Aerosol Optical Properties and Biogenic SOA: Effect on Hygroscopic Properties and Light Absorption

Andrey Khlystov (DRI), R. Subramanian (CMU)

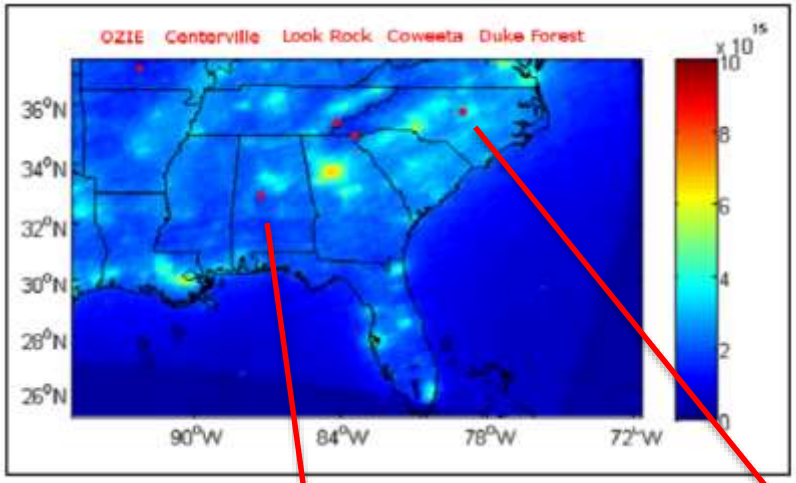
Antonis Tasoglou, Spyros Pandis (CMU),

Provat Saha , Andrew Grieshop (NCSU),

Amara Holder, Mike Hays, John Walker (EPA)

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant # 83541101

Two field measurement campaigns



NO2 column density from OMI averaged for summer of 2010,derived using techniques described in Russell et al. (2010)

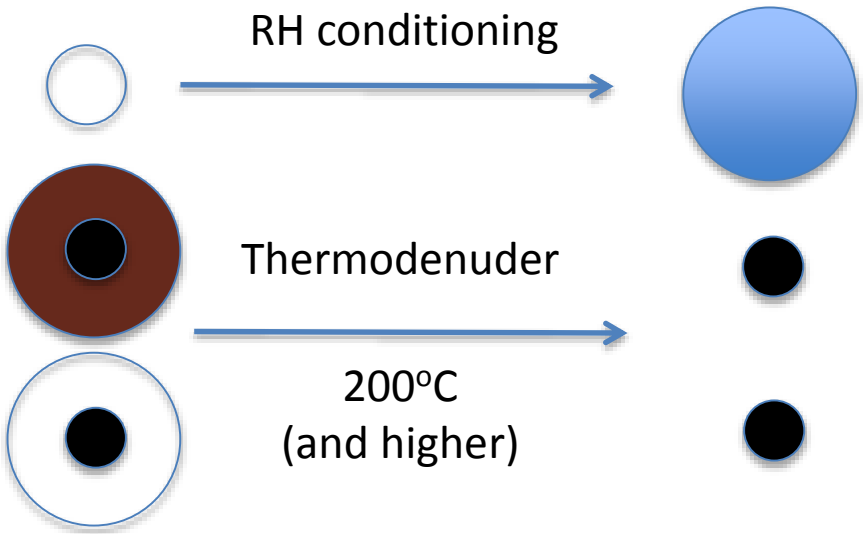
- Two SE US sites characterized by different degrees of biogenic and anthropogenic influence
- Investigate influence of organic aerosol on aerosol optical properties

Centerville, AL, 1 June – 15 July 2013

Duke Forest (Chapel Hill, NC), 30 May – 26 June 2015

Science questions / approach

- What is bSOA contribution to hygroscopic growth and light scattering
- What is bSOA contribution to light absorption
  - Brown carbon
  - "Lensing" effect



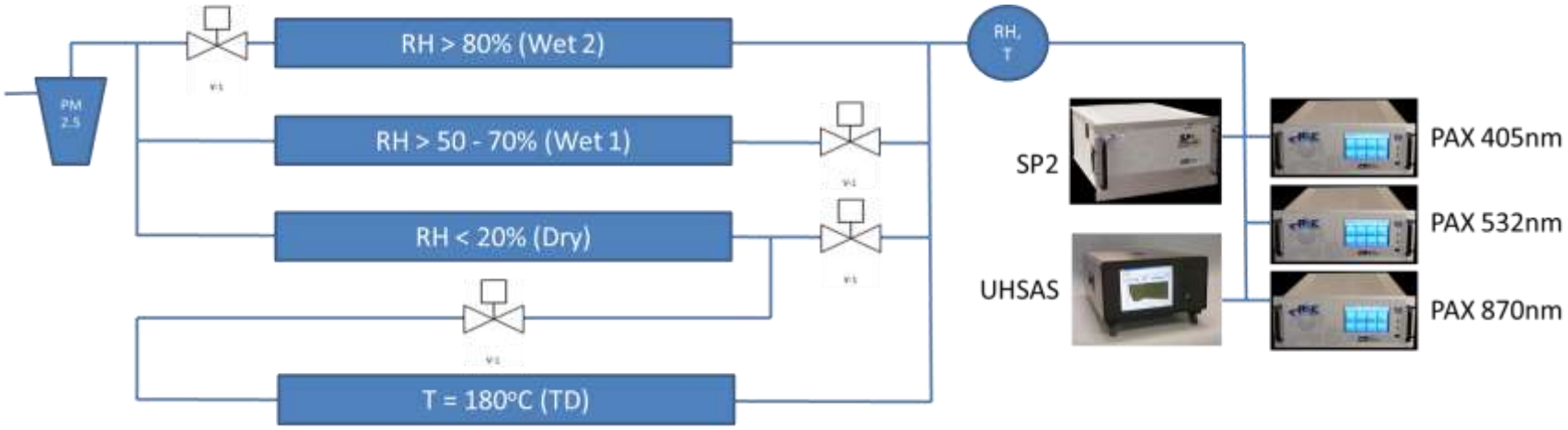
Measurements at 3 wavelengths:

Contribution to hygroscopic growth and light scattering, $B_{scat}(RH)$

Contribution to light absorption:

- Brown carbon (also from wavelength dependence of B_{abs})
- Lensing effect ($B_{abs,coated} > B_{abs,\ not\text{-}coated}$)

