Time Evolution of Aerosol Light Scattering Observed in Wildland Fires in BBOP

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ASR Atmospheric System Research

About changes in Mass Scattering Efficiency, Aerosol Size Distribution, and Tar Balls that occur in a fire plume within a few hours.

Wildland fires sampled in Pacific NW during BBOP

Flights included one or two sets of transects.
Each set contained up to 6 plume crossings

Time evolution determined by comparing measurements near the fire source to those 2 to 4 hours downwind.

CO is used as a conservative tracer to account for dilution

We are focused on processes that:
operate on a ½ to 4 h time span and
have radiative impacts due to aerosol scattering and absorption

Common Features

Ratio Org/CO does not change much, ~ 25%
Ratio Scattering/CO can double

Table gives percent change in Org/CO, Scat (550nm) /CO, and Scat./Org over ~ 2 hours.

Last column gives values of MSE over fire and downwind

Flight	Org/CO	Scat/CO	Scat/Org	Mass Scat. Eff.
726a	+18%	+28%	+7%	5.8 – 6.2
730b	+25%	+81%	+41%	3.4 – 4.8
821b	+27%	+101%	+48%	3.4 – 5.0

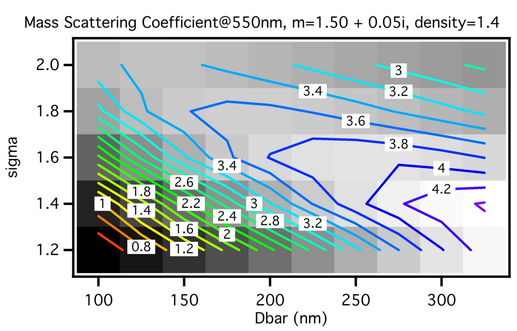
Notes:

Mass scattering efficiency (MSE) is scattering per unit mass.
MSE depends on particle size and refractive index
BB values reported in the literature are centered on ~ 3.5

Org (~ equal total aerosol mass) has not been corrected for the SP-AMS collection efficiency (CE).
If CE=0.5, then the MSEs above are doubled, yielding likely unrealistic values

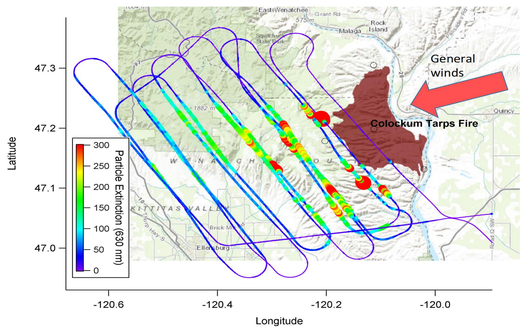
Can the increase in MSE be explained?
Change in aerosol size distribution?
Change in SP-AMS detection?

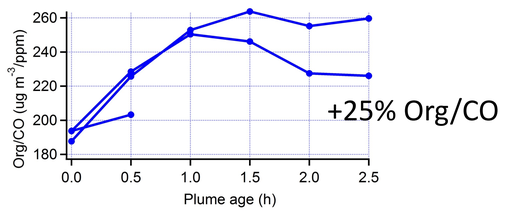
Mie Calculations – an example set of Log Normals

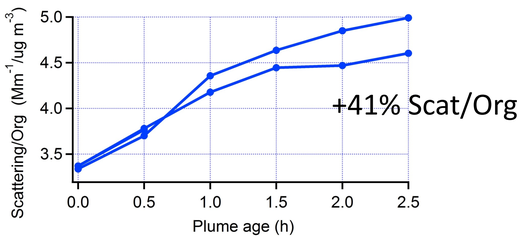


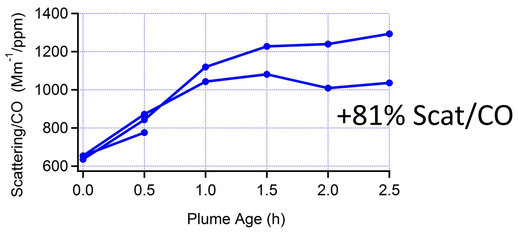
Large value for MSE difficult to explain

