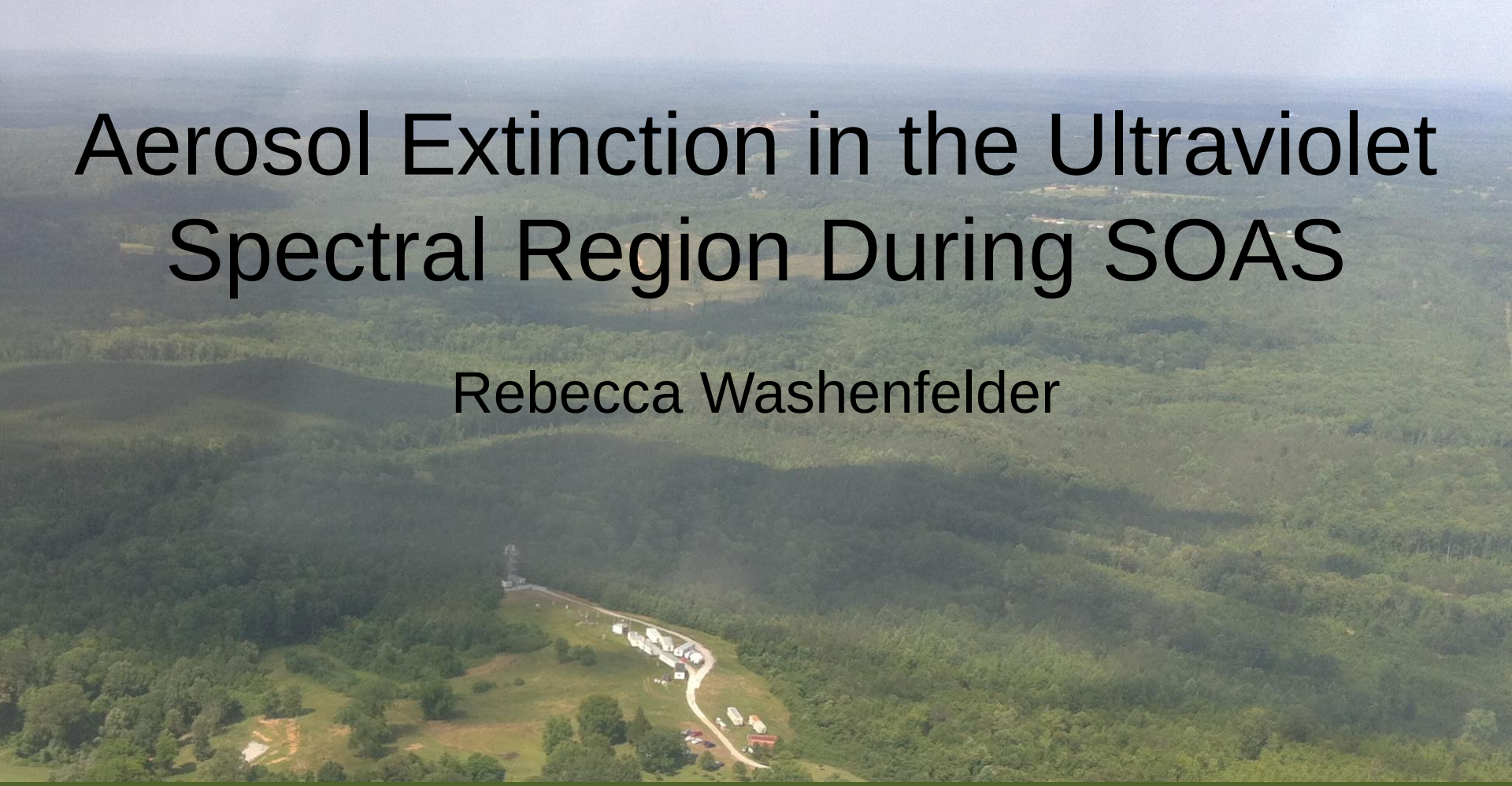
Aerosol Extinction in the Ultraviolet Spectral Region During SOAS

Rebecca Washenfelder



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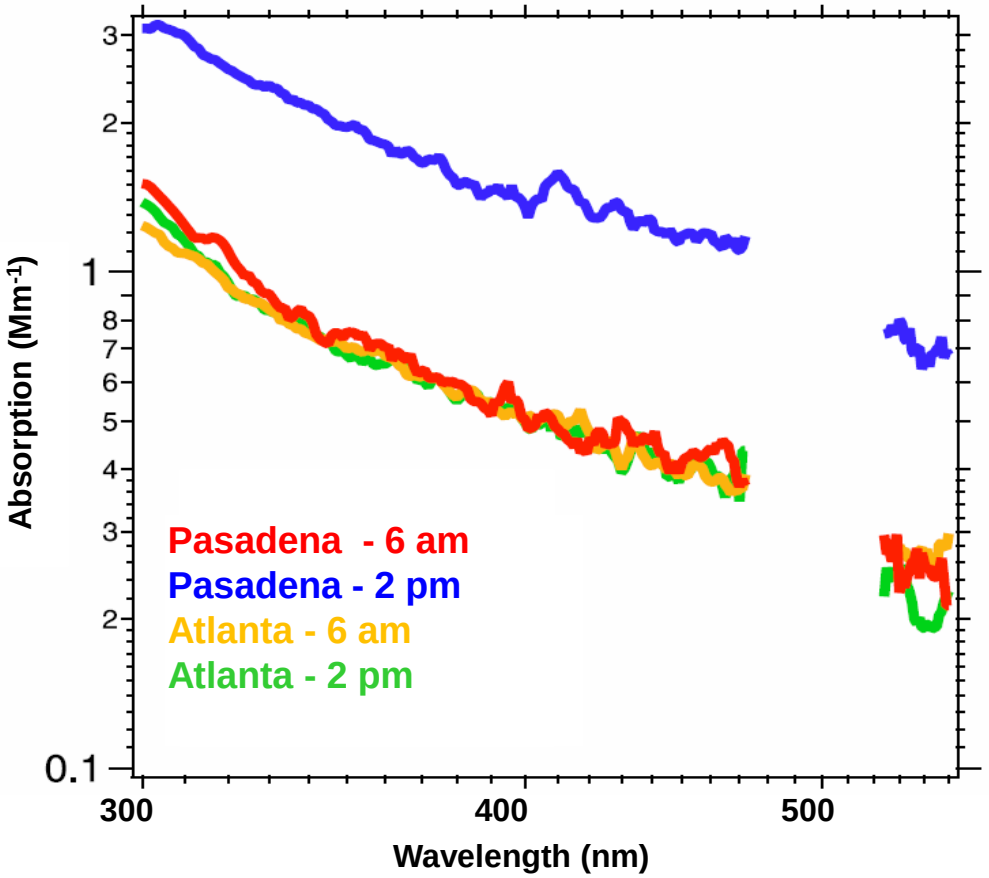
Reed College: Julie Fry, Ben Ayres, Danielle Draper, Hannah Allen

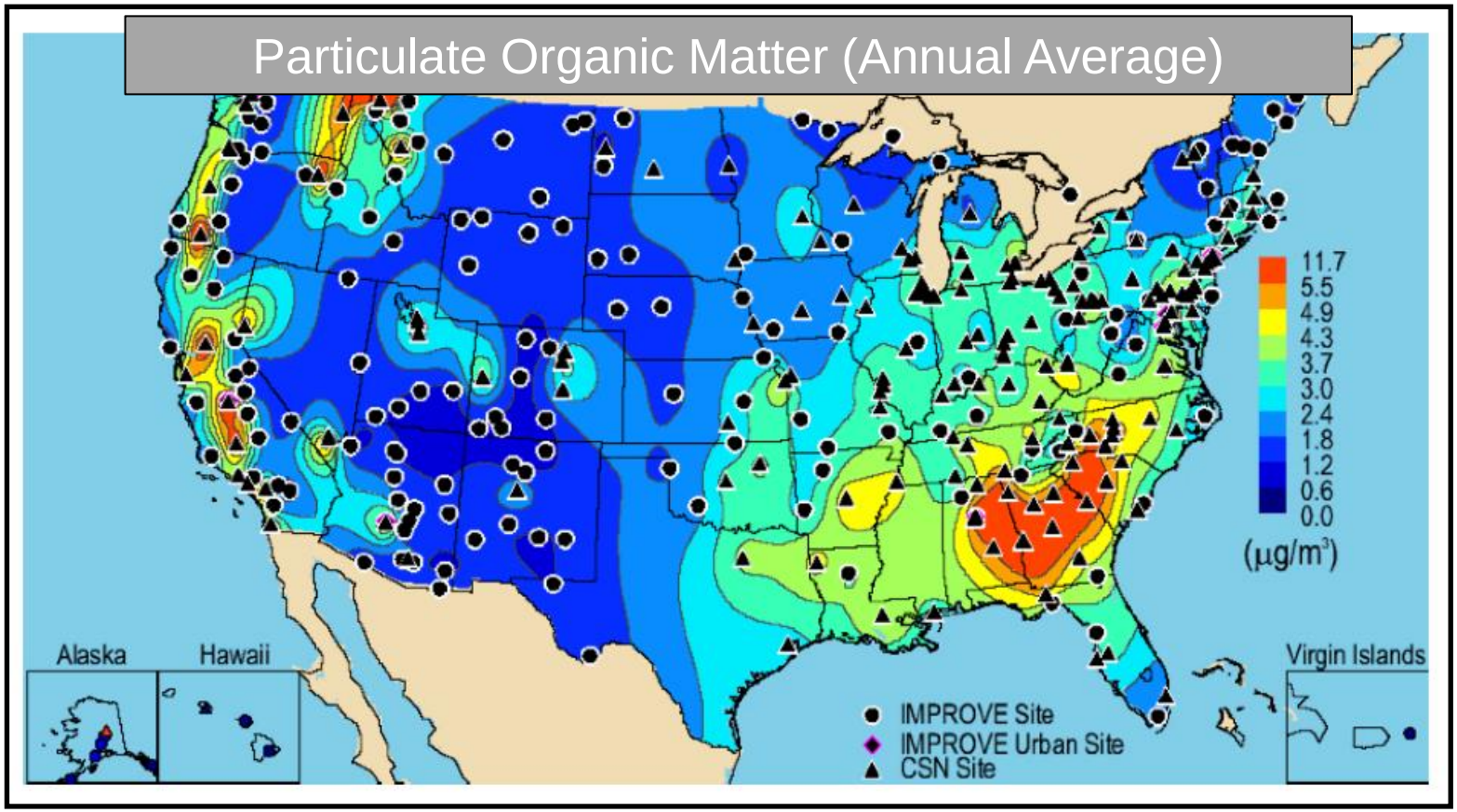
Brown Carbon Shows Wavelength-Dependent Absorption