Measurement setup during SOAS



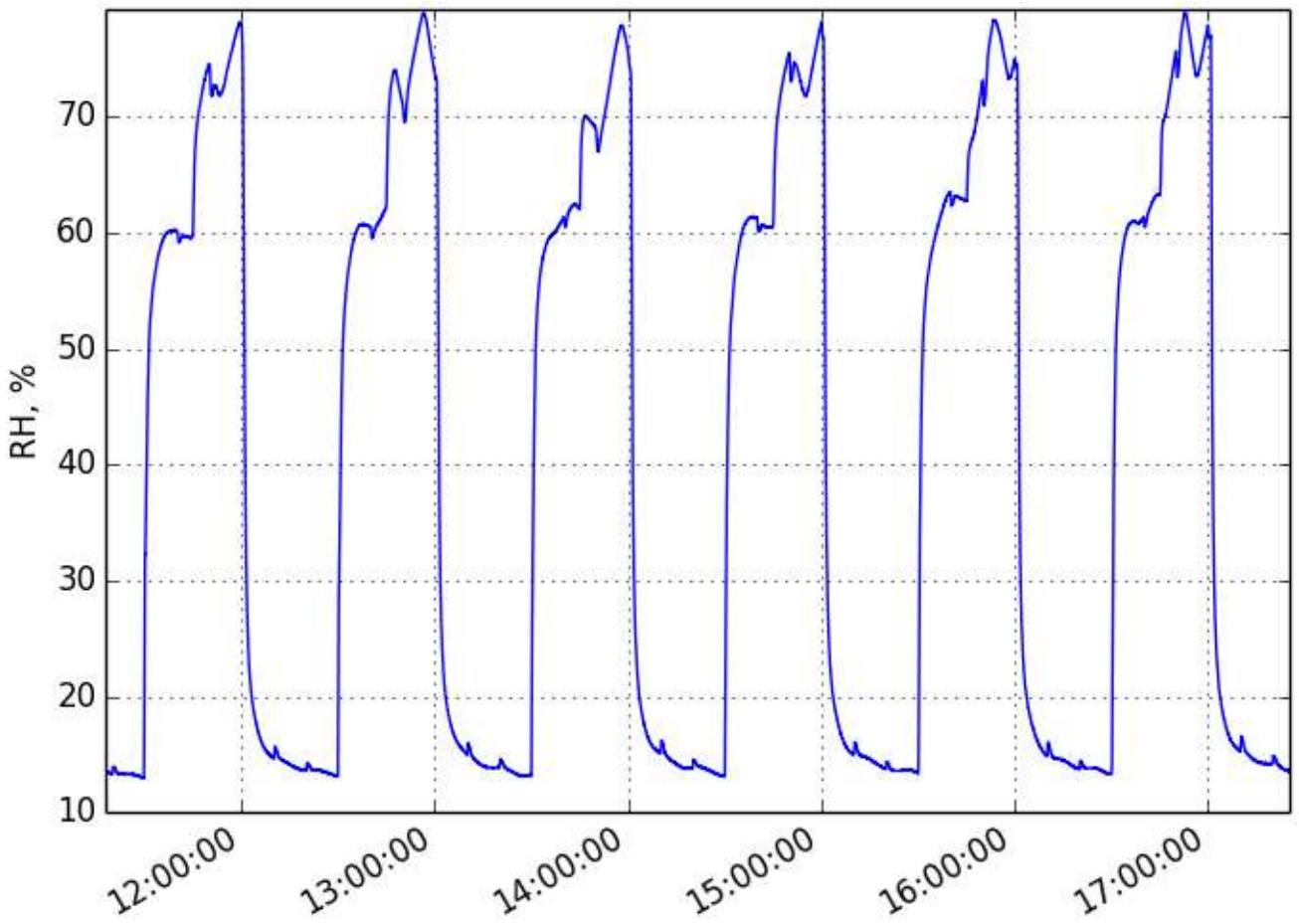
RH and temperature conditioning:

- "Dry" line: < 20% RH
- "Intermediate" line: ~60-70% RH
- "High RH" line: > 85% RH
- Thermodenuder (TD): 180 C or scanning
- Lines are switched every 15 min

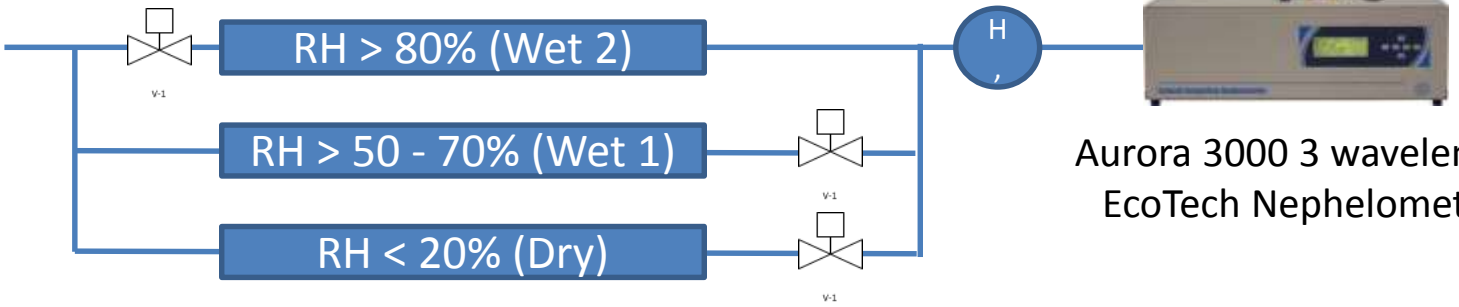
Measured parameters:

- Aerosol scattering and absorption at 405nm, 532nm, 870nm
- Single particle black carbon and coating thickness
- Particle size distribution above 70nm (only in July)

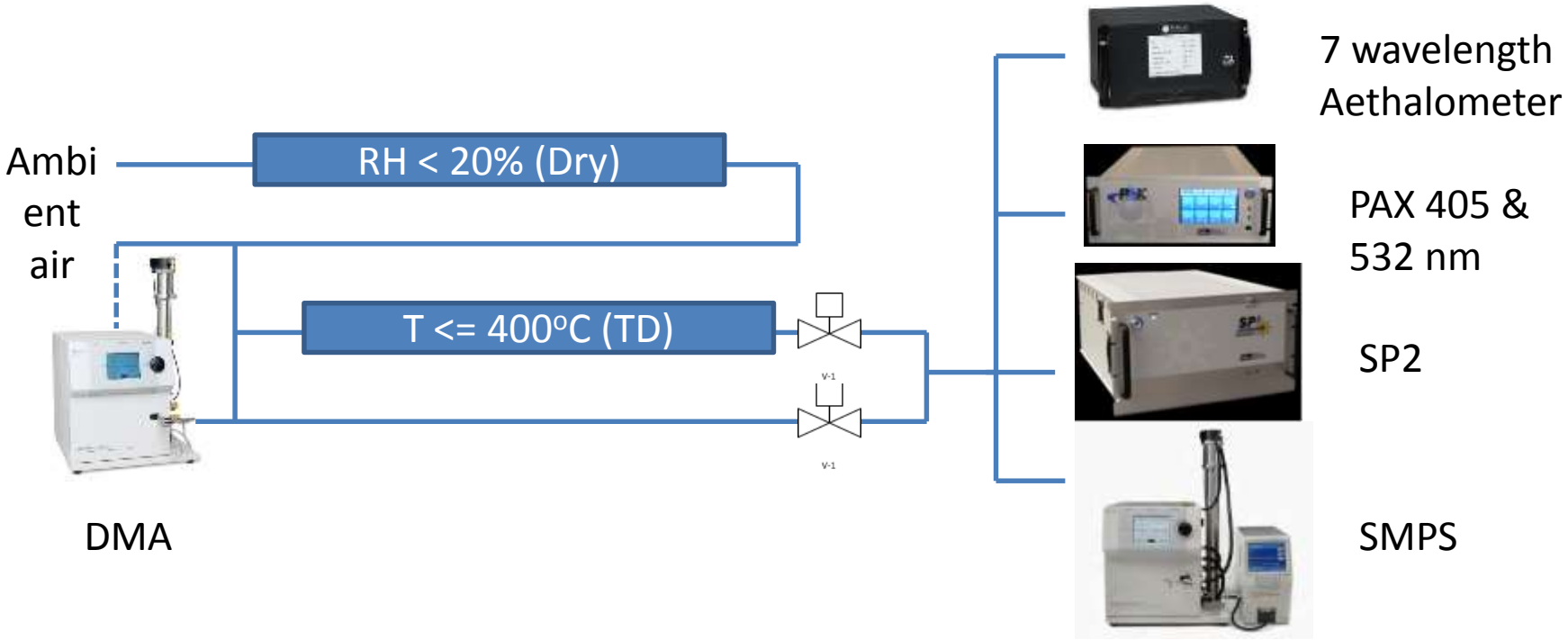
Relative humidity cycles



Measurement setup (Duke Forest)



