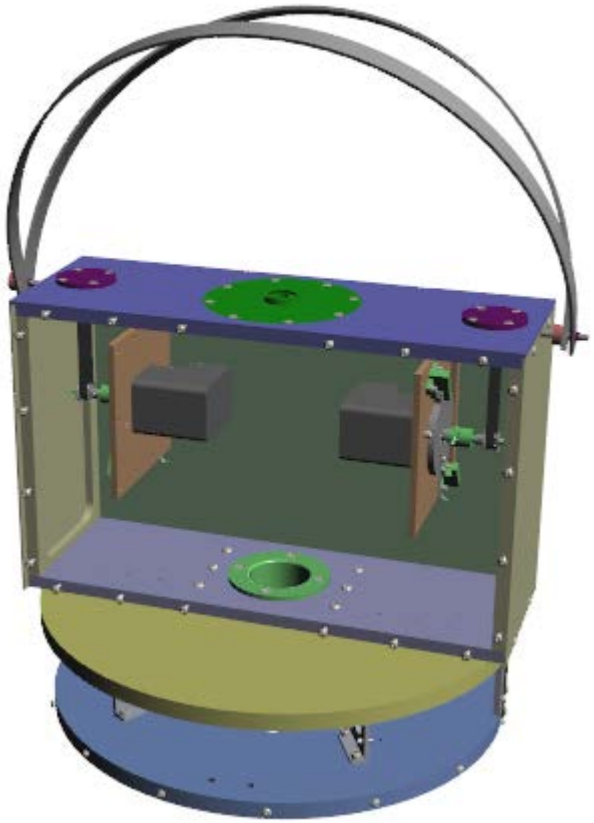
# SAS-Ze





Pacific Northwest
NATIONAL LABORATORY

# SAS-He optical collector



**SAS-He**

Pacific Northwest
NATIONAL LABORATORY

# SAS systems collect robust metadata

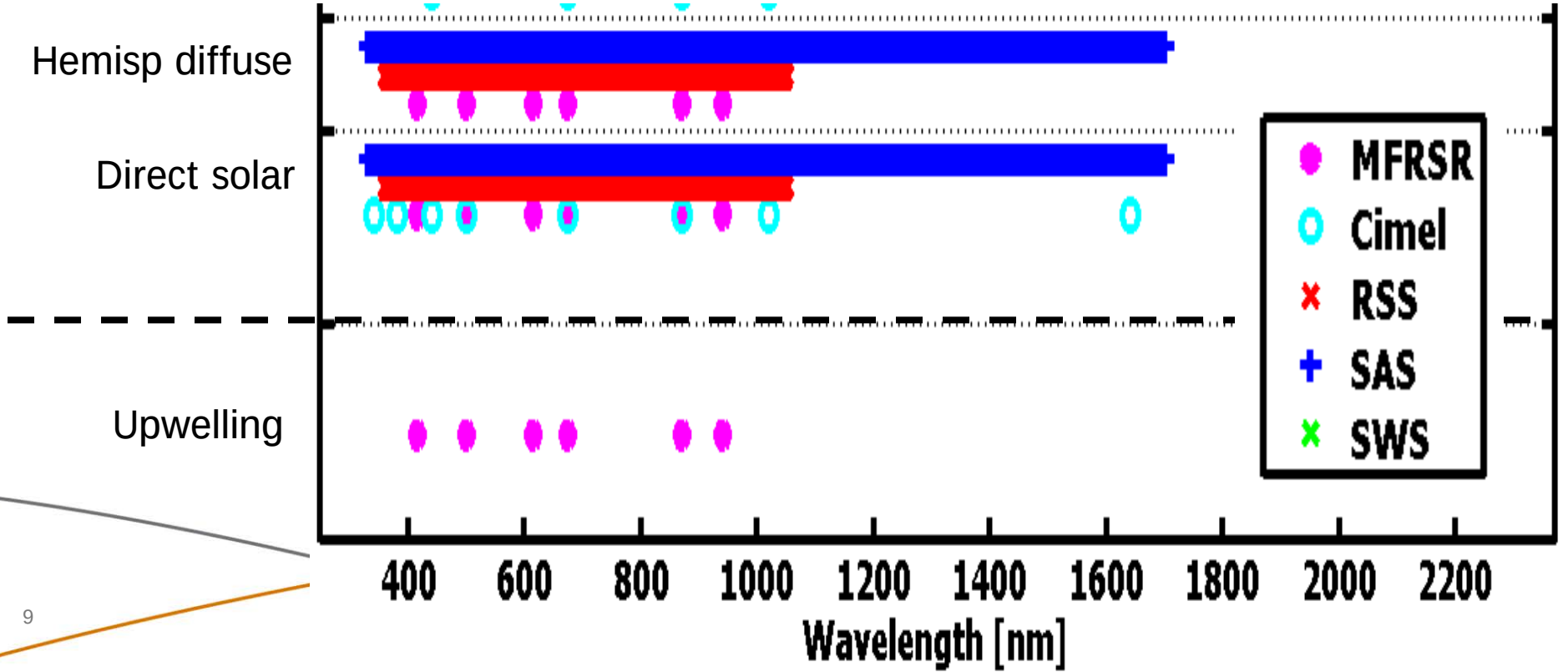
- GPS location and time
- Surface atmos. pressure
- Several relevant T and RH readings
- X-Y tilt confirming level to ~0.02° precision
- N,S,E,W, and band vertical to < 0.1° accuracy
- Detection of band or motor slippage to < 0.1°
- Frequent detector dark measurements
- Solar ephemeris info

