Aerosols for LSST

Nicholas Mondrik (Harvard)

DESC PCWG Workshop Oct. 2018

Topics

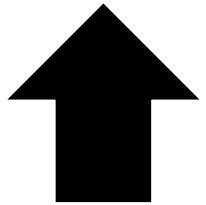
- Overview of progress w/ Gemini – GMOS-S data
- Concerns with GMOS-S dataset
- Other methods of measuring aerosols
- Discussion

Gemini Data

What do the data consist of?

- Target: TYC 9511-1775-1
- Data taken in 2 modes:
  - 5.0 arcsec slit
  - No slit
- Dates of observations:
  - First: 2016-08-06
  - Last: 2017-02-02
- Total number: 141 total
  - 70 5” slit images
  - 71 no slit images

- Data taken in “poor” conditions
- Data taken over 69 nights
  - Almost always 1 5” + 1 no slit image per night

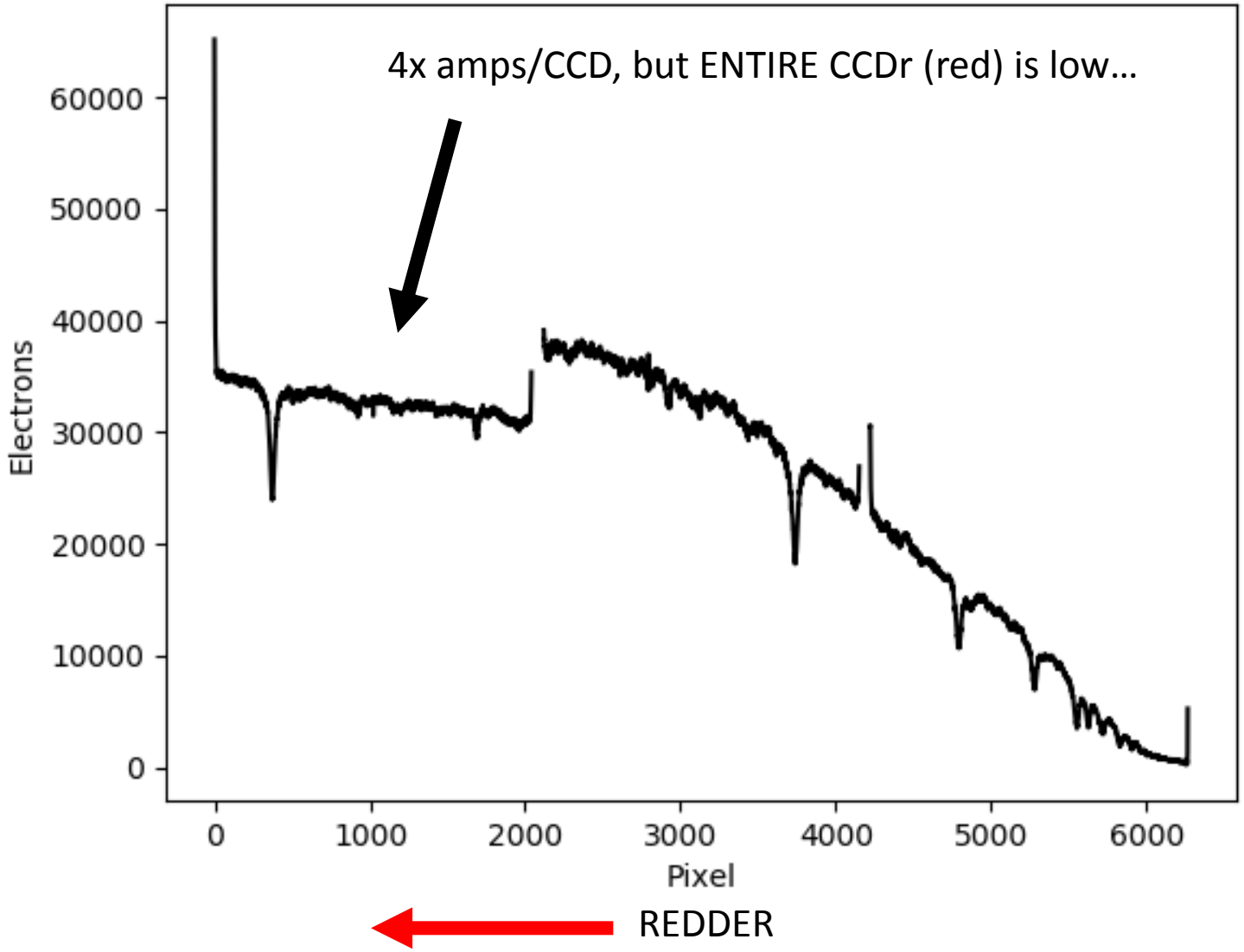


Not ideal…

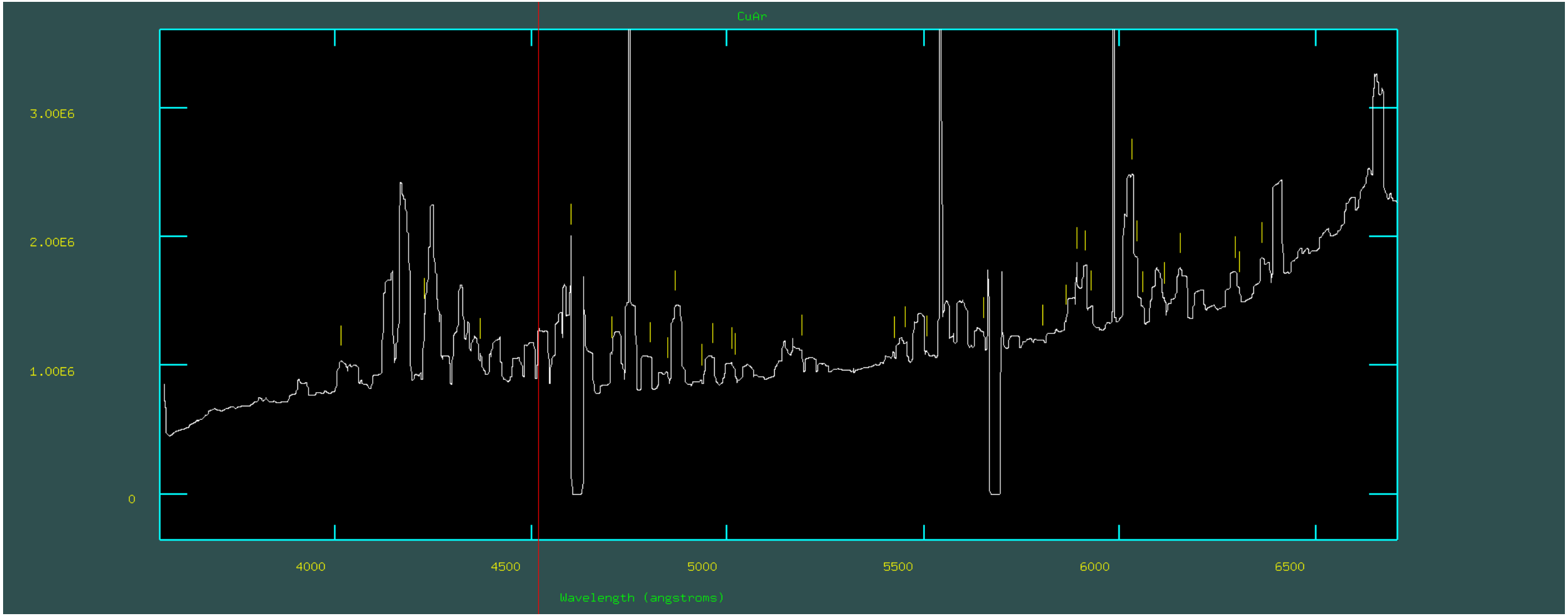
Extracting data – Pipeline currently under development…

