Aerosol Chemistry and Processing at Mt. Bachelor Summit during the Biomass Burning Observation Project (BBOP): Influences from Wildfire Plumes

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Mt. Bachelor Observatory (MBO), Oregon, 2.7 km a.s.l.

- The only high elevation/free trop. research site
- Continuous observations of CO, O_3, aerosols a
- Frequent detection of Asian pollution and biomass burning plumes;
- In summer 2013 added a High-Resolution Aerosol Mass Spectrometer

High Resolution Aerosol Mass Spectrometer

LiCOR

- Aerosol light extinction, EC/OC, BC
- O_3, CO, CO_2, NO_x, NO_y, VOCs, PAN
- Meteorological data
- Mercury …

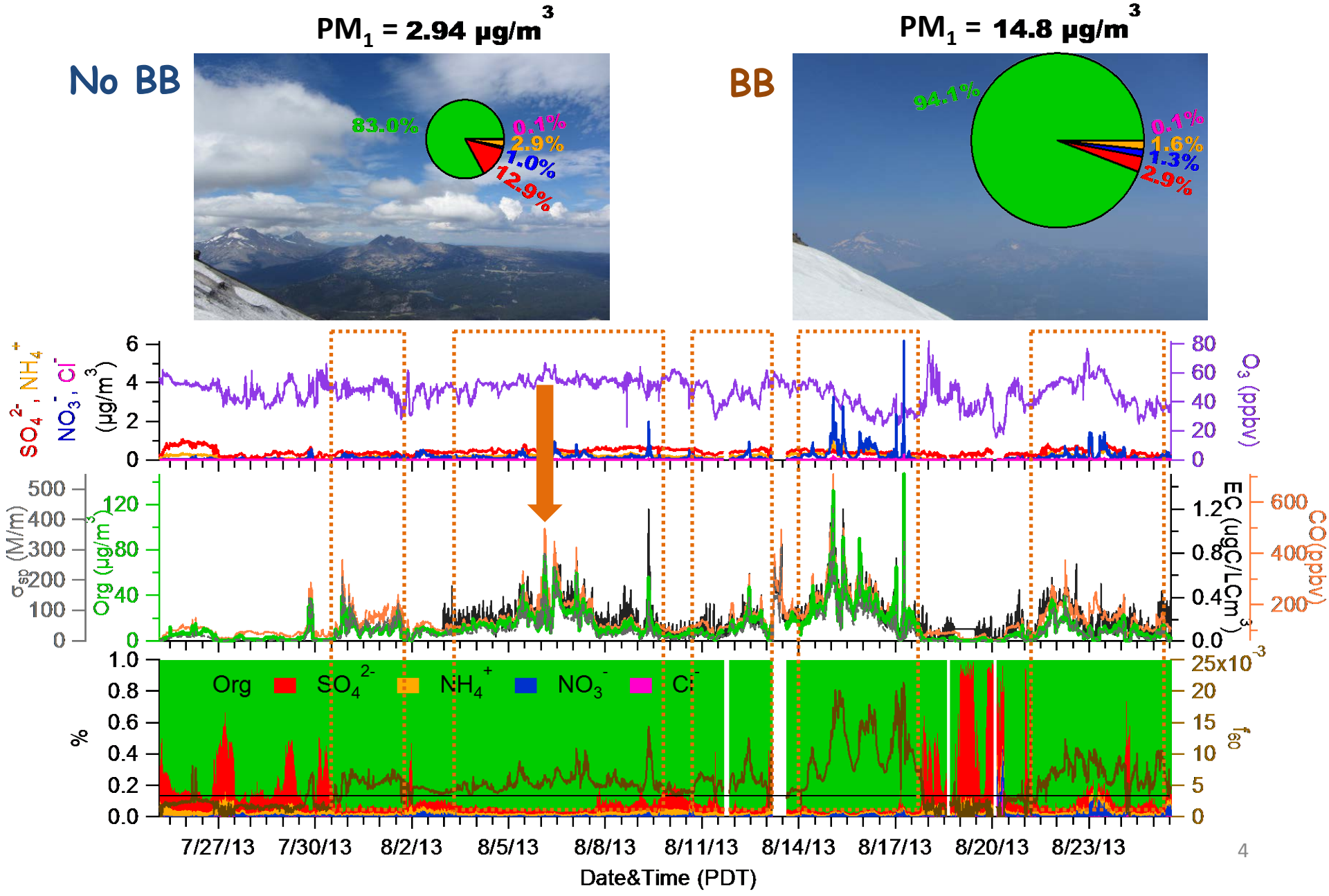
