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

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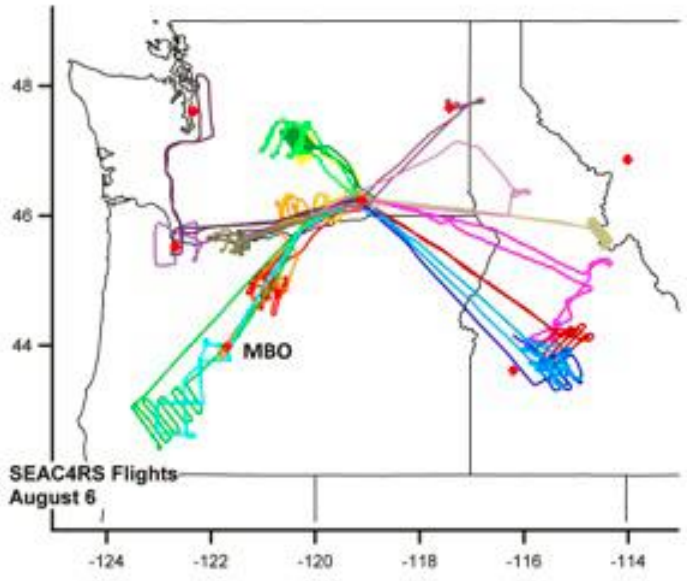
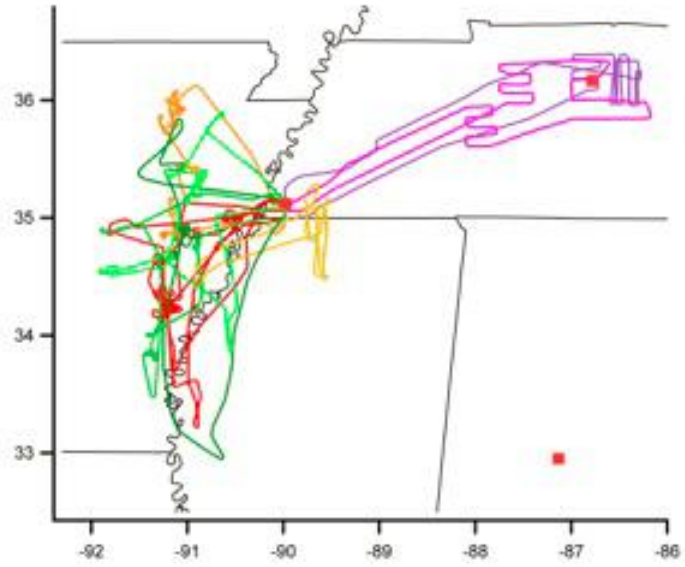
Biomass Burn Observation Project (BBOP)

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.





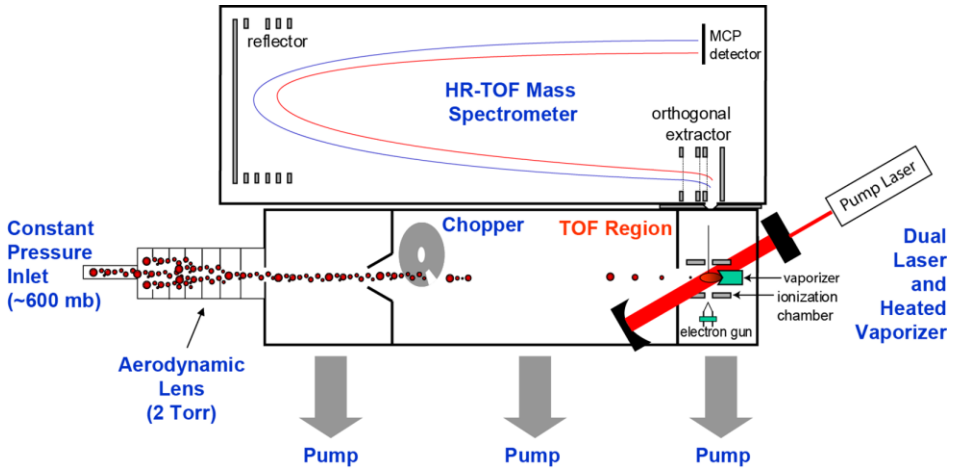
Wildland Fires (17):
Shrub, Forest
Urban: Seattle (3), Portland (2), Spokane (2)
MBO (3)
SEAC4RS: Joint mission Aug., 6

Prescribed Agricultural burns (24):
rice, soybean, sorghum
Urban: Nashville (2), Memphis (2)

Chemical and Optical Measurements

Chemical & Physical Measurements	
NR-PM:	SP-AMS, TEM
rBC:	SP2, SP-AMS, TEM
Size:	UHSAS, PCASP, FIMS

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)



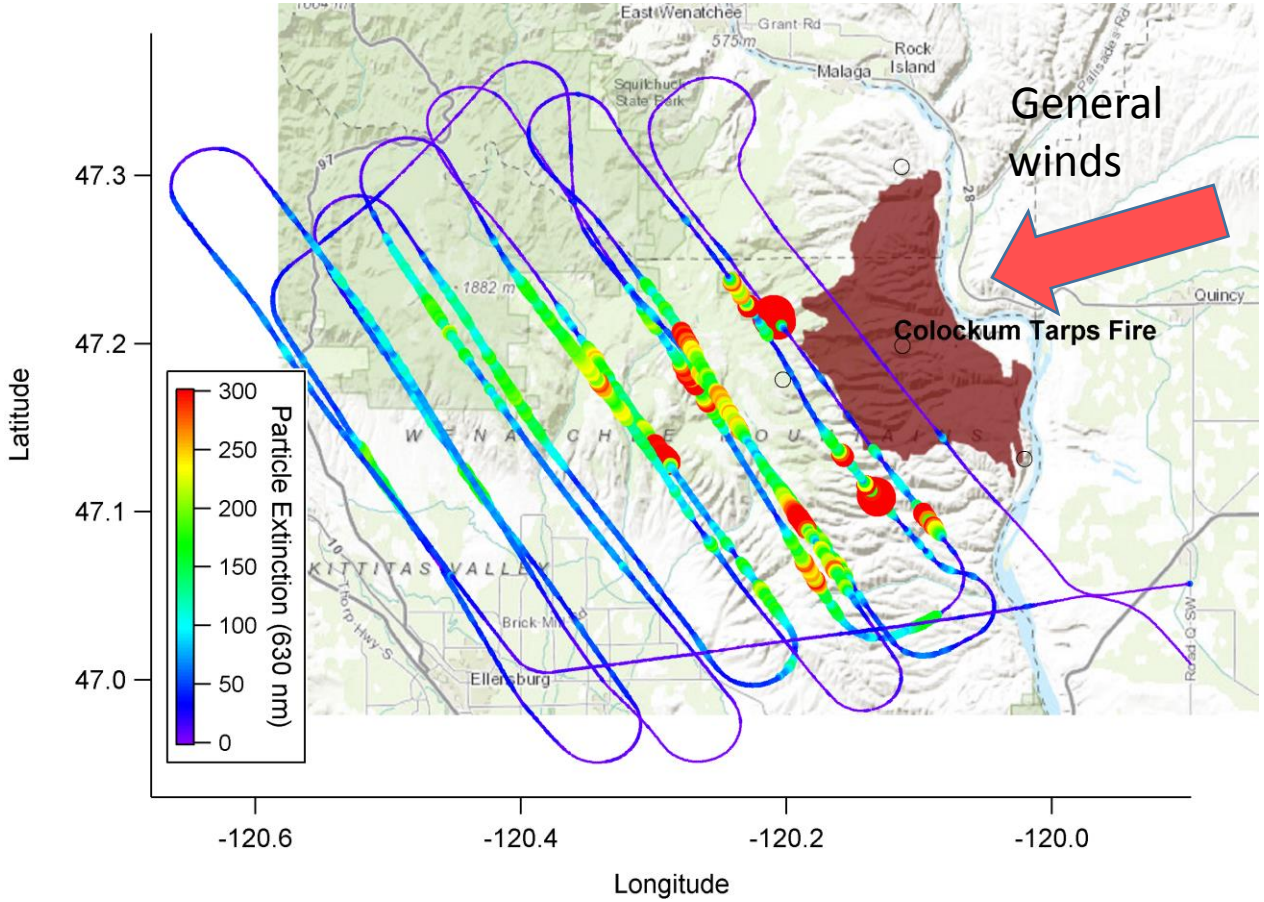
Soot Particle Aerosol Mass Spectrometer (SP-AMS)