- Bias subtraction
- Cosmic ray removal
- Sky subtraction
- -> No flat fielding
- -> No QE correction (technically are sensitive only to QE differential)
- (Pseudo-) Optimal extraction -> LSF assumed to be Moffat, but Voigt and Gaussian are also implemented. Have plans to implement empirical LSF
- Pixel – Pixel matching between exposures
- Convolve to match seeing between exposures
- Wavelength calibrate

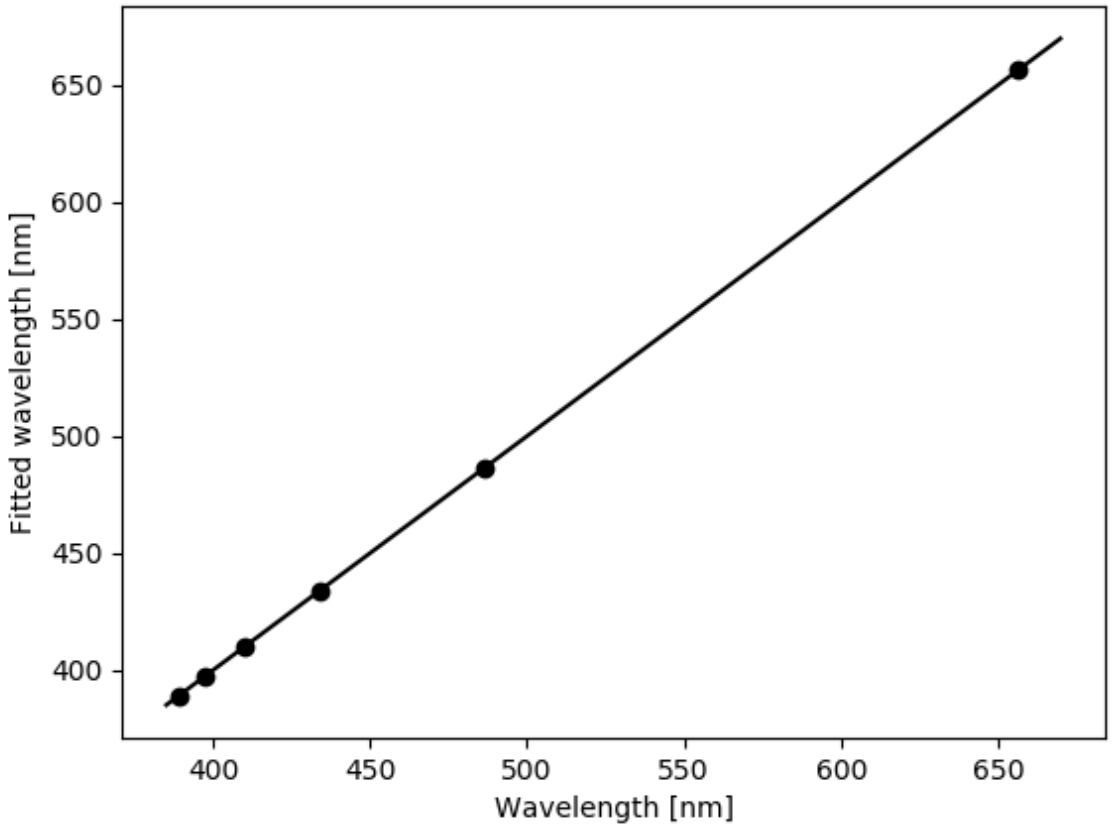
More on the QE Correction

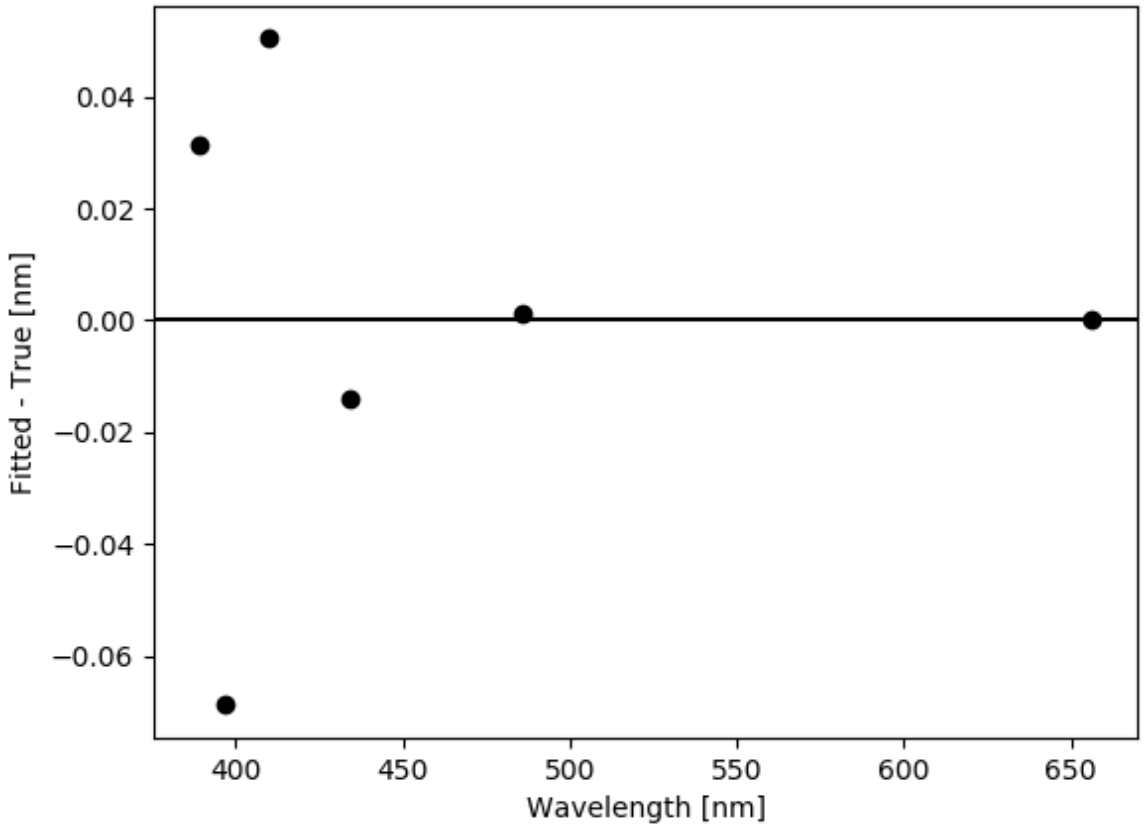


Cu-Ar line lamp + 5.0” slit

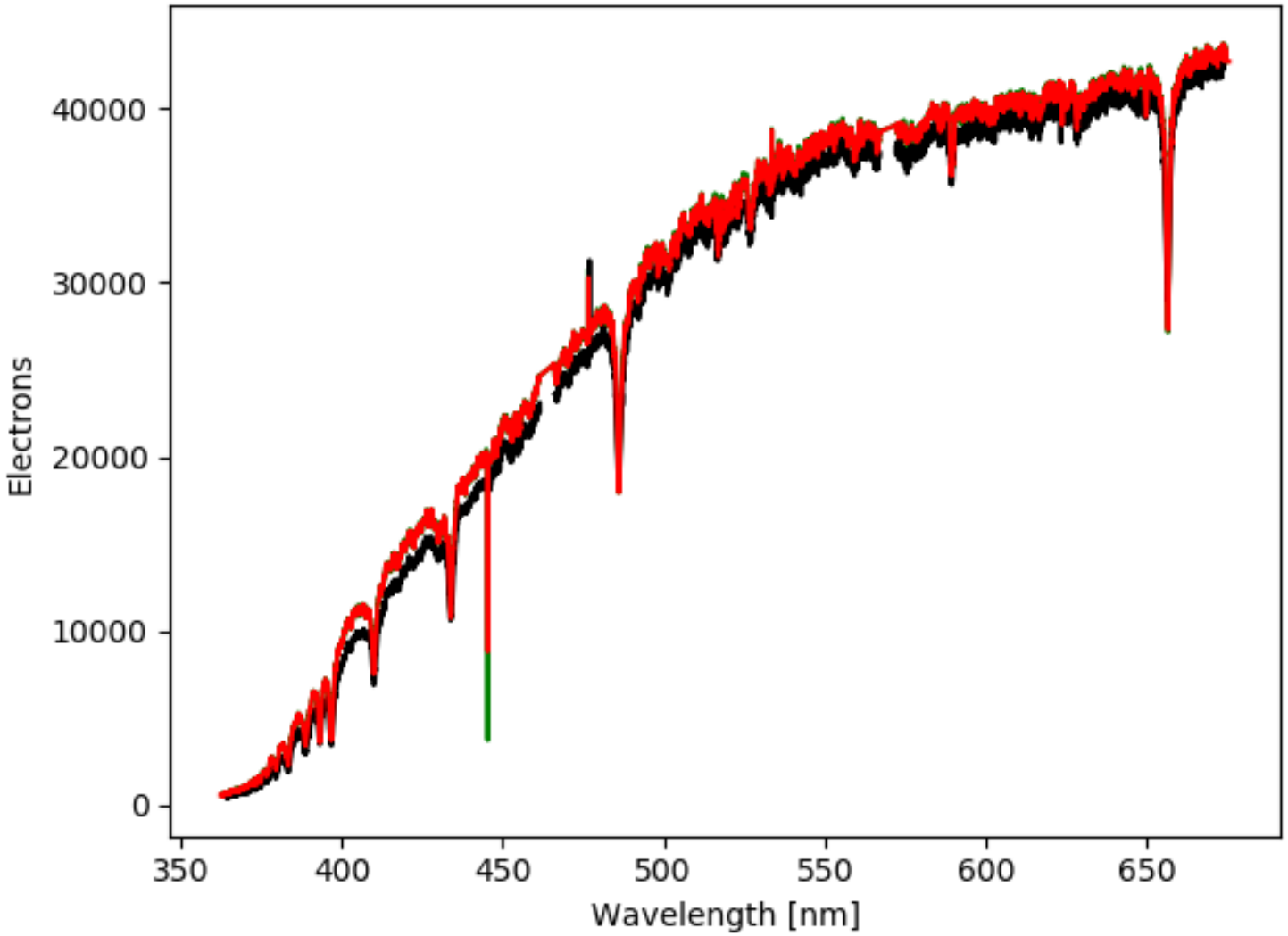


Wavelength solution

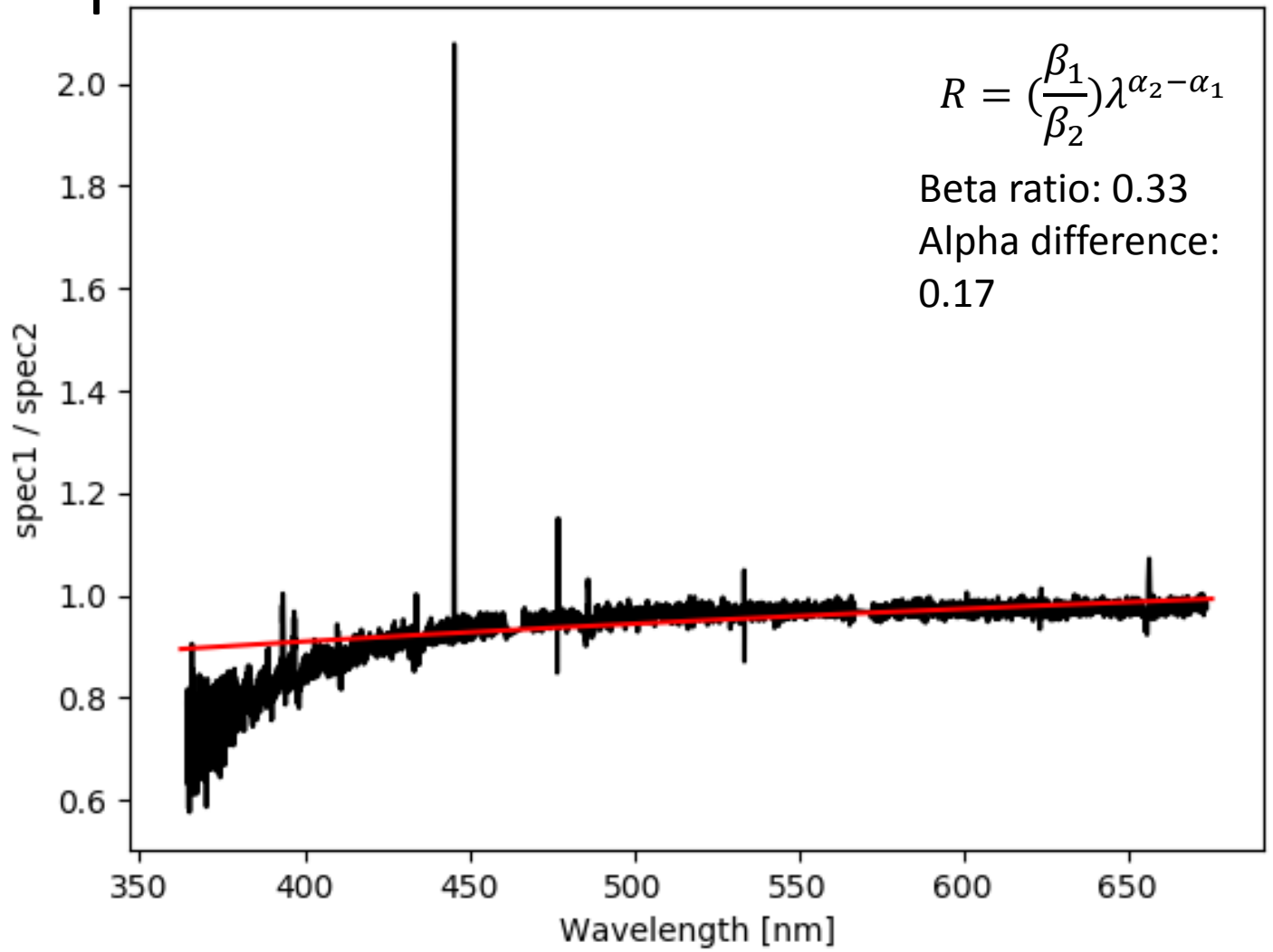