Past Studies on Fires, PM and O_3

View from Mt. Bachelor of the Sisters fire on 9/19/2012. Up to 9 ppmv and 1000 µg/m^3 PM_1 seen at MBO.

- **MBO is an ideal location to study wildfire plumes due to frequent fires in the PNW and N. Calif.**
- **9 publications with MBO data on the relationships between PM, O_3 and a variety of wildfire tracers;**
- **Large uncertainties remain about primary and secondary aerosol production, ozone production and radiative effects of smoke plumes.**

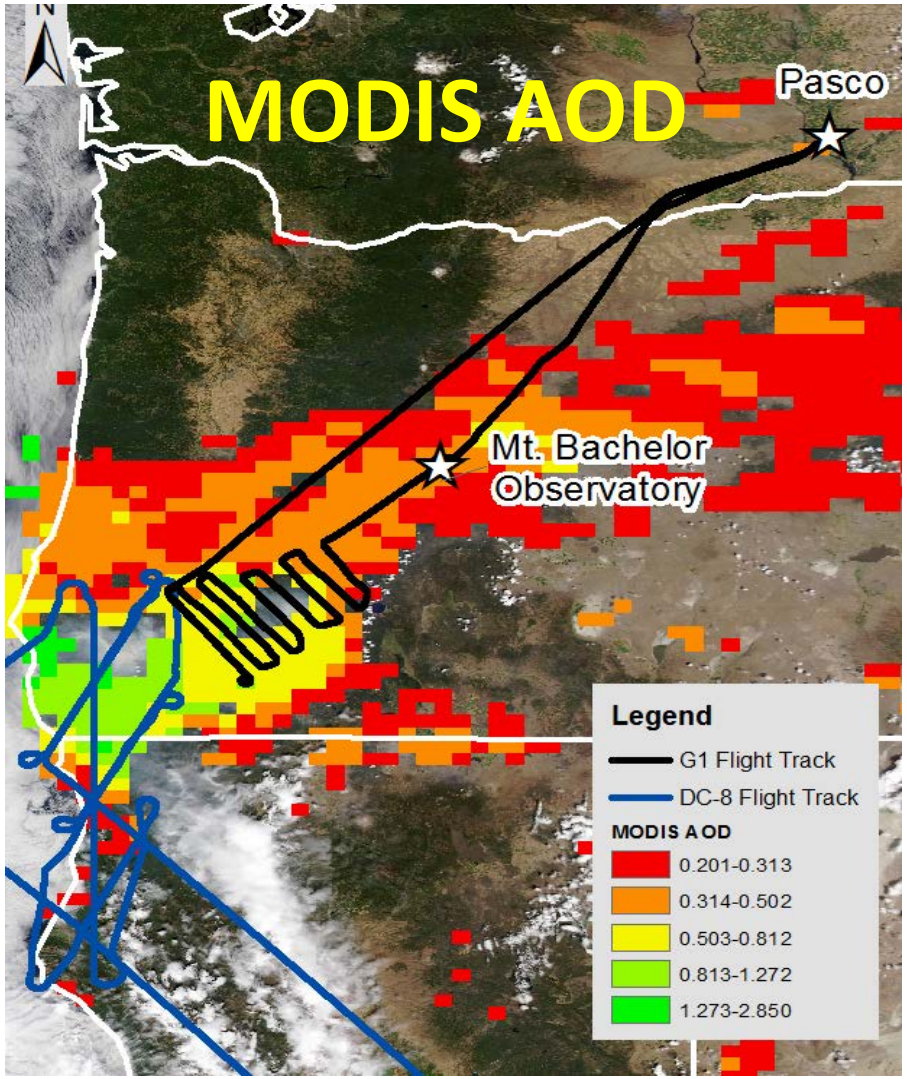
Past work by Jaffe's group has demonstrated large variability in emissions and chemistry from fire to fire. Why? What are the controlling factors?