SSA's derived from SCAT/EXT

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

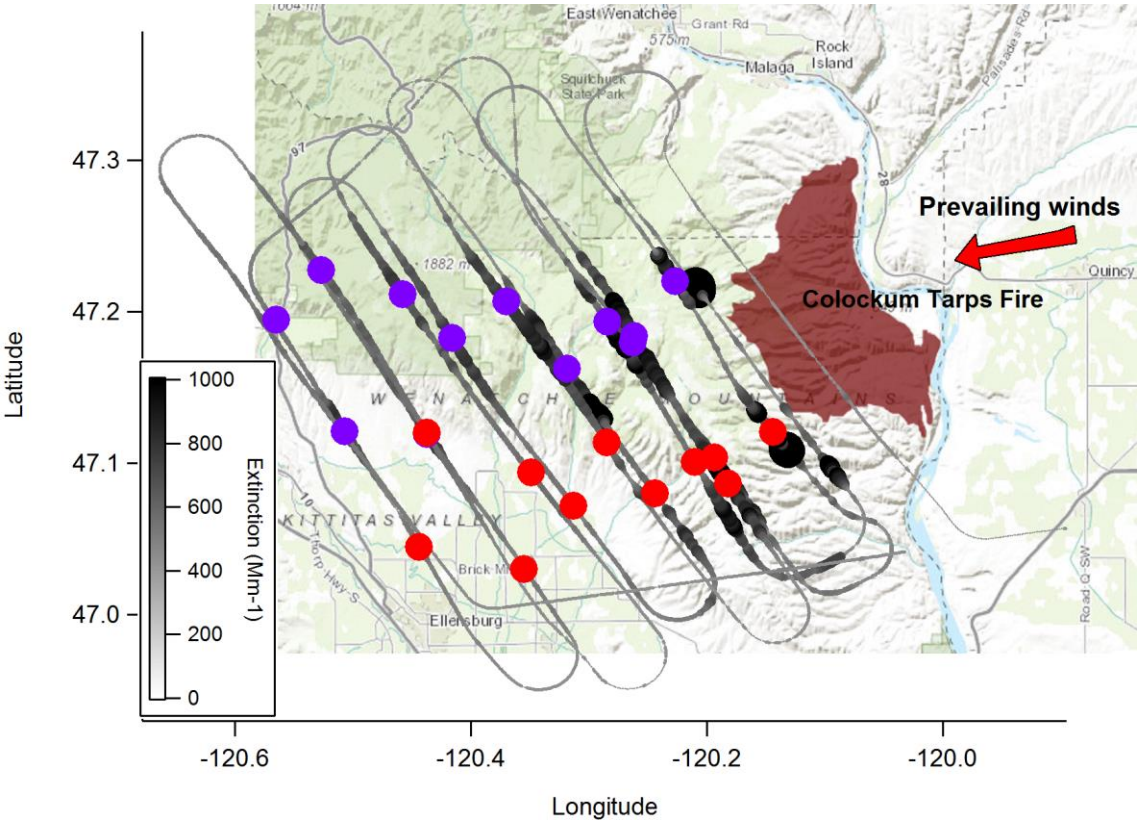
Colockum Tarps Fire (2nd flight July 30)

