Continuous Light Absorption Photometer (CLAP) Performance

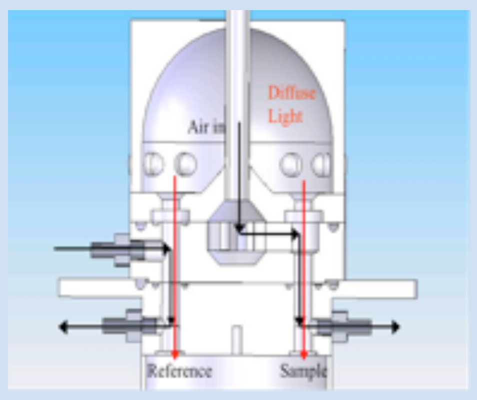
J.Ogren[1], J.Wendell[1], P.Sheridan[1], D. Hageman[1,2] and A. Jefferson[1,2]

1. NOAA Earth System Research Laboratory, Boulder, CO 2. Cires, University of Colorado, Boulder, CO

CLAP Design

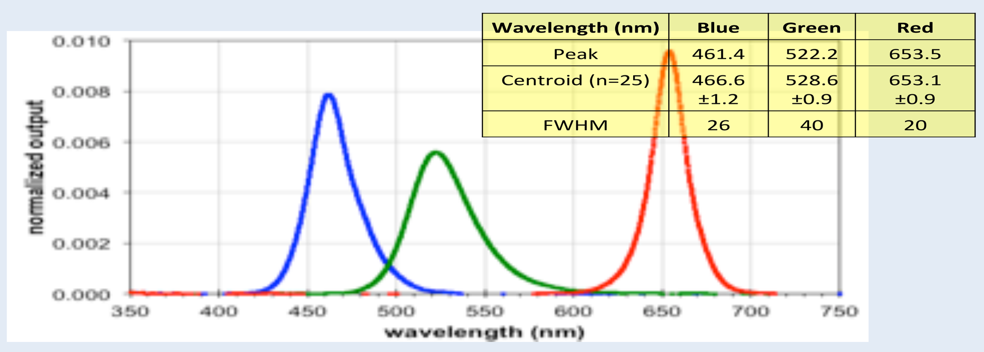
The CLAP is a small, inexpensive, filter-based , aerosol absorption photometer that is optimized for remote operation and ease of use. The CLAP features

- 2 Reference and 8 sample spots on one filter
- Automated spot change at user-defined transmission levels
- Longer times between filter changes results in less data loss
- Heated optical block to reduce sensitivity to sample RH and room temp
- Simple user interface (press button to change filter)
- Data output optimized for machine processing
- Remote internet control of operating parameters



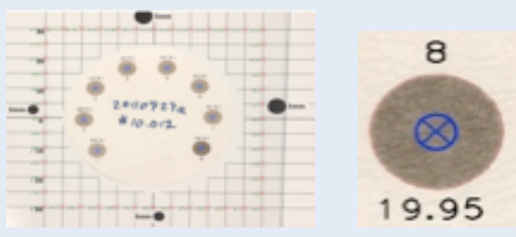
Instrument Calibrations

Measured LED spectral output



Wavelength (nm)	Blue	Green	Red
Peak	461.4	522.2	653.5
Centroid (n=25)	466.6 ±1.2	528.6 ±0.9	653.1 ±0.9
FWHM	26	40	20

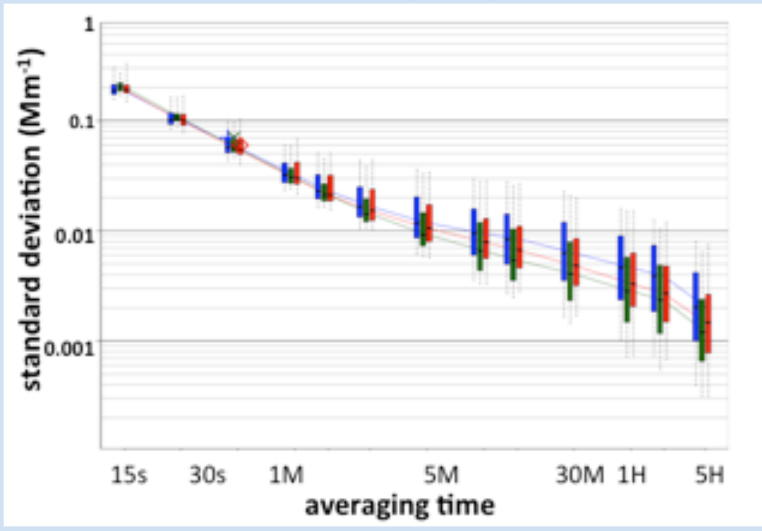
Spot size measurement



- Average area = 19.9 ± 0.5 mm² (n=200)
- Automated analysis of test filters from each CLAP
- Measurement uncertainty is 2%
- Improvement over method with magnified eye piece