# 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

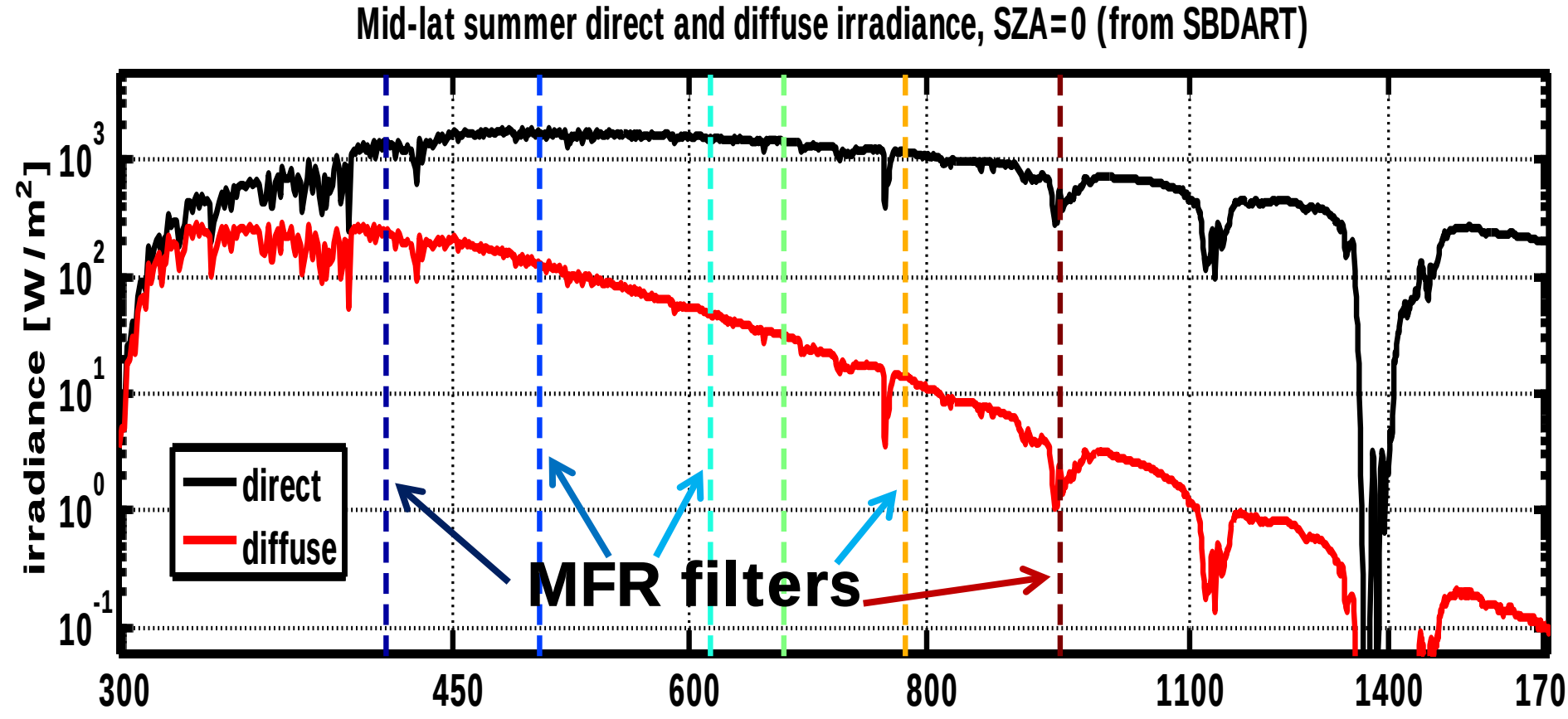
# Where do the SAS instruments fit in?