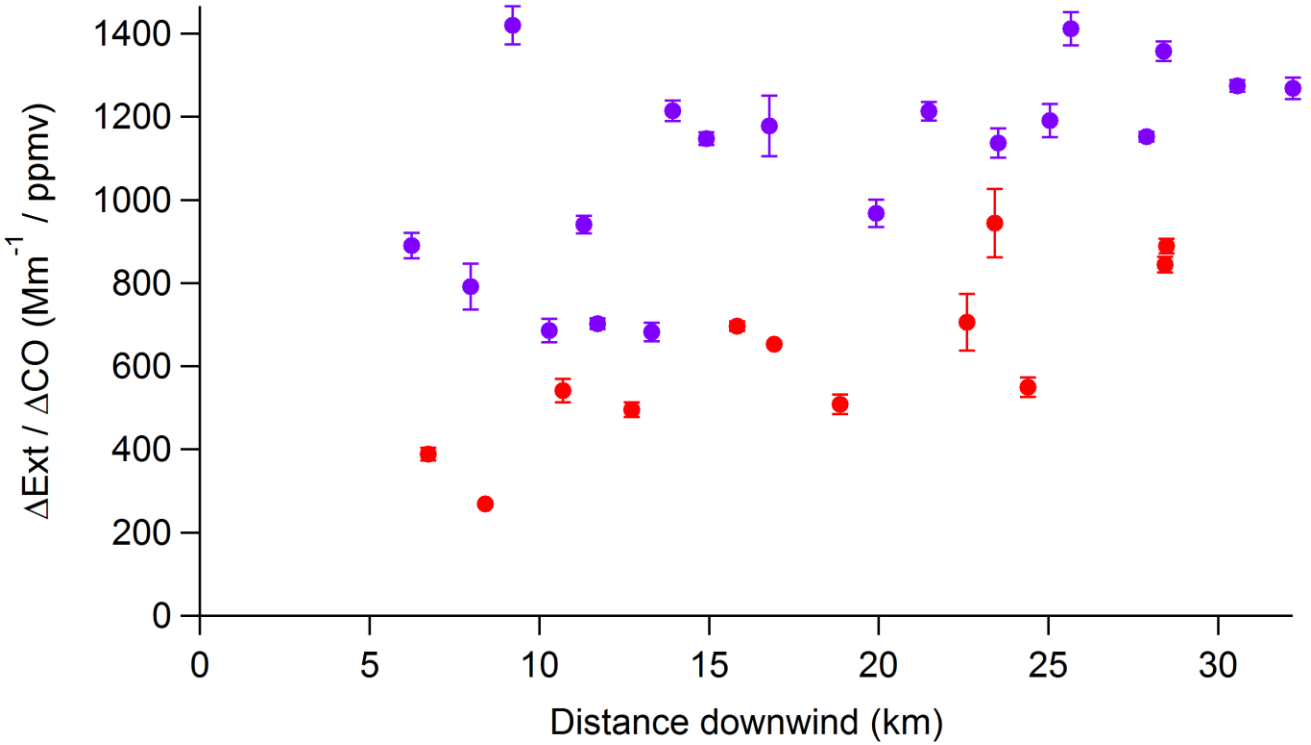
Extinction



- Downwind transects across fire front tracking plumes

ΔExtinction / ΔCO downwind

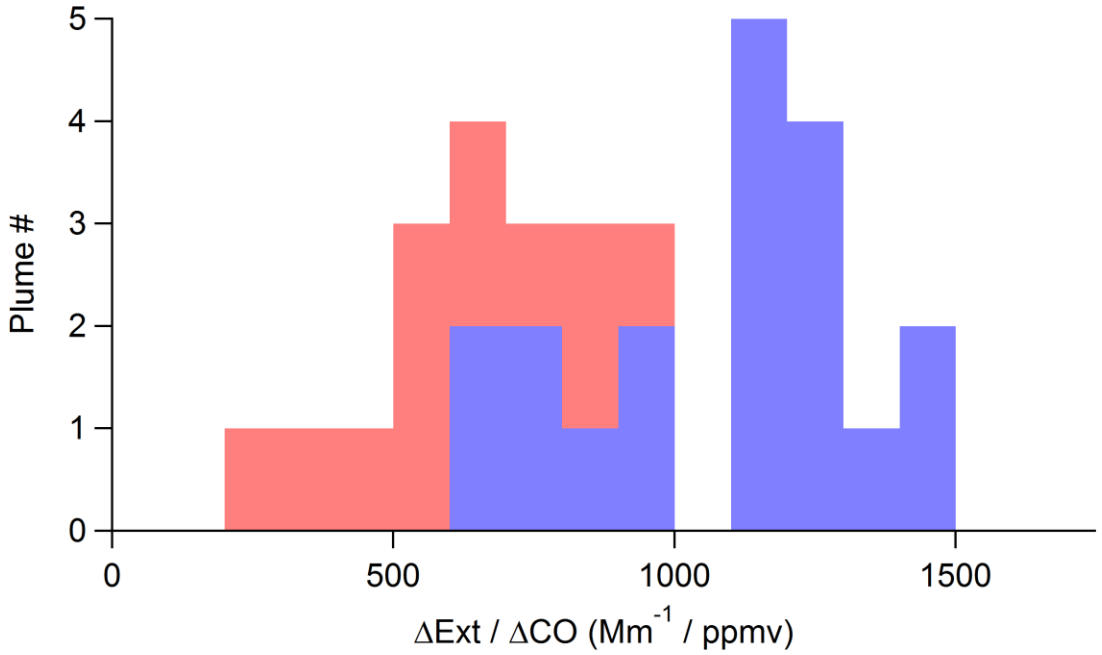




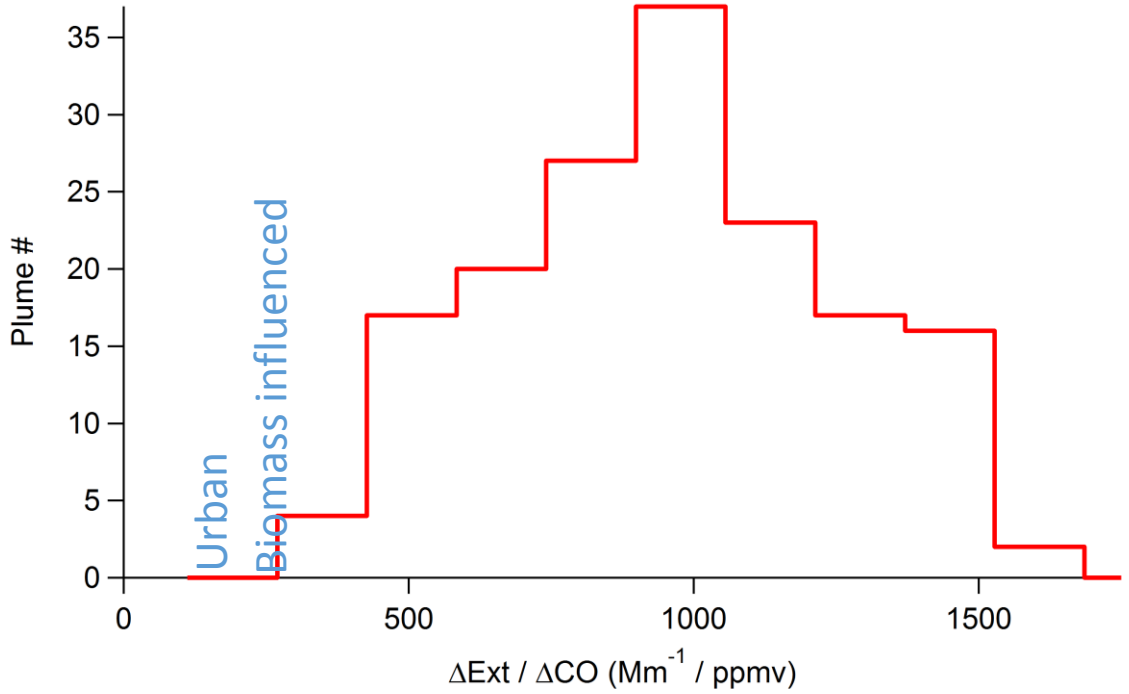
- Extinction relative to CO is increasing downwind
- Different burn plumes from same fire
- Average MCE ~ 0.92 in both plumes (red ≥ purple)

ΔExtinction / ΔCO

Flight 730b (31 plumes)



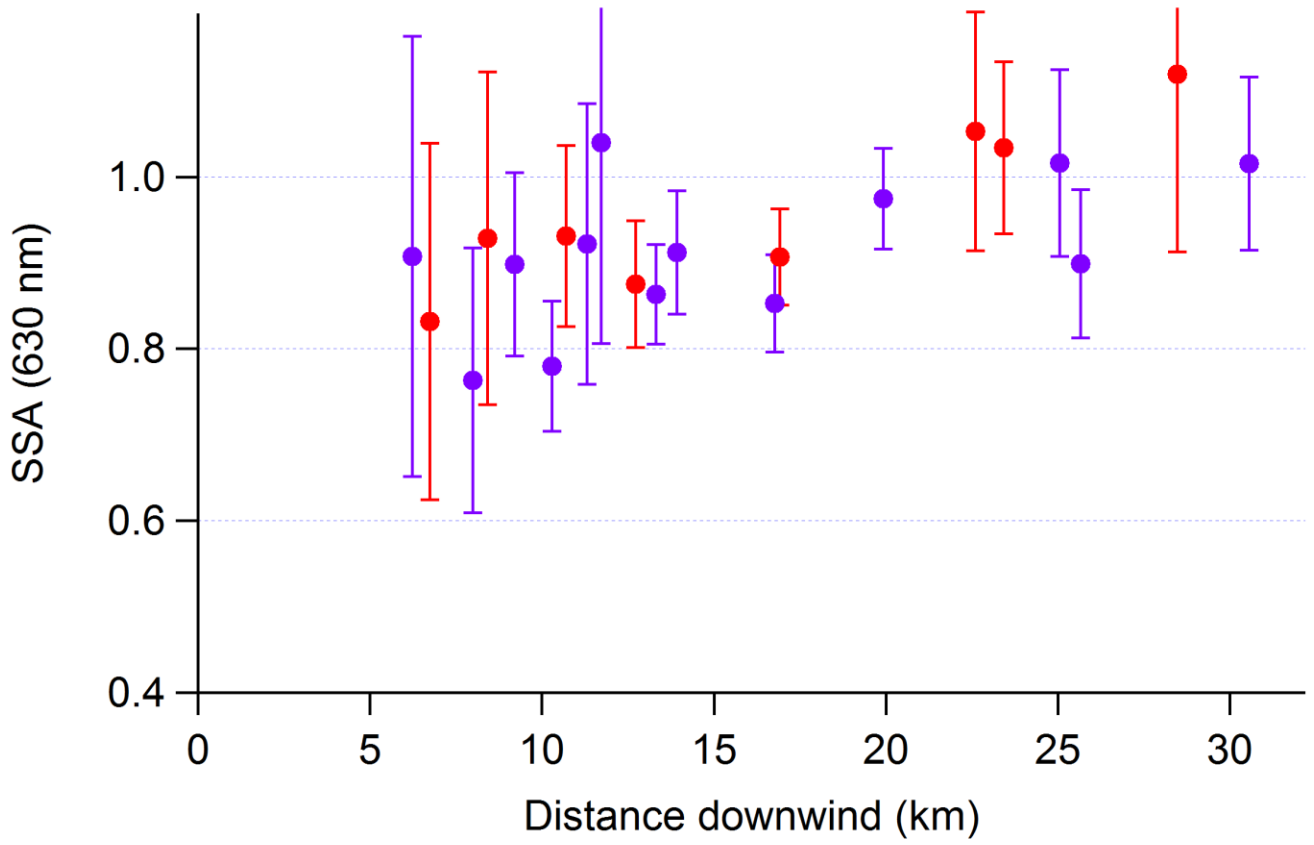
BBOP wildfires (173 plumes)