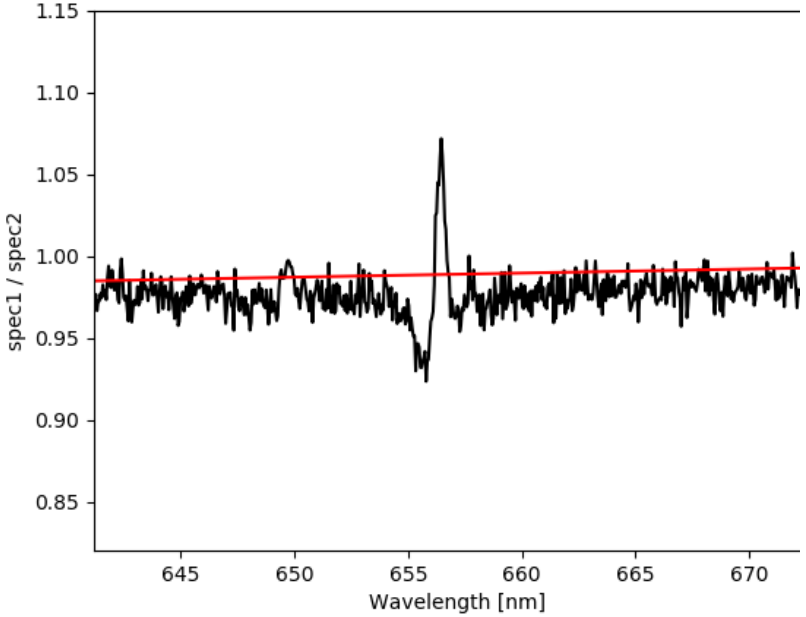
Extracted Spectrum

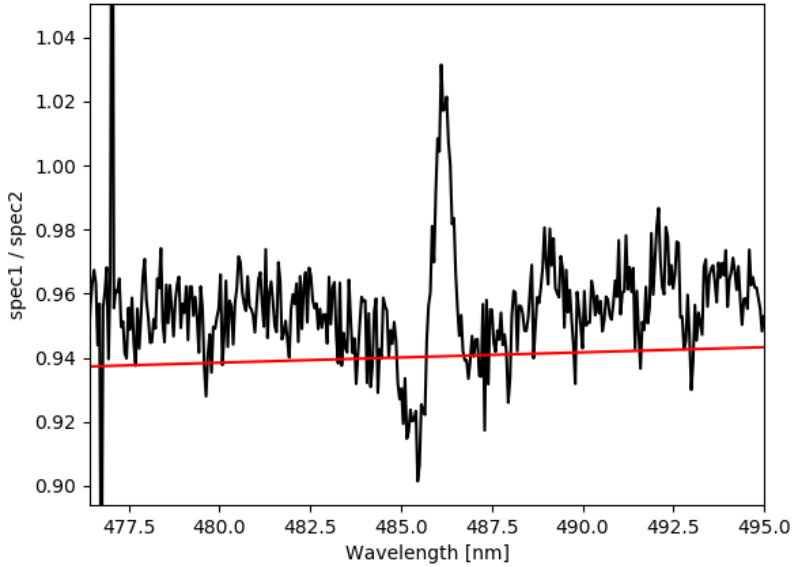


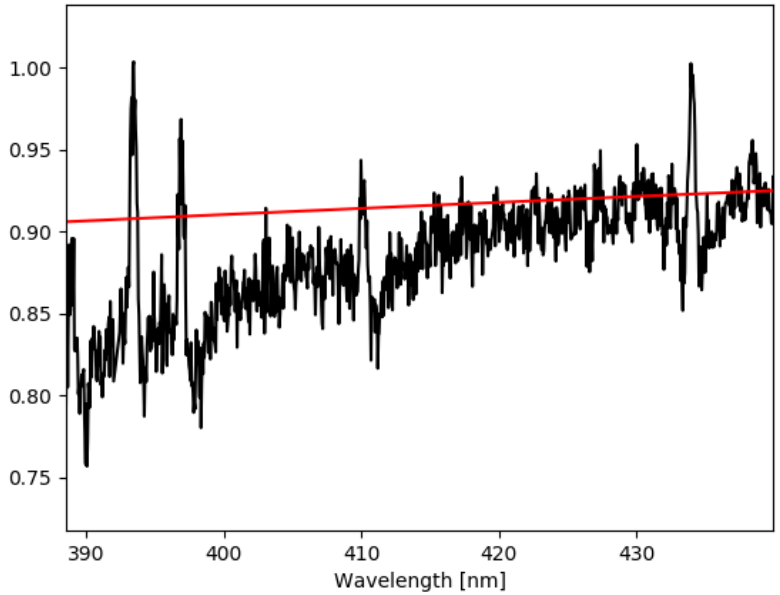
Ratio of Spectra



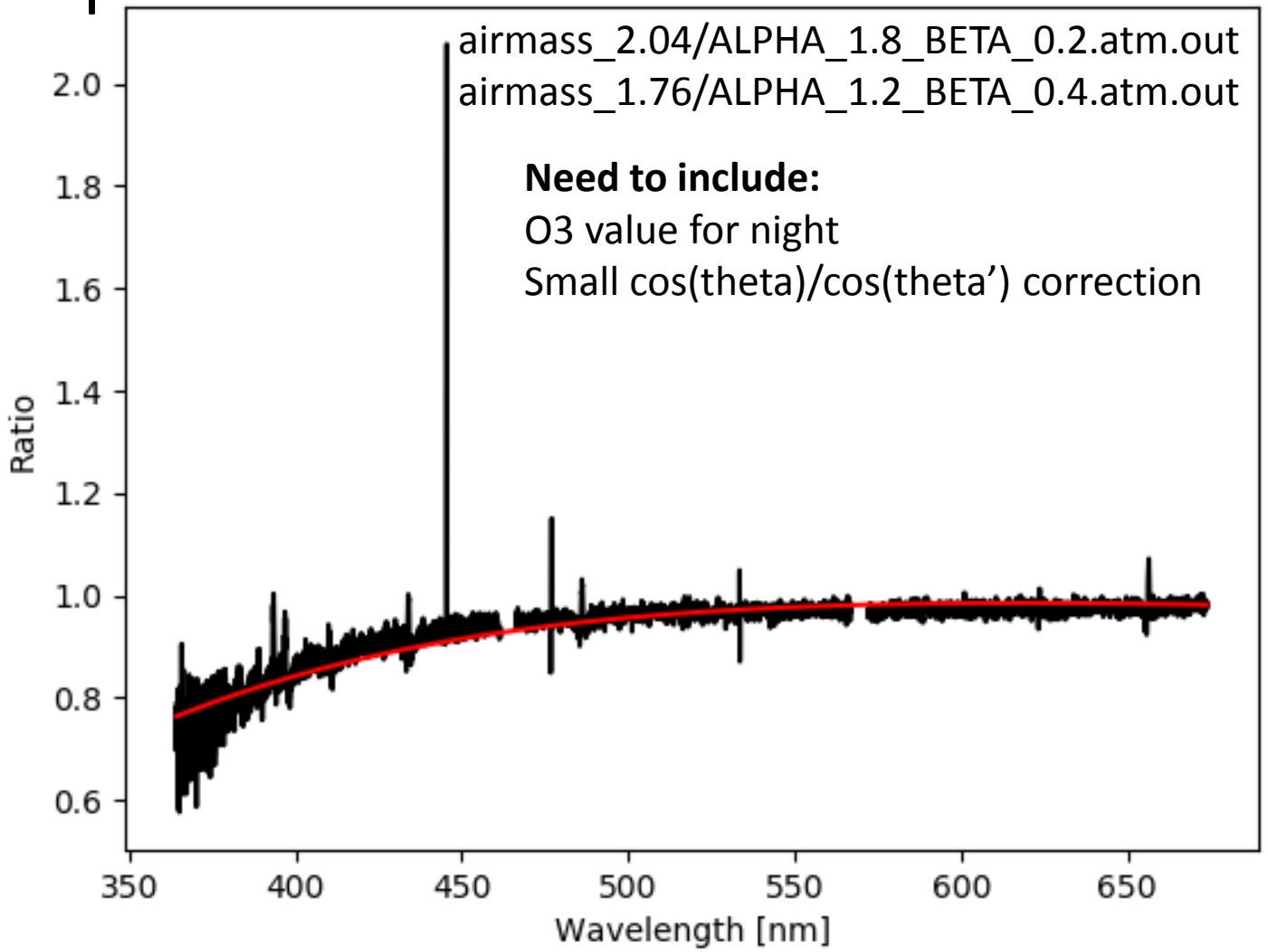
Wavelength Solution is not Perfect…





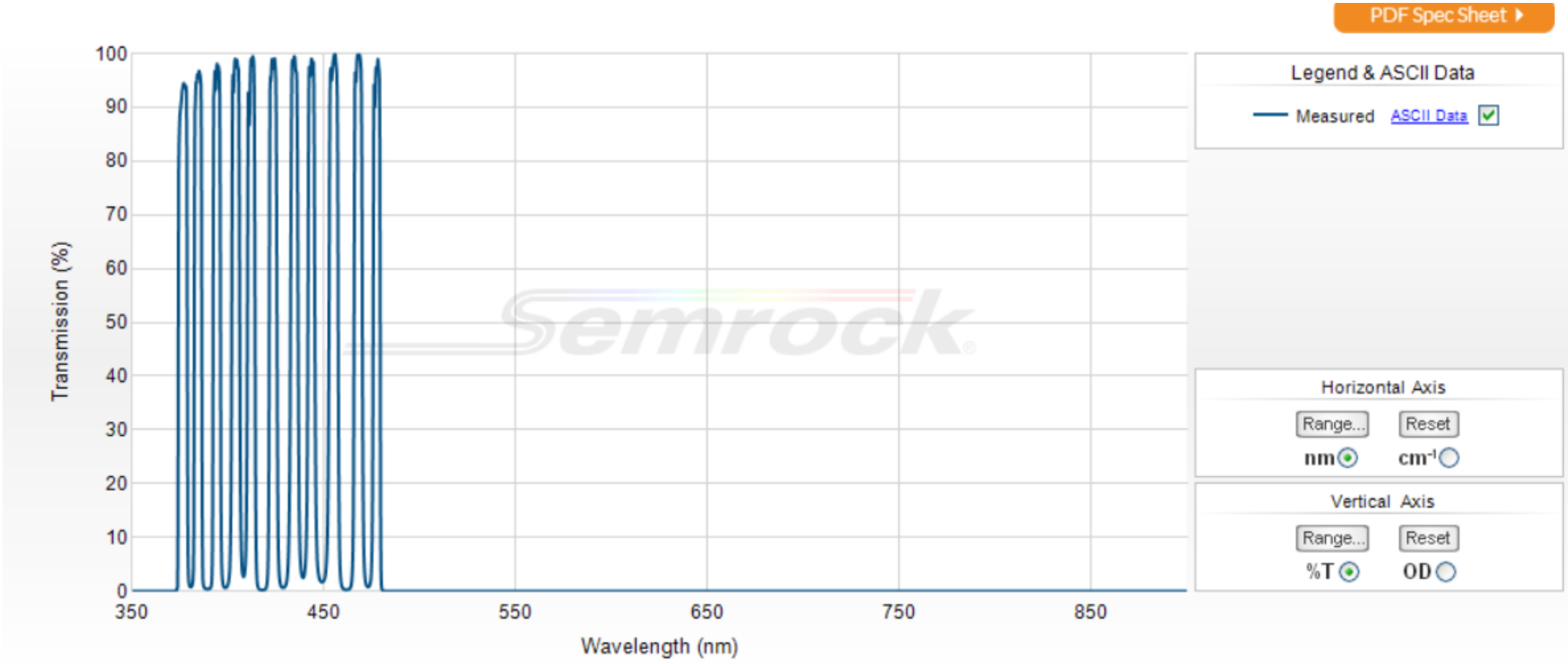


Ratio of Spectra



Concerns

- Wavelength solution – Is ~one angstrom peak-to-peak good enough?
  - What is plan to do better on AuxTel w/ LACI? Stubbs wants Semrock filter in beam
- What is repeatability of back-to-back measurements w/ GMOS?
  - These data do not exist. Should we propose for more Gemini time? 1-2 nights of consistent monitoring?