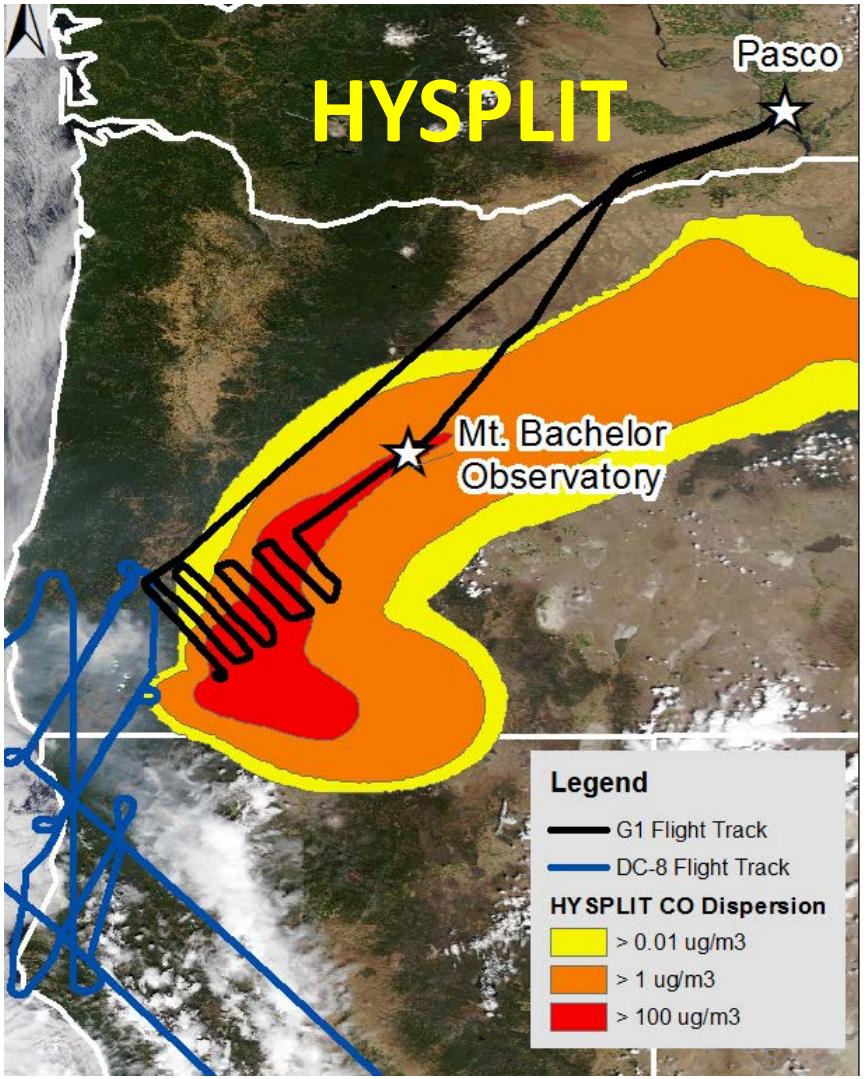
Aerosol Temporal Variations: 7/15 – 8/25, 2013



Whiskey Complex Fire, Aug. 6, 2013

Overlay of G1 and DC8 flight tracks, with MODIS AOD (left) and HYSPLIT Dispersion model (right)





Modified Combustion Efficiency (MCE)

$$\frac{\Delta CO_2}{\Delta CO + \Delta CO_2}$$

Smoldering combustion:
CO, CH4, OVOC, OC, etc.