Particles collected with a Particle-Into-Liquid-Sampler (PILS) and measured by long-path UV/Visible spectroscopy:

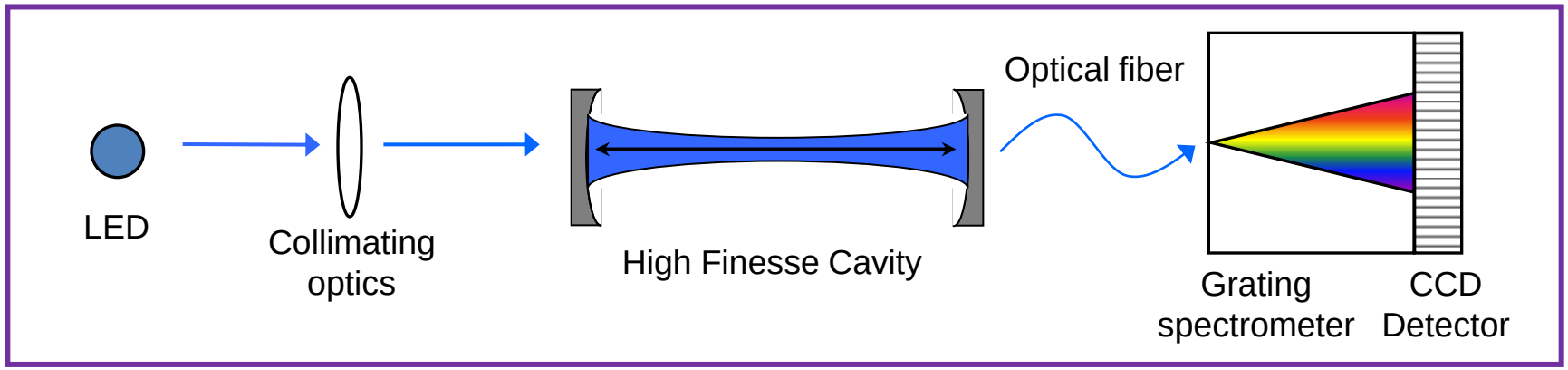


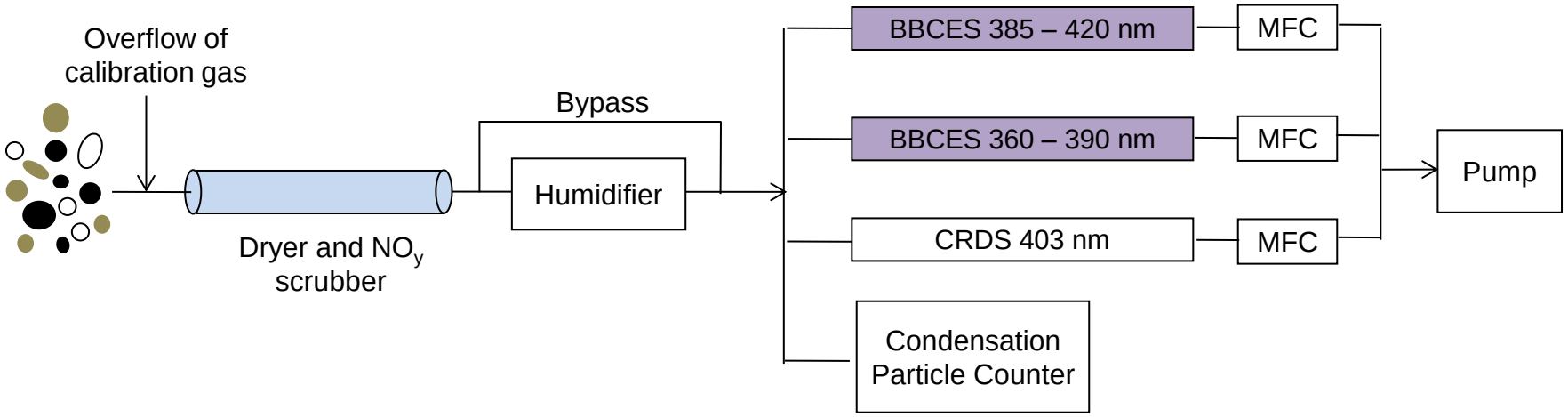
(Zhang et al., *Geophys. Res. Lett.*, 2011)

Organic Aerosol Concentrations Are High in the Southeast U.S.



Broadband Measurements of Aerosol Extinction





1. Total aerosol extinction as a function of wavelength.
2. Average aerosol cross section as a function of wavelength.
3. Complex refractive index.

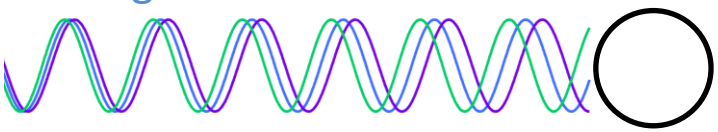
Aerosol Complex Refractive Index

Refractive index is represented as m = n + ki

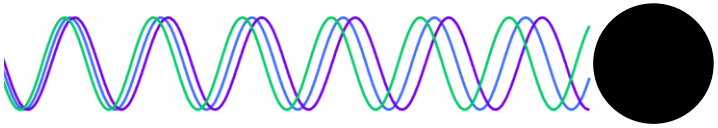
scattering absorption

For particle diameter = 500 nm

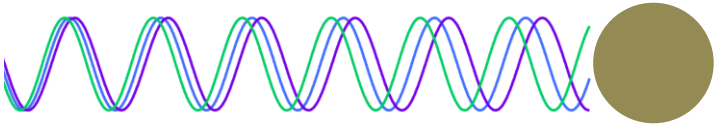
Wavelength = 360 - 420 nm m = 1.6 + 0i

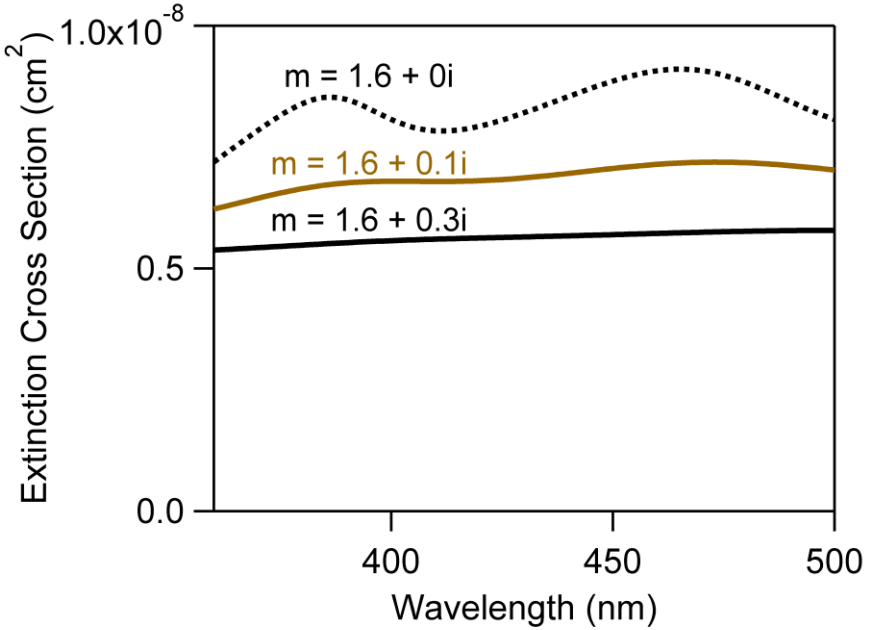


m = 1.6 + 0.3i



m = 1.6 + 0.1i





Aerosol Extinction Cross Section

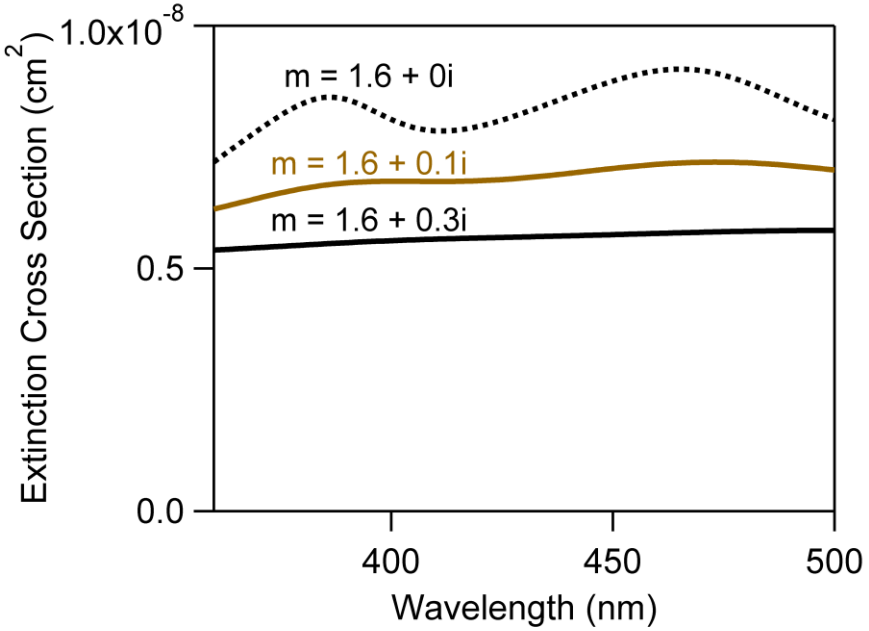
Aerosol extinction cross section (σ) is a function of:

- Wavelength (λ)
- Particle diameter (D_p)
- Refractive index (n, k)