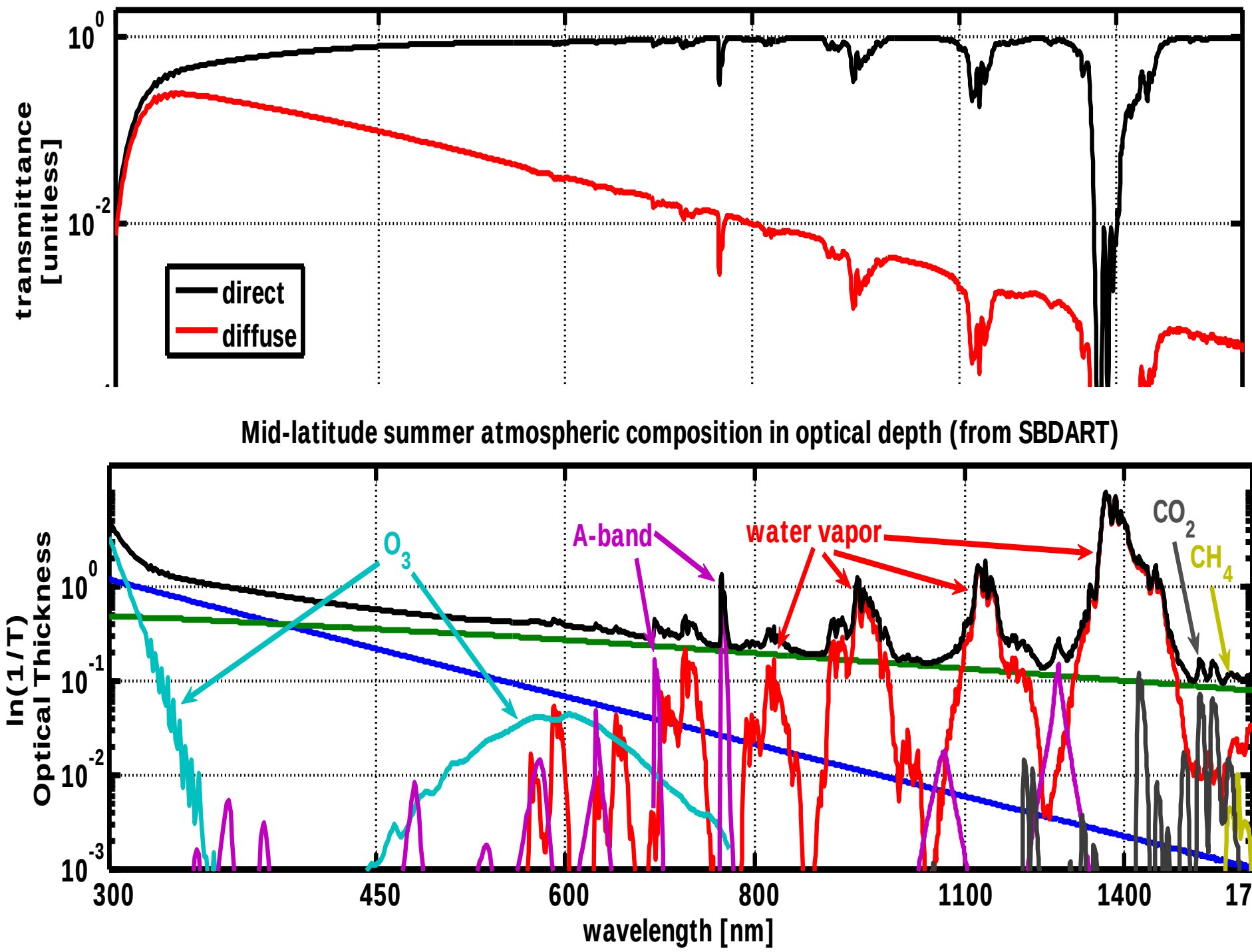
- **SAS-He similar to MFRSR & RSS, complementary to NIMFR & Cimel.**
  - MFRSR & RSS use similar diffuser and shadowband approach
  - RSS has shorter wavelength range but finer resolution for UV.
  - NIMFR, Cimel: free of cosine correction but measure only discrete wavelengths rather than continuous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