Dingle et al., 2016 ACPD

- ΔExt/ΔCO for a single fire spans nearly the full range of observed wildfire plumes

SSA (630 nm) measurements downwind

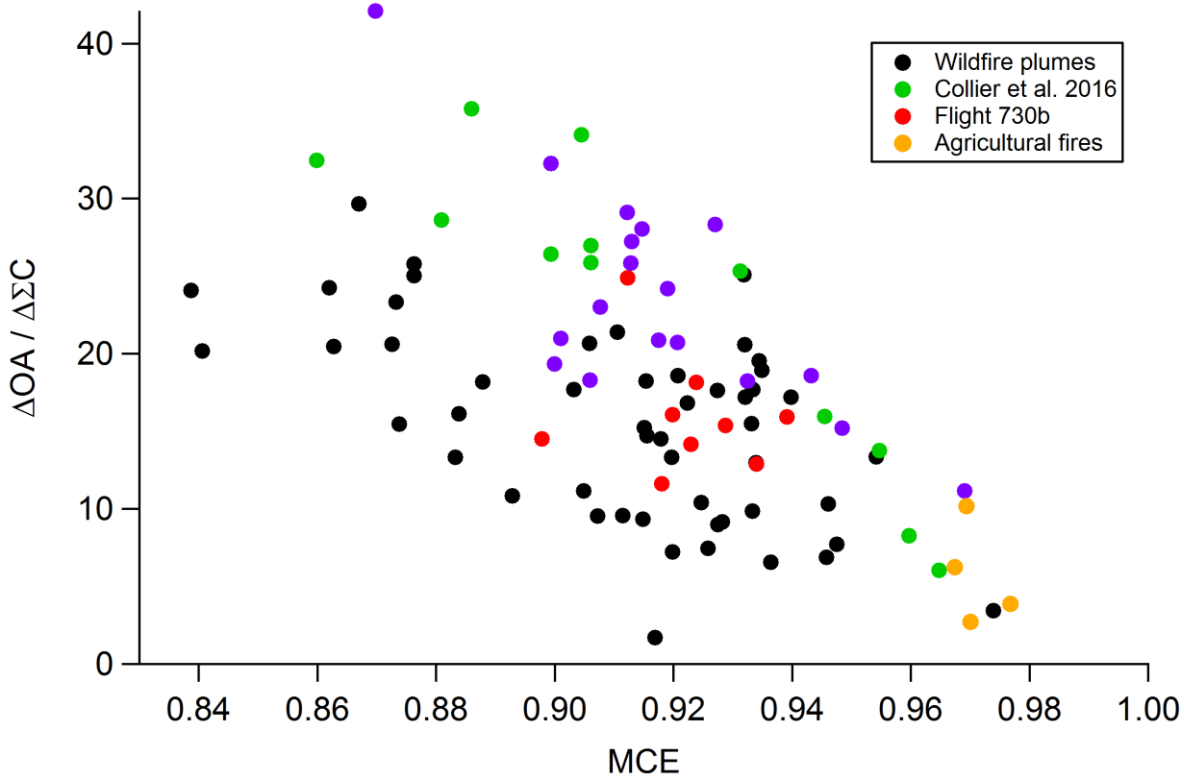


- No apparent differences in SSA with burn plume
- Increasing SSA (630 nm) with downwind transport indicating changes in particle scattering > particle absorption
- Reach SSA ~ 1 within ~3 hours down wind

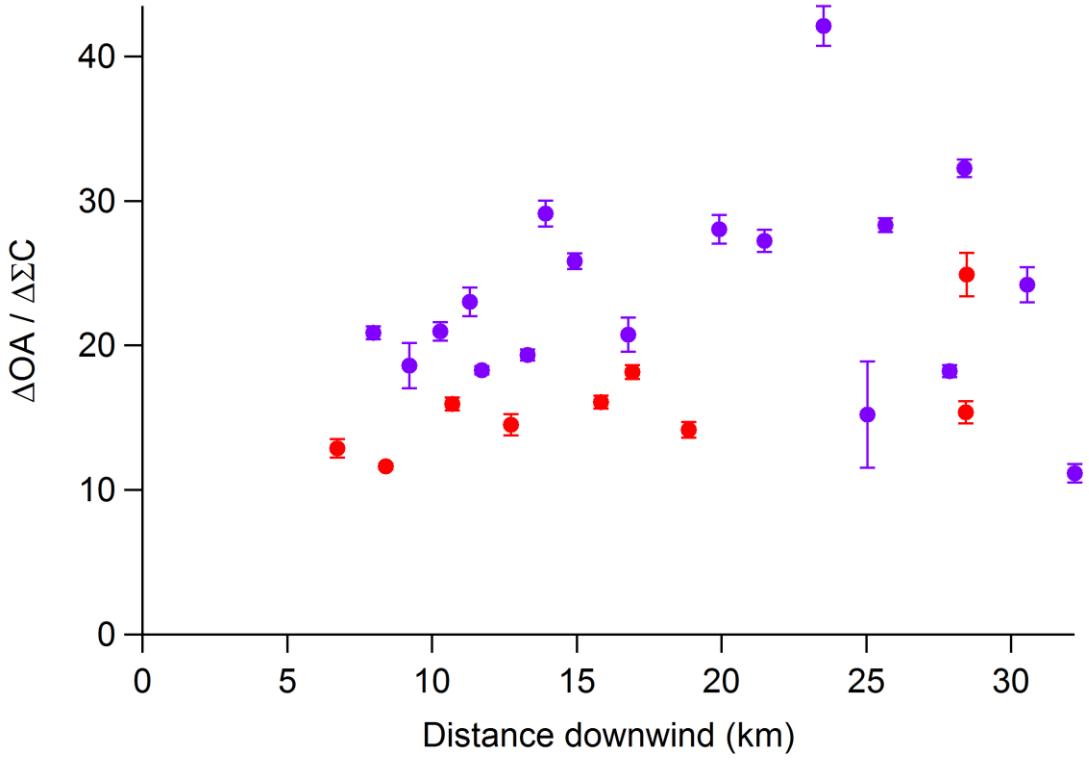
Collier, S. *et al. Environ. Sci. Technol.* acs.est.6b01617 (2016)

Biomass burning PM chemical composition

BBOP wildfires (96 plumes)