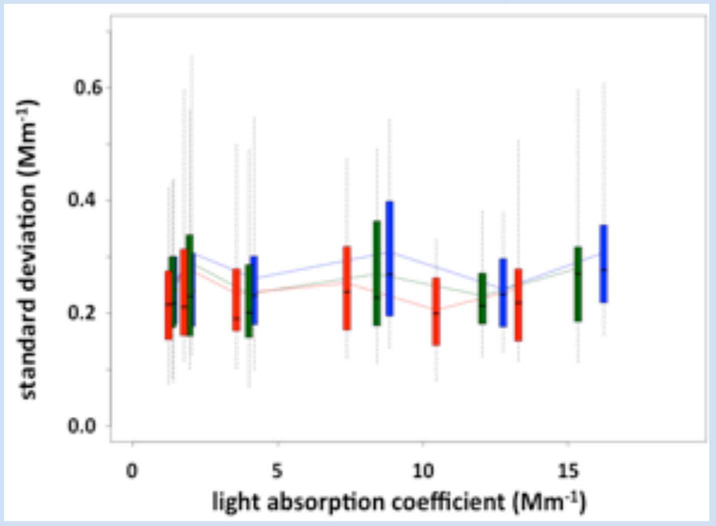
Noise and Precision

Noise vs averaging time

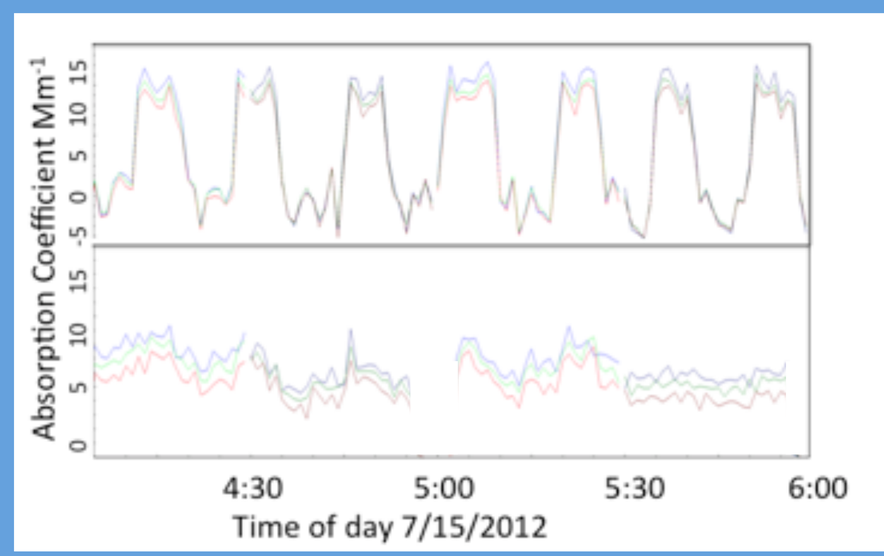


Boxplots represent 194 CLAP detectors. Symbols show average noise of 6 PSAPs.

Precision analysis

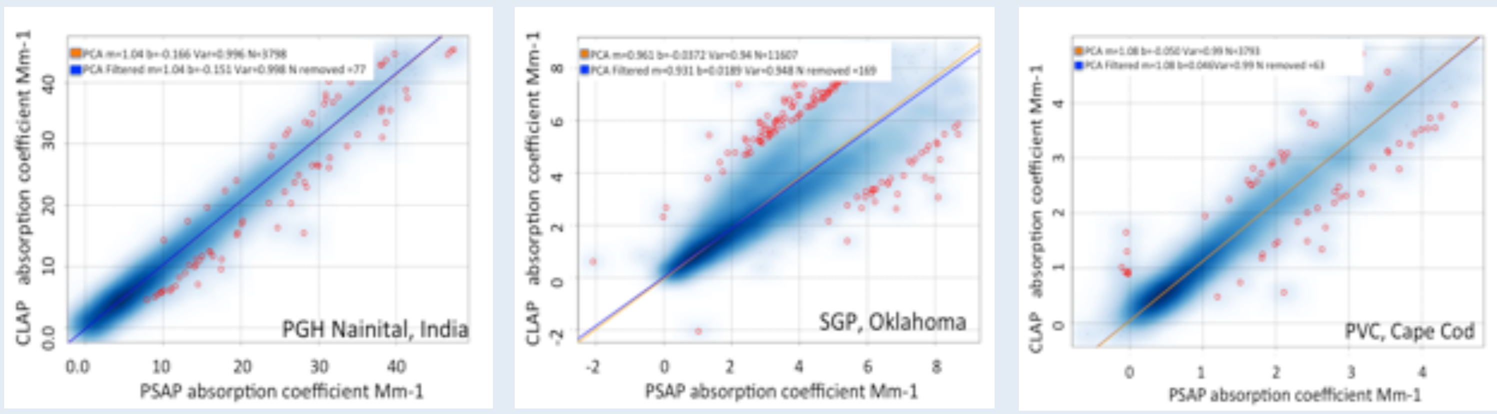


Boxplots show variability of 7 instruments operated in parallel.