Aurora 3000 3 wavelength
EcoTech Nephelometer



7 wavelength
Aethalometer

PAX 405 &
532 nm

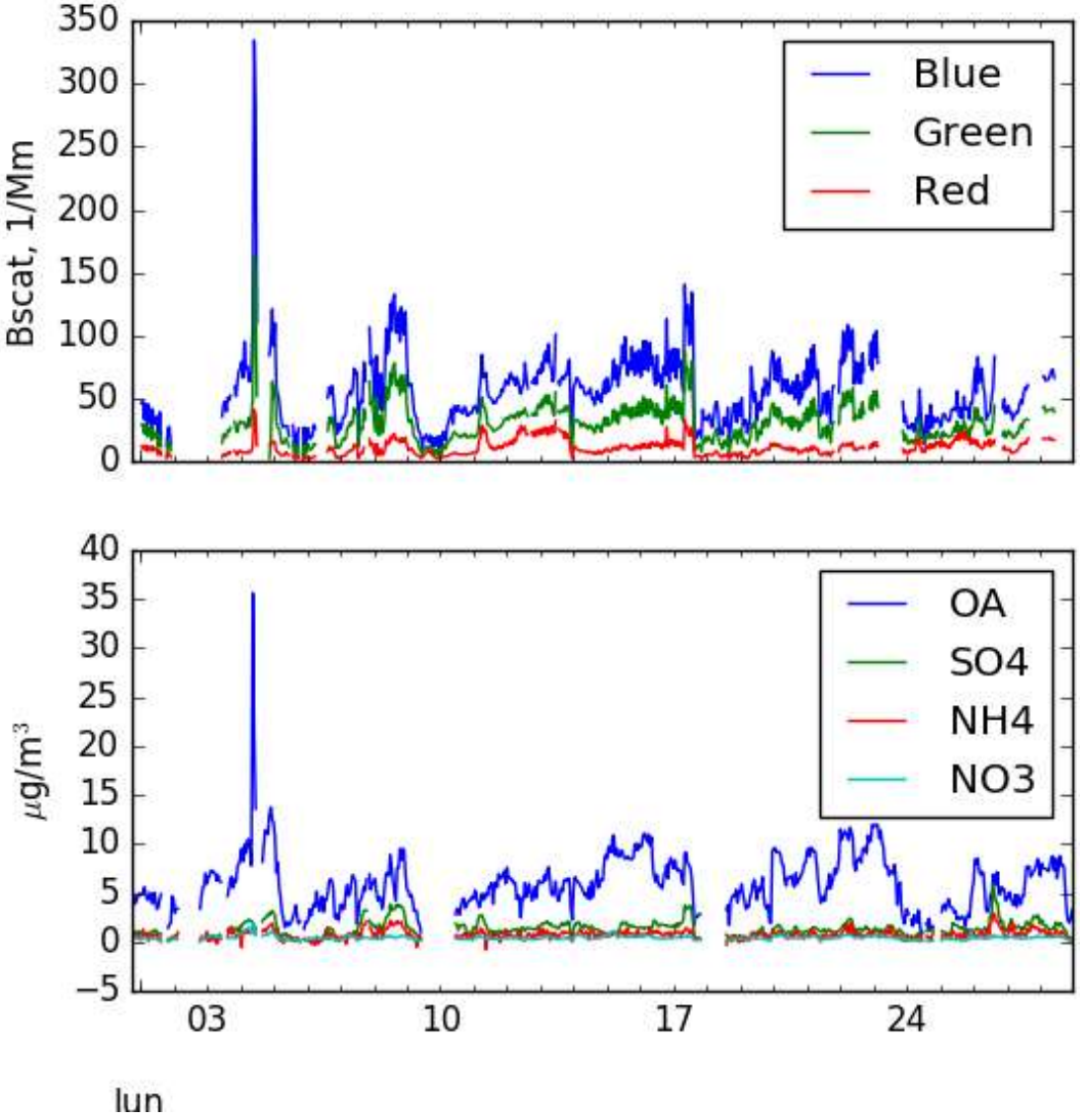
SP2

SMPS

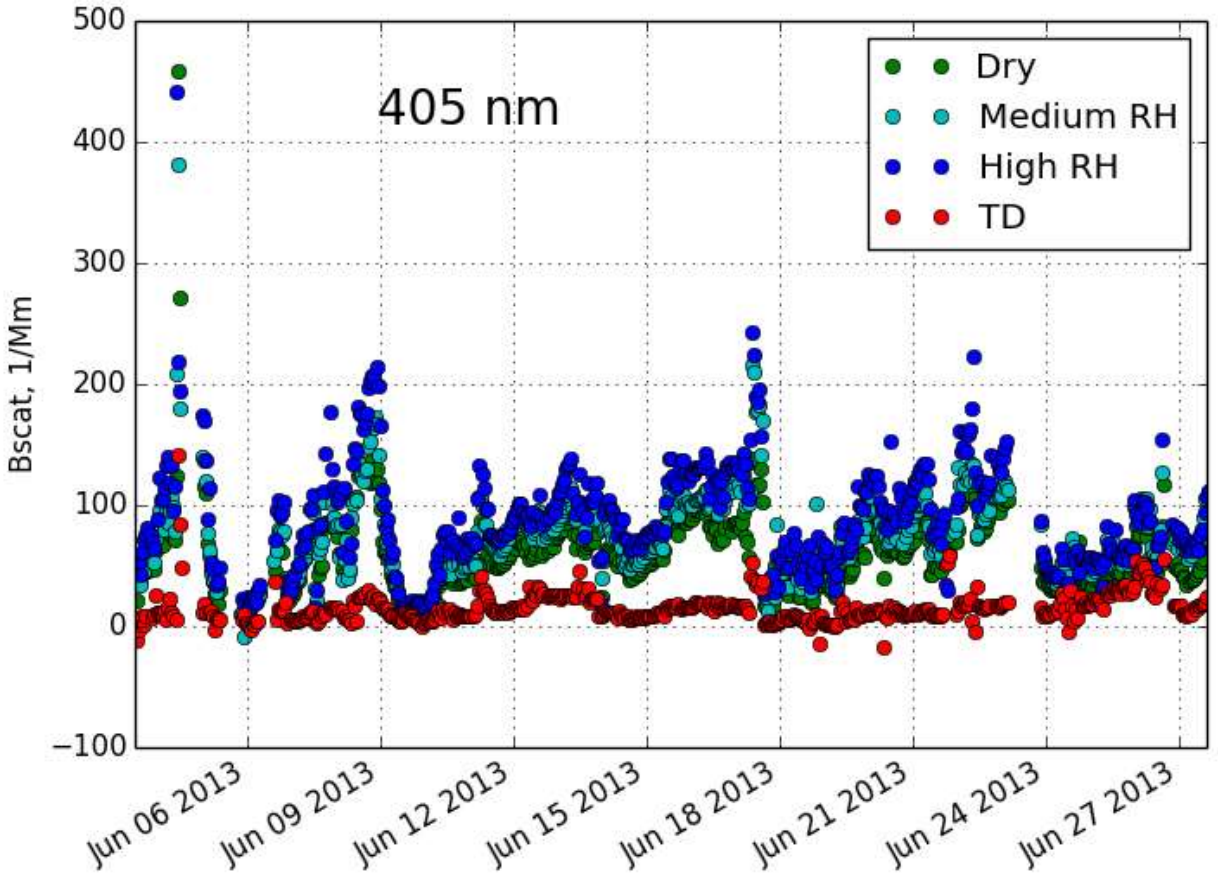
DMA

