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Low Cost Shortwave Spectroradiometer for Retrieval of Cloud Properties

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Retrievals of

- Cloud optical depth (COD)
- Droplet effective radius (R_{eff})
- Thermodynamic phase

With

- 1 second sample interval
- $\frac{1}{2}$ degree zenith field of view
- 400-1665 nm spectra
- Resolution: 2.2 nm (VIS), 9.8 nm (NIR)



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NIR-Enhanced TWST (TWST-EN) Current Status

- TWST-EN commercially available in two design variants.
 1. Compact grating spectrometers – 400-1665 nm.
 2. Grating (VIS) and FTIR (NIR) spectrometers – 400-2500 nm.
- Current field use customers:
 - DOE/ARM/ARI, SGP small field campaign. 2/2020-2/2022. (TWST-EN, grating spectrometers). ARI sky camera also on same pedestal now.
 - NOAA, Table Mountain fixed deployment and CHEESEHEAD 2019 field campaign (VIS).
 - Brookhaven National Lab, in process of deploying at BNL (NIR-Enhanced and VIS units).
 - University of Valencia (TWST-EN, grating/FTIR).
- Current instrument code does real-time COD retrievals.
- *Reff* and phase retrievals are done offline and could be made available.
- Other computed and logged data: calibrated spectra, dark frames, calibration data, O₂ A-band equivalent width, enclosure internal temperature and humidity.



Cloud Properties Sensor
Southern Great Plains
April 2020

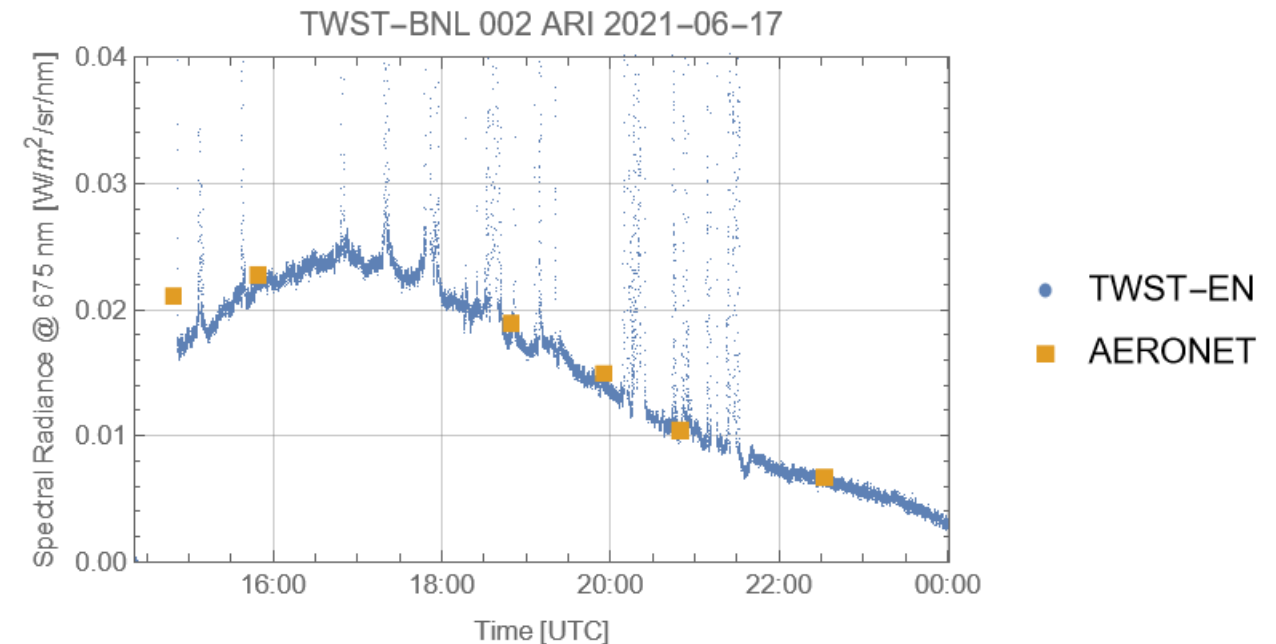


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Calibration, Accuracy and Stability

- Radiometric calibration is done using LabSphere Helios NIST transfer standard. 100 W, 3000K QTH Lamp.

Wavelength (nm)	Ref. STD Relative Uncertainty	Total Relative Uncertainty
350	3.6%	14.2%
450	1.1%	6.1%
555	0.8%	3.1%
654	0.8%	1.7%
900	0.9%	0.9%
1600	0.8%	3.1%



- Accuracy and stability in the field are still being assessed. Usually within a few percent of co-located AERONET, but comparison is only valid for very clear sky.
- Dark frames are taken every minute (typically) to remove temperature dependent baseline drift.
- Linearity has not yet been rigorously characterized versus temperature.
- Currently developing temperature-controlled LED-based field calibrator for examining these effects under operational conditions.



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Strengths and Limitations for Field Use

- Entire instrument, other than computer, is field deployable. IP67, NEMA 4X enclosure. Computer connected via USB extender. Power over ethernet or AC power at instrument.
- Easy to set up and operate. Has been successfully deployed numerous times by non-ARI personnel, (e.g., ARM operations team at TCAP, BAECC, and SGP), requiring minimal instruction.
- Data files are netCDF4 and easily interpreted.
- Low cost.
- Low size, weight and power. 370 mm x 320 mm x 180 mm enclosure. ~20 lbs. ~1/2 W.
- Very low maintenance, other than keeping the window clean.
- 100 m maximum range of USB extender.

E. Niple, H. E. Scott, J. A. Conant, S. H. Jones, F. J. Iannarilli and W. E. Pereira, "Application of oxygen A-band equivalent width to disambiguate downwelling radiances for cloud optical depth measurement," *Atmos. Meas. Tech.*, 9, 4167-4179. 2016.