Flaming combustion:
NO, CO2, EC, etc.

smoldering
MCE ~ 0.80

wildland fires vary along spectrum over time

flaming
MCE ~ 1.00

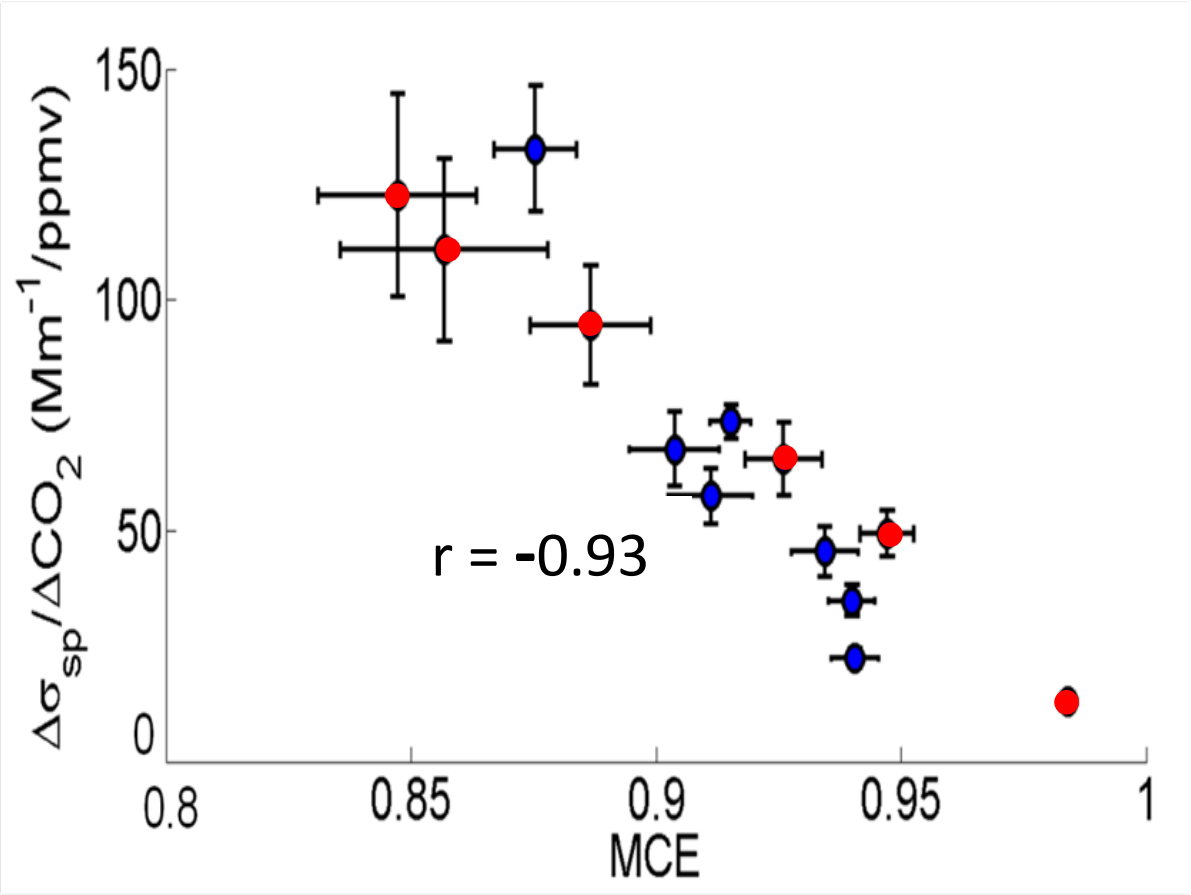
Plume Identification & MCE Calculation

Method (Wigder, Jaffe et al.):

- Significant enhancement in CO and aerosol scattering (σ_{sp})
- R^2 of CO/CO_2 > =0.85
- Distinct plume in CO and CO_2 that begins and ends at approximately the same concentration (to minimize impact of change in background)
- Fire source identified using satellite imagery and model
- calculate transport time using HYSPLIT trajectories

Plume #	Plume Period (PDT)	Duration (hr)	MCE	Suggested Origin	Approx. Transport hrs
18	2013/8/05 09:50 – 11:10	1.3	0.93	SW OR & NW CA	14-34
19	2013/8/13 05:20 – 09:40	4.3	0.95	N CA	24-30
20	2013/8/13 09:40 – 12:00	2.3	0.85	N CA	24-30
21	2013/8/15 00:20 – 02:35	2.3	0.89	N CA	10-12
22	2013/8/15 05:00 – 07:05	2.1	0.86	N CA	10-12
23	2013/8/21 17:30 – 22:30	5.0	0.98	SW OR & NW CA	25-45

Influence of Modified Combustion Efficiency (MCE) on Pollutant Enhancements in Wildland Fire Plumes (Wigder, Jaffe et al., in prep.)