- Use Modtran or libRadtran for atmo modeling? (probably can’t tell a difference at this point in time)



- Your filter spectrum may differ slightly from the typical spectrum above, but is certified to meet the optical specifications noted below.

Non-Astronomers care about this too

A new method for nocturnal aerosol measurements with a lunar photometer prototype

A. Barreto[1], E. Cuevas[1], B. Damiri[2], C. Guirado[1,3,4], T. Berkoff[5], A. J. Berjón[1], Y. Hernández[1], F. Almansa[1], and M. Gil[6]

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[2]Cimel Electronique, Paris, France
[3]Institute of Environmental Assessment and Water Research, Spanish National Research Council (CSIC), Barcelona, Spain
[4]Atmospheric Optics Group, Valladolid University (GOA-UVA), Valladolid, Spain
[5]University of Maryland Baltimore County, Baltimore, Maryland, USA
[6]Instrumentation and Atmospheric Research Department, National Institute for Aerospace Technology (INTA), Madrid, Spain

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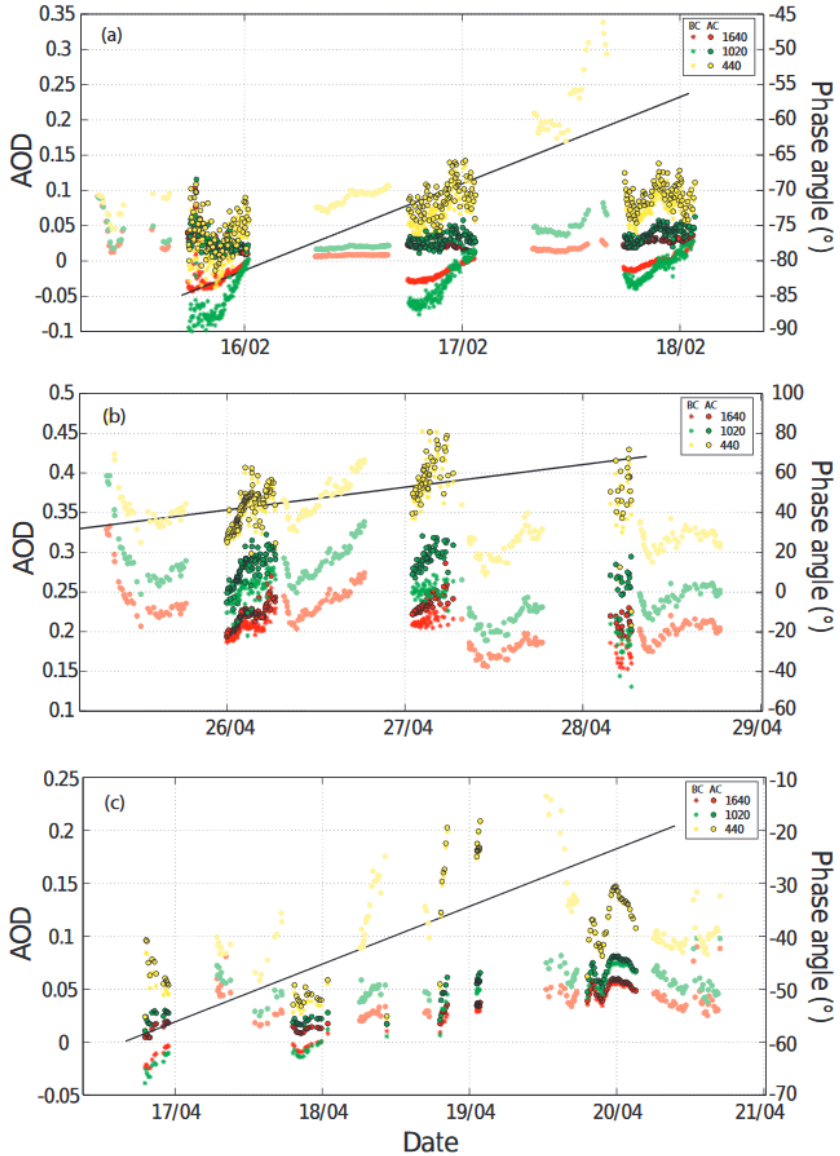

Figure 8. AOD before correction (BC) and after correction (AC) at **(a)** Carpentras, **(b)** Dakar and **(c)** Lille in 2016. Opaque colors represent daylight data. The black line and right *y* axis correspond to the phase angle evolution in this period.