Centerville, AL
1 June – 15 July 2013

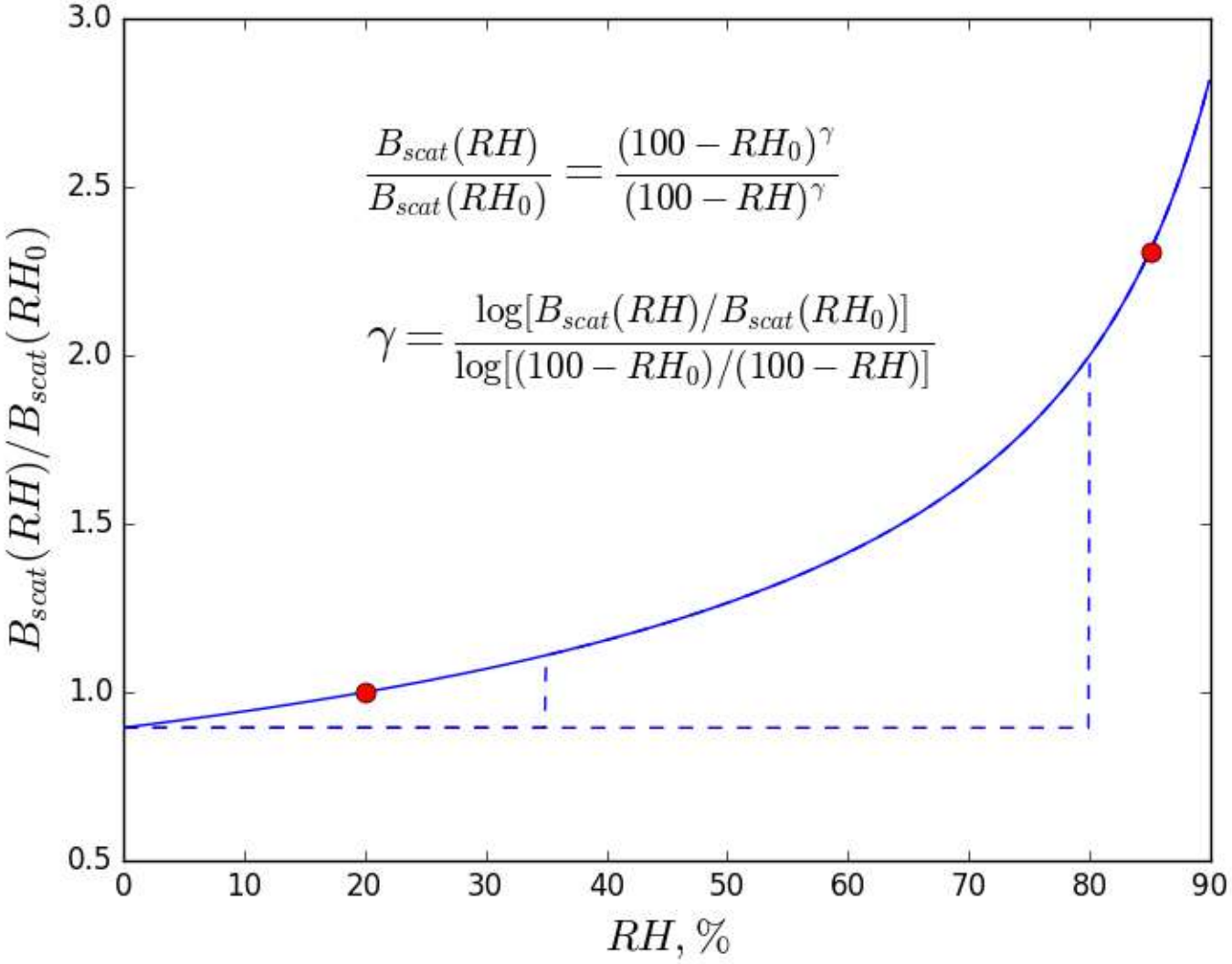
Dry scattering during SOAS



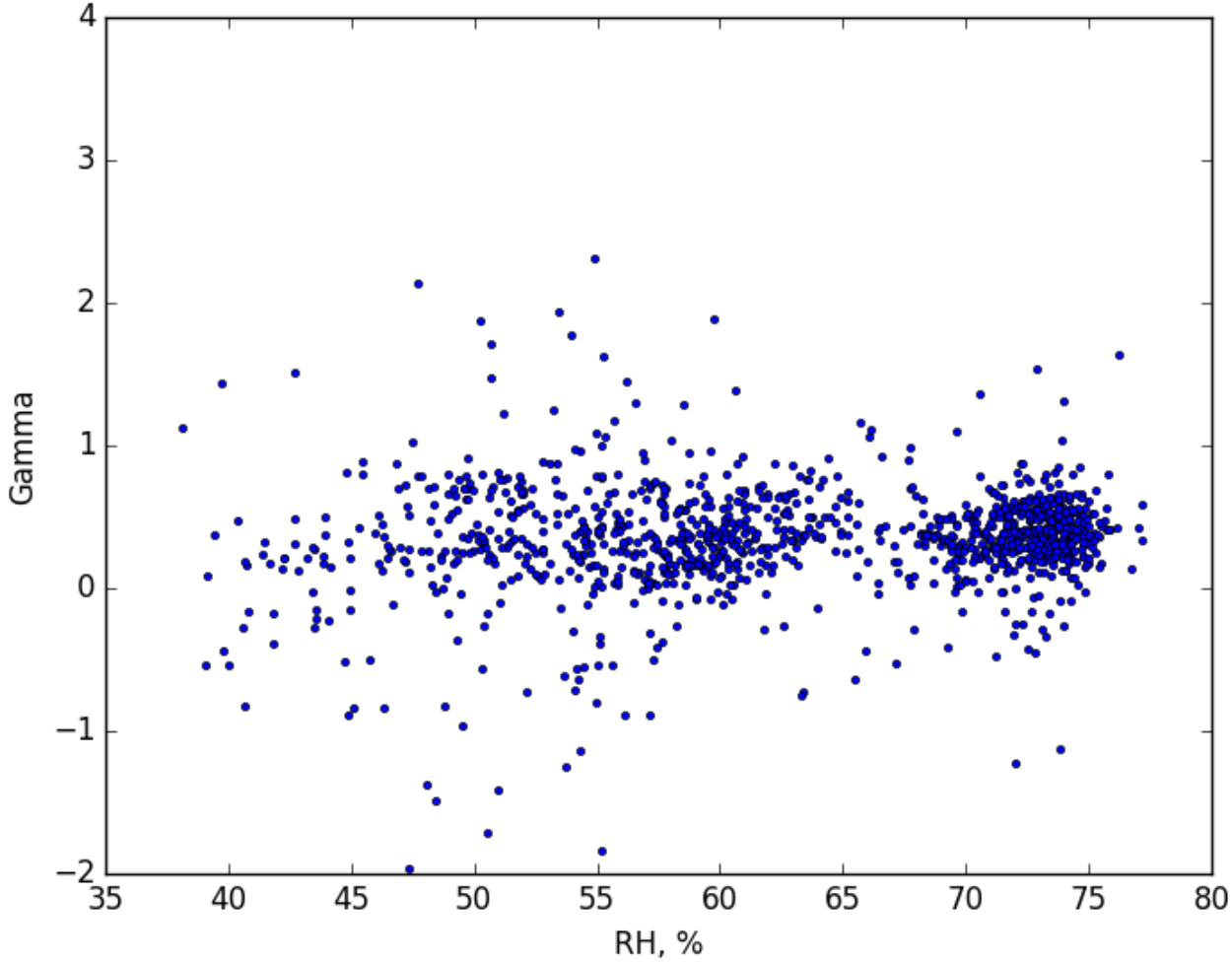
Scattering during different measurement cycles (SOAS)