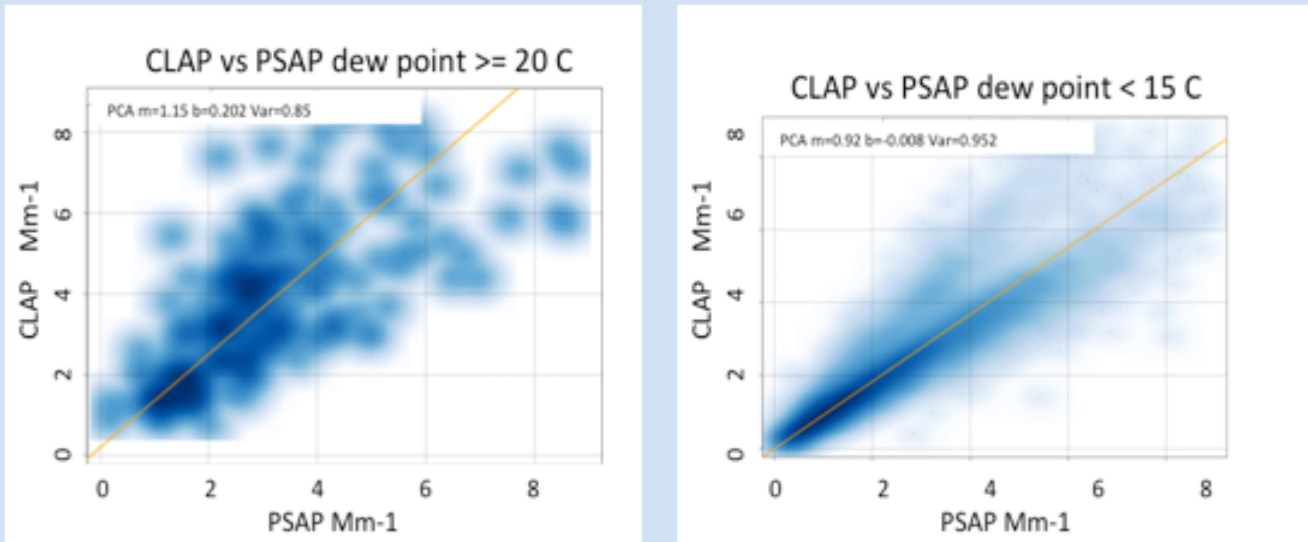
The above traces show the PSAP (top) and CLAP(lower) raw signal from SGP. At high dew points the PSAP signal oscillates with the trailer temperature. The PSAP signal depression at high RH is evident in the higher CLAP vs PSAP slope at high dew points.

CLAP and PSAP comparison



CLAP and PSAP data are adjusted to 550 nm. The density plots are 6 months (PVC), 9 months (PGH) and 2 years (SGP) of hourly data. The red circles represent 3 standard deviations of the data from the fit. Two fits using principal component analysis (PCA) are with all data and with the red circles removed (PCA Filtered).

