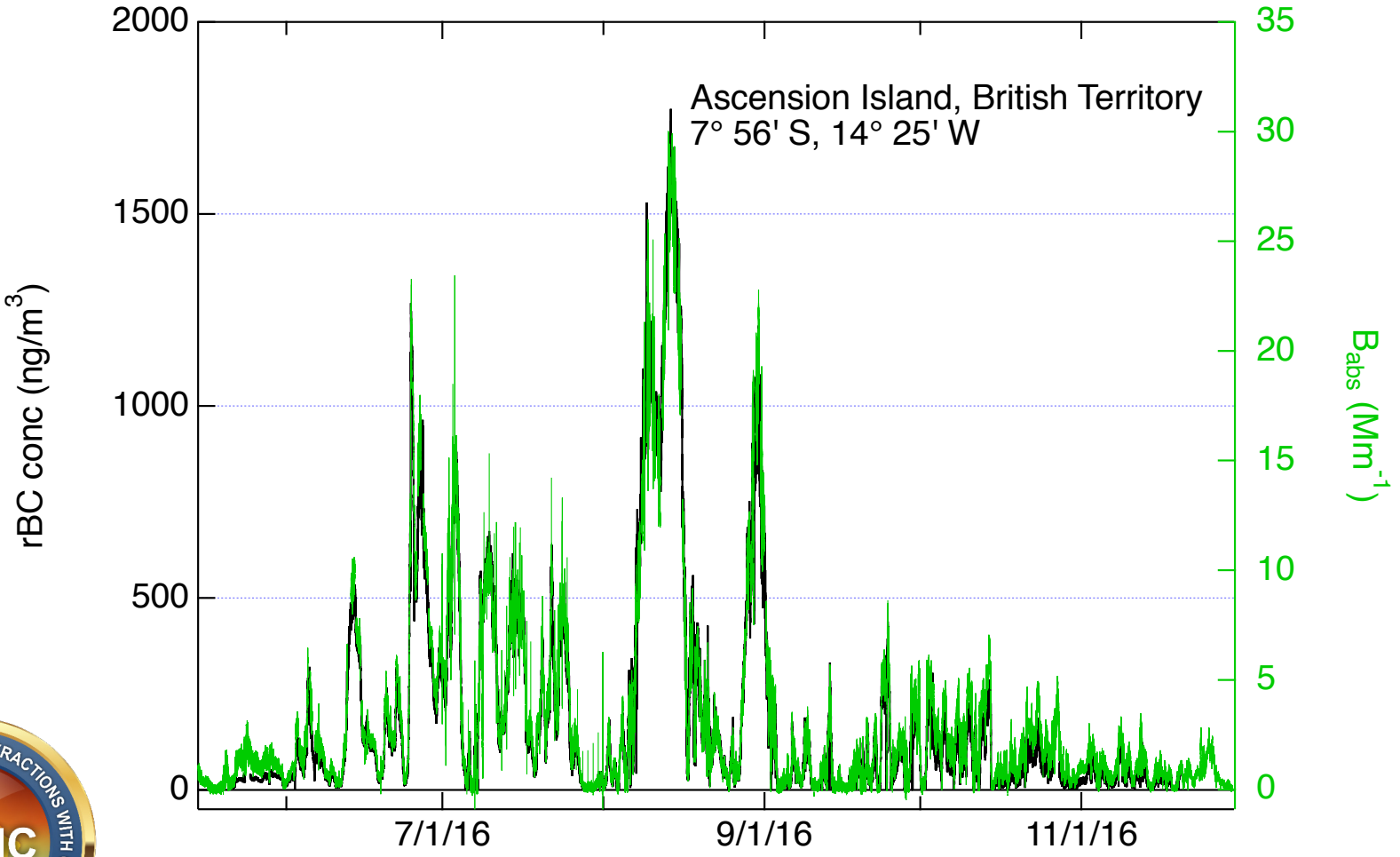
Refractory Black Carbon (rBC) Aerosol Loadings, and Particle Microphysical and Optical Properties