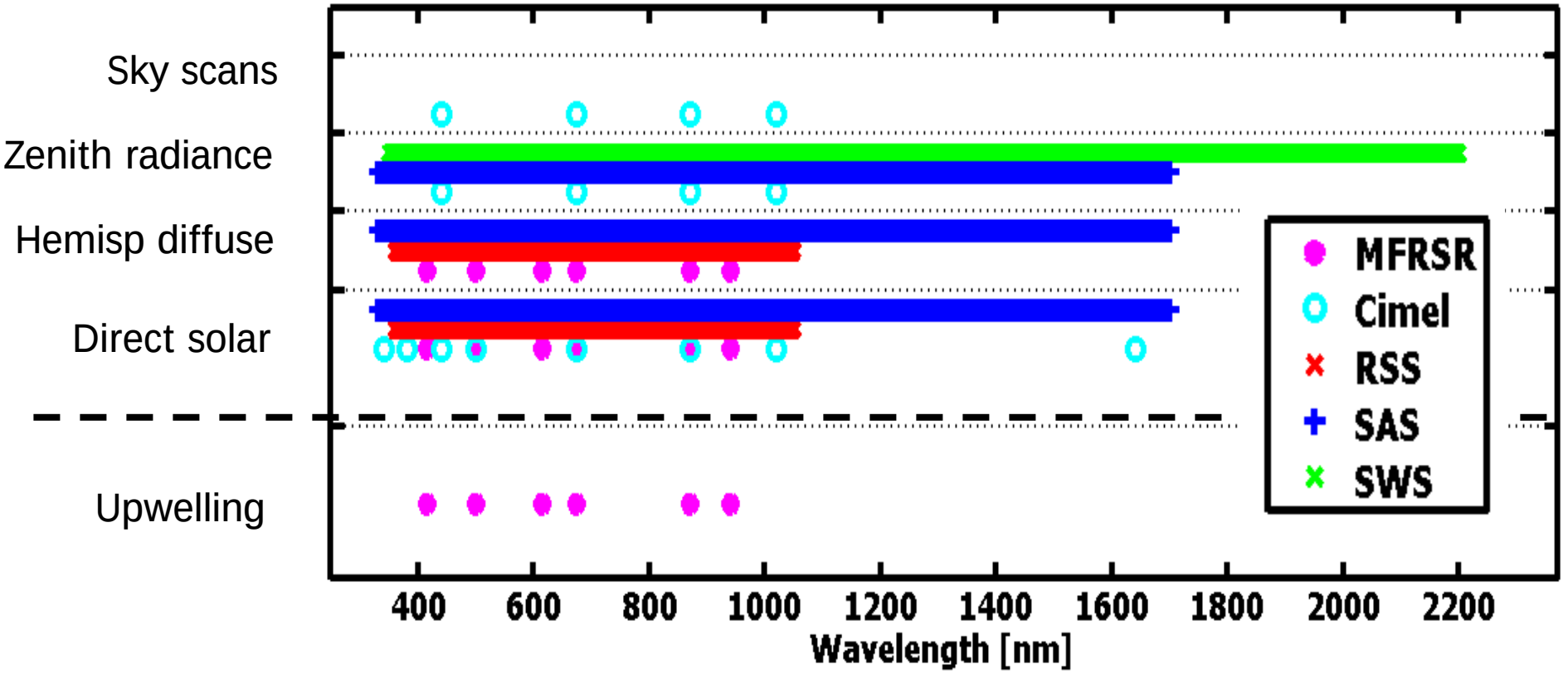
## SAS-He science applications:

- Radiation closure with cloud and aerosols
- Aerosol: AOD, Å, ω, g, phase function information
- Cloud: OD, $R_{eff}$, 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




transmittance [unitless]
direct
diffuse
Mid-latitude summer atmospheric composition in optical depth (from SBDART)
ln(1/T) Optical Thickness
O3
A-band
water vapor
CO2
CH4
wavelength [nm]

## 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