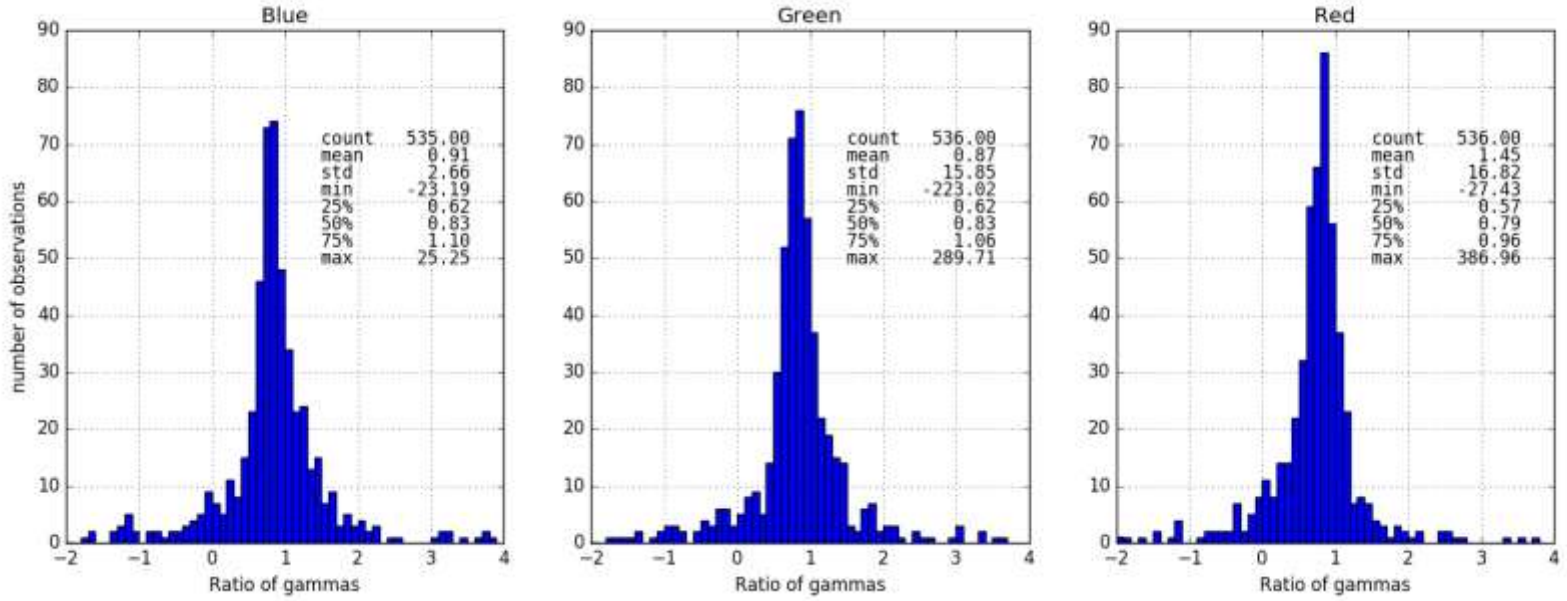
Effect of RH on light scattering



The aerosol is wet below 80% RH (upper hysteresis curve)