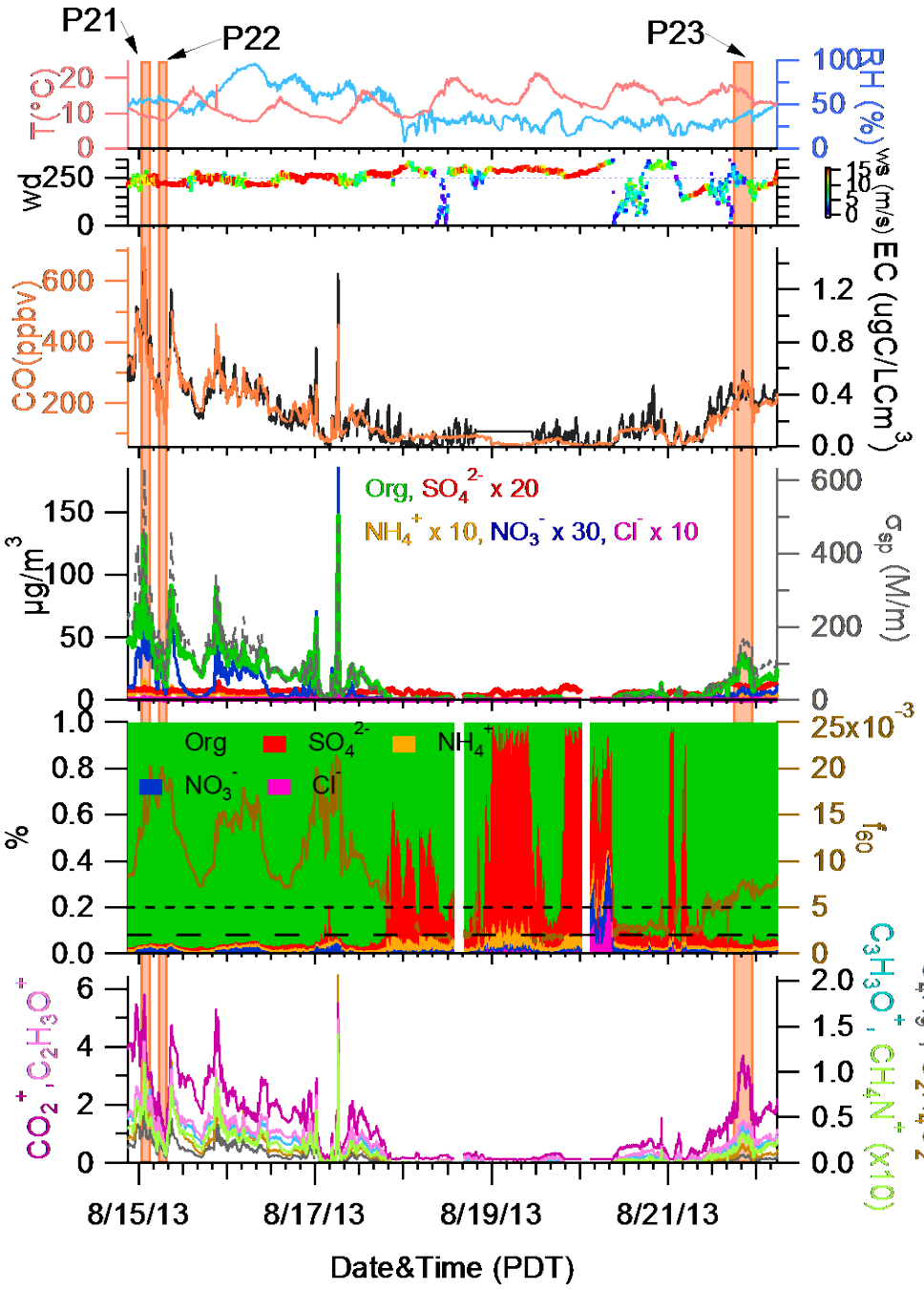
Low MCE: more smoldering combustion

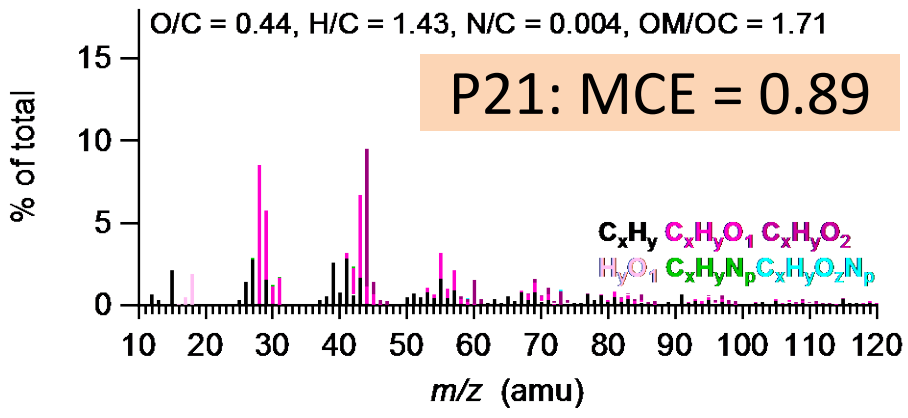
High MCE: more flaming combustion

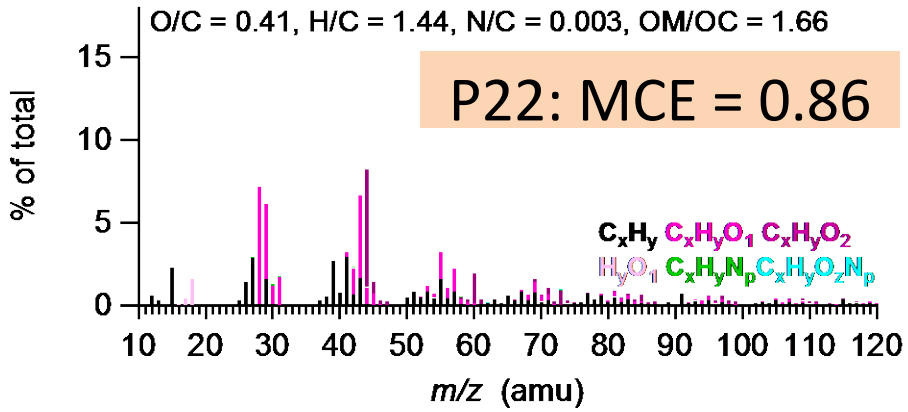
Aged fire plumes (1-2 days) at MBO from 2012-2013 shows negative correlation