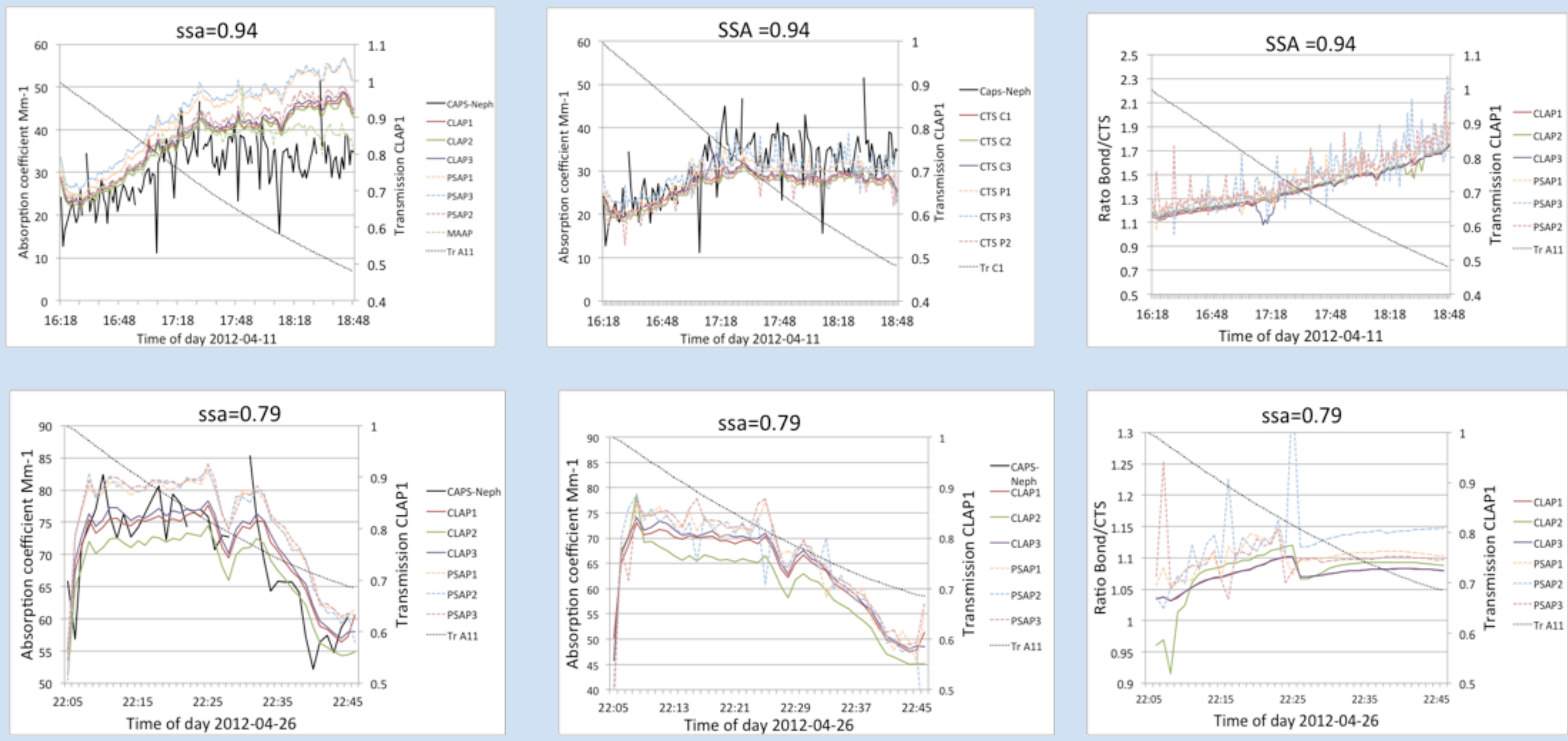
Effect of high dew point on data



Laboratory comparison

3 CLAPS, 3 PSAPS, a TSI nephelometer and an Aerodyne CAPS were connected to a large mixing chamber to evaluate correction schemes for CLAP and PSAP. The reference absorption was the difference between scattering and absorption ("CAPS-neph"). Tests were run on white $(NH_4)_2SO_4$ aerosol alone and mixed with varying concentrations of black fulllerene aerosol. Results are preliminary as more tests are needed. All instruments are wavelength corrected to 656 nm. The upper and lower traces show runs at high and low single-scattering albedos.

Bond et al. correction | CTS correction | Ratio Bond/CTS



Model comparison

A constrained 2-stream radiative transfer model (CTS) was developed to represent radiative transfer in filter-based light absorption analyzers (Müller et al., 2013), and replaces the purely-empirical correction scheme currently in use for the PSAP (Bond et al., 1999). Constraints in CTS are based on laboratory studies of filter transmittance when loaded with known amounts of white and black aerosols. Work is in progress to include the effect of particle penetration depth into the filter substrate in CTS.

Summary

Field studies reveal a much noisier, and slightly lower, PSAP signal relative to the CLAP at high sample dew point values. For laboratory measurements of an externally-mixed $(NH_4)_2SO_4$ and fullerene aerosol the PSAP signal is slightly higher than that of the CLAP. The PSAP signal increased relative to the CLAP signal at lower filter transmittances. Both instruments were corrected to the same wavelength, use the same filter substrate and same Bond et al. correction scheme. The CTS radiative transfer model better predicts the absorption behavior at low transmission and with low-absorbing aerosol than the Bond et al. scheme. Further comparisons, model development, and instrument calibration with the NOAA photoacoustic absorption spectrometer and cavity-ring down extinction spectrometer are proposed.

Bond et al., *Aerosol Science and Tech*, 30, 1999
Müller et al., *Atmos. Meas. Tech. Disc.*, in prep.