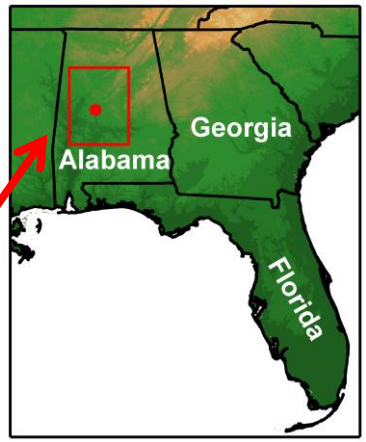
$\sigma = f(\lambda, D_p, n, k)$

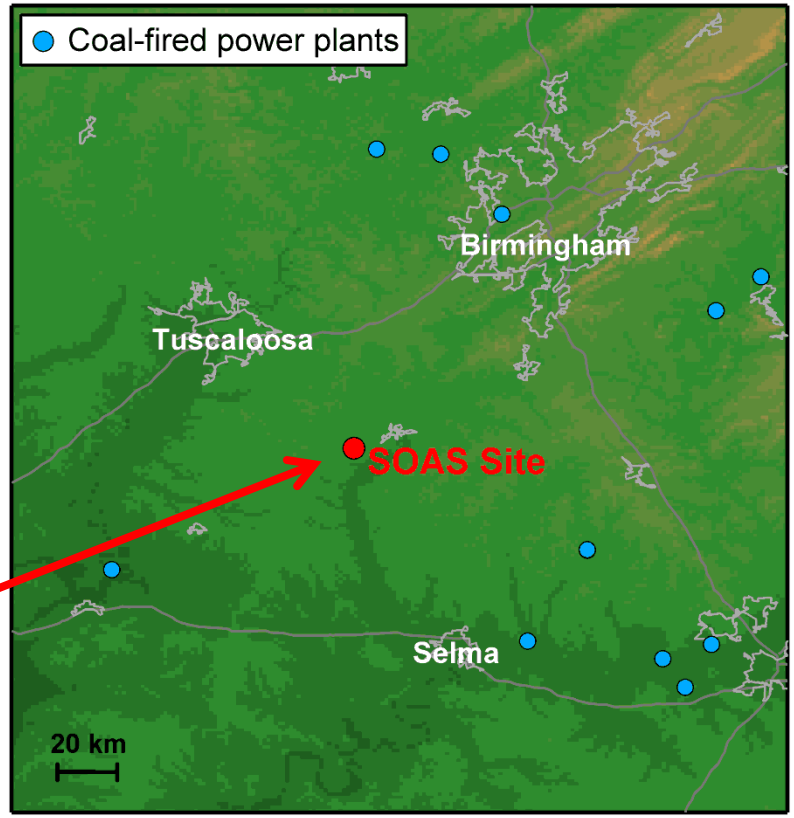
BBCES measures extinction: α

$\sigma = \alpha / N$



NOAA BBCES field instrument at SOAS 2013

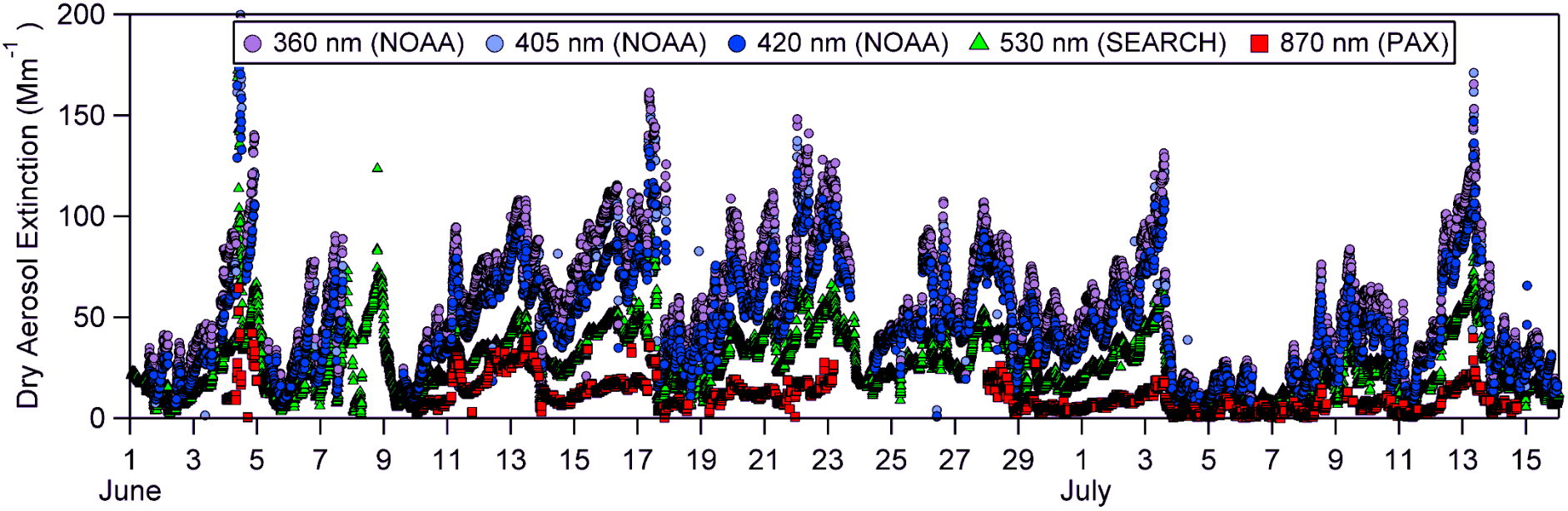




Measurements of Aerosol Optical Properties During SOAS 2013

Scattering Measurements			
PAX	Carnegie Melon/RTI	405 nm	Dry, Ambient, Humidified
PAX	Carnegie Melon/RTI	532 nm	Dry, Ambient, Humidified
Nephelometer	ARA – SEARCH	530 nm	Dry, Ambient
Nephelometer	Georgia Tech	530 nm	<40% RH, Ambient
PAX	Georgia Tech	532 nm	<40% RH
PAX	Carnegie Melon/RTI	870 nm	Dry, Ambient, Humidified
Absorption Measurements			
PILS with UV/VIS	Georgia Tech	300-600 nm	
PAX	Carnegie Melon/RTI	405 nm	Dry, Ambient, Humidified
PAX	Carnegie Melon/RTI	532 nm	Dry, Ambient, Humidified
PAX	Georgia Tech	532 nm	<40% RH
PAX	Carnegie Melon/RTI	870 nm	Dry, Ambient, Humidified
Aethelometer	ARA – SEARCH	325; 880 nm	
Aethelometer	Georgia Tech	7 wavelengths	Dry, Dried and denuded
SP2	Carnegie Melon/RTI	1064 nm	
Total Extinction Measurements			
CRDS	NOAA	403 nm	Dry, Humidified
BBCES	NOAA	355 – 420 nm	Dry, Ambient, Humidified

