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

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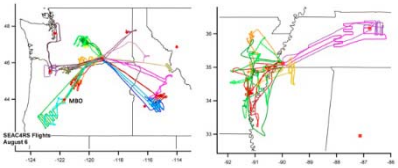
Introduction and Methods

Biomass Burn Observation Project (BBOP)

A Department of Energy (DOE) sponsored study to measure wildland fires in the Pacific Northwest and prescribed agricultural burns in the Central Southeastern US from the DOE Gulfstream-1 aircraft platform over a four month period in 2013.



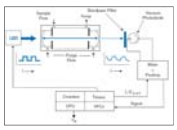
Wildland Fires:
Shrub, Forest
Urban: Seattle (3), Portland (2), Spokane (2)
MBO (3)
SEAC4RS: Joint mission Aug., 6

Prescribed Agricultural burns:
rice, soybean, sorghum
Urban: Nashville (2), Memphis (2)

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)

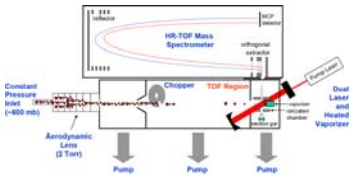
CAPS PMex



Chemical & Physical Measurements

NR-PM:	SP-AMS, TEM
rBC:	SP2, SP-AMS, TEM
Szie:	UHSAS, PCASP, FIMS

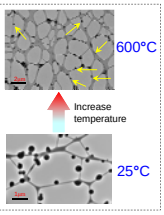
SP – AMS



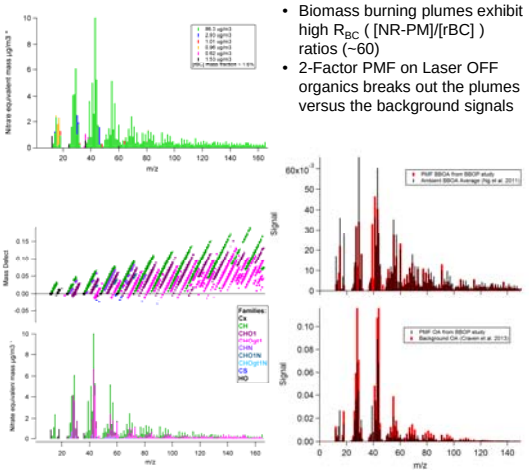
Tar ball observations

Tar balls have been observed infrequently in biomass burning plumes; very little is known about the formation mechanism(s) and evolution of tar balls. Tar ball formation and evolution were clearly observed in BBOP samples examined using electron microscopy and laboratory experiments on their volatility are on-going. Controlled laboratory study are planned to augment field observations on TB formation and to further examine preliminary heating experiments.

Tar balls smaller, but still present

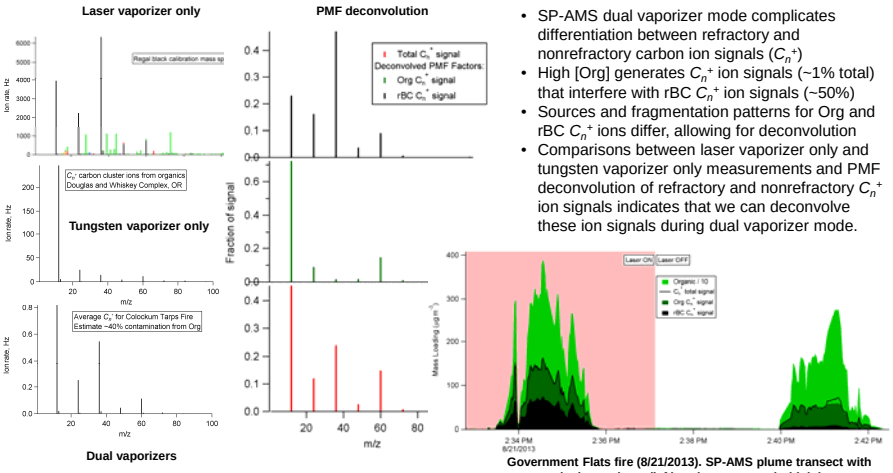


Nonrefractory composition



- Biomass burning plumes exhibit high R_{BC} ([NR-PM]/[rBC]) ratios (~60)
- 2-Factor PMF on Laser OFF organics breaks out the plumes versus the background signals