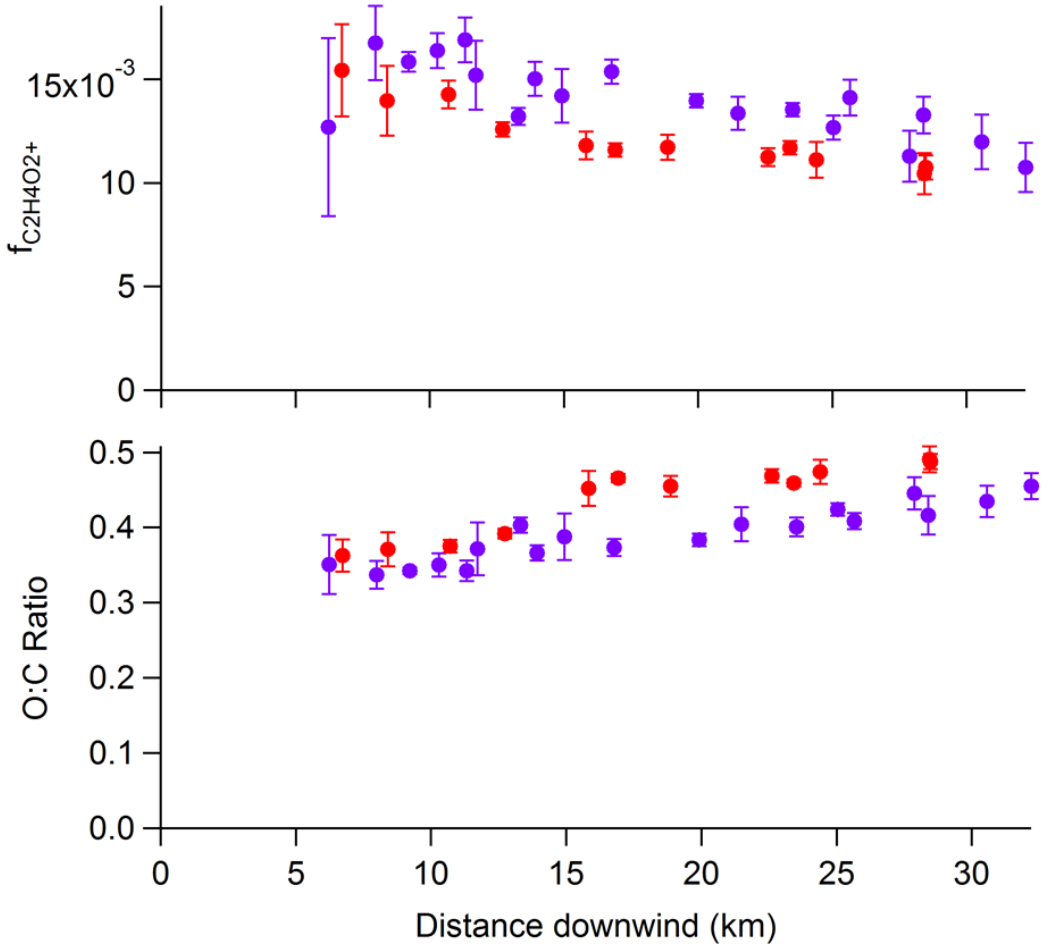
Flight 730b (27 plumes)

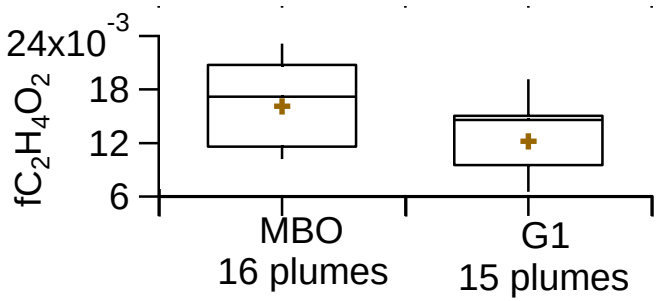


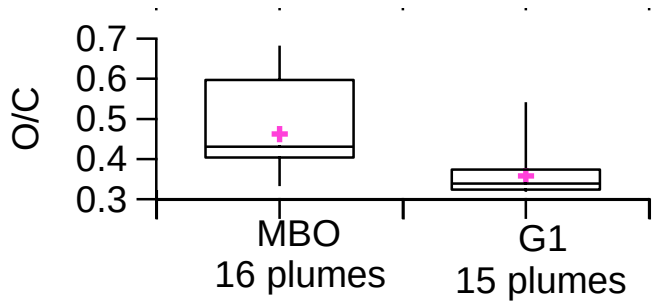
- Biomass burning plumes were > 92 % Organic
- While MCE appears to be strong driver, atmospheric changes may provide secondary variances