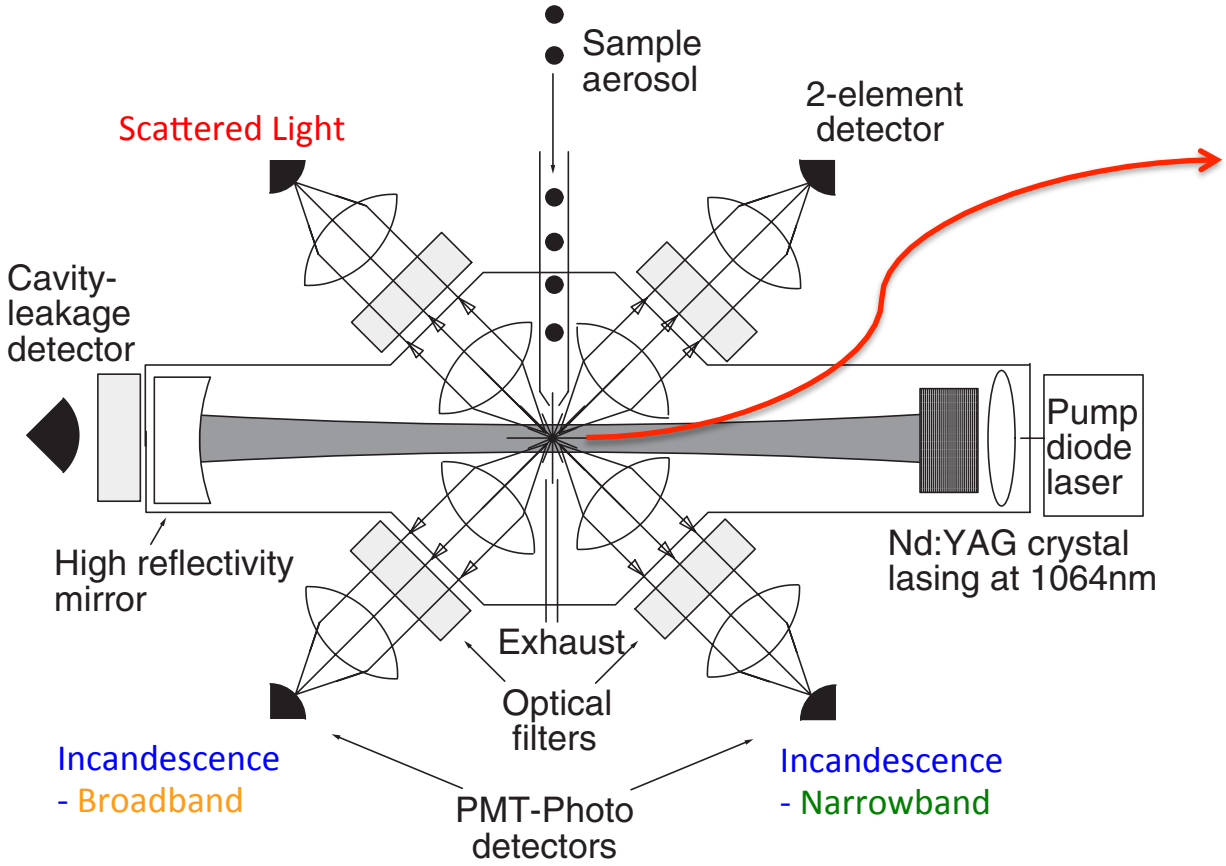
A. Sedlacek

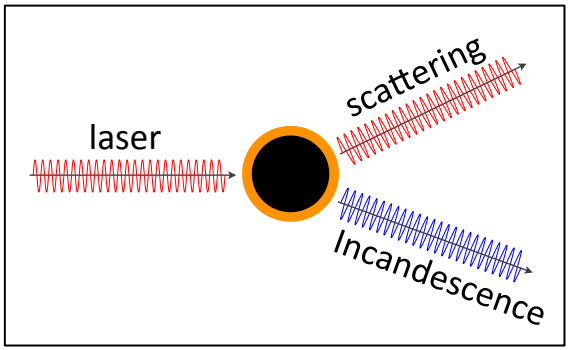


PSAP data – S. Springston

Single Particle Soot Photometer (SP2)

Probe refractory black carbon (rBC) using laser-induced incandescence





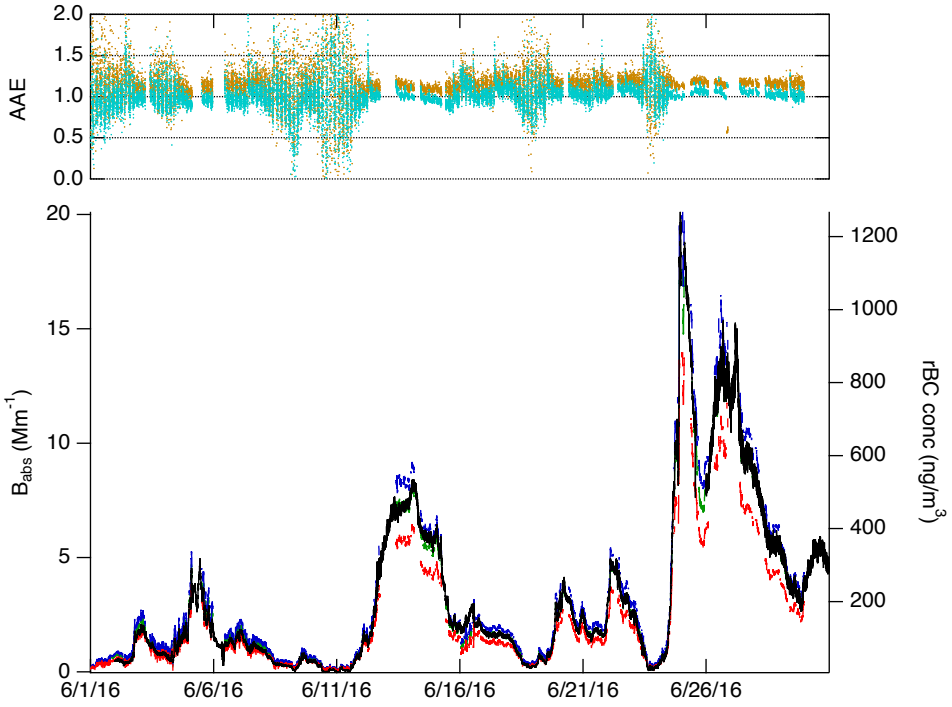
Schematic from
Schwarz et al., 2008

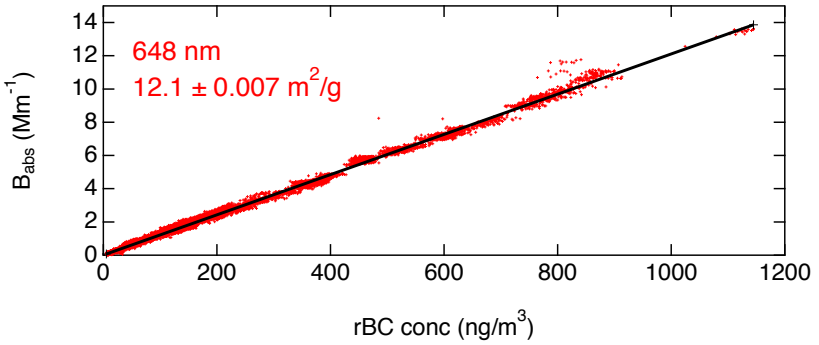
Mixing state probe:

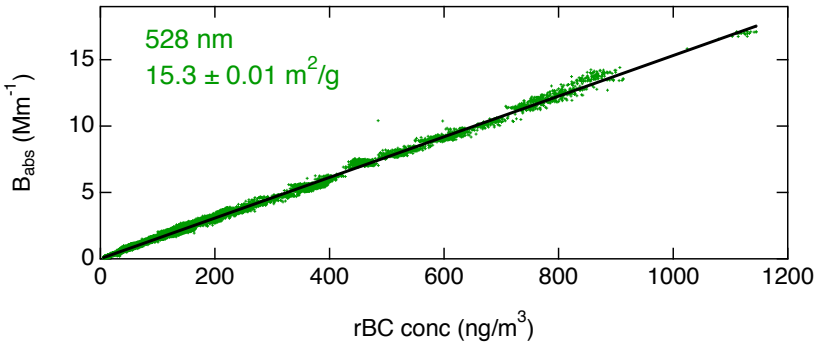
rBC-containing particle scattering & rBC particle incandescence

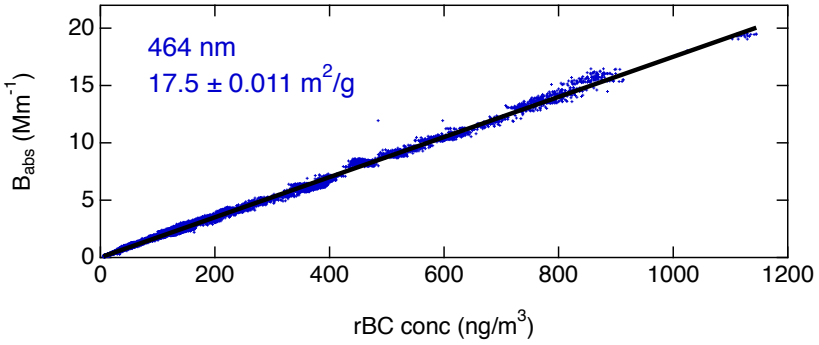
ASI Optical Properties – June 2016

Early in the BB Season





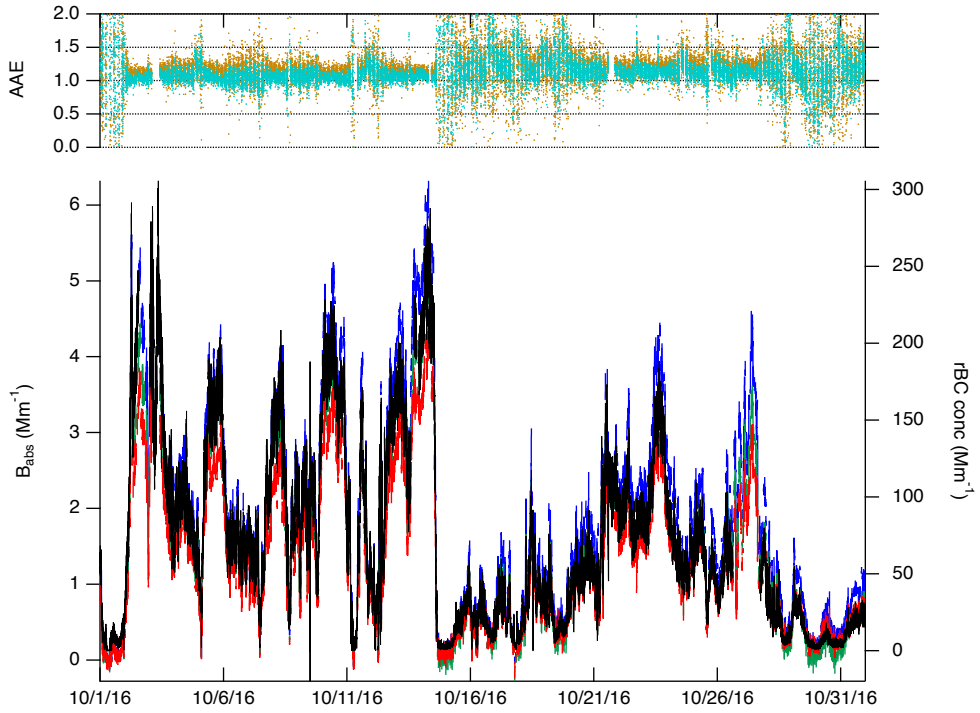


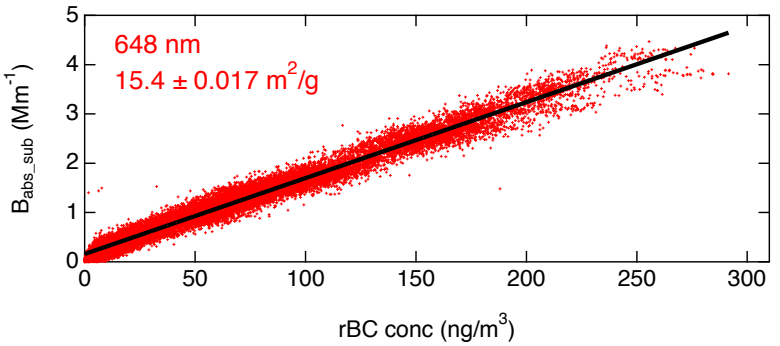


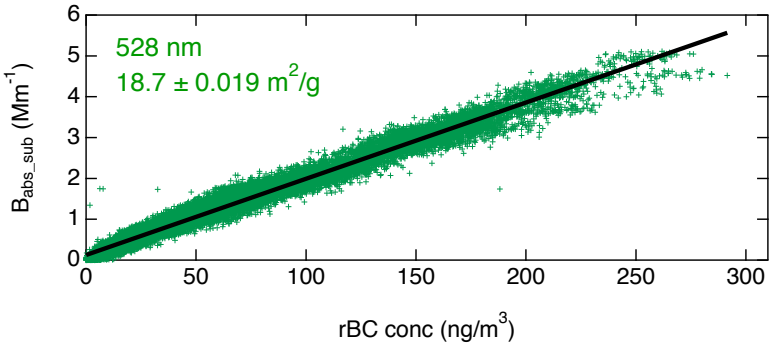
PSAP data – S. Springston

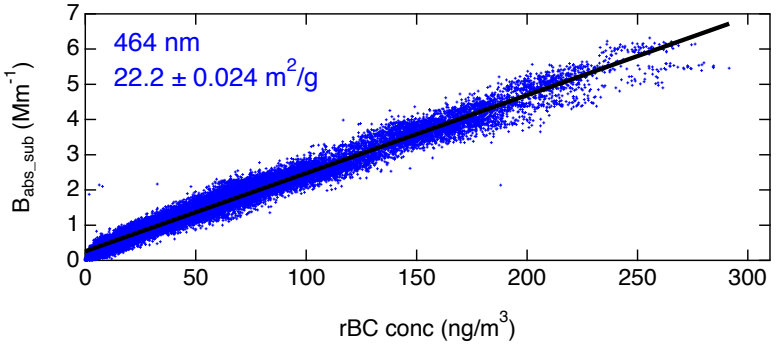
ASI Optical Properties – Oct 2016

