

Chemical composition and optical properties of wildland and agricultural biomass burning particles measured downwind during BBOP study

Timothy Onasch¹, John Shilling², Edward Fortner¹, Mikhail Pekour², Andrew Freedman¹,
Larry Kleinman³, Arthur Sedlacek³, Duli Chand², Douglas Worsnop¹

¹Aerodyne Research Inc., Billerica, MA

²Pacific Northwest National Laboratory, Richland, Washington, USA

³Brookhaven National Laboratory, Upton, USA

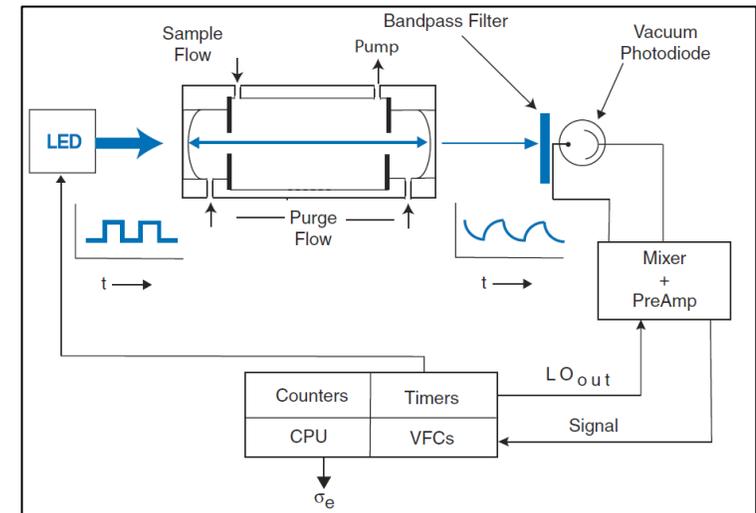
Optical Measurements

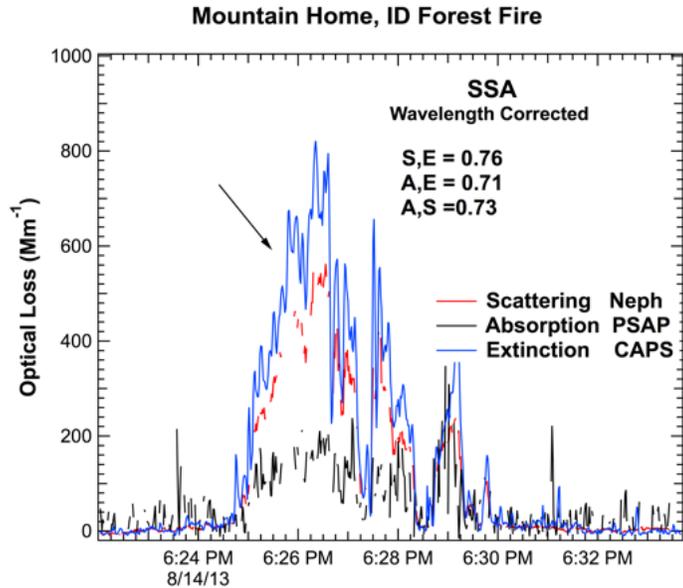
Extinction:	1- λ CAPS PMex (630 nm)
Scattering:	3- λ Nephelometer (450, 550, 700 nm)
Absorption:	1- λ PAS (355 nm)
	1- λ PTI (532 nm)
	3- λ PSAP (462, 523, 648 nm)

SSA's derived from SCAT/EXT

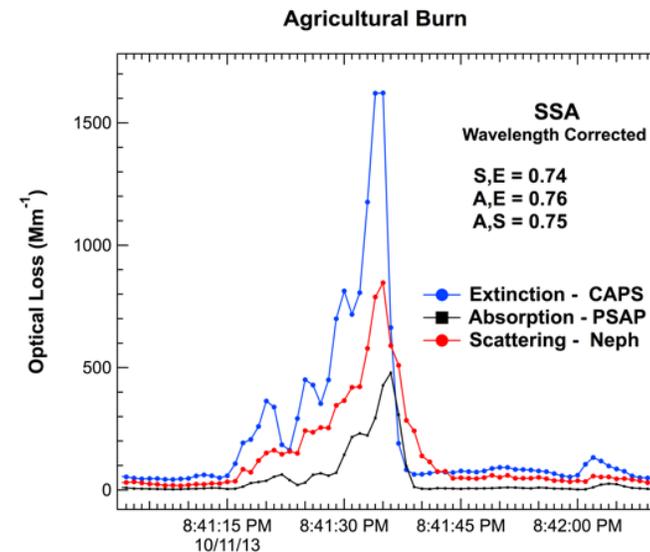
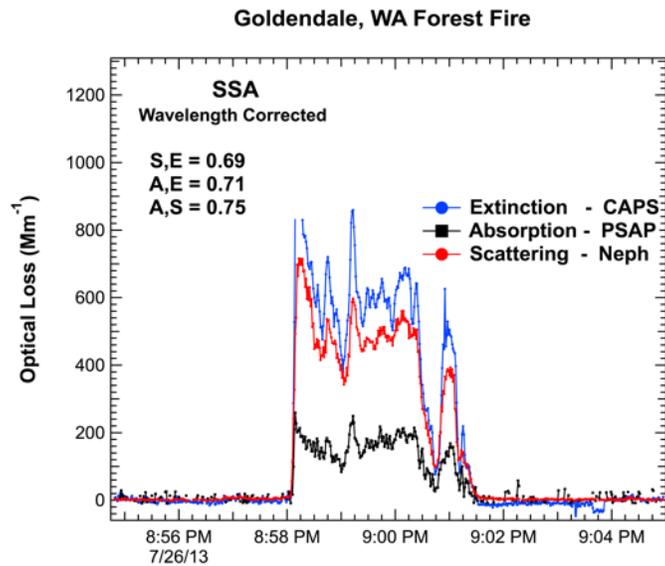
- SCAT: NEPH (550 and 700 nm)
 - Interpolated at 630 nm using Angstrom coefficient
- EXT: CAPS PMex (630 nm)