Aerosol Extinction and Chemical Composition



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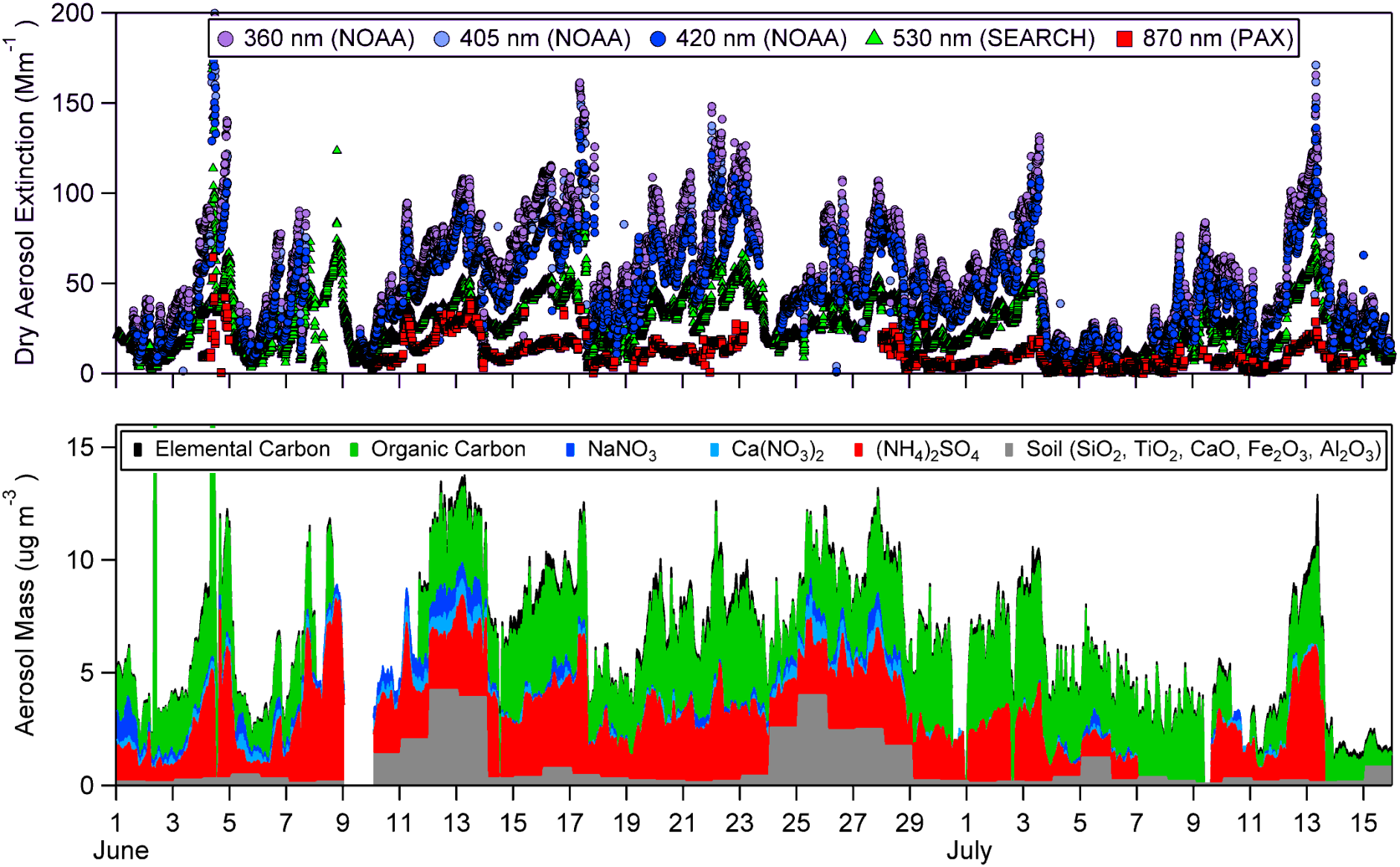
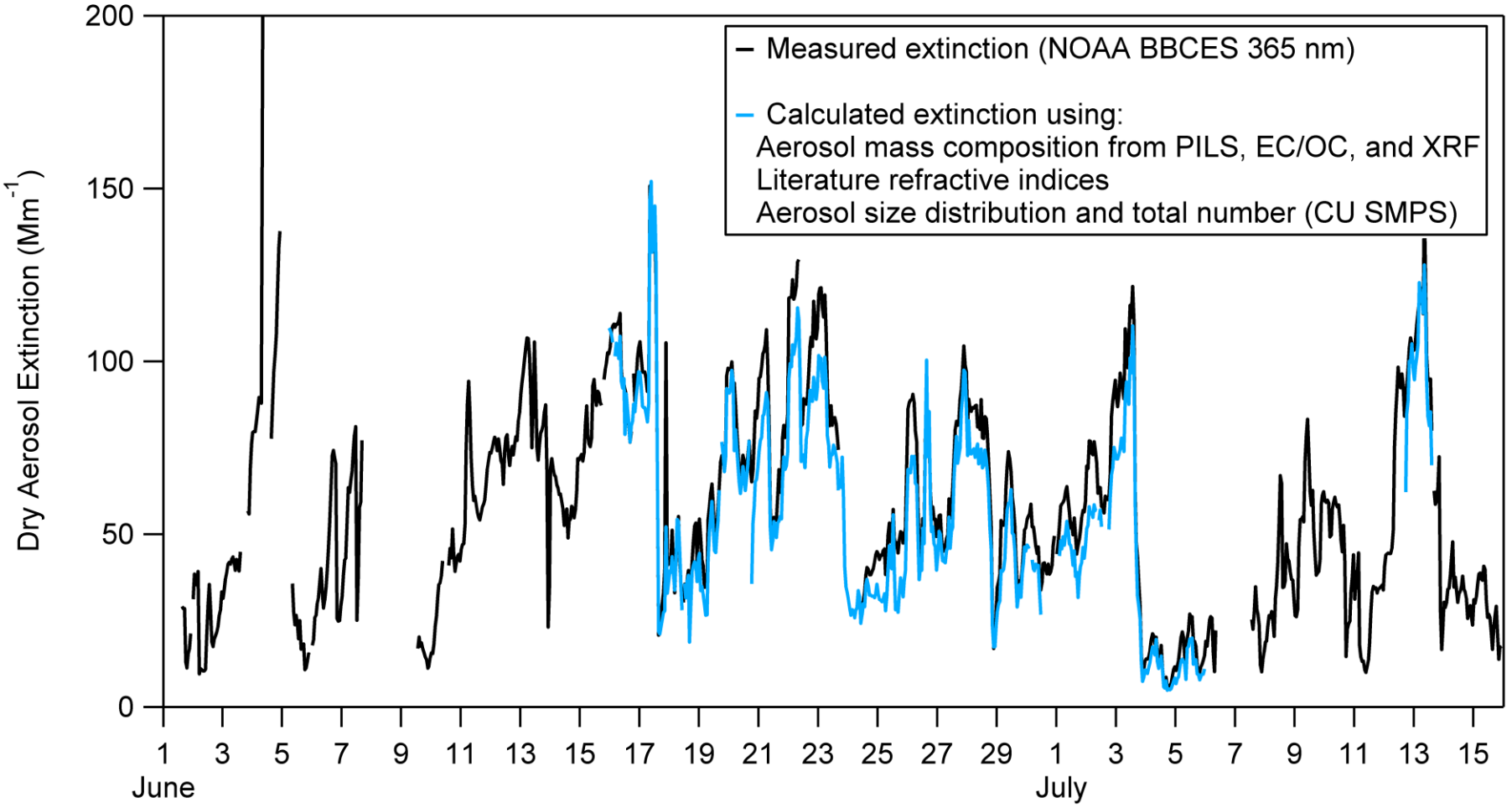
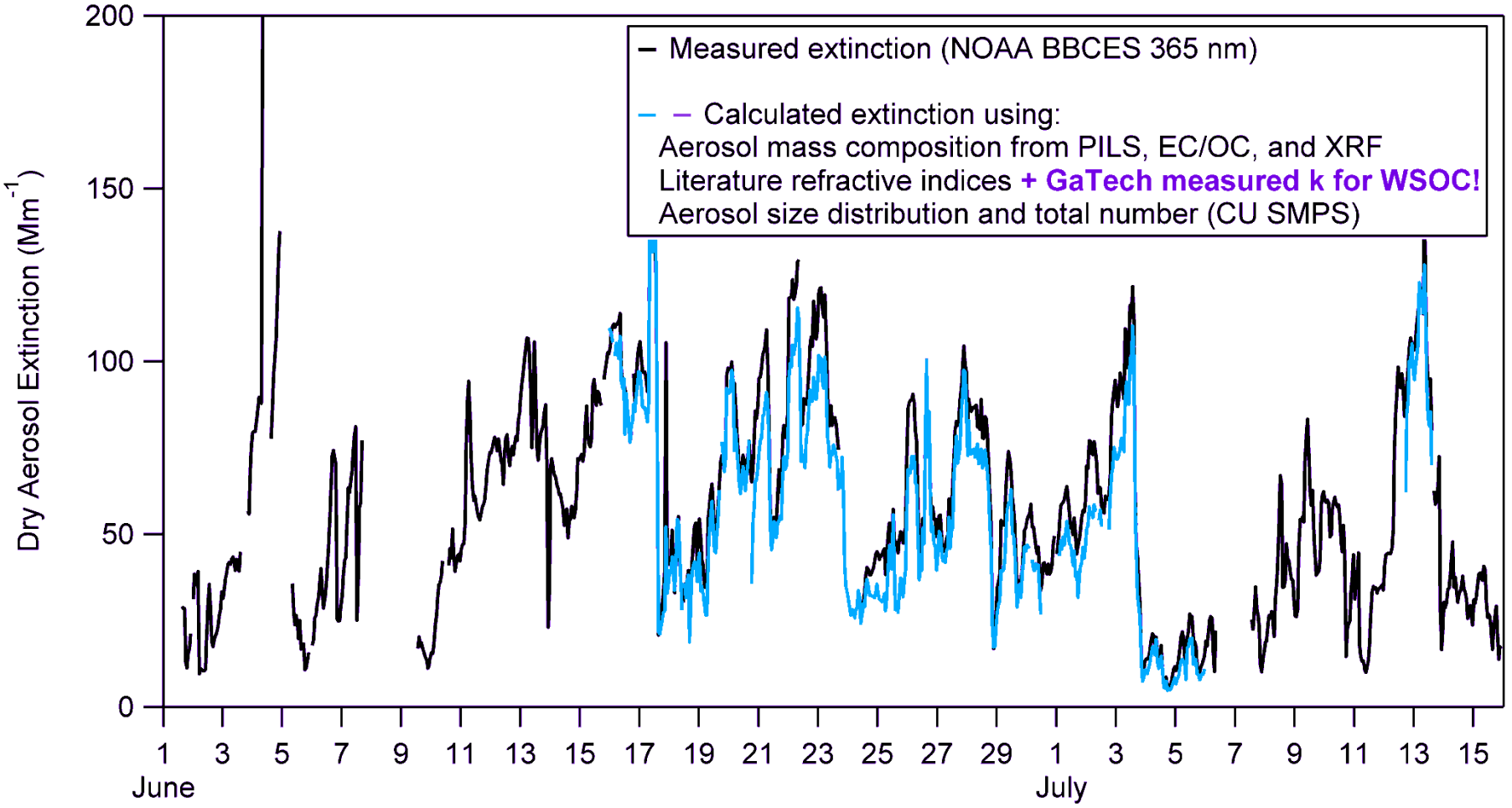


Optical Closure Comparison



Refractive index for black carbon from *Bond and Bergstrom 2005*
Other refractive indices from *Hand and Kreidenweis 2002*