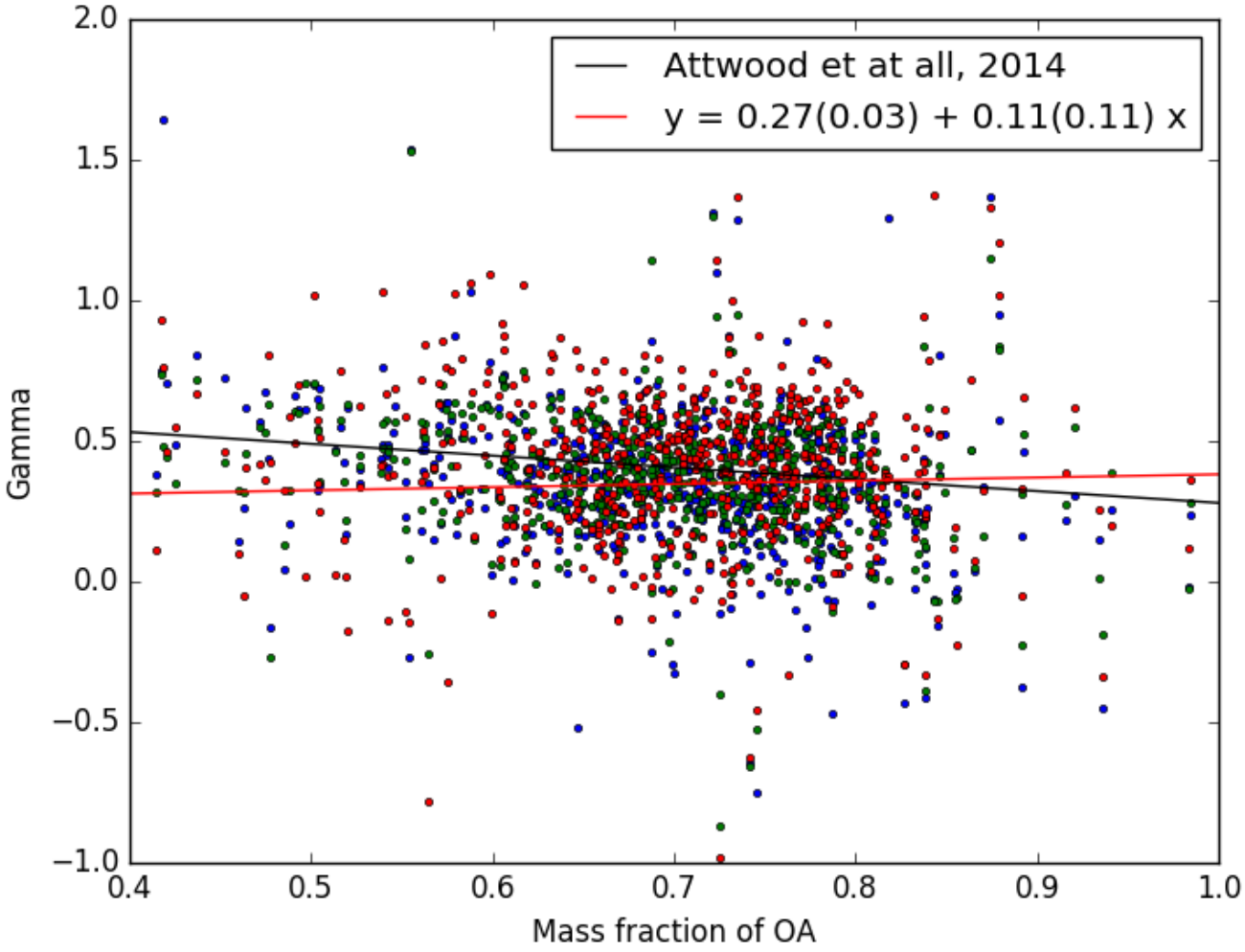


Gamma at “intermediate” RH is lower than at “high” RH



- The “intermediate” RH gamma is ~20% lower than “high” RH gamma.
- Could indicate partial deliquescence at either “intermediate” RH or that the gamma approximation does not work

Effect of OA on light scattering enhancement due to RH (SOAS)



“Dry” absorption from PAX (SOAS)

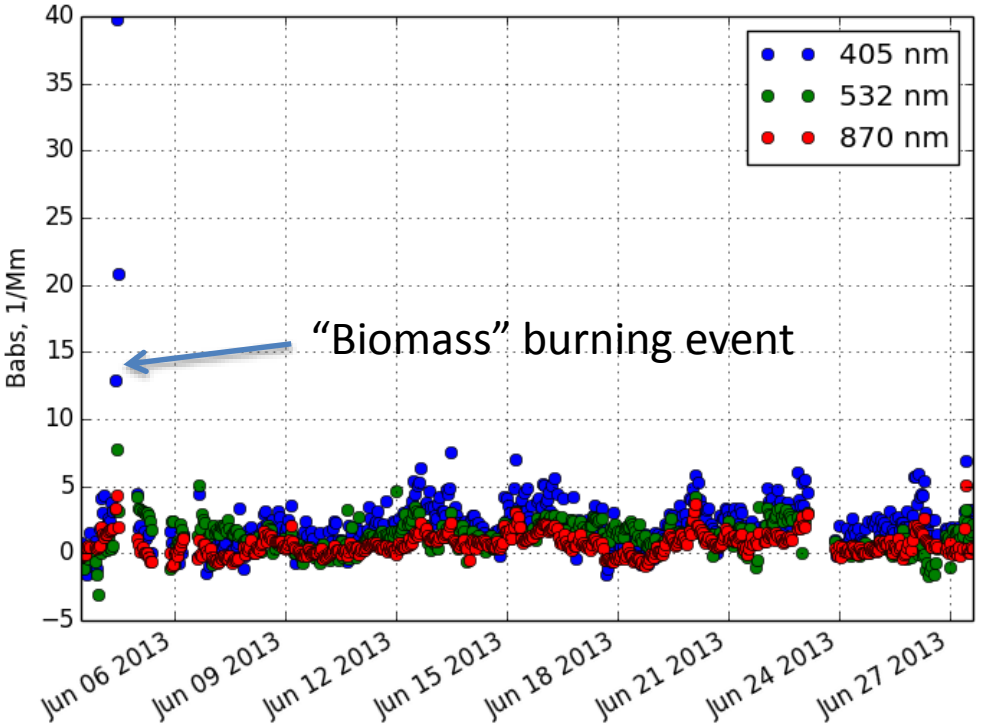
Very low light absorption:

Blue: 1.53 Mm^{-1}

Green: 0.35 Mm^{-1}*

Red: 0.49 Mm^{-1}

*Green PAX data unreliable (unstable laser power, background, etc.)

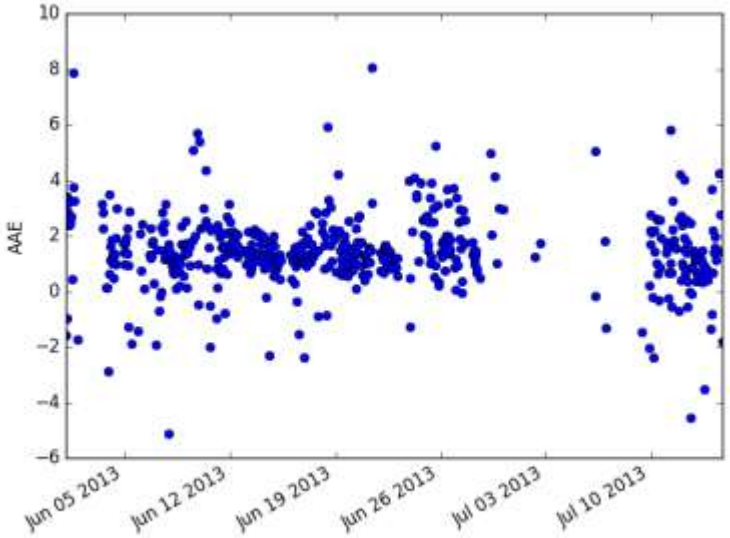


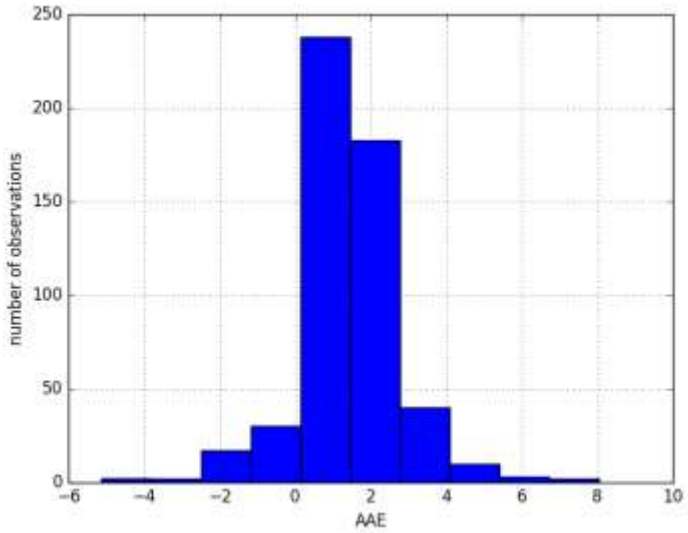
Angstrom Absorption Exponent during SOAS

- Defines dependence of B_{abs} on wavelength:

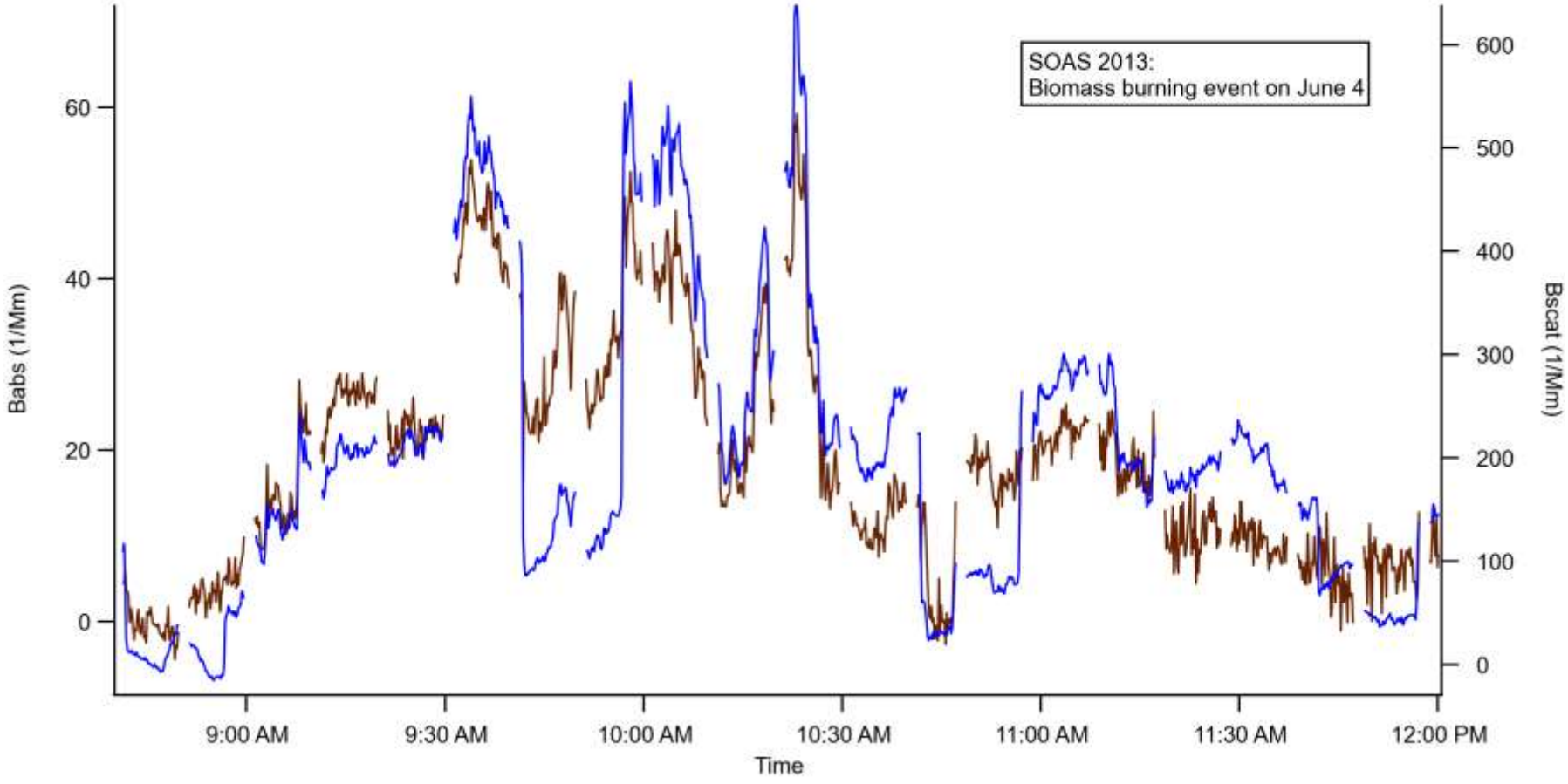
$$B_{abs,\lambda} \propto \frac{1}{\lambda^{\alpha}}$$

- Brown carbon is characterized by AAE > 2
- During SOAS average AAE = 1. 5 (blue/red)
- No clear indication of brown carbon