CAPS PMex

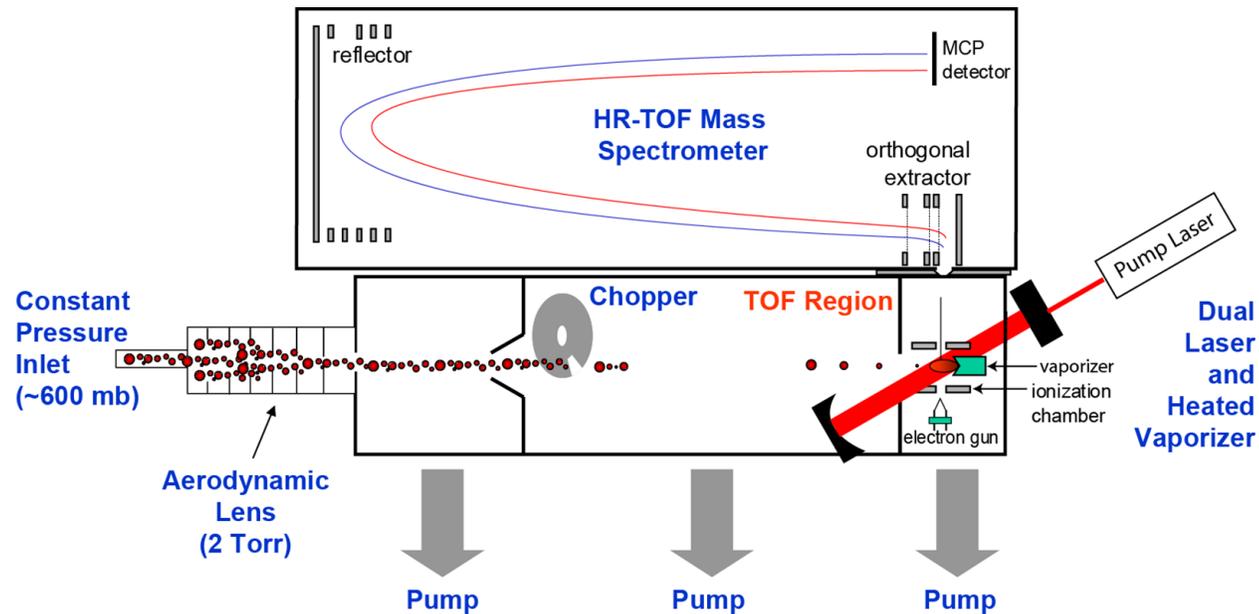




- Select examples of correlations and closure between CAPS PMex (630 nm) EXT, NEPH (700 nm channel modified to 630 nm) SCAT, and PSAP (648 nm) ABS for wildland and agricultural burns
- SSA ~ 0.7 to 0.75
- Apparent closure between three optical measurements

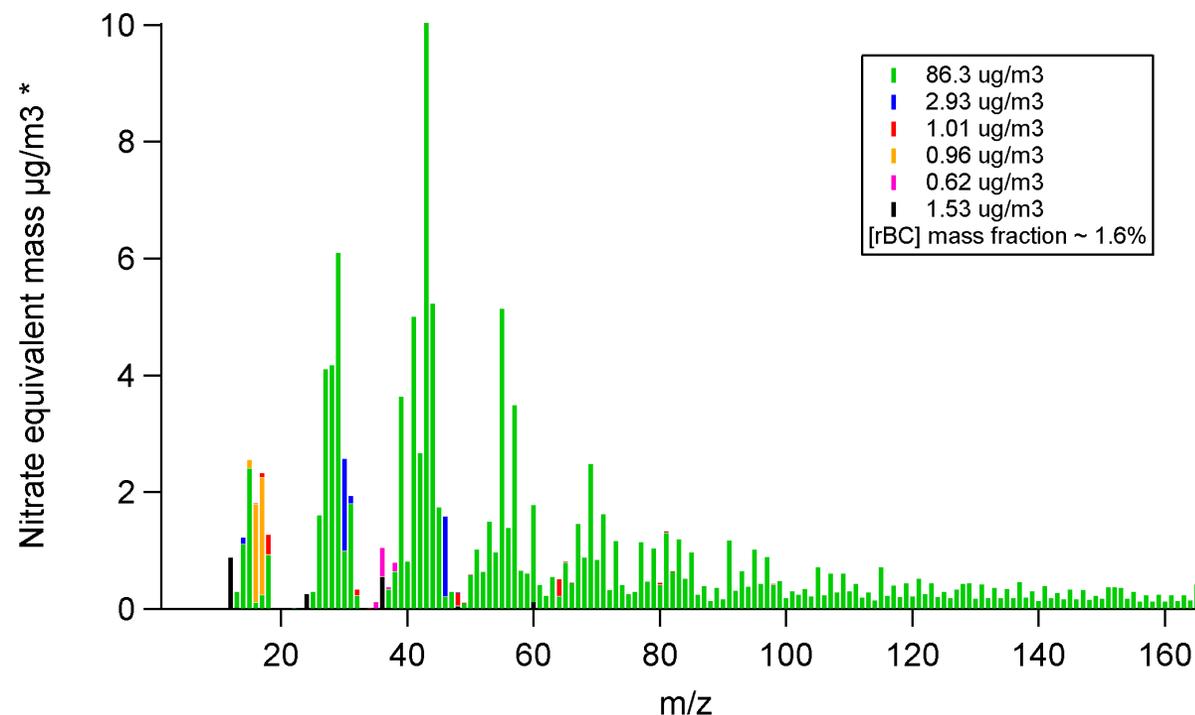


Soot Particle Aerosol Mass Spectrometer (SP-AMS)