Late in the BB Season





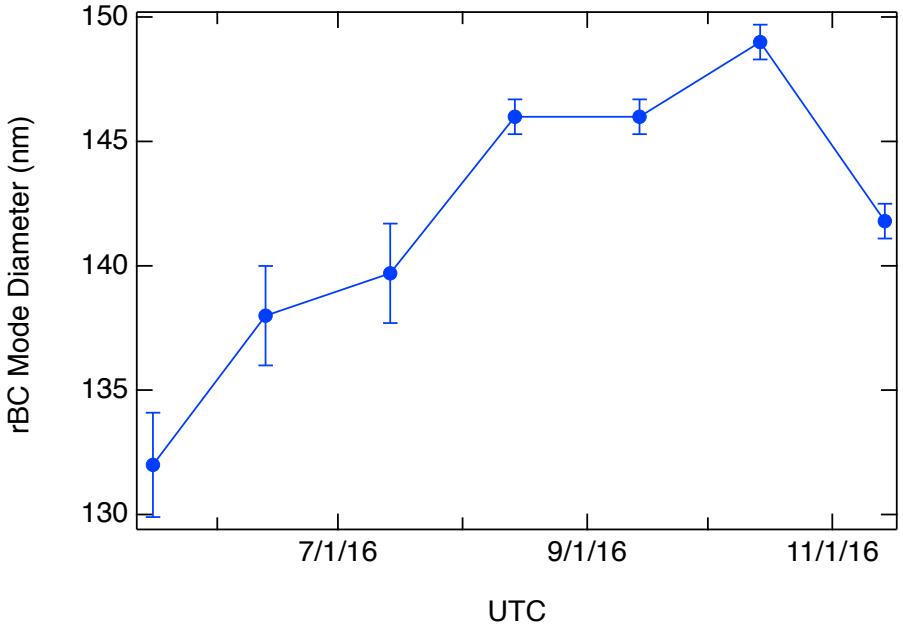


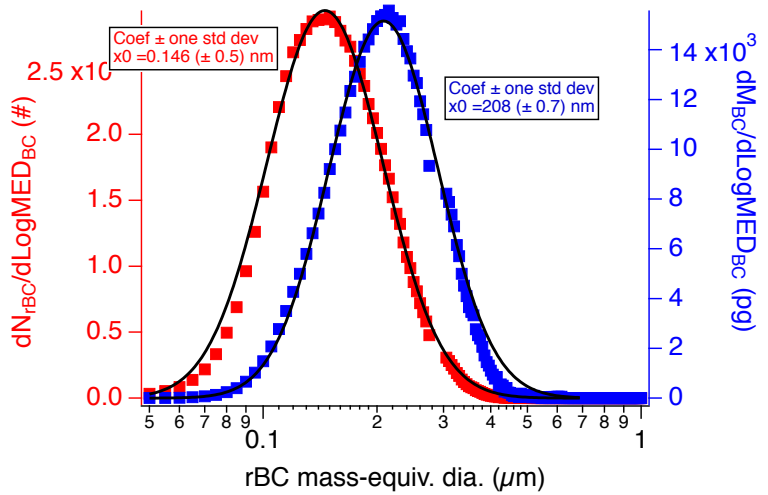


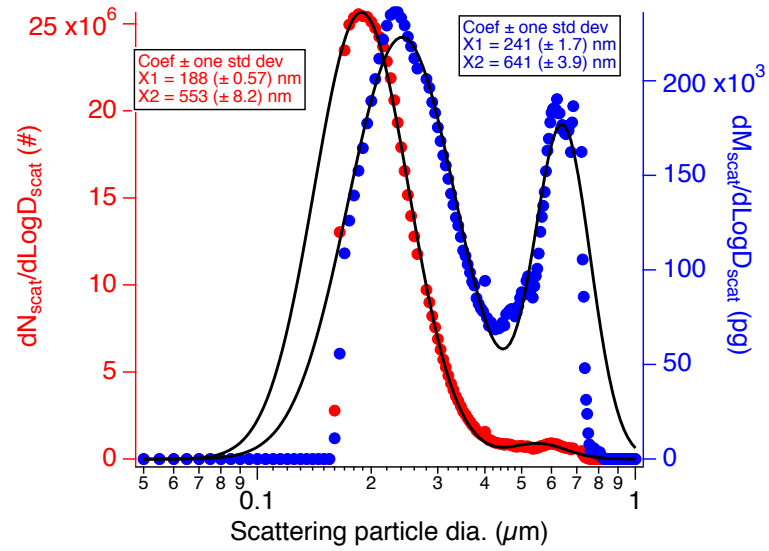
PSAP data – S. Springston

Refractory Black Carbon (rBC) Microphysical Properties

- rBC size mode appears to increase during BB season – differing sources BB rBC
- SP2 scattering channel reveals the presence of larger (> 500 nm) particles – sea salt