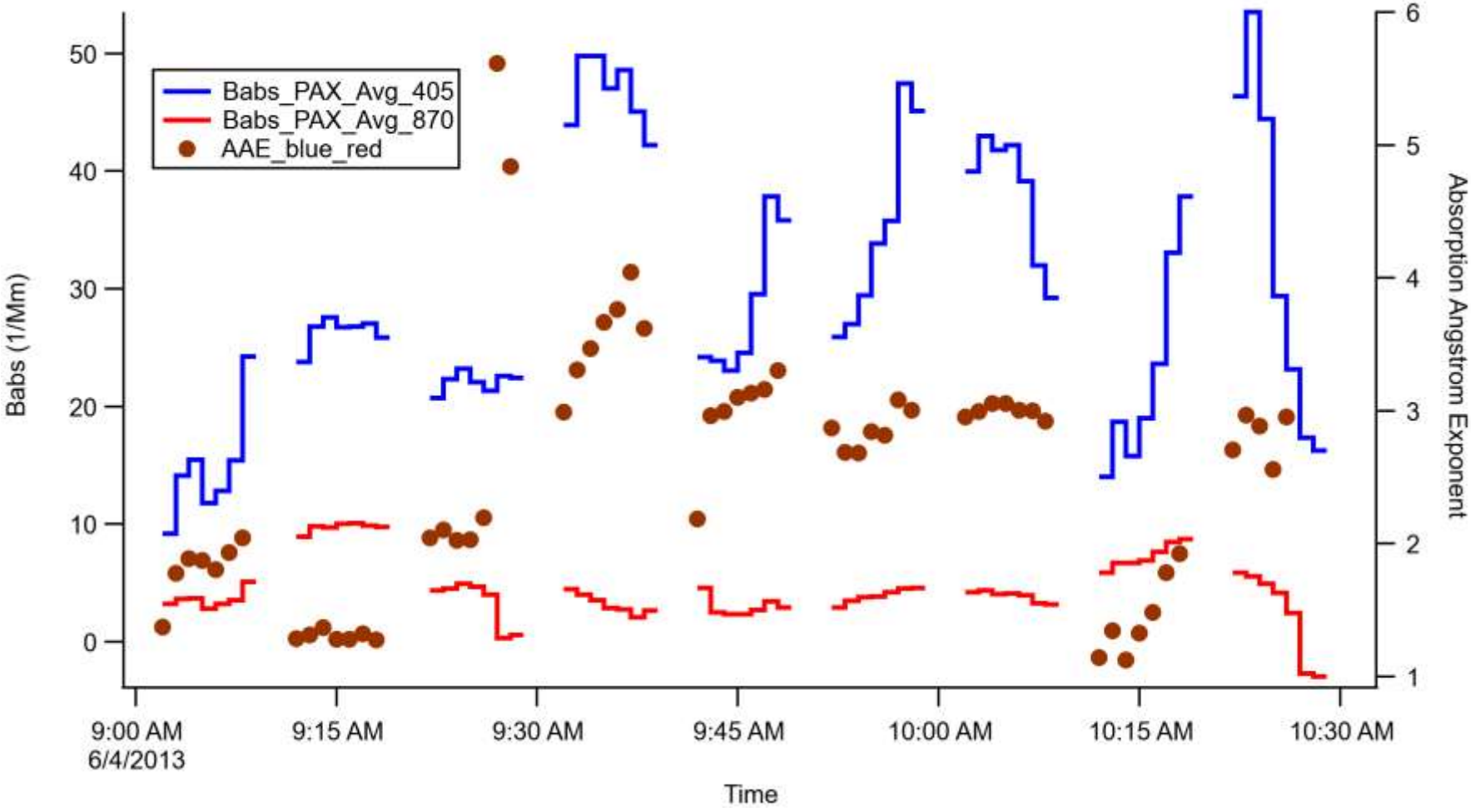




Biomass burning on 6/4/2013



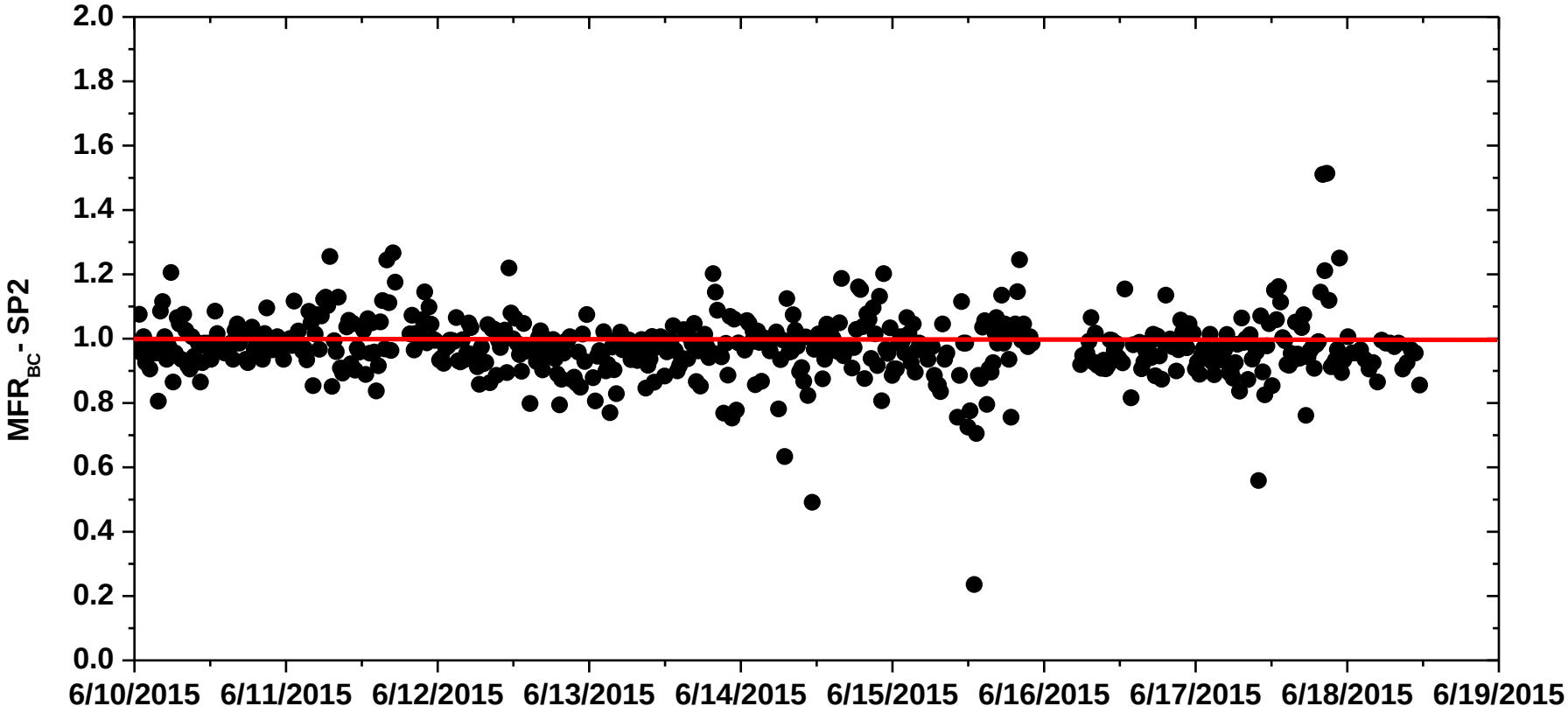
AAE during 6/4/13 event is about 3, indicating presence of brown carbon



Small particle losses in the TD

$$MFR_{BC} = \frac{BC_{,TD}(t-1) + BC_{,TD}(t+1)}{2 * BC_{,ambient}(t)}$$

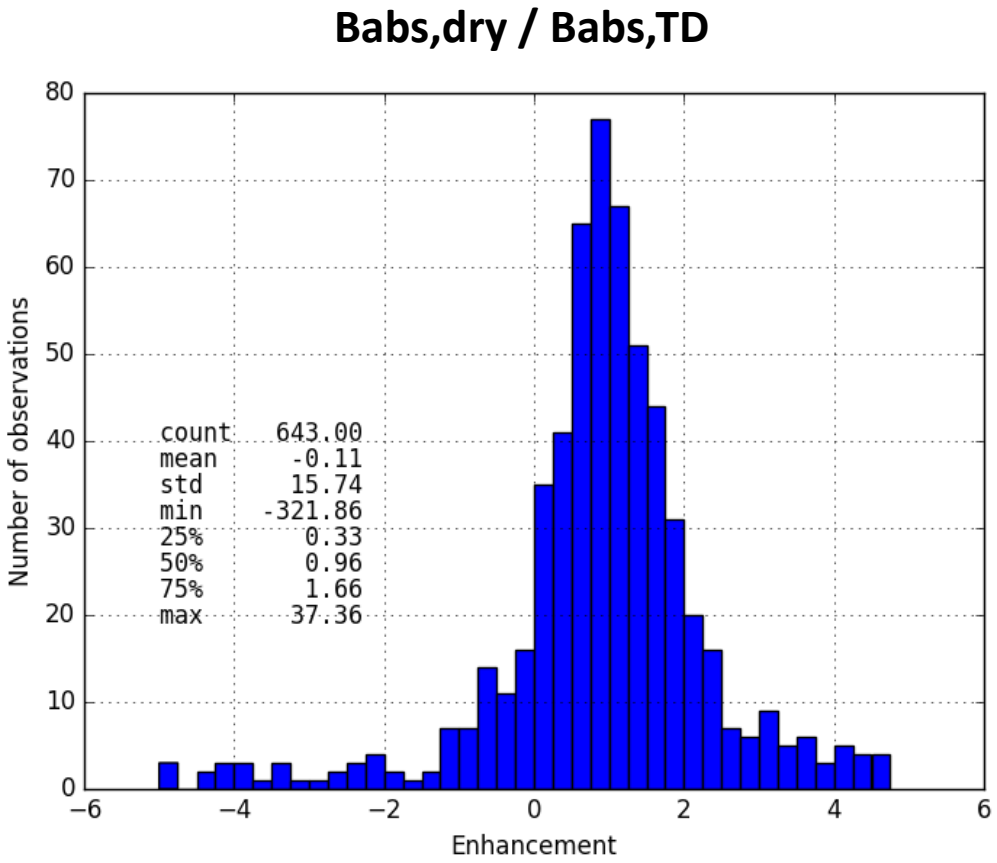
$MFR_{BC,\ avg}$= 0.97 ± 0.09



Contribution of semi-volatile species to light absorption (SOAS)

- Campaign-average B_{abs}:
  - Dry: 1.53 Mm^{-1}
  - TD: 1.21 Mm^{-1}
  - Suggests 26% enhancement

- Pairwise heated/dry measurements suggest that there is only 4% difference



Duke Forest (Chapel Hill, NC)
30 May – 26 June 2015

Data evaluation is in progress and not yet ready for sharing

Summary

- SOAS:
  - OA had small to positive effect on humidity enhancement of light scattering, though very uncertain.
  - With a few exceptions, no significant effect of OA on light absorption was observed (probably due to the very low absorption relative to uncertainties).
- Duke Forest:
  - Measurements are completed, data evaluation is in progress