Nocturnal Aerosol Optical Depth Measurements with a Small-Aperture Automated Photometer Using the Moon as a Light Source

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(Manuscript received 18 November 2010, in final form 5 April 2011)

ABSTRACT

A method is described that enables the use of lunar irradiance to obtain nighttime aerosol optical depth (AOD) measurements using a small-aperture photometer. In this approach, the U.S. Geological Survey lunar calibration system was utilized to provide high-precision lunar exoatmospheric spectral irradiance predictions for a ground-based sensor location, and when combined with ground measurement viewing geometry, provided the column optical transmittance for retrievals of AOD. Automated multiwavelength lunar measurements were obtained using an unmodified Cimel-318 sunphotometer sensor to assess existing capabilities and enhancements needed for day/night operation in NASA's Aerosol Robotic Network (AERONET). Results show that even existing photometers can provide the ability for retrievals of aerosol optical depths at night near full moon. With an additional photodetector signal-to-noise improvement of 10–100, routine use over the bright half of the lunar phase and a much wider range of wavelengths and conditions can be achieved. Although the lunar cycle is expected to limit the frequency of observations to 30%–40% compared to solar measurements, nevertheless this is an attractive extension of AERONET capabilities.

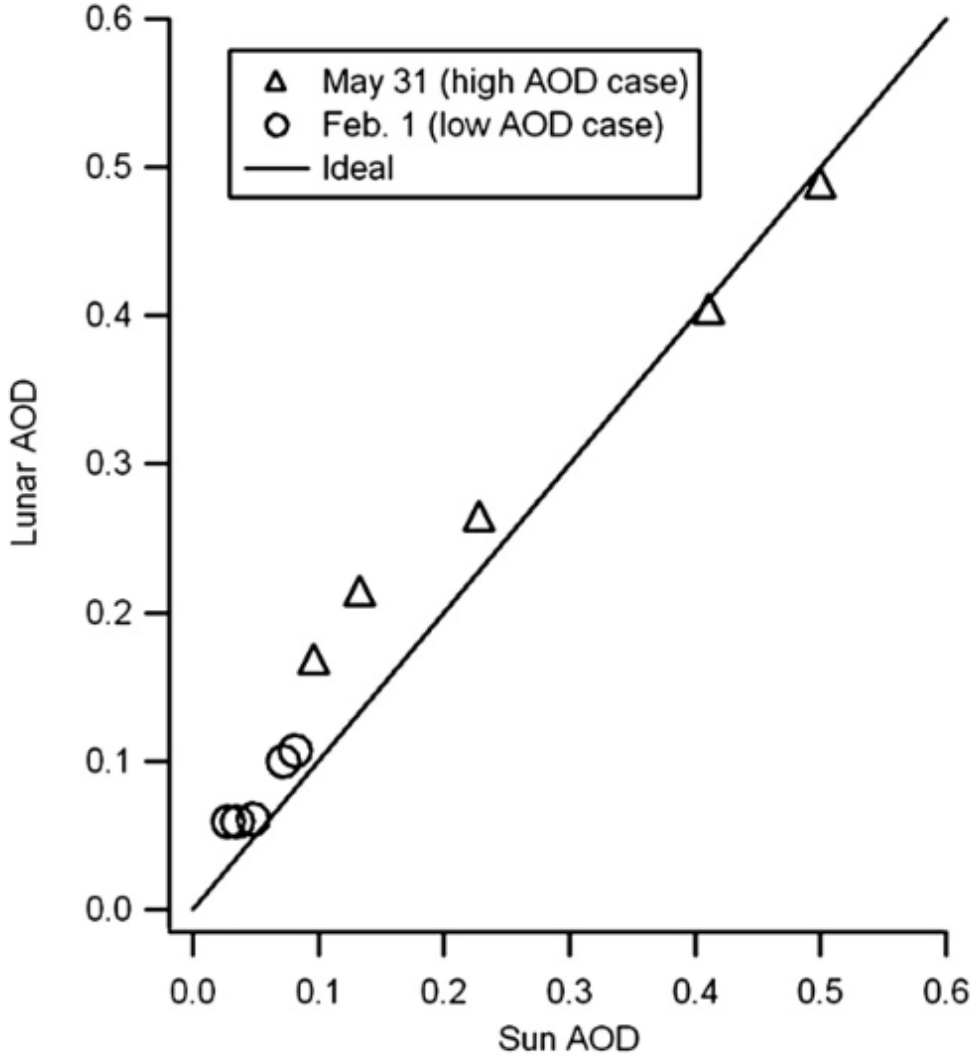


FIG. 8. Correlation plot of AOD lunar values closest in time to AOD solar values for 31 May high-AOD case (triangles) and 1 Feb low-AOD case (circles).

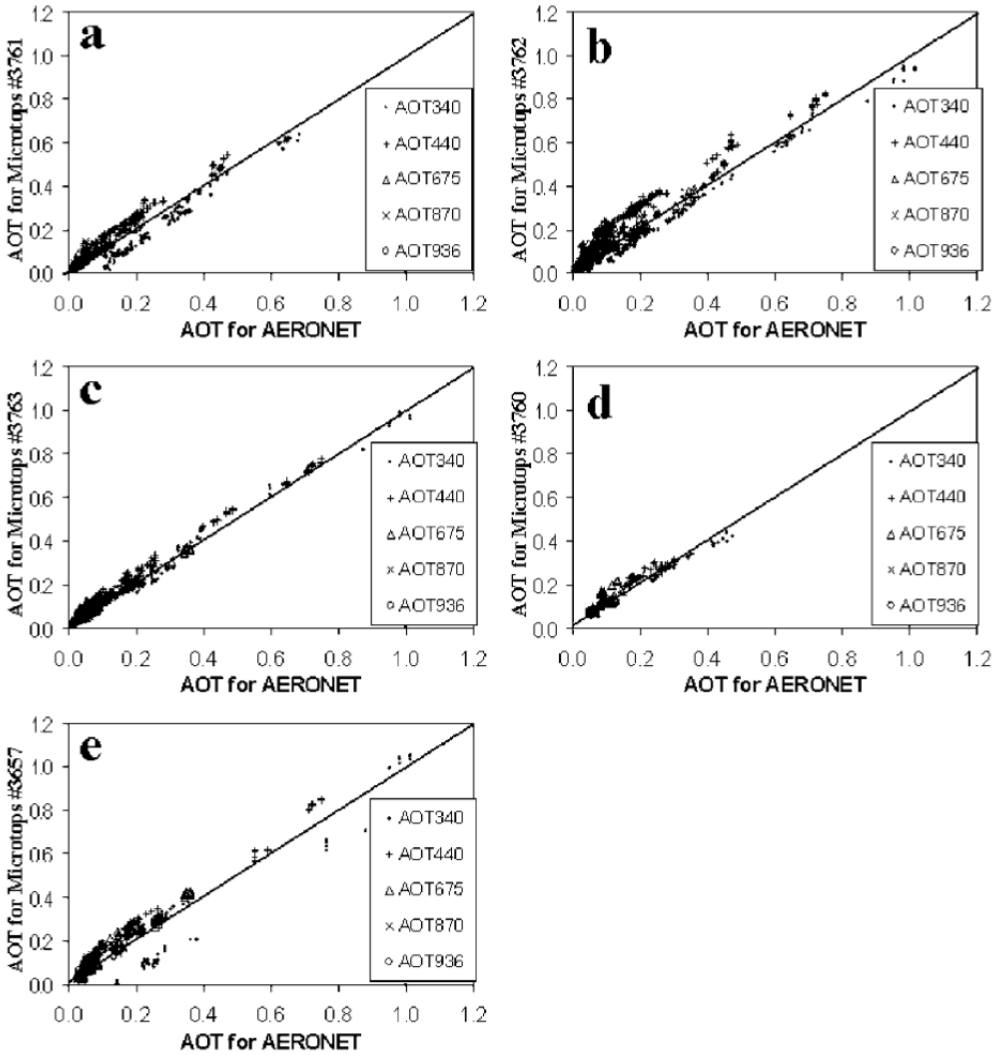
A me al depth
(AOD) ey lunar
calibrat edictions
for a gr try, pro-
vided tl ar mea-
surem pabilities
and enl ONET).
Results depths at
night n utine use
over the chieved.
Althou l to solar
measur