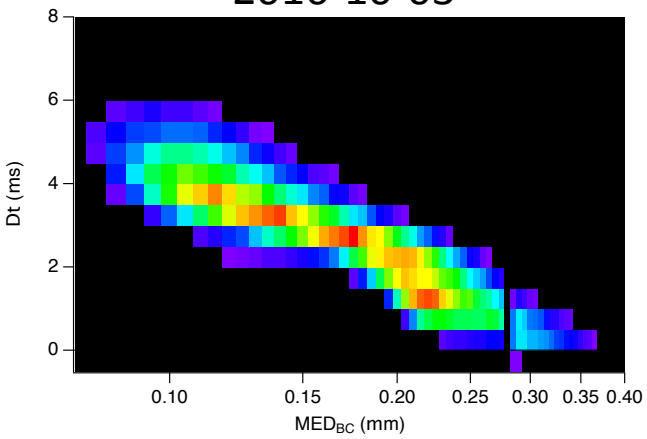


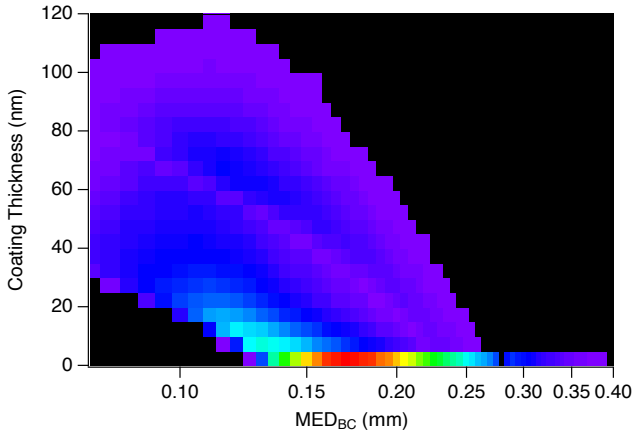
Oct. 23, 2016

Refractory Black Carbon (rBC) Microphysical Properties

SP2 Lagtime analysis reveals ASI rBC is coated

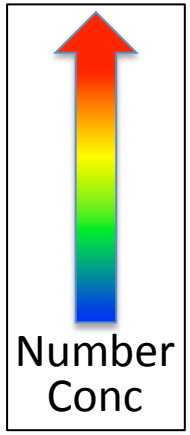
2016-10-03



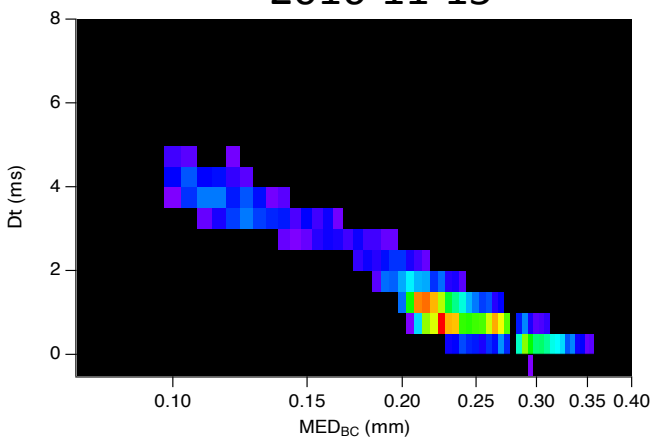


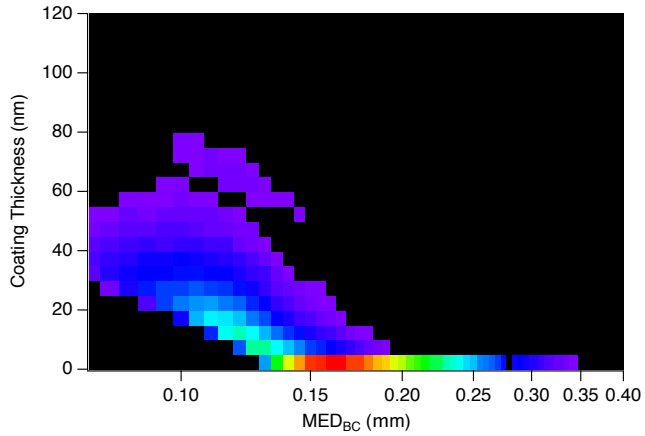
BB event

rBC/DCO = 14 ng/m3 - ppb



2016-11-15





Uncoated rBC

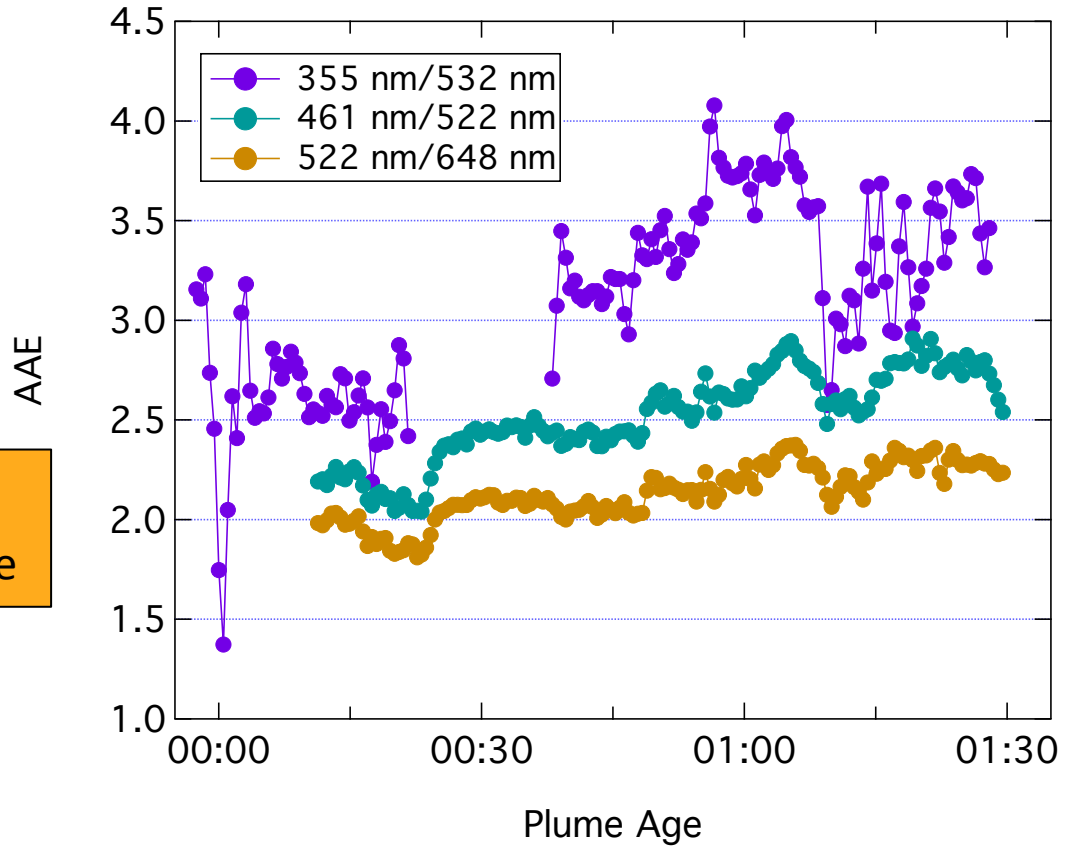
rBC/DCO = ~3 ng/m3 - ppb

Evidence of Brown Carbon (BrC) Absorption

Absorption Angstrom Exponent is a measure of the wavelength dependence of aerosol light absorption