Optical Closure Comparison



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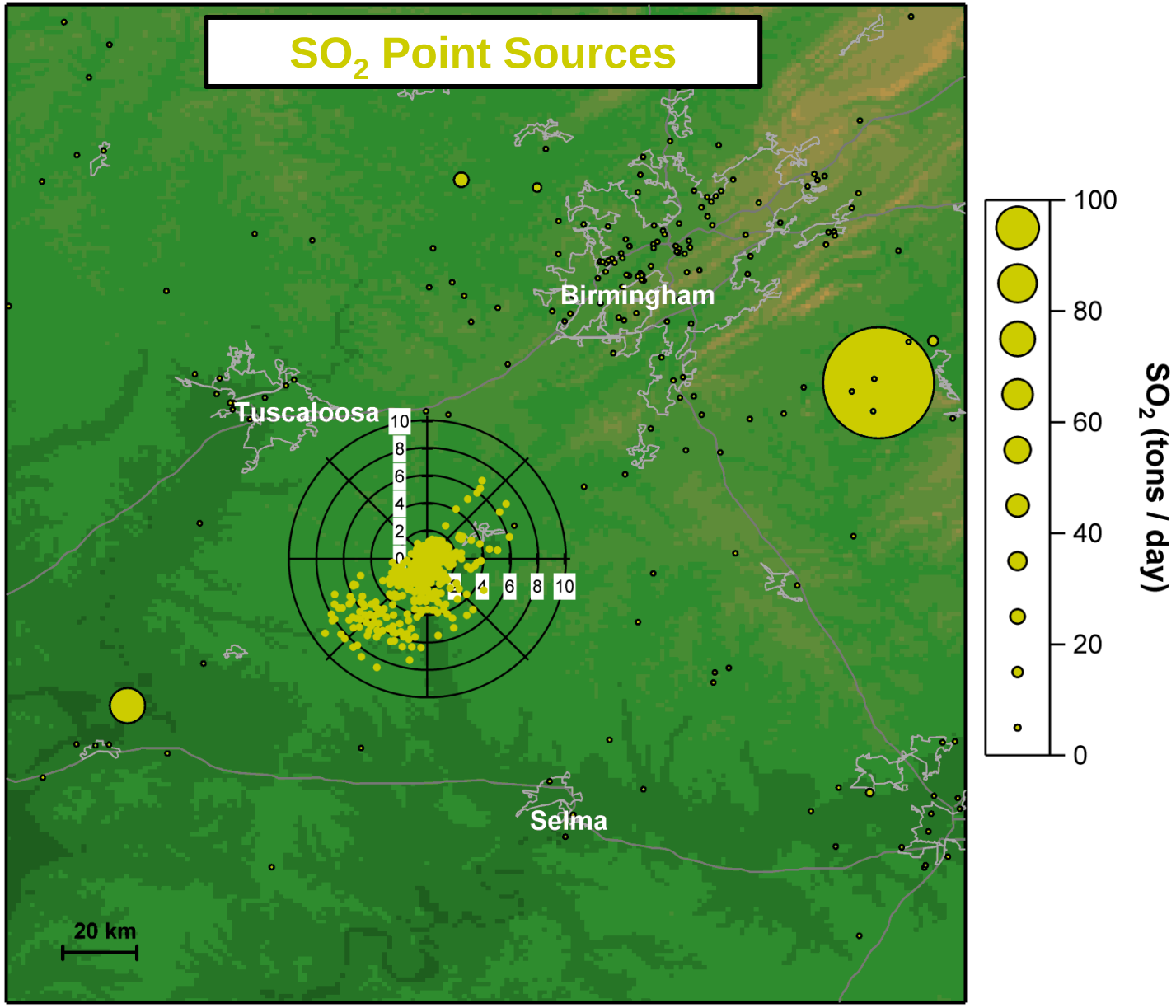
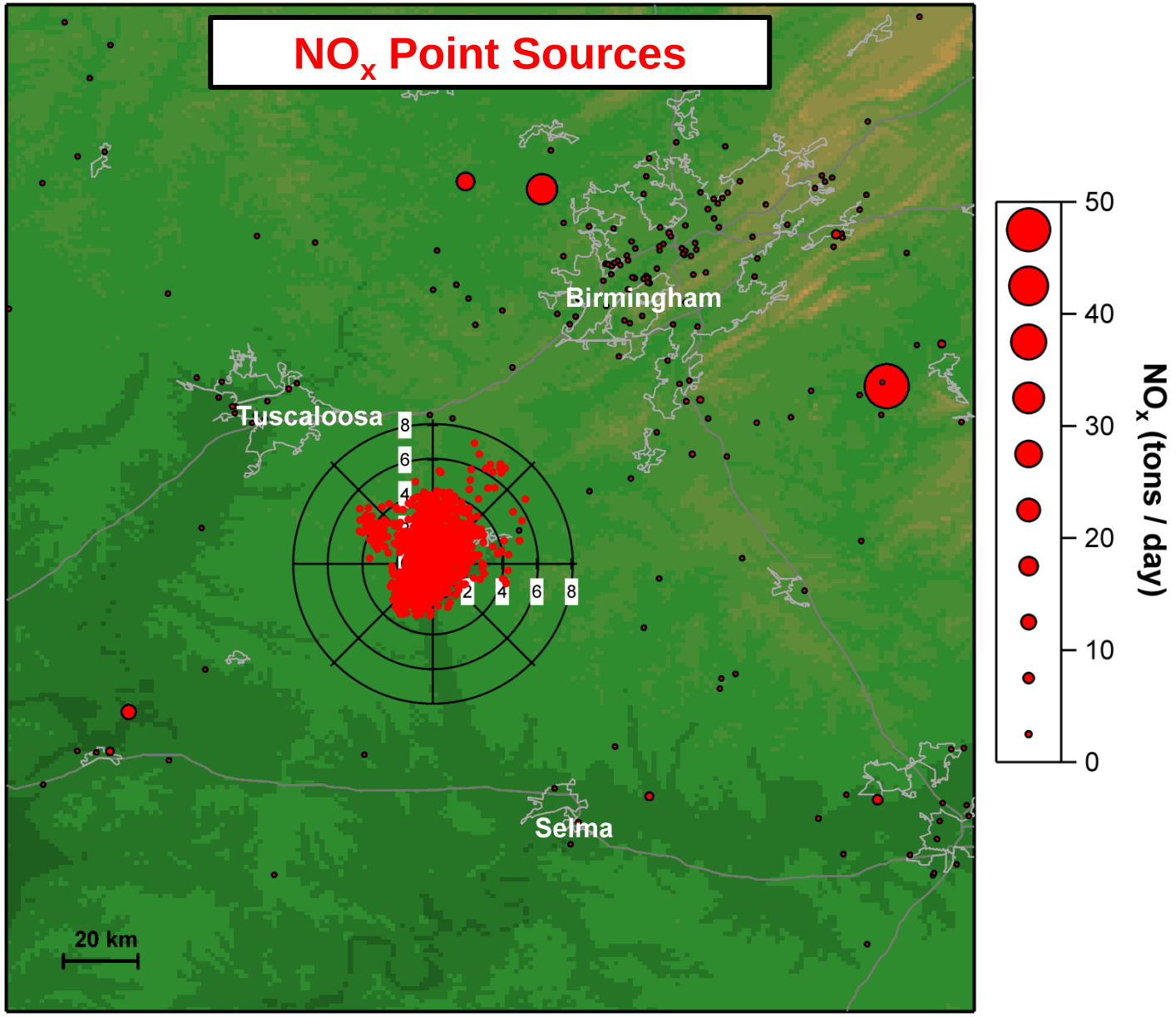
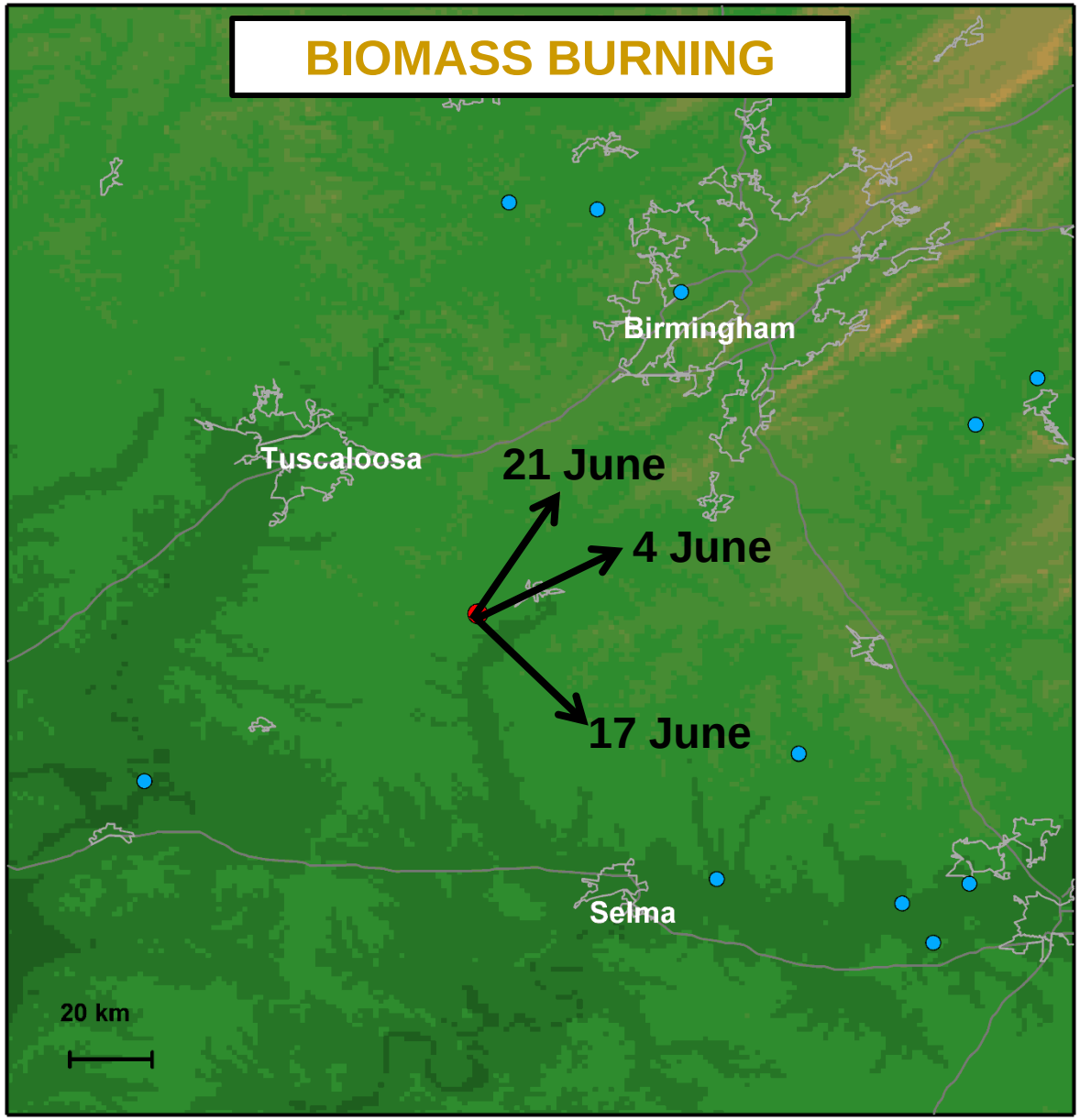
Identifying Emission Sources: Power Plants