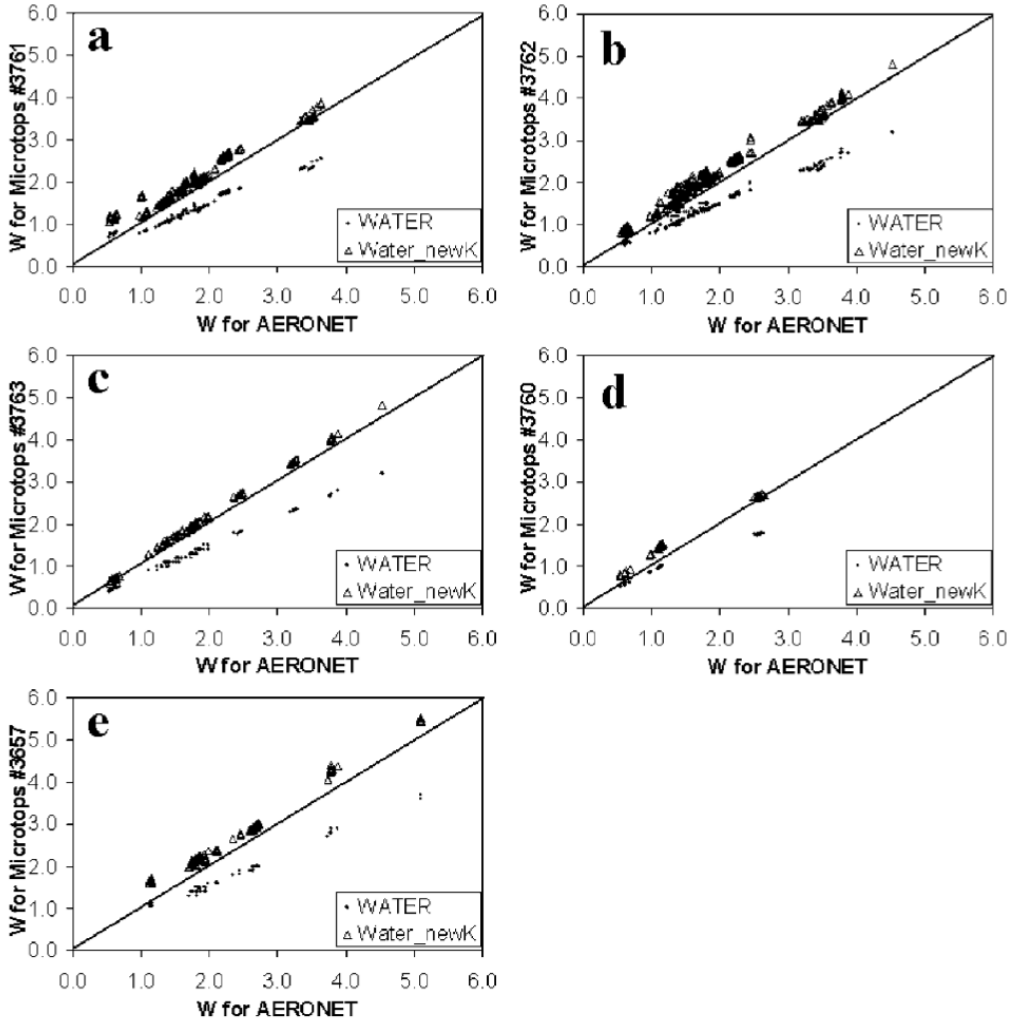
Sun Microtops II photometers

OPTICAL CHANNELS	STRAY LIGHT
340 ± 0.3nm, 2nm FWHM	340nm: 1E-6 <650nm; 1E-5 <1.0µm
380 ± 0.4nm, 4nm FWHM	380nm: 1E-6 <650nm; 1E-5 <1.0µm
440 ± 1.5nm, 10nm FWHM	440nm: 1E-5 <1.0µm
500 ± 1.5nm, 10nm FWHM	500nm: 1E-6 <1.1µm; 1E-5 <1.2µm
675 ± 1.5nm, 10nm FWHM	675nm: 1E-6 <1.1µm; 1E-5 <1.2µm
870 ± 1.5nm, 10nm FWHM	870nm: 1E-6 <1.1µm; 1E-5 <1.2µm
936 ± 1.5nm, 10nm FWHM	936nm: 1E-6 <1.1µm; 1E-5 <1.2µm
1020 ± 1.5nm, 10nm FWHM	1020nm: 1E-6 <1.1nm; 1E-5 <1.2µm

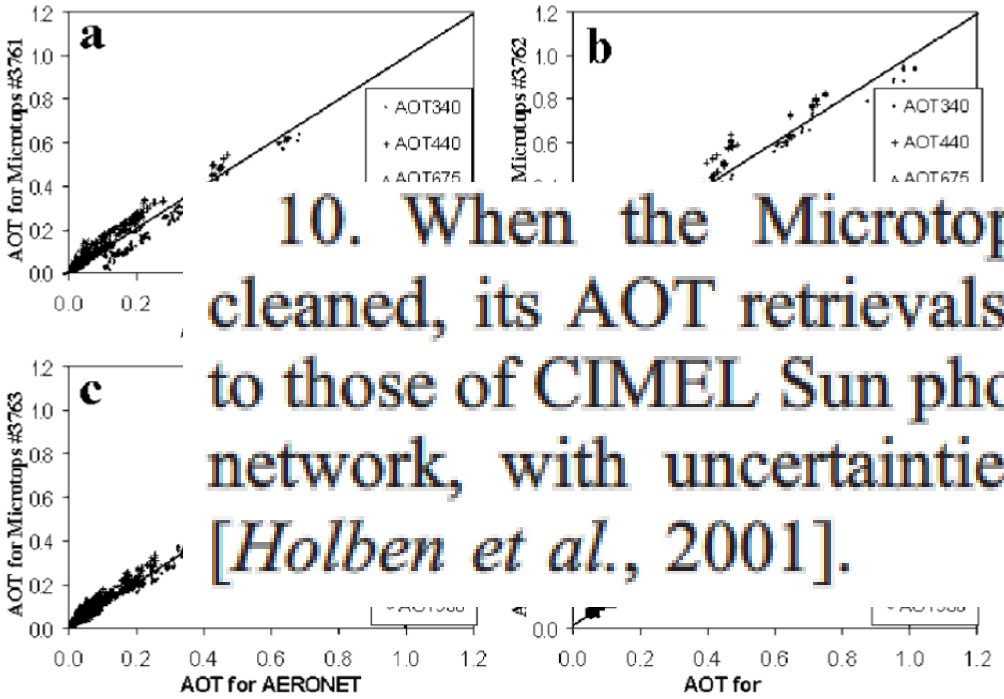
SPECIFICATIONS	
Resolution	0.01W/cm^2 on 305nm Channel
Dynamic Range	>300,000
Viewing Angle	2.5°
Precision	1-2%
Non-linearity	max 0.002% FS
Operating Environment	0 to 50°C, No Precipitation
Computer Interface	RS232 / USB with Adapter
Power Source	4xAA Alkaline Batteries
Weight	21 oz. (600 grams)
Size	4”W x 8”H x 1.7”D (10x20x4.3 cm)

Sun Microtops II performance (relative to AERONET)