- AAE ~ 1 for BC
- AAE > 1.5 for BrC

BBOP focused on the near-field evolution of BB aerosols



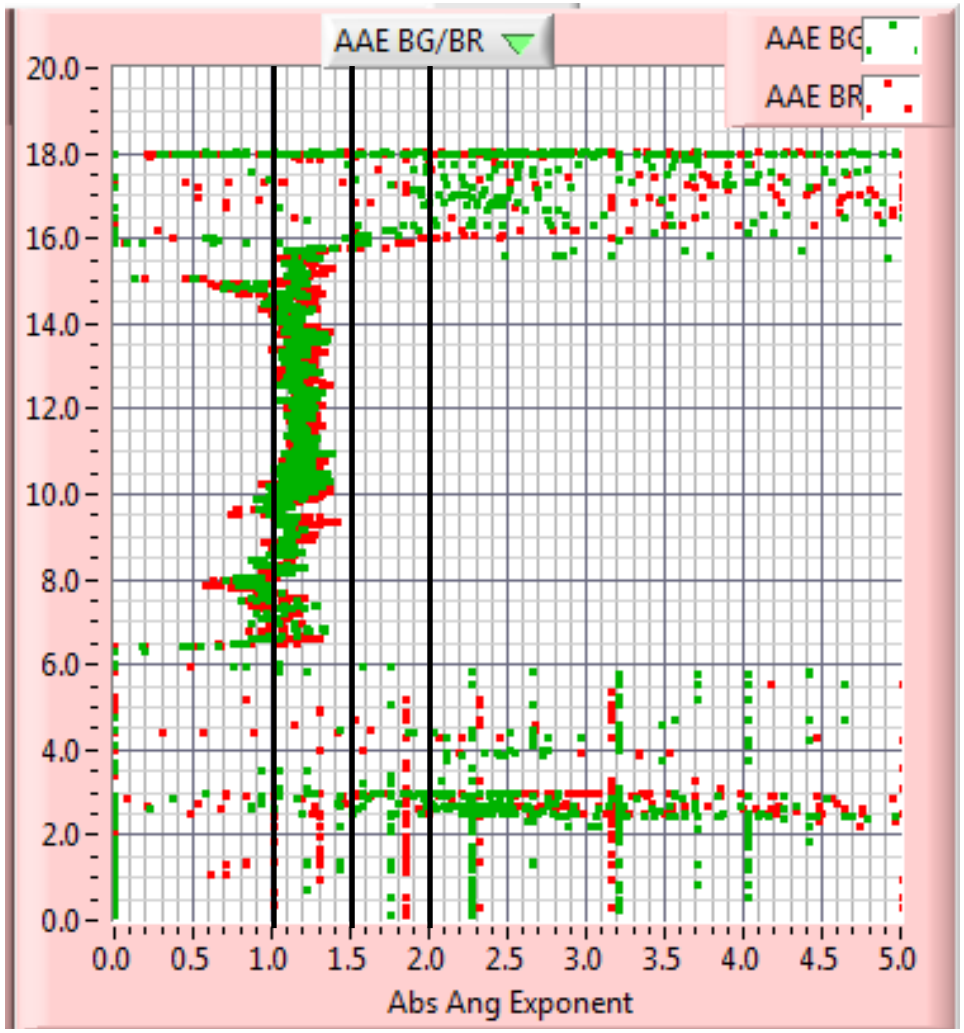
AAE values (2-4) indicates BrC

30% increase in AAE with plume age

Arnott and Sedlacek

PSAP-derived AAE Profile from ORACLES

NASA-ORACLES mission provides a very nice opportunity to put ASI data in context

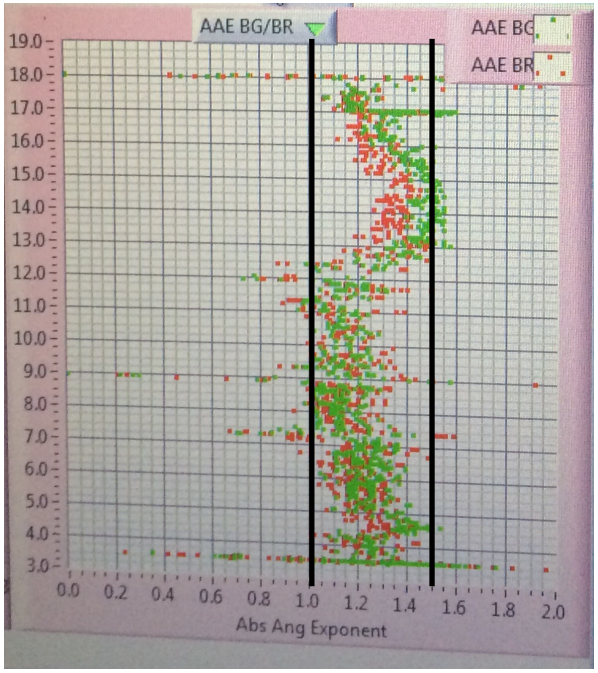