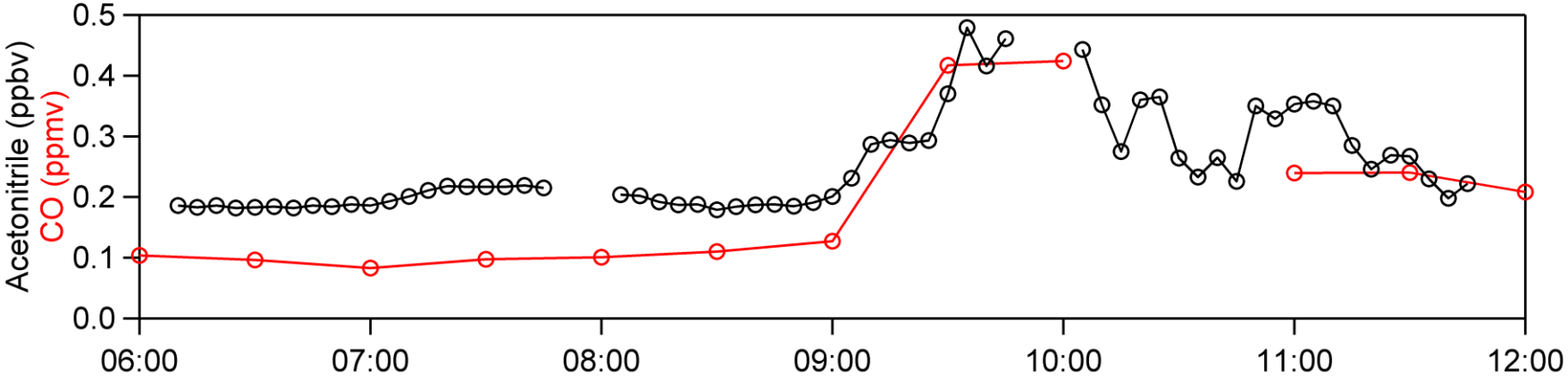
Identifying Emission Sources: Urban



Identifying Emission Sources: Biomass Burning



June 4 – Biomass Burning



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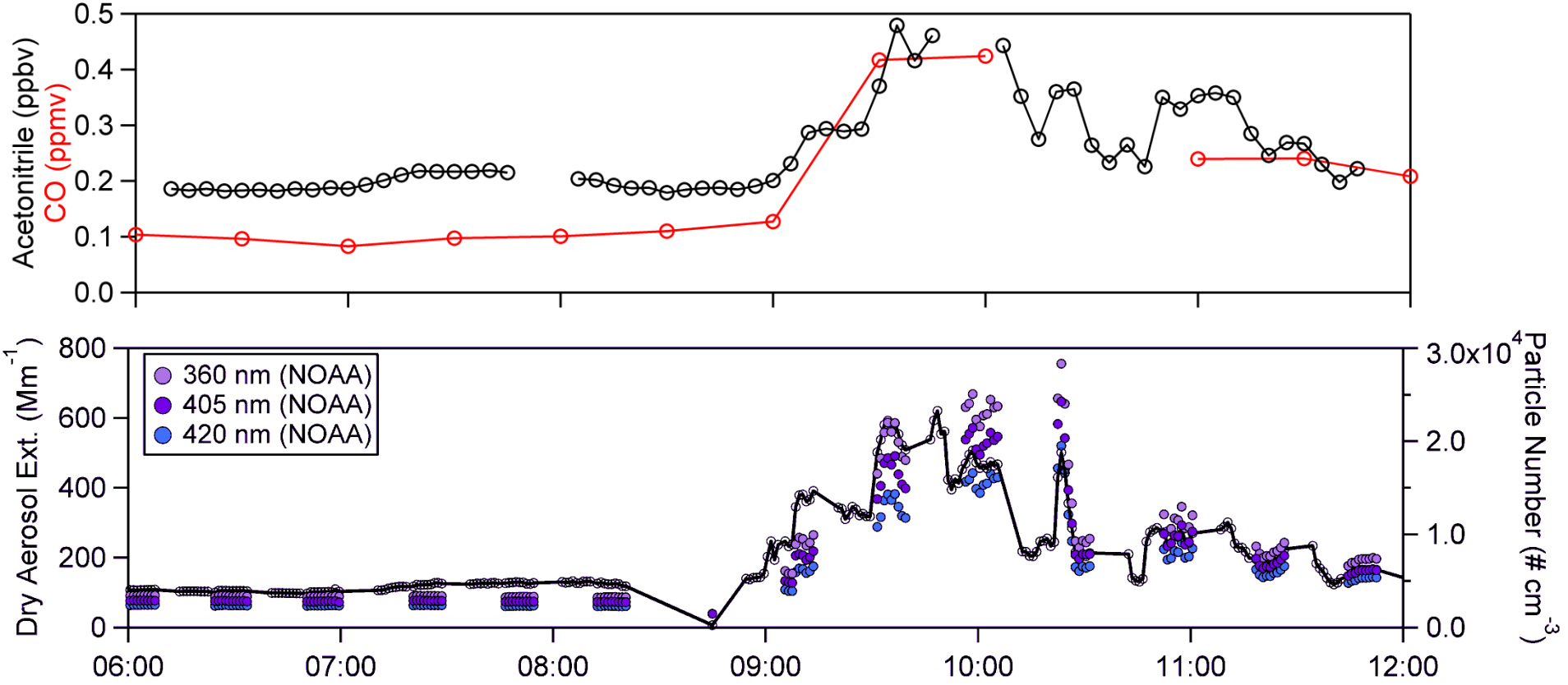

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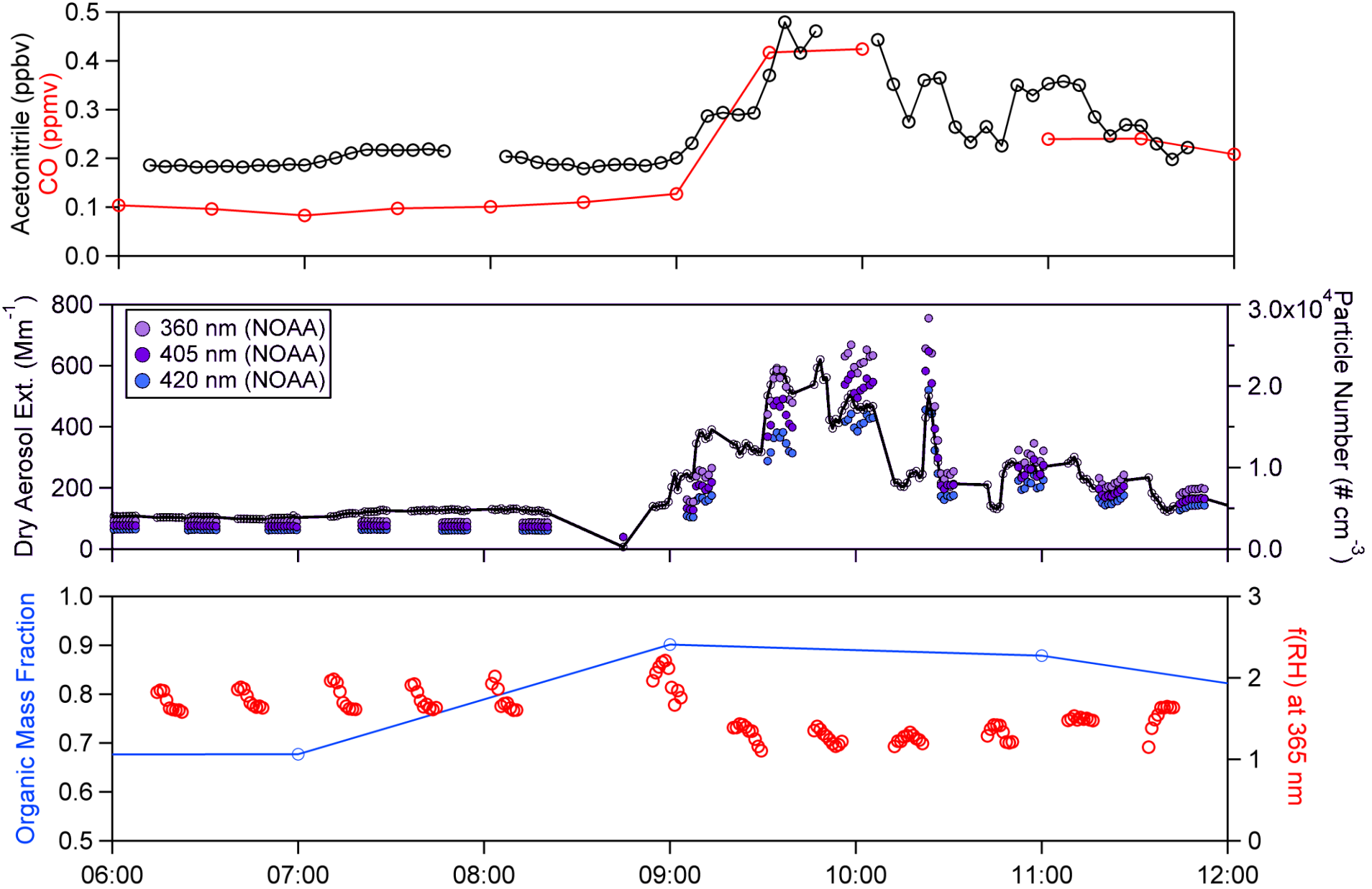
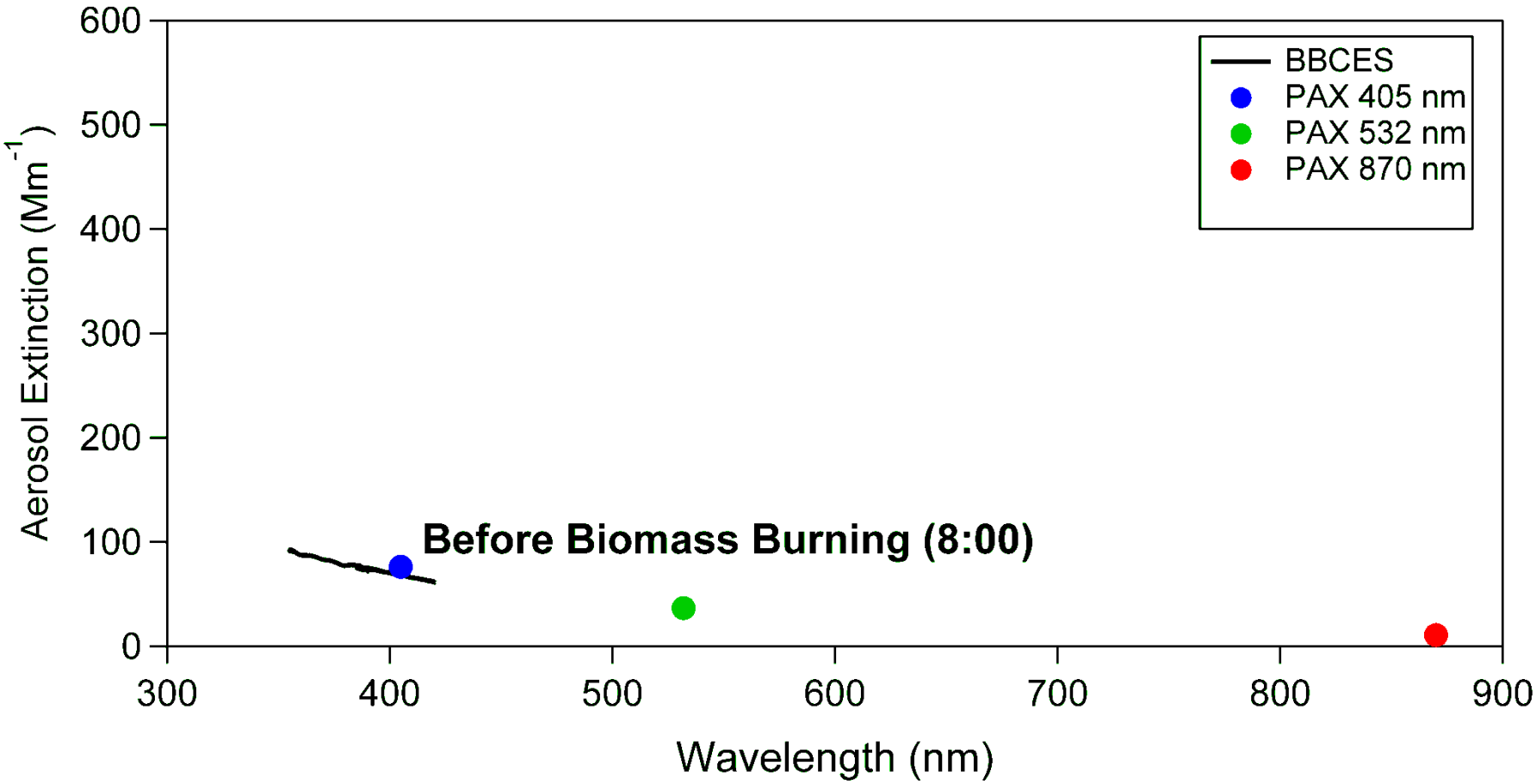
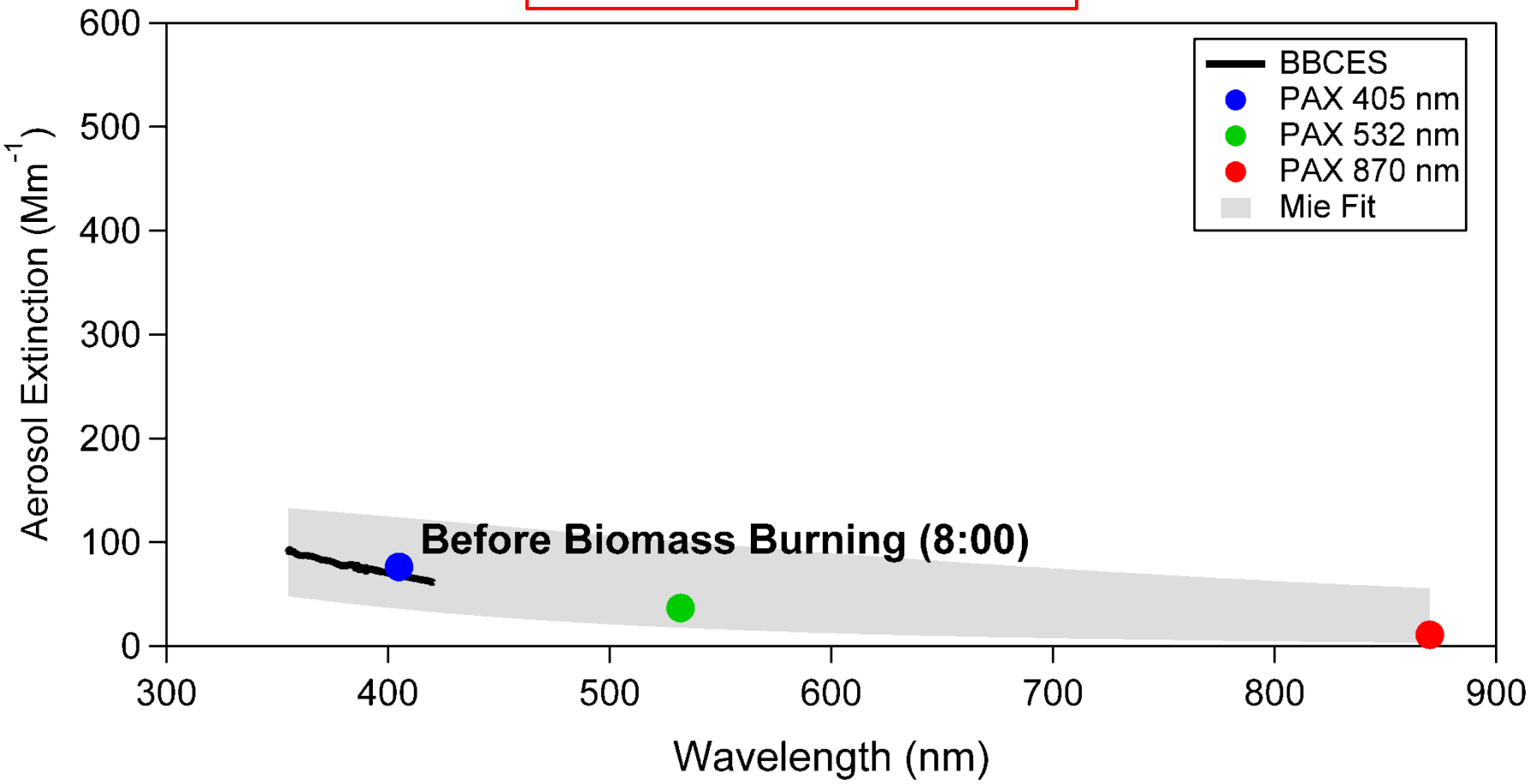