Refractory black carbon measurements



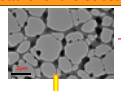
- SP-AMS dual vaporizer mode complicates differentiation between refractory and nonrefractory carbon ion signals (C_n^+)
- High [Org] generates C_n^+ ion signals (~1% total) that interfere with rBC C_n^+ ion signals (~50%)
- Sources and fragmentation patterns for Org and rBC C_n^+ ions differ, allowing for deconvolution
- Comparisons between laser vaporizer only and tungsten vaporizer only measurements and PMF deconvolution of refractory and nonrefractory C_n^+ ion signals indicates that we can deconvolve these ion signals during dual vaporizer mode.

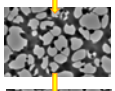
Government Flats fire (8/21/2013). SP-AMS plume transect with dual vaporizers (left) and tungsten only (right)

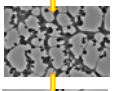
Evolution of biomass plumes

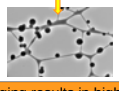
Tar ball formation

Fresh aerosol particles spread over the substrate



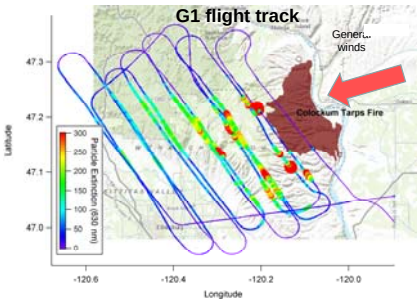




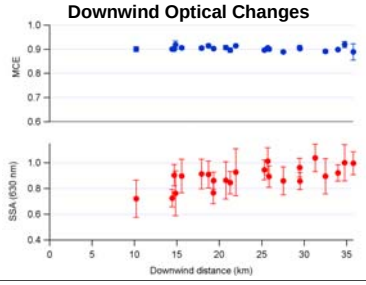


Aging results in highly spherical particles called Tar Balls

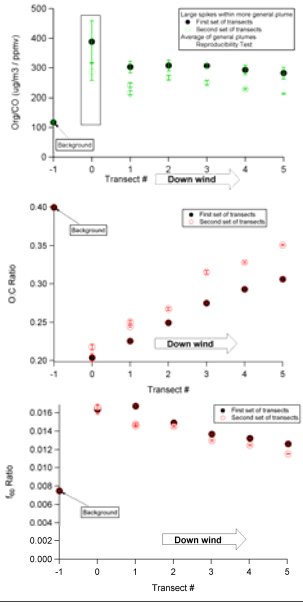
Observation of Rapid Downwind Transformations



Downwind Optical Changes



Downwind Chemical Changes



Summary

- Rapid physical, chemical and optical changes in biomass burning particles measured downwind (< 3 hours) from wildland fires in Pacific Northwest.
- Organic aerosol loadings ([Org]/[CO]) appear to be relatively constant with time downwind suggesting that the competing evaporation of primary and condensation of secondary particulate material may be of similar order within the first few hours.
- Whereas the [Org]/[CO] ratios are nearly constant, the chemical composition of the Org PM is rapidly changing, with the O:C and OM:OC increasing and primary components, such as anhydrosugar markers, decreasing.
- TEM's observe apparent loss of low viscous PM and formation of tar balls; perhaps providing explanation for relatively constant organic aerosol loadings downwind.
- SSA's increase downwind, indicating scattering increases faster than absorption (i.e., increase in aerosol mass, size, and/or real refractive index); potentially related to changes in organic aerosol chemistry

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