Collier et al., 2016

OA chemical changes downwind

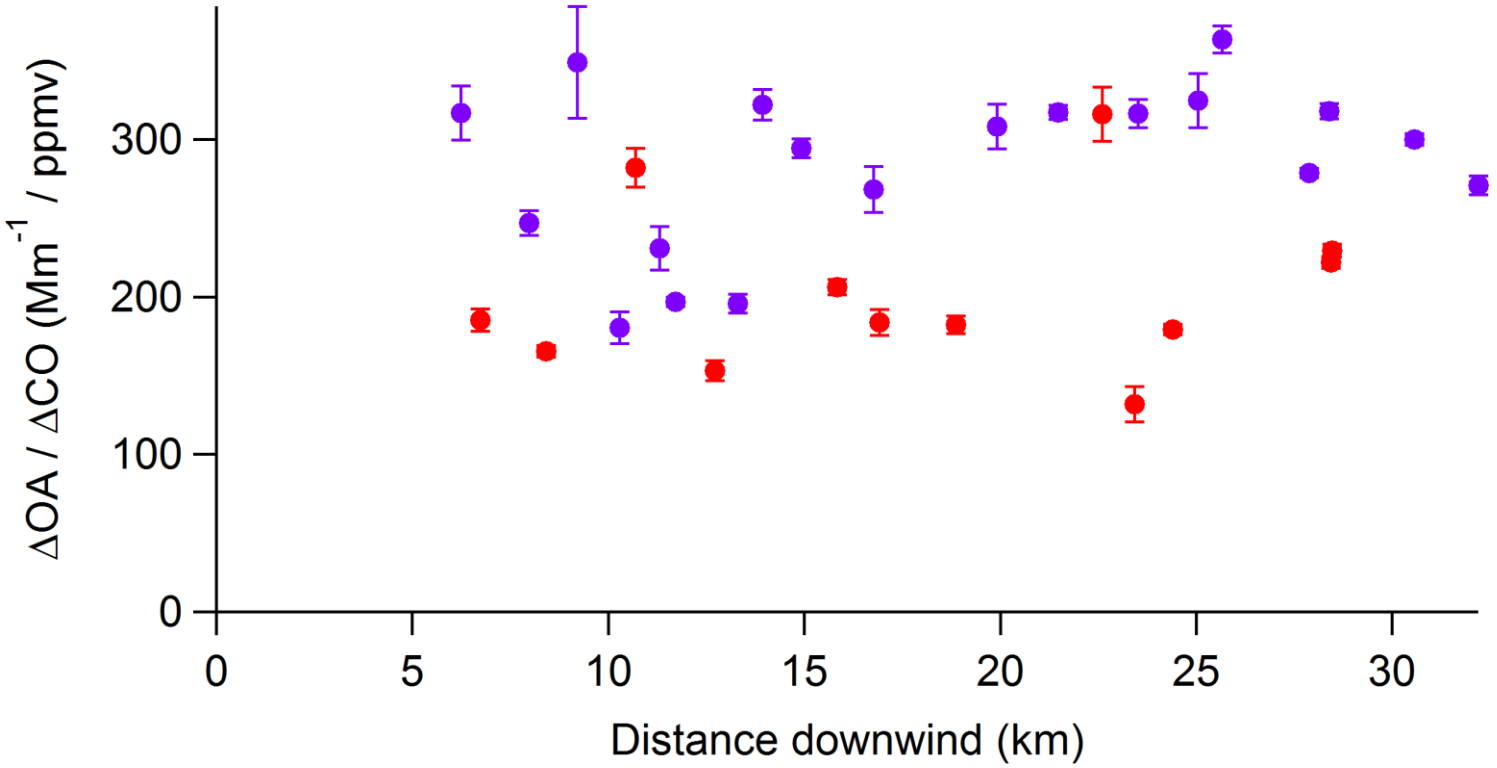






- f60 decreases with downwind distance
- O:C ratio increases with downwind distance
- G1 organics less oxidized than MBO, further down wind
- Observations are consistent with loss of primary OA and/or gain of secondary OA due to photochemical processes

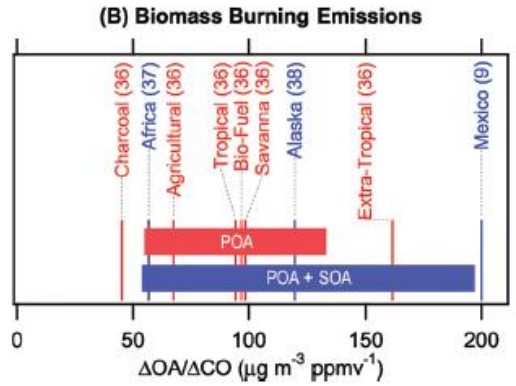
ΔOA / ΔCO downwind



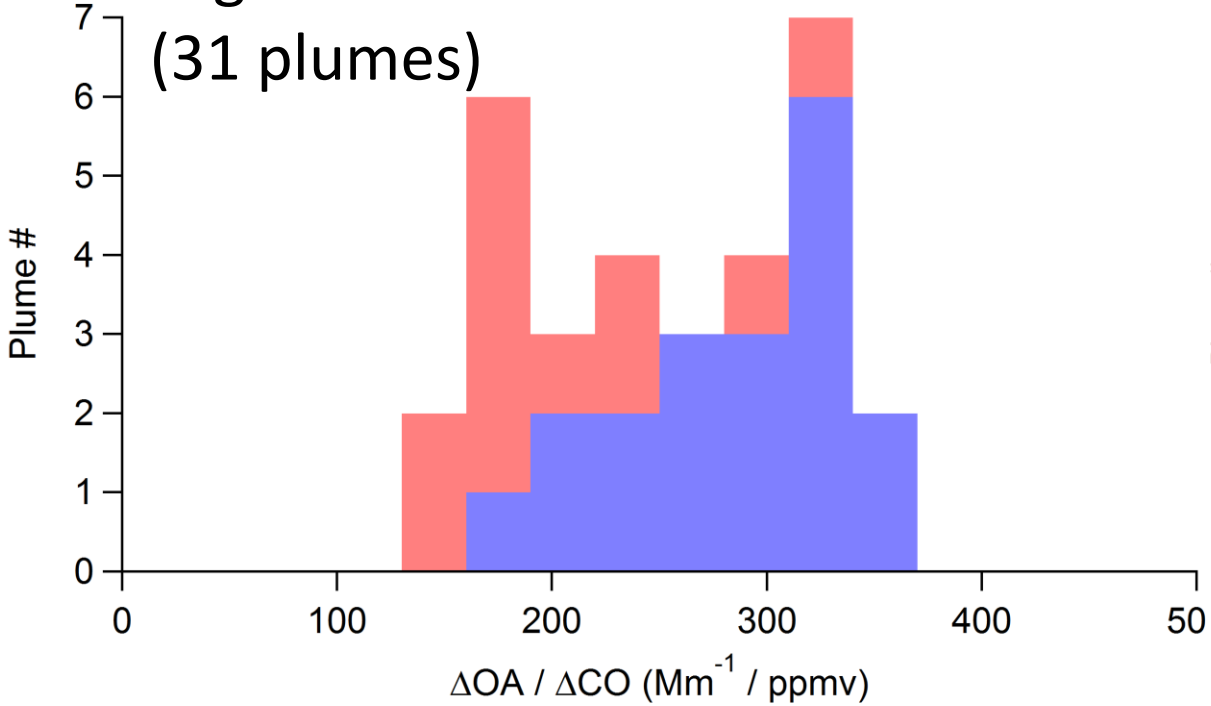
- Differences in ΔOA/ΔCO with burn plume
- Constant ΔOA/ΔCO with downwind plume transport time

ΔOA / ΔCO

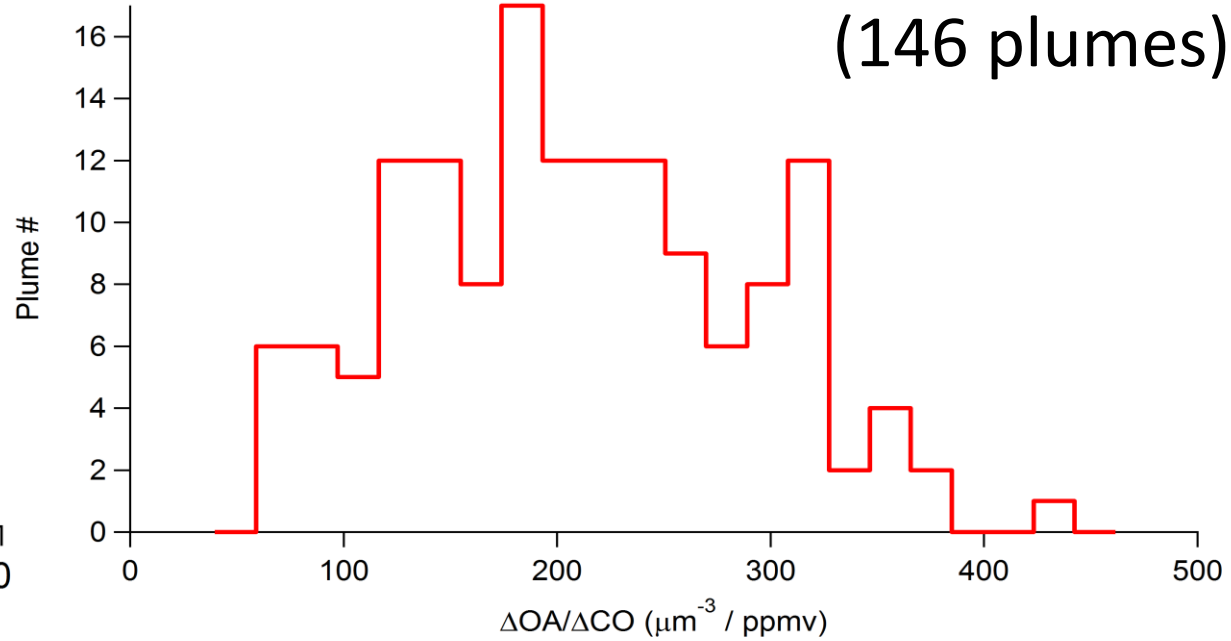
De Gouw et al. *Environ. Sci. Technol.* **2009,** *43,* 7614–7618



Flight 730b
(31 plumes)