Wavelength-Dependent Refractive Index



Wavelength-Dependent Refractive Index

Refractive Index = n + *i*k
n = 1.4 – 1.8
k = 0.0 – 0.5



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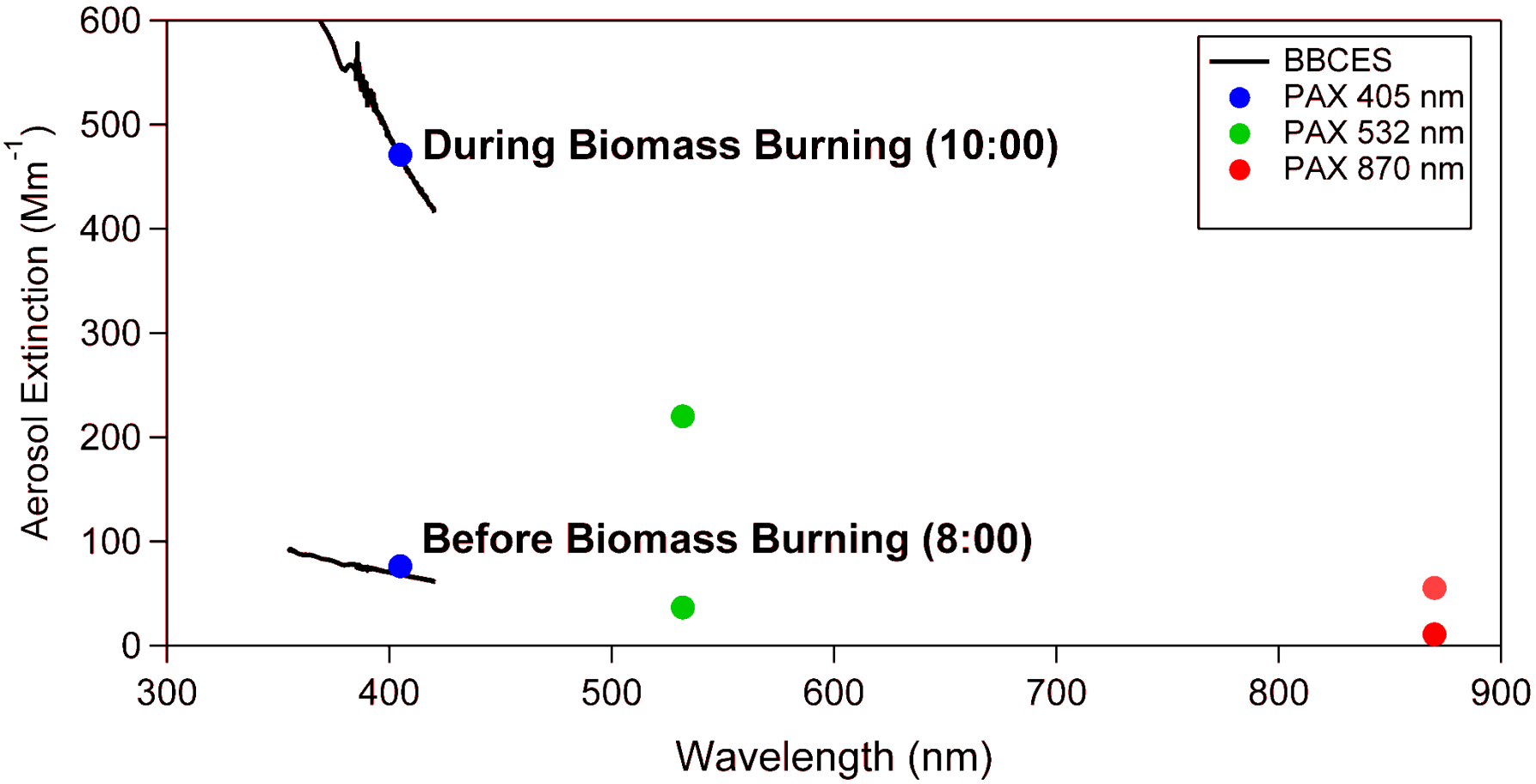