Colockum Tarps fire 730b with tar ball analysis

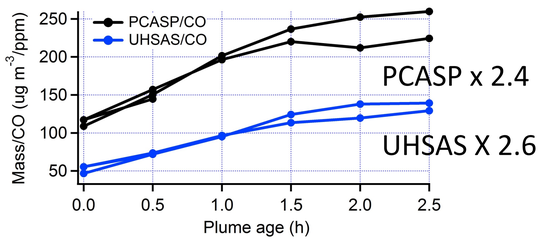






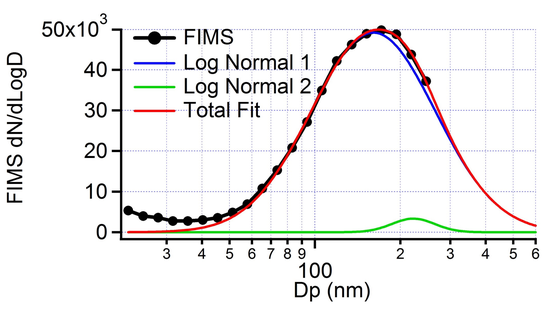


Optical Particle Probes



In fire plumes, PCASP and UHSAS yield unrealistic results, partly due to coincidence
PCASP has binning problems
UHSAS has un-physical statistics

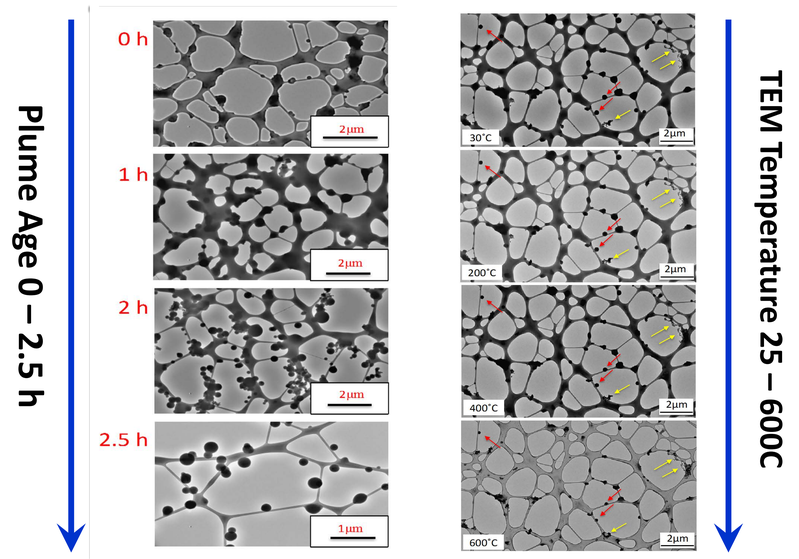
FIMS data fitted to Log Normals

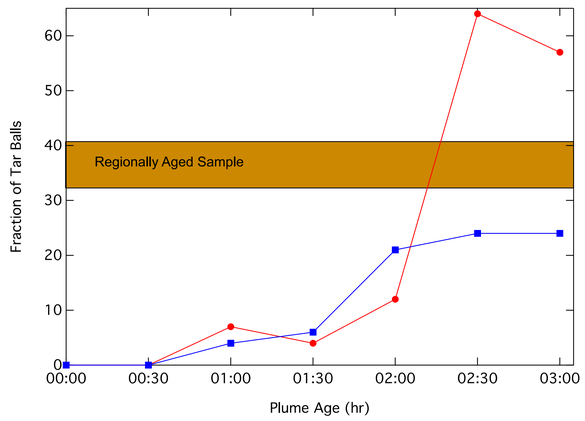


Data ends at 270 nm.
Extrapolation to ~ 600 nm needed

Tar Balls

Kouji Adachi, Peter Buseck, TEM





Fraction of particles that are Tar Balls increase with Age
Tar Balls are refractory, surviving slow heating to 600C
AMS vaporizes aerosol at 600C.

Tar Ball mass fraction ~ 25% at 2.5 hours
AMS might be missing 25% of Org mass

MSE change decreases if aged Org is 25% > measured

Flight	Org/CO	Scat/CO	Scat/Org	Mass Scat. Eff.
726a	+48%	+28%	-14%	5.8 – 5.0
730b	+56%	+81%	+13%	3.4 – 3.8
821b	+59%	+101%	+18%	3.4 – 4.0

Path Forward
More case studies of Tar Balls
Detection efficiency of TB by AMS in lab

Lab expts on UHSAS response to coincidence

Constrain size distribution using all particle and scattering data