BBOP wildfires
(146 plumes)

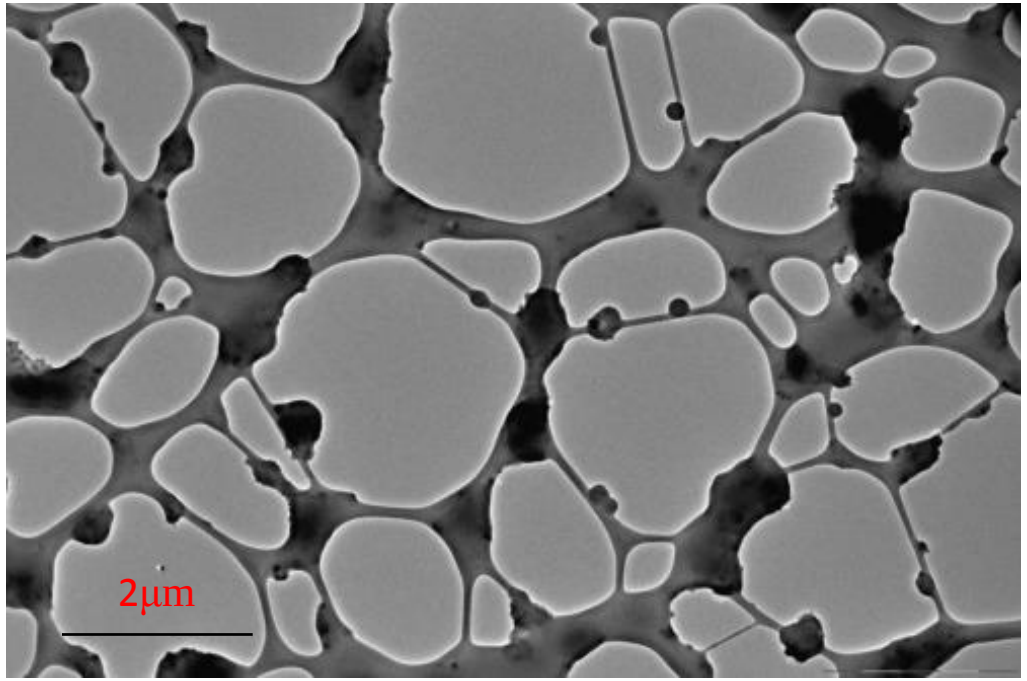


- ΔOA/ΔCO for a single fire spans nearly the full range of observed wildfire plumes
- Near field measurements are higher than previous measurements

TEM observations downwind

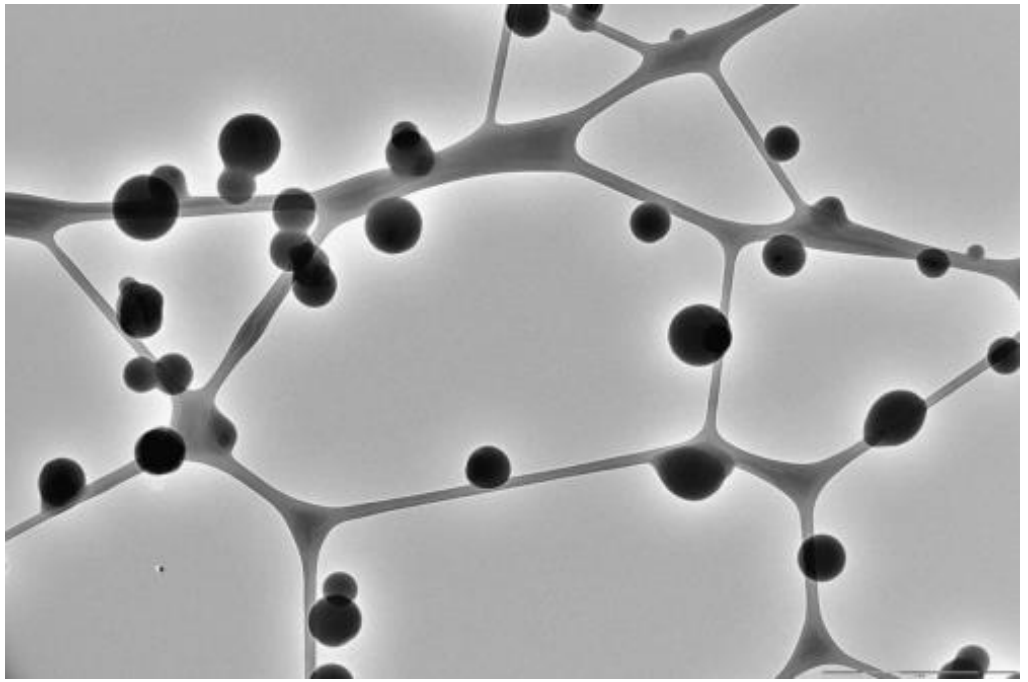
Fresh aerosol particles spread over the substrate

~0 hours



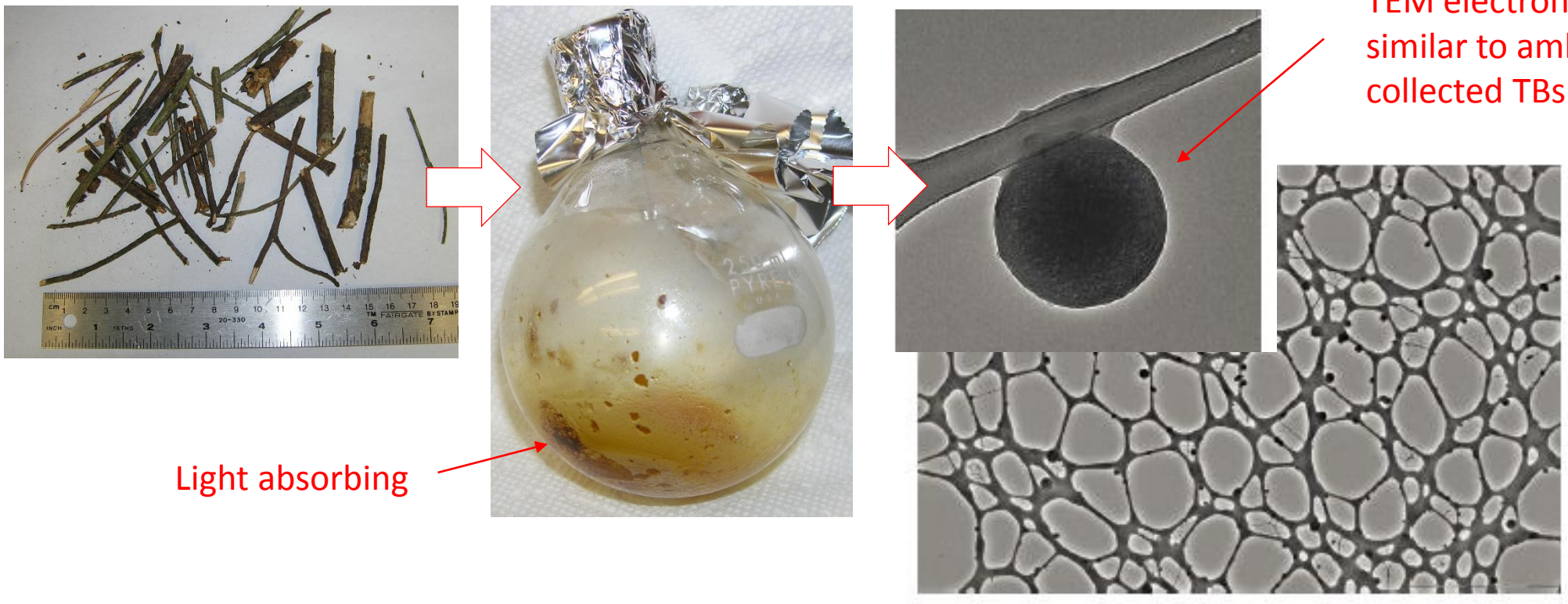
Aging results in highly spherical particles: Tar Balls