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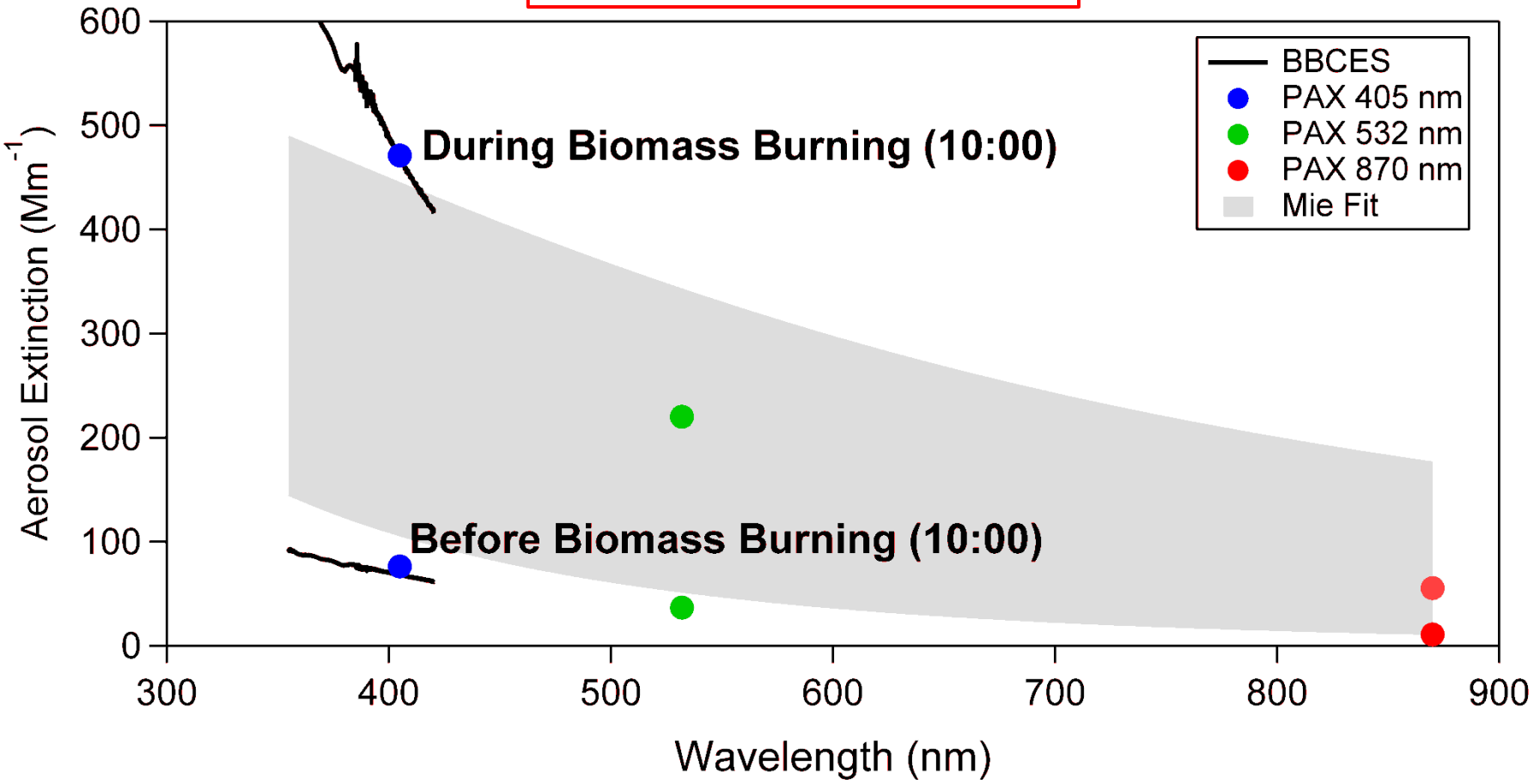


Conclusions and Future Work

- Direct measurement of aerosol extinction at 365 nm versus the calculated extinction using aerosol mass composition, size distribution, and literature refractive indices agrees well.

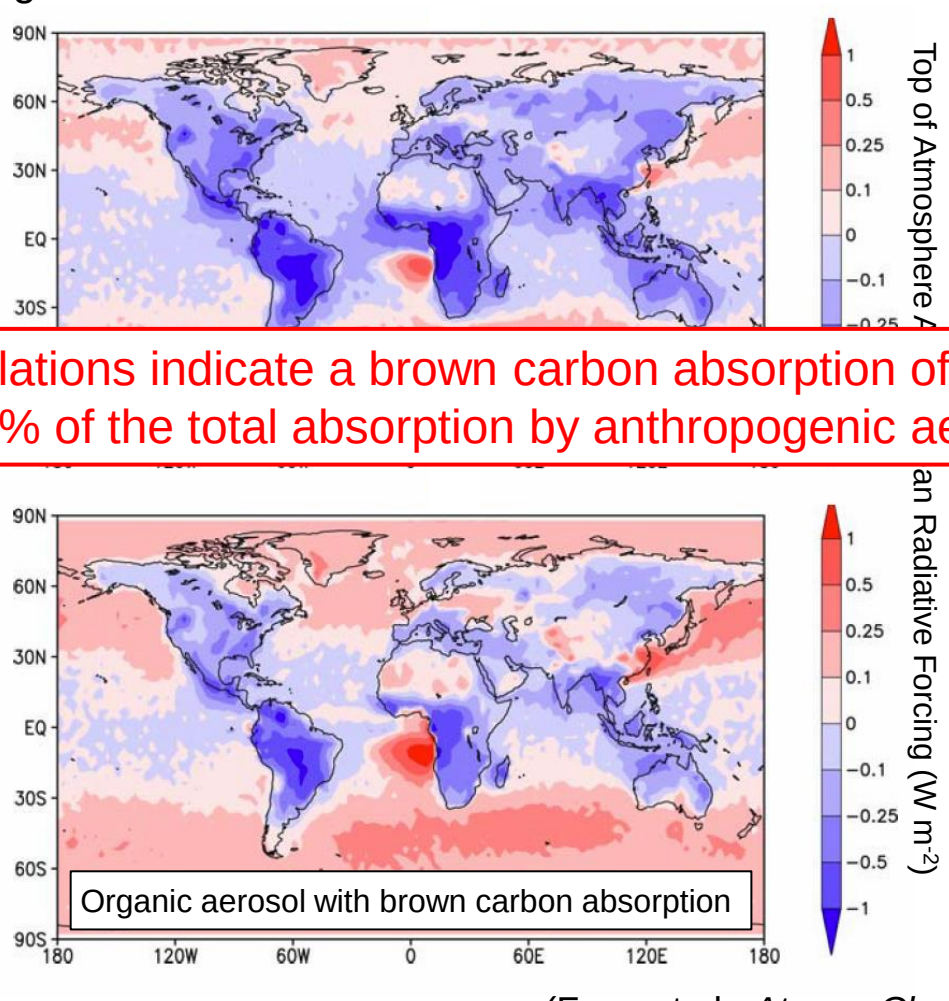
- Direct absorption by brown carbon aerosol makes a small (~0.01%) contribution to the total extinction at 365 nm.

- Three biomass burning events were observed, with increased organic aerosol mass, aerosol extinction, and reduced aerosol hygroscopicity.

- Modeling aerosol extinction during the first biomass burning plume requires a complex refractive index that depends on wavelength, consistent with absorption by brown carbon.

Importance of Wavelength-Dependent Aerosol Absorption

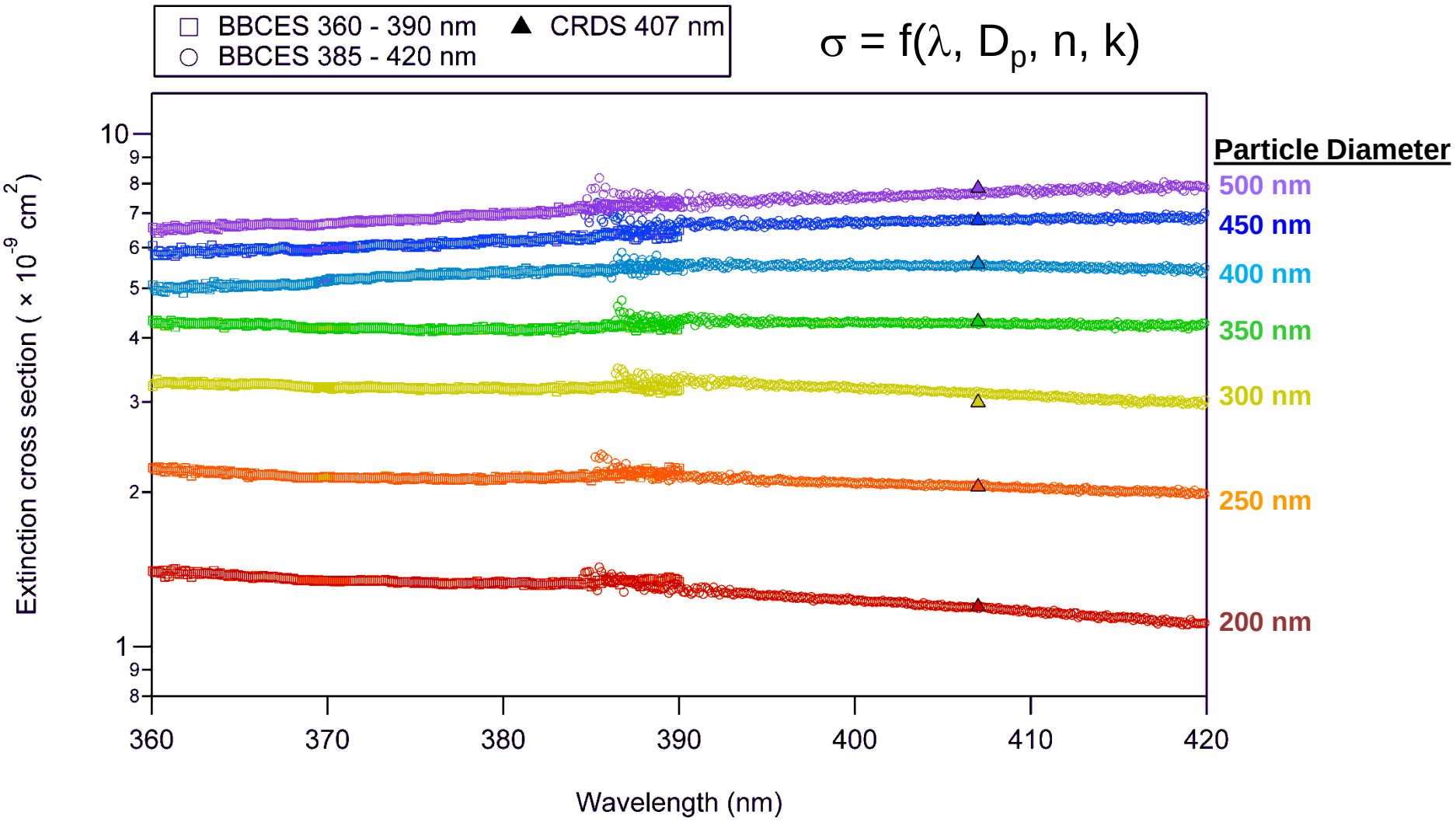
Feng et al. examined the effect of including absorption by brown carbon aerosol in a global model.



The global simulations indicate a brown carbon absorption of +0.25 W m^{-2}. This is 19% of the total absorption by anthropogenic aerosols.

(Feng et al., *Atmos. Chem. Phys. Discuss.*, 2013)

Suwannee River Fulvic Acid Extinction Cross Section



Suwannee River Fulvic Acid Complex Refractive Index