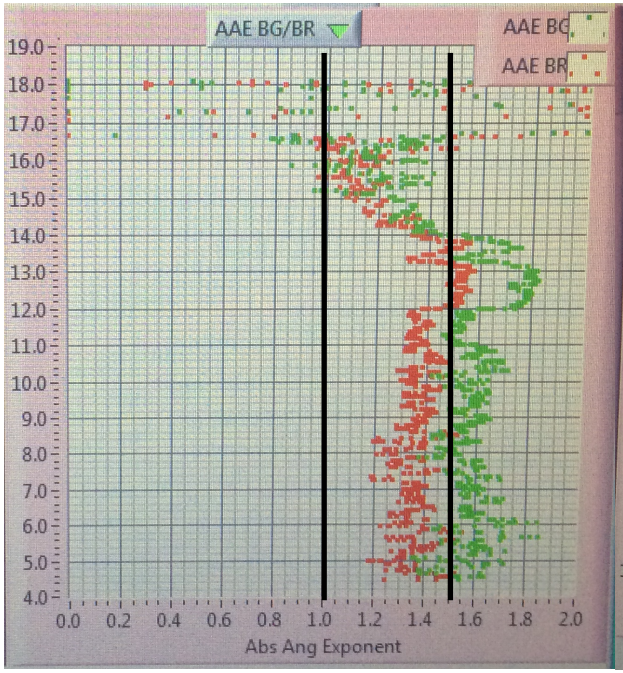
Courtesy S. Howell (HIGEAR)

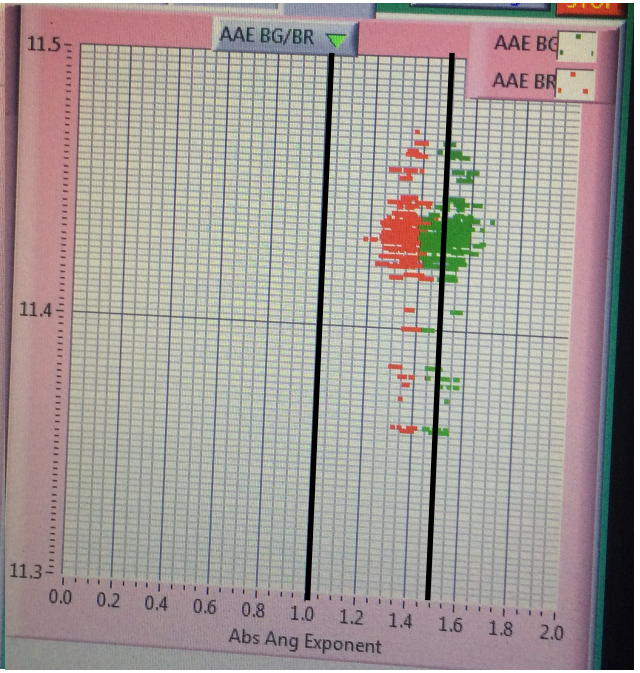
Early in ORACLES, unexpectedly low AAE values were observed

PSAP-derived AAE ~ 1.2
Expectations for a BB plume (AAE ~ 2)

PSAP-derived AAE Profiles for “Fresher” Smoke Plume







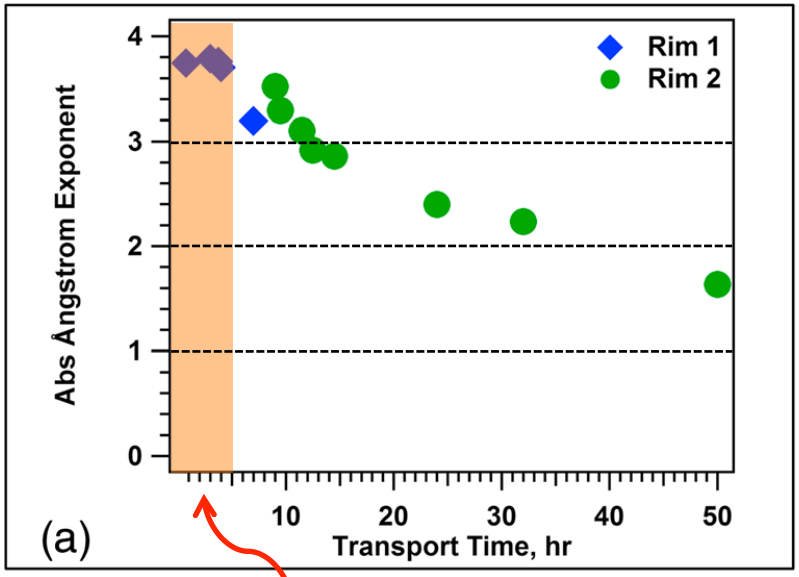
Courtesy S. Howell & S. Freitag (HIGEAR)