between aerosol scattering enhancement ratio ($\Delta\sigma_{sp}/\Delta CO_2$) and MCE due to:

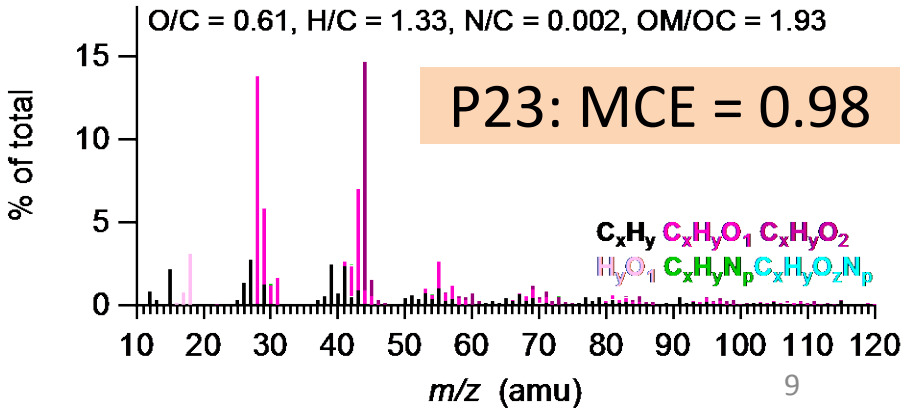
1) **Greater primary emissions of aerosols at low MCE**
2) **Greater SOA formation at low MCE due to greater emissions of oxygenated VOCs**

Influence of MCE on Aerosol Chemistry





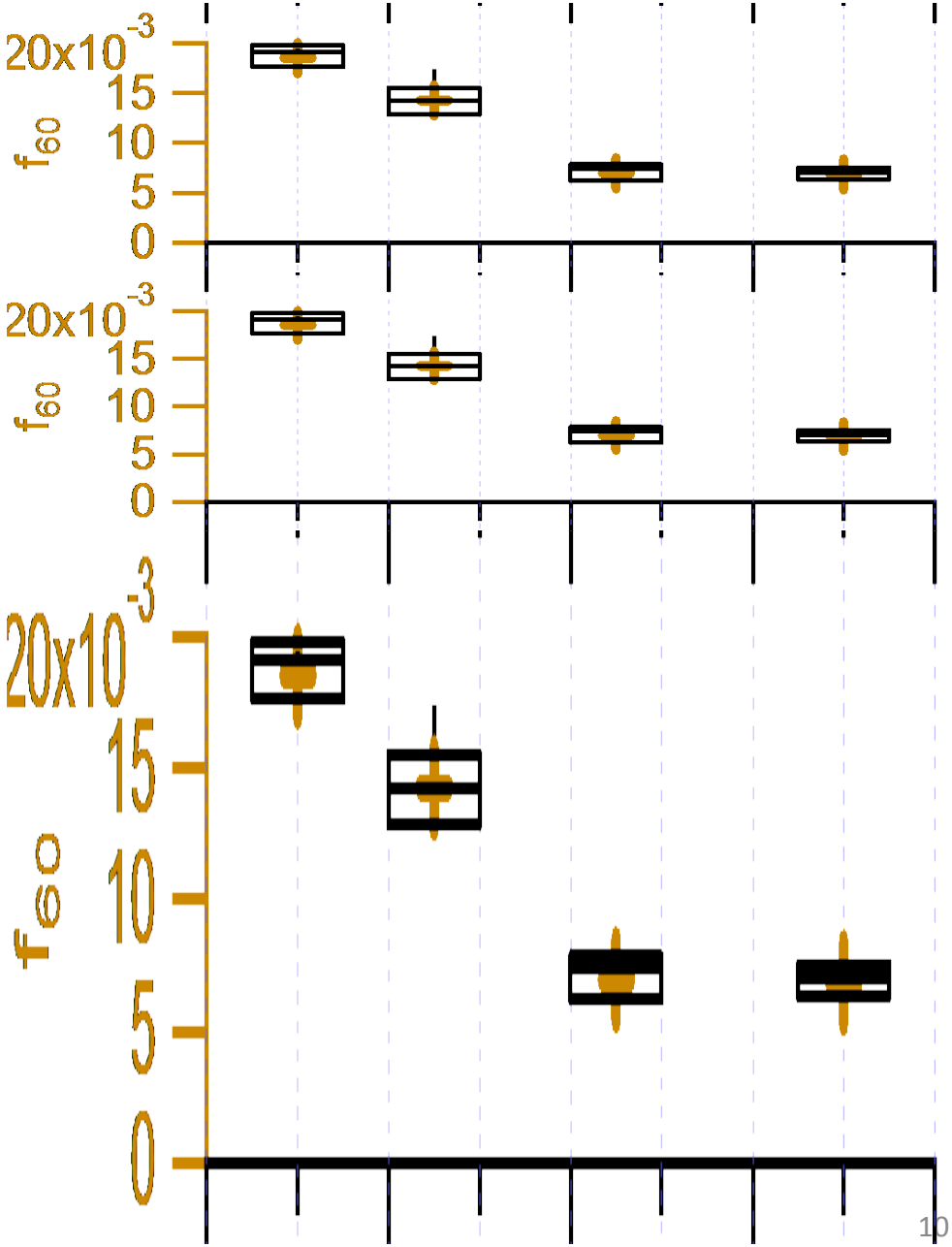