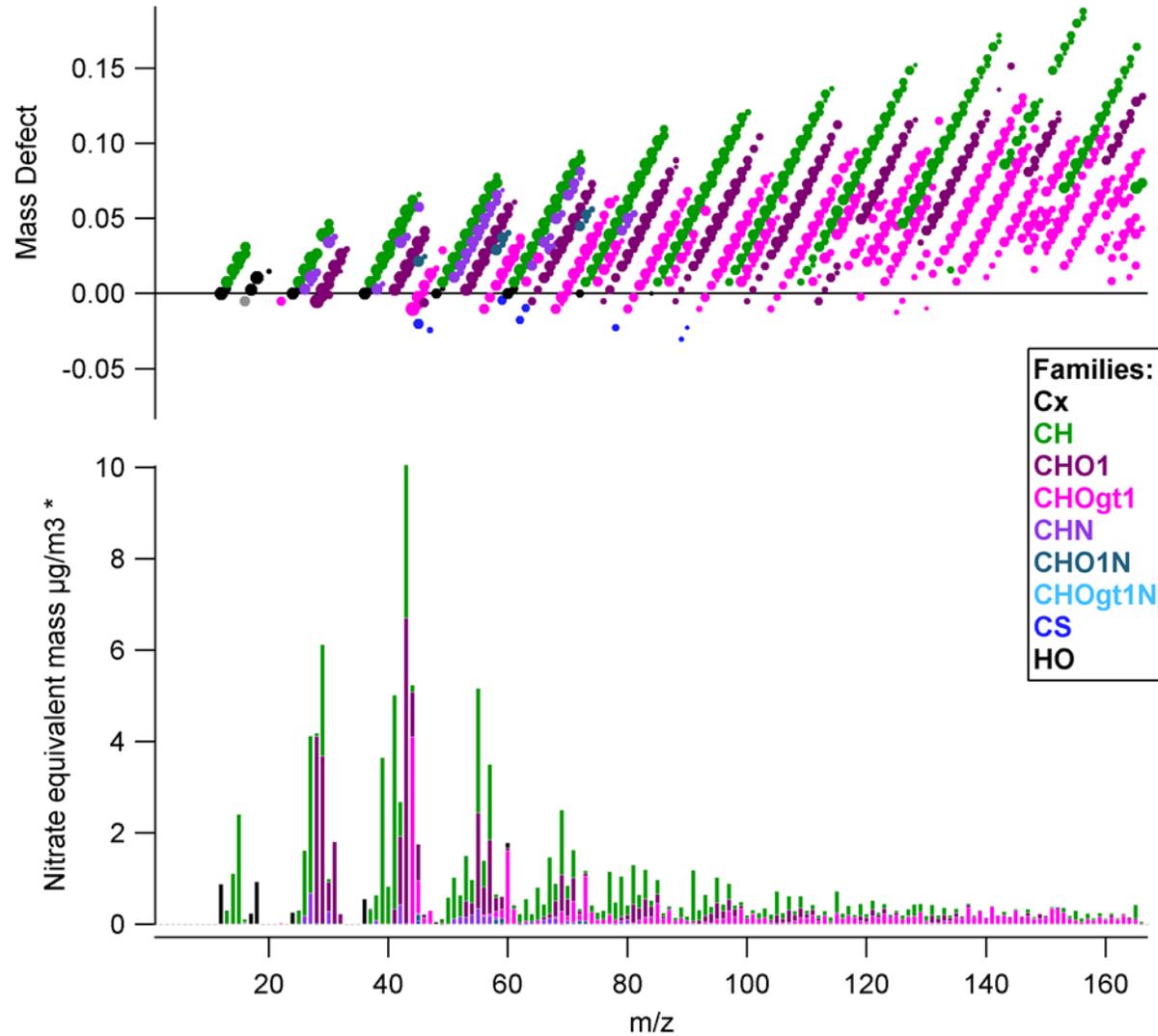
- First research flights for SP-AMS
- Operated behind a constant pressure inlet
- Utilized dual vaporizers (laser and resistively heated tungsten)
 - With the laser vaporizer off, the instrument is a standard HR-AMS
 - Laser vaporizer provides sensitivity to refractory black carbon (rBC) particles
 - Differences between the two vaporizers will provide information on rBC containing particle chemistries