AAE derived from fresher plume exhibits is higher than more aged plume

ASI Optical Properties – June 2016

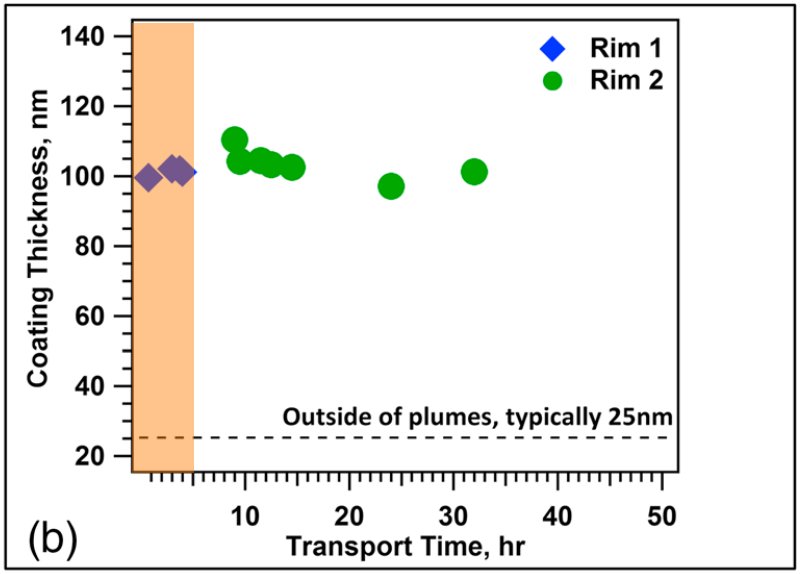
Forrister et al., (from the SEAC4RS campaign) recently reported on the decrease in AAE as a function of plume age. Conclusion is that AAE reduction due to chemical bleaching (as opposed to photo bleaching or removal)

PSAP: 470 nm and 532 nm



Aging window of interest in BBOP

SP2



Forrister et al., (2015) GRL

Possible Explanations for Low AAE Values

- No BrC (> 460 nm) was ever created
- BrC was created but through photolytic and/or oxidative bleaching loses its color

Atmos. Chem. Phys., 15, 6087–6100, 2015
www.atmos-chem-phys.net/15/6087/2015/
doi:10.5194/acp-15-6087-2015

Atmospheric Chemistry and Physics Open Access

Photochemical processing of aqueous atmospheric brown carbon

R. Zhao[1], A. K. Y. Lee[1], L. Huang[2], X. Li[3], F. Yang[4], and J. P. D. Abbatt[1]

BrC originating from biomass burning. Photochemical processing induced significant changes in the absorptive properties of BrC. The imine-mediated BrC solutions exhibited rapid photo-bleaching with both direct photolysis and OH oxidation, with atmospheric half-lives of minutes to a few hours. The nitrophenol species exhibited photo-enhancement in the visible range during direct photolysis and the onset of OH oxidation, but rapid photo-bleaching was induced by further OH exposure on an atmospheric timescale of an hour or less. To illustrate the atmospheric relevance of this work,

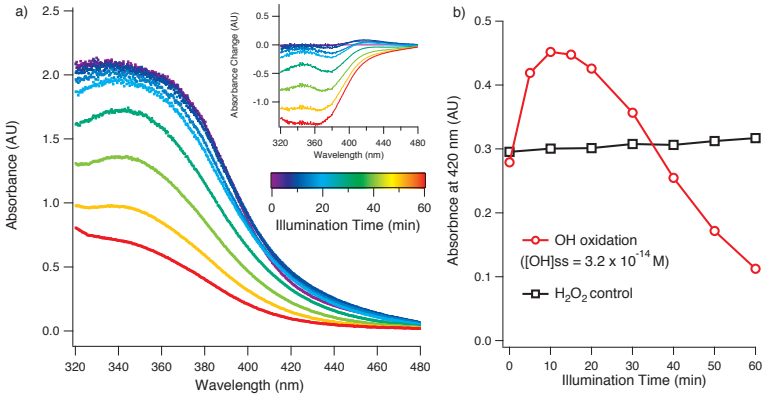


Figure 8. Spectral change of 4NC solution (10 μM) during an OH oxidation experiment **(a)**, with the inset showing absorbance change compared to the initial condition. The color coding represents the illumination time. The time profiles of absorbance at 420 nm are shown in **(b)**.

Unaccounted for bleaching of BrC will impact modeling of BrC radiative forcing contribution

Absorbing Aerosol-centric Research Questions

- Where is the BrC?
  - AAE ≈ 1 suggests no BrC absorption
  - BrC bleaching or removal?
- What is driving the observed change rBC mode size?
  - Source fuel dependence?
- Are the PSAP B_{abs} values biased high?
  - Limitation of correction schemes for addressing 500 – 1000 nm pure scatterers?

Back up Slides

Incandescence "Lagtime" used as a Proxy for Coating Thickness

$\Delta\tau_{\text{Lagtime}} = t_{\text{incandescence Peak}} - t_{\text{scattering Peak}}$ = time to "boil off" coating