~2.5 hours



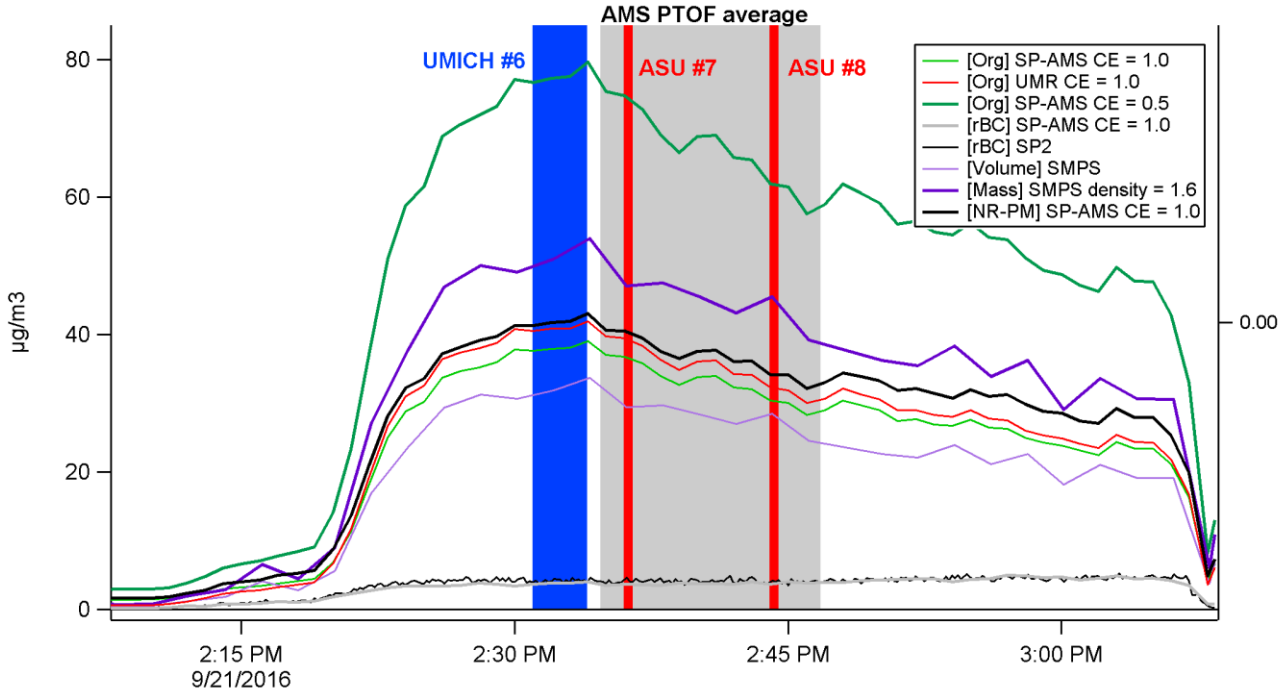
- Loss and/or conversion of low viscous materials

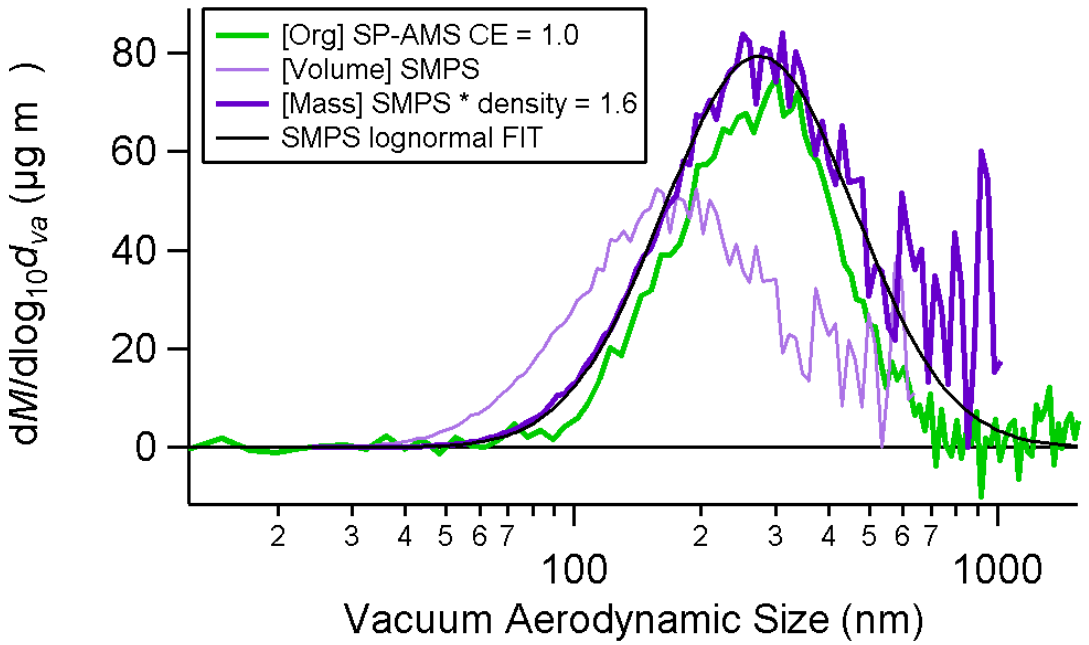
Laboratory generated tar balls



- Tar ball formation and evolution were clearly observed in BBOP samples examined using electron microscopy. We initiated a laboratory study of tar balls to examine chemical and optical properties to augment field observations.

Characterized by SP-AMS, SMPS, SP2





- Observed AMS collection efficiencies (CE) of ~0.8, indicating that AMS is sensitive to TBs, but TBs are more refractory than liquid organics (less refractory than AS)
- SP2 and SP-AMS observed minor rBC component in lab TBs (<10%)
- Investigating chemical signatures for potential identification in field observations and correlations with optical properties

Summary

- Rapid physical, chemical and optical changes in biomass burning particles measured downwind (< 3 hours) from wildland fires in Pacific Northwest.
- ΔEXT/ΔCO and SSA increase downwind, indicating scattering increases faster than absorption.
- The chemical composition of OA is rapidly changing, with the O:C and OM:OC increasing and primary components decreasing. Governed by MCE and atmospheric chemistry.
- 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.
- Variability in different burn plumes from one wildland fire similar to the variability in chemical and optical properties for all sampled wildland fires
- TEM's observe formation of tar balls in field. Generated laboratory tar balls to investigate chemical/physical properties and real-time instrument sensitivities.

Acknowledgements

- Thanks to the G1 Flight Crew and Ground Crew and the other researchers on board for their help.
- Thanks to DOE Atmospheric System Research and ARM Climate Research Facility for funding and logistical support.

Discussion slide

- The DOE 2013 BBOP study is an important project with the correct methodology for providing needed information on biomass burning emissions and plume evolutions.
- Highly suggest that DOE ARM/ASR conduct a second BBOP project in concert with other biomass burning studies already scheduled in years 2018-2019 (FIREX, FIRECHEM, FASMEE, etc.) to take advantage of the planned intensives