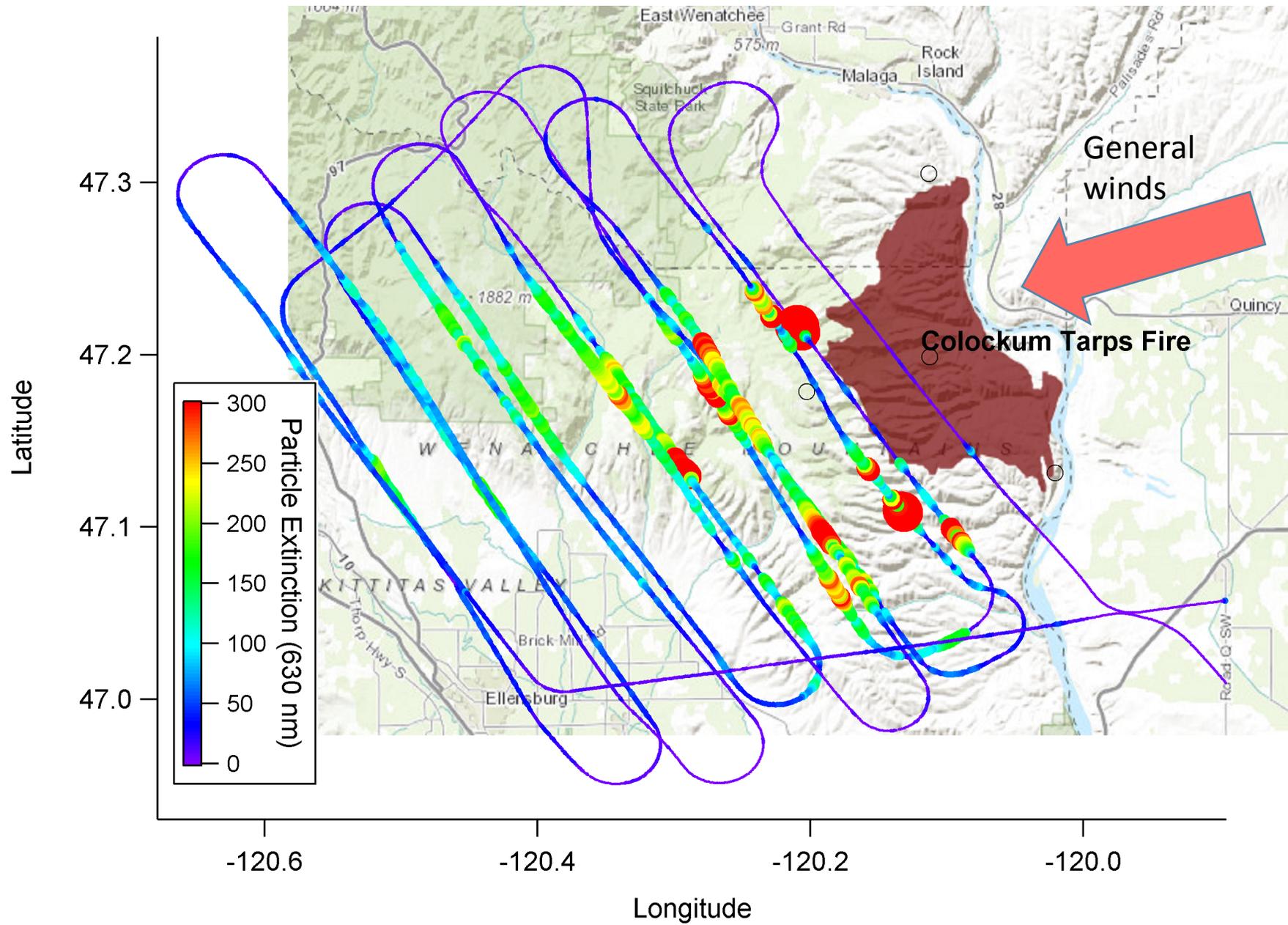
Average [rBC] mass fraction



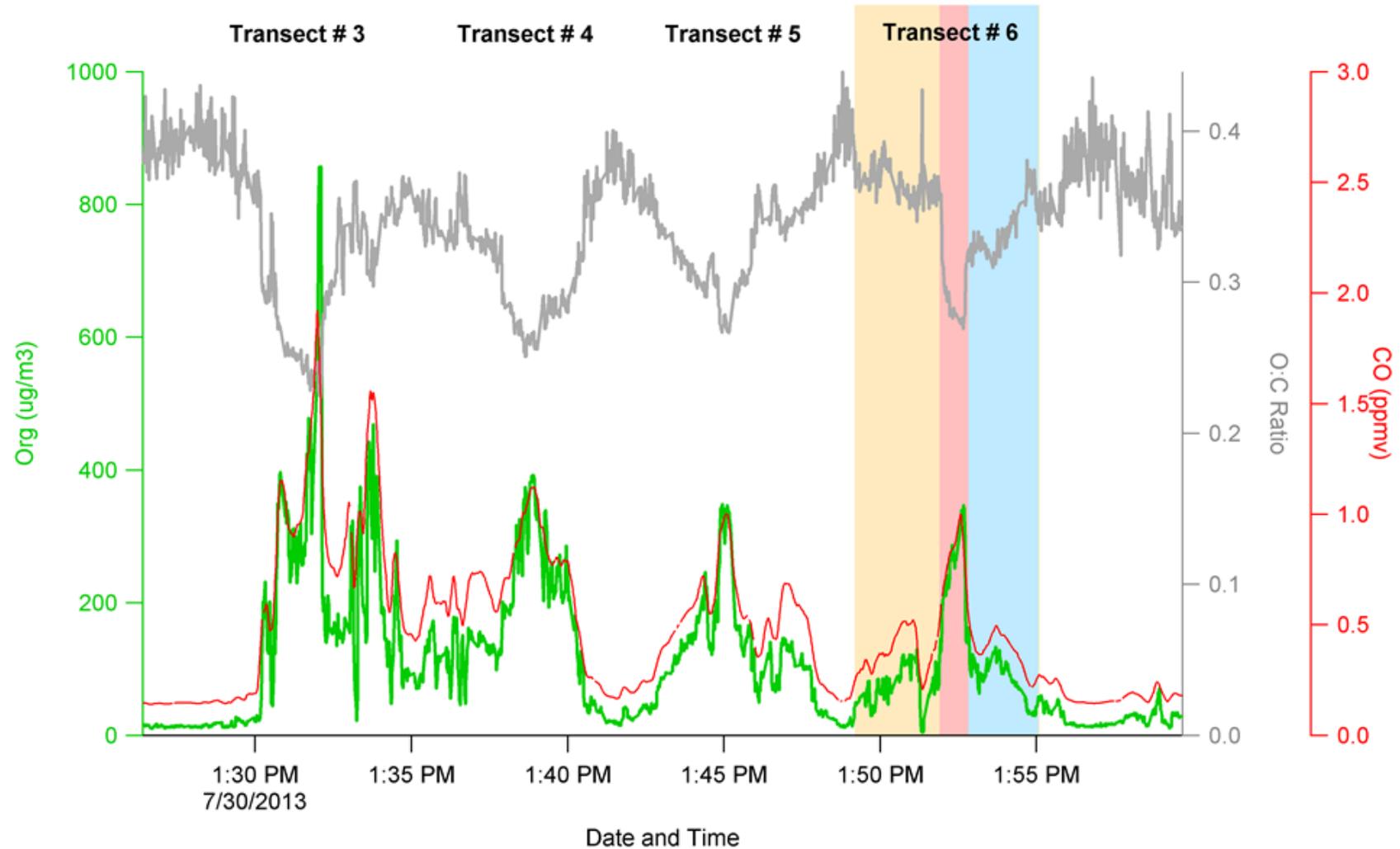
- SP-AMS operated with dual laser and heated tungsten vaporizer
- Biomass burning plumes exhibited high R_{BC} ($[NR-PM]/[rBC]$) ratios ($\gg 10$)