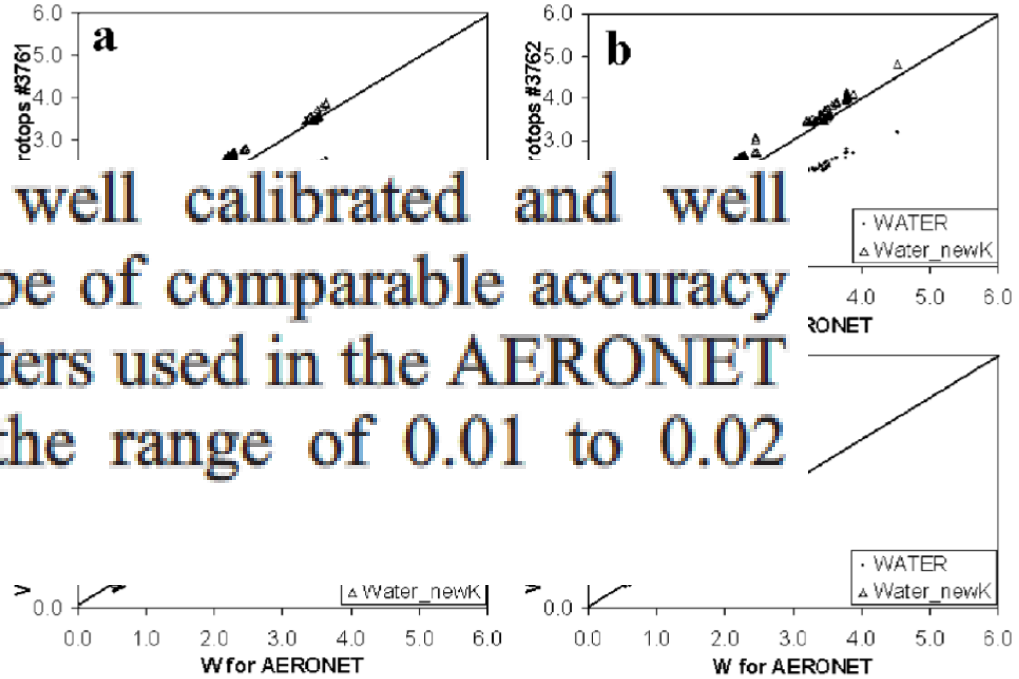




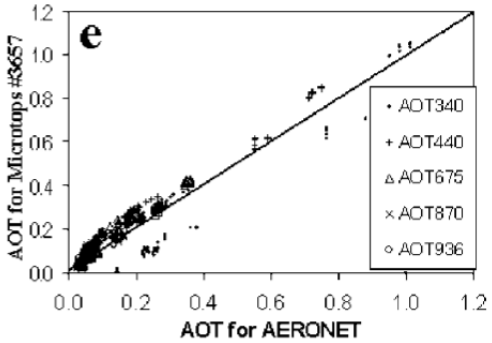
Sun Microtops II performance (relative to AERONET)

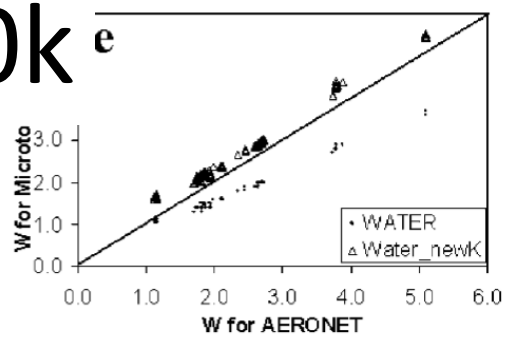


10. When the Microtops is well calibrated and well cleaned, its AOT retrievals can be of comparable accuracy to those of CIMEL Sun photometers used in the AERONET network, with uncertainties in the range of 0.01 to 0.02 [*Holben et al.*, 2001].

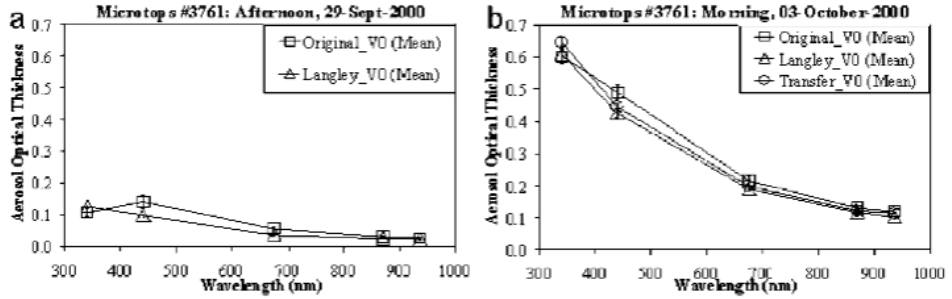


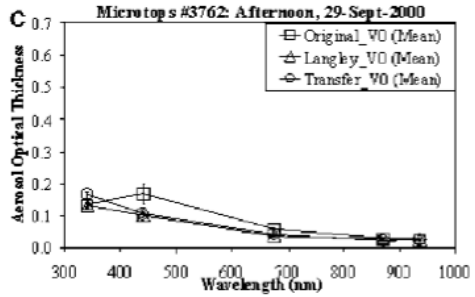
Price: 10k

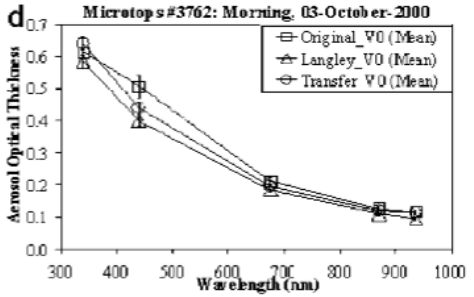


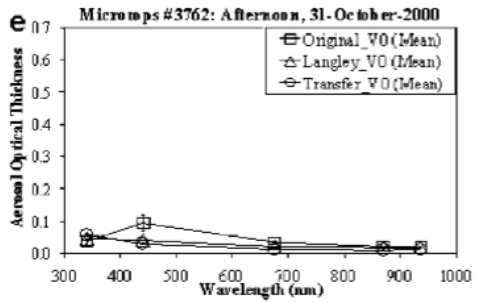


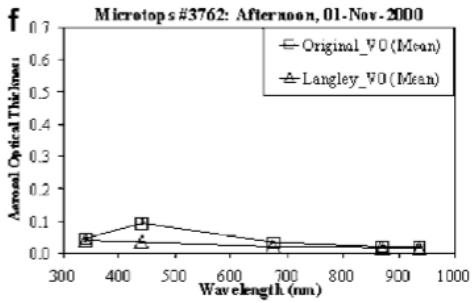
Calibration with(out) AERONET

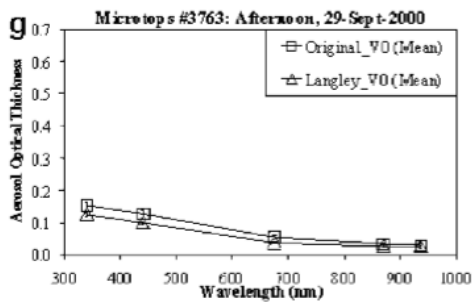












LHATPRO - Humidity And Temperature PROfilers

One being installed at La Silla (?) by NISTStars crew (S. Deustua et al.)

- vertical profiles of atmospheric temperature
- vertical profile of atmospheric humidity (relative and absolute humidity)
- Liquid Water Path (LWP)
- Integrated Water Vapor (IWV)

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Only $250K!

ater Path (LWP)

- Integrated Water Vapor (IWV)
- wet delay
- dry delay
- stability indices

General notes on aerosol/atmosphere stuff (non-exhaustive list)

- Auxiliary/external aerosol/PWV monitoring equipment? Worth investing in?
  - Can at worst provide priors for beginning of night atmo solutions
  - At best can predict which filters would be best to observe in that night + provide cross validation for AuxTel output
  - Eg., Microtops device is portable; can be taken to Hawaii/Blanco/wherever to test calibration w/ other survey data --> close the loop on an external system
- Wavelength solutions(!)
- Target selection + cadence (Augustin working on?)
- Empirical vs theoretical atmospheres?
- If not doing ratios (which only give stability), how will we monitor AuxTel throughput? Need to measure at least once.
  - Possible to put a starDICE-like LED-head w/ collimator on dome of AuxTel to make a Frankenstein's monster version of CBP+starDICE?