Average Chemical Composition

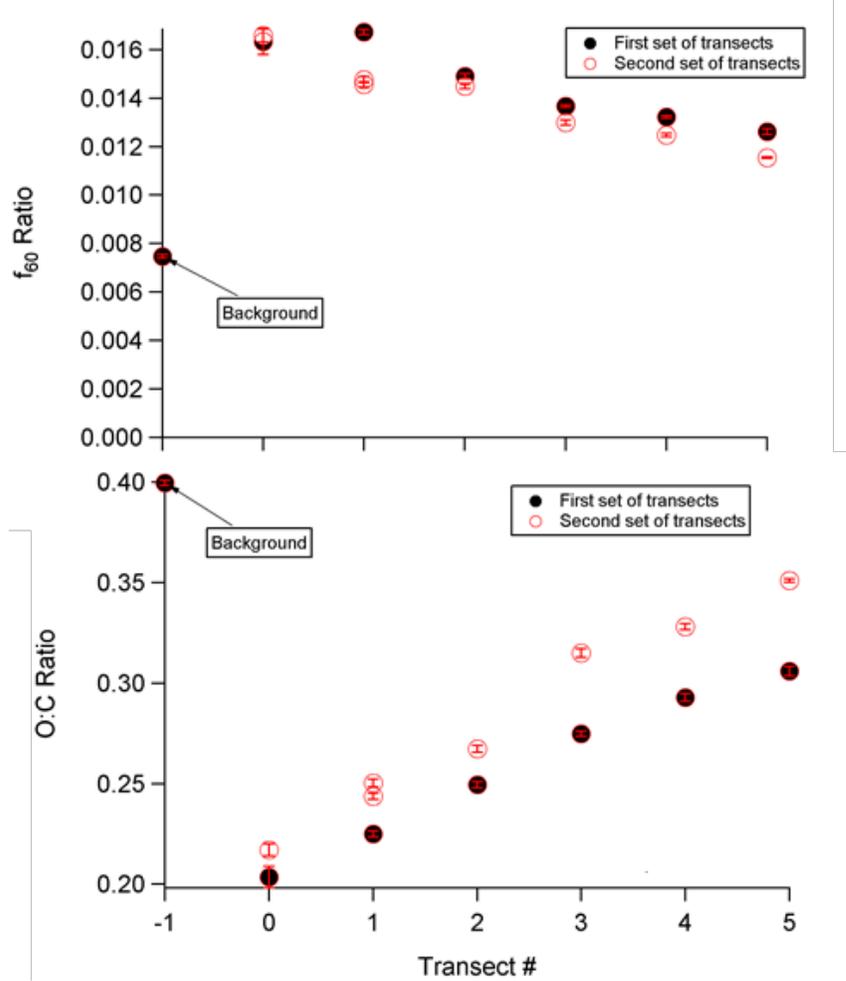
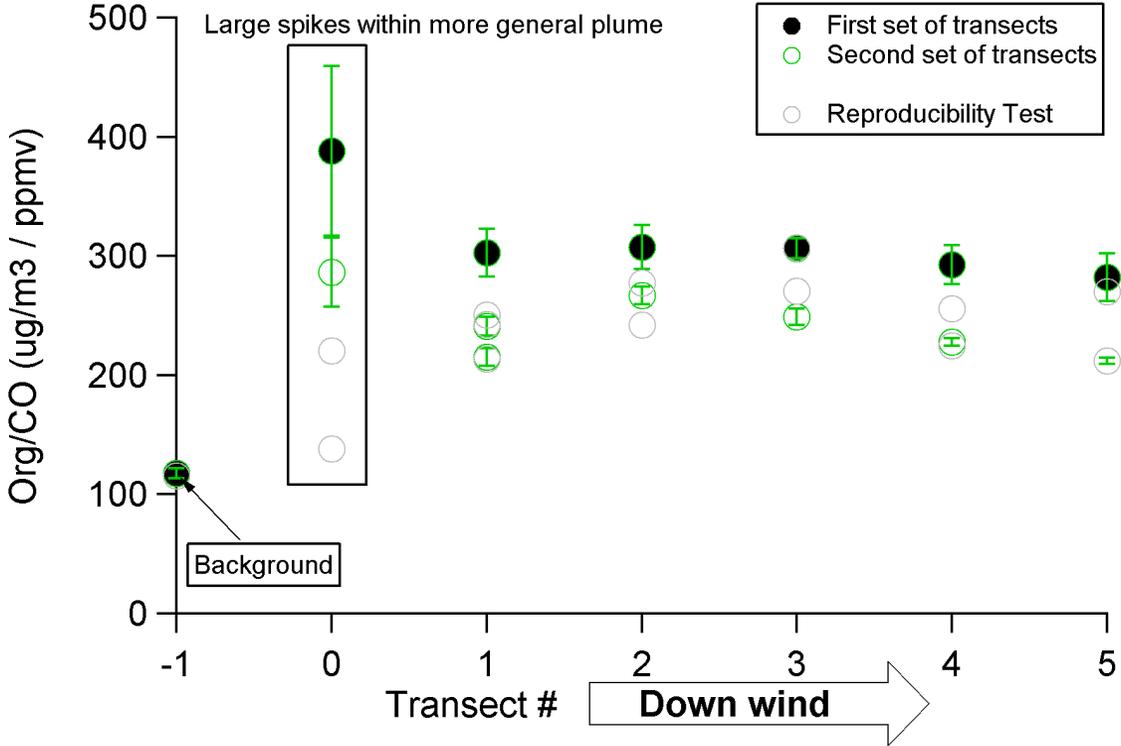




How to define transects?



Downwind Chemical Changes



Summary:

Examining Different Parameters As Plume Evolves

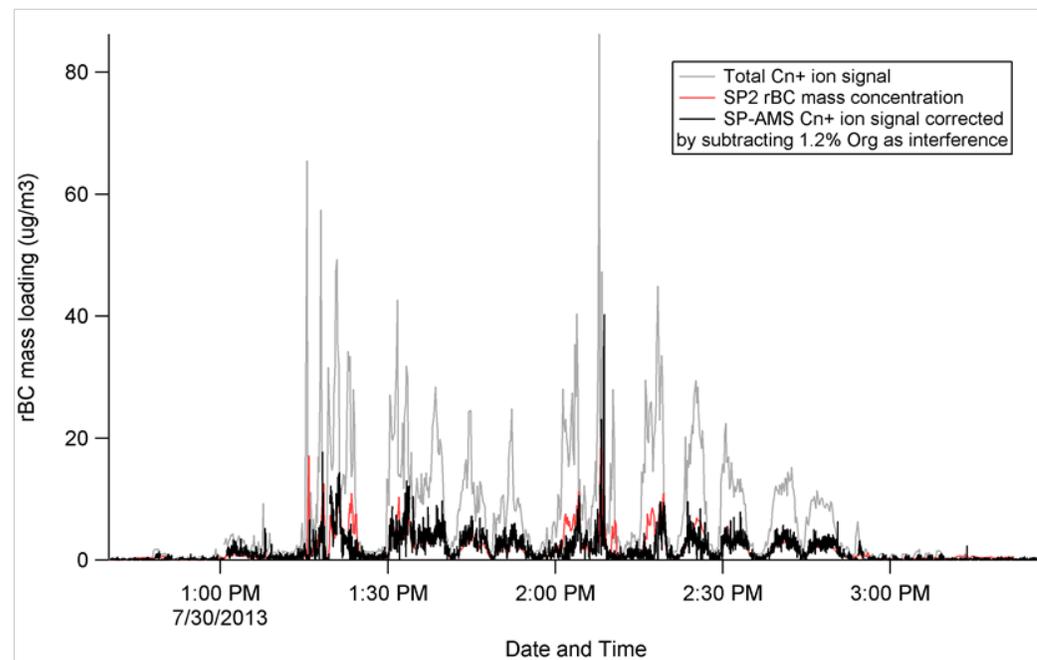
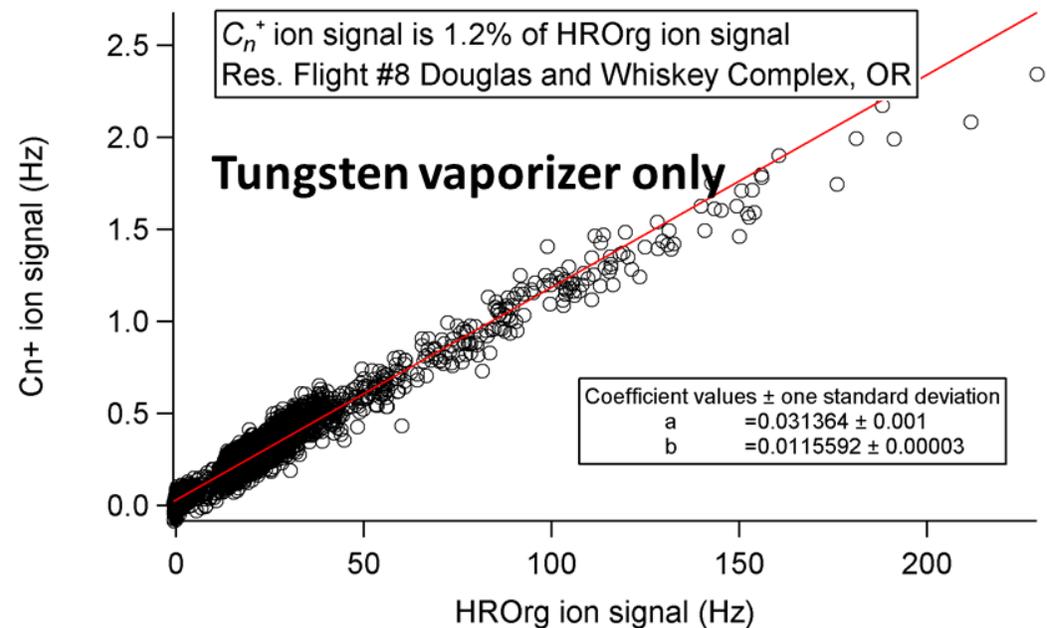
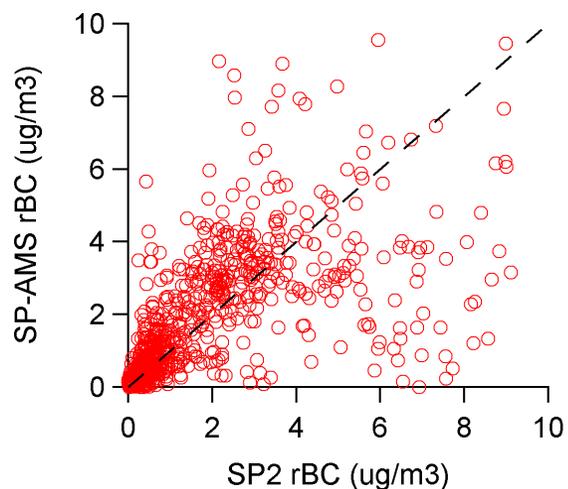
- Characterize optical properties (SSA at 630 nm)
- Measure Particulate Emissions (e.g., Org/CO)
- Characterize Aerosol Chemistry
 - O:C increases, f_{60} decreases
- Gain better understanding of Volatility Losses/SOA Production
- Characterizing plumes by combustion conditions (location, fuel and MCE)

DOE ASR proposal to analyze complete data sets

Extra Slides

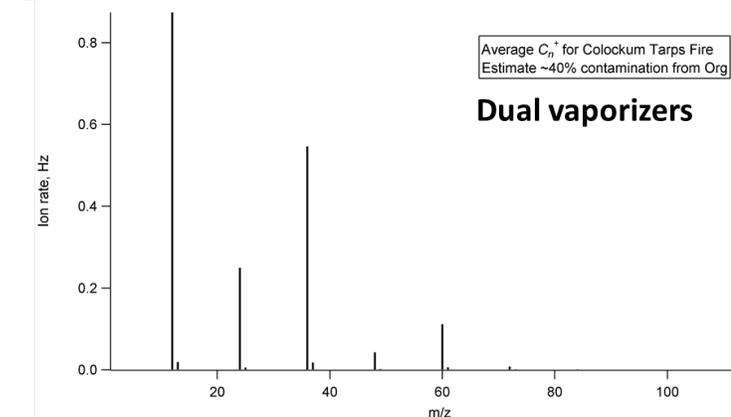
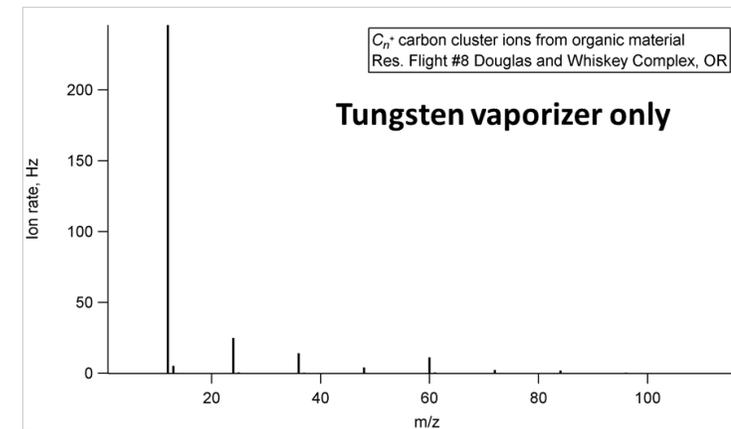
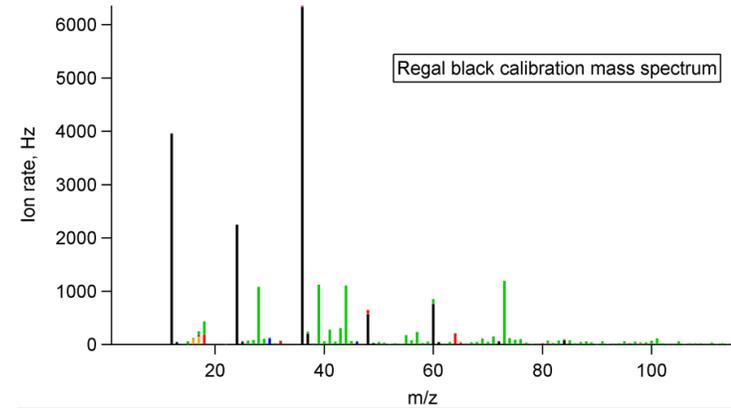
Comparison with SP2

- High [Org] generates C_n^+ ion signals (~1.2% total) that interfere with rBC C_n^+ ion signals (~50%)
- First cut provides a good correlation with SP2



rBC fragmentation

- Sources and fragmentation patterns for Org and rBC C_n^+ ions differ, allowing for deconvolution
- Investigate further with PCA and PMF analysis



Biomass Burning Observation Project (BBOP)



Used G1
Aircraft to
sample
biomass
fires as they
occur

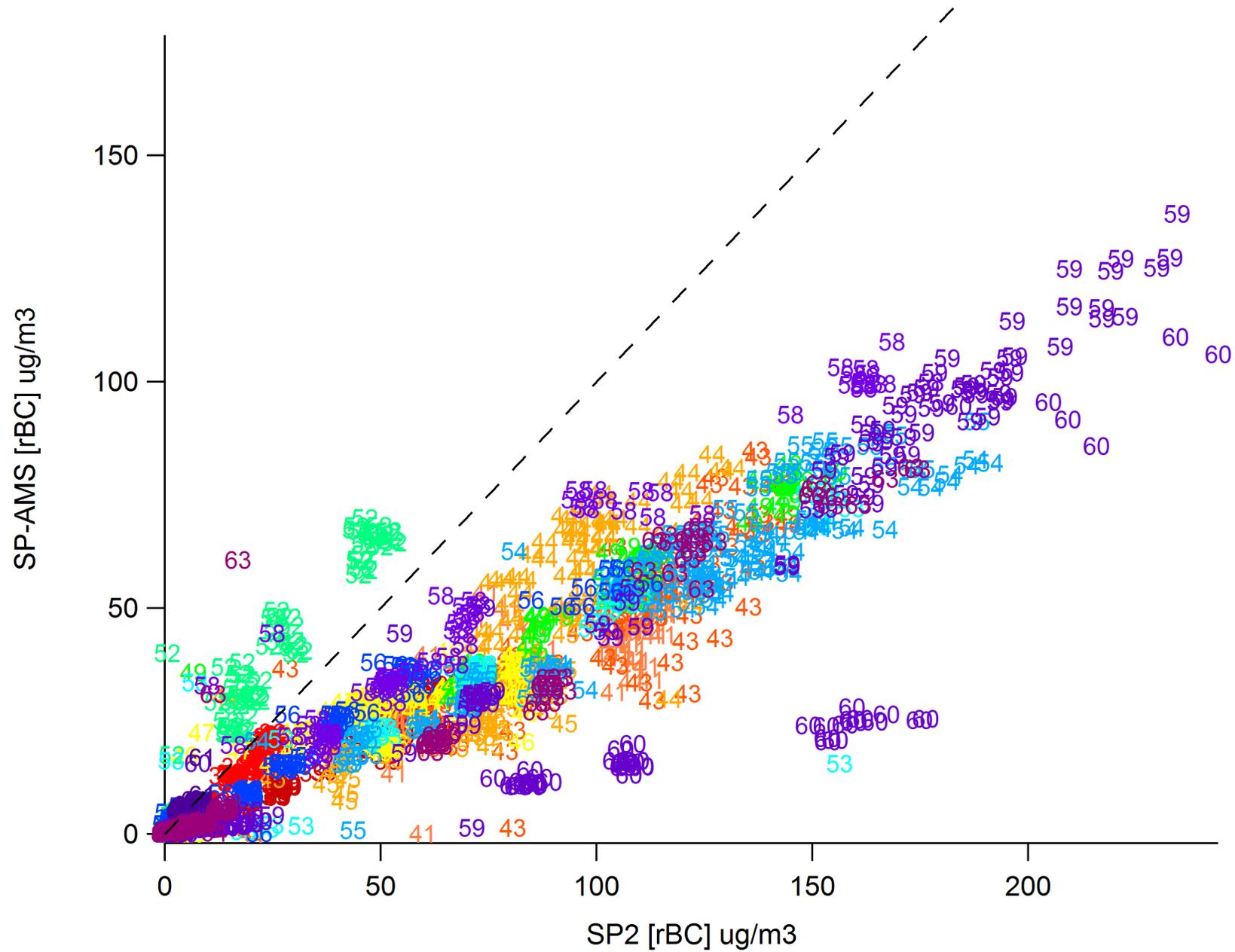


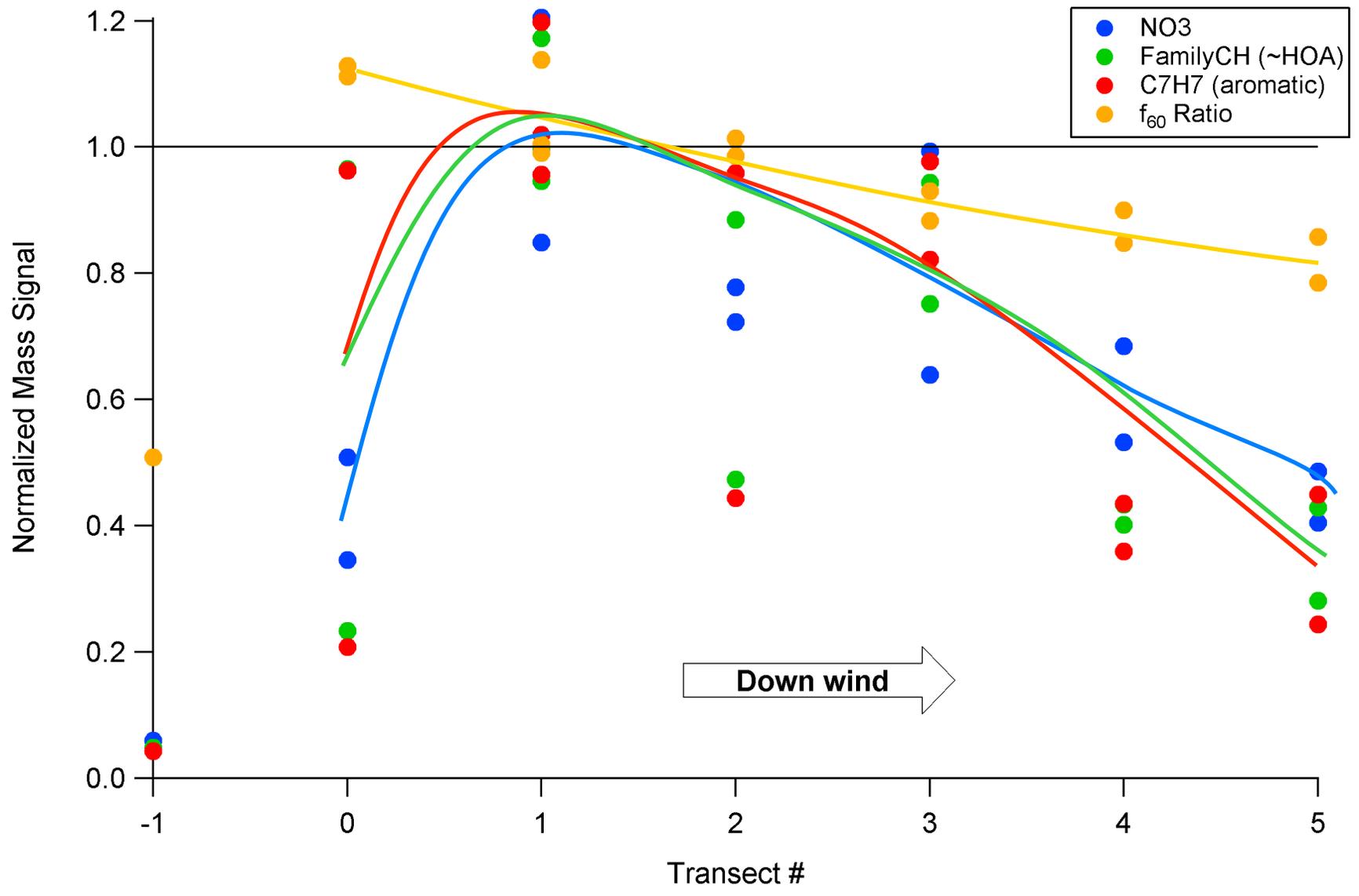
Crop Burning in
Mississippi Valley



Forest Fires in
Northwest USA

DOE ARM
BNL (Sedlacek)





- The Biomass Burning Observation Project (BBOP), a Department of Energy (DOE) sponsored study, measured wildland fires in the Pacific Northwest and prescribed agricultural burns in the Central Southeastern US from the DOE Gulfstream-1 (G-1) aircraft platform over a four month period in 2013. The chemical composition of the emitted particulate emissions were characterized using an Aerodyne Soot Particle Aerosol Mass Spectrometer (SP-AMS) and will be presented in the context of the fire location and source. The SP-AMS was operated with both laser and resistively heated tungsten vaporizers, alternatively turning the laser vaporizer on and off. With the laser vaporizer off, the instrument operated as a standard HR-AMS. Under these sampling conditions, the non-refractory chemical composition of the biomass burning particles will be characterized as a function of the fuel type burned and the observed modified combustion efficiency and observed changes during downwind transport. Specific attention will focus on the level of oxidation (i.e., O:C, H:C, and OM:OC ratios), anhydrosugar, and aromatic content. With the laser vaporizer on, the SP-AMS was also sensitive to the refractory black carbon content, in addition to the non-refractory components, and will be presented within the context of technique-specific collection efficiencies. Under these sampling conditions, additional information on the mass of black carbon, the OM/BC ratio, and the R_{BC} (coat-to-core) ratio will be examined, with a focus on correlating with the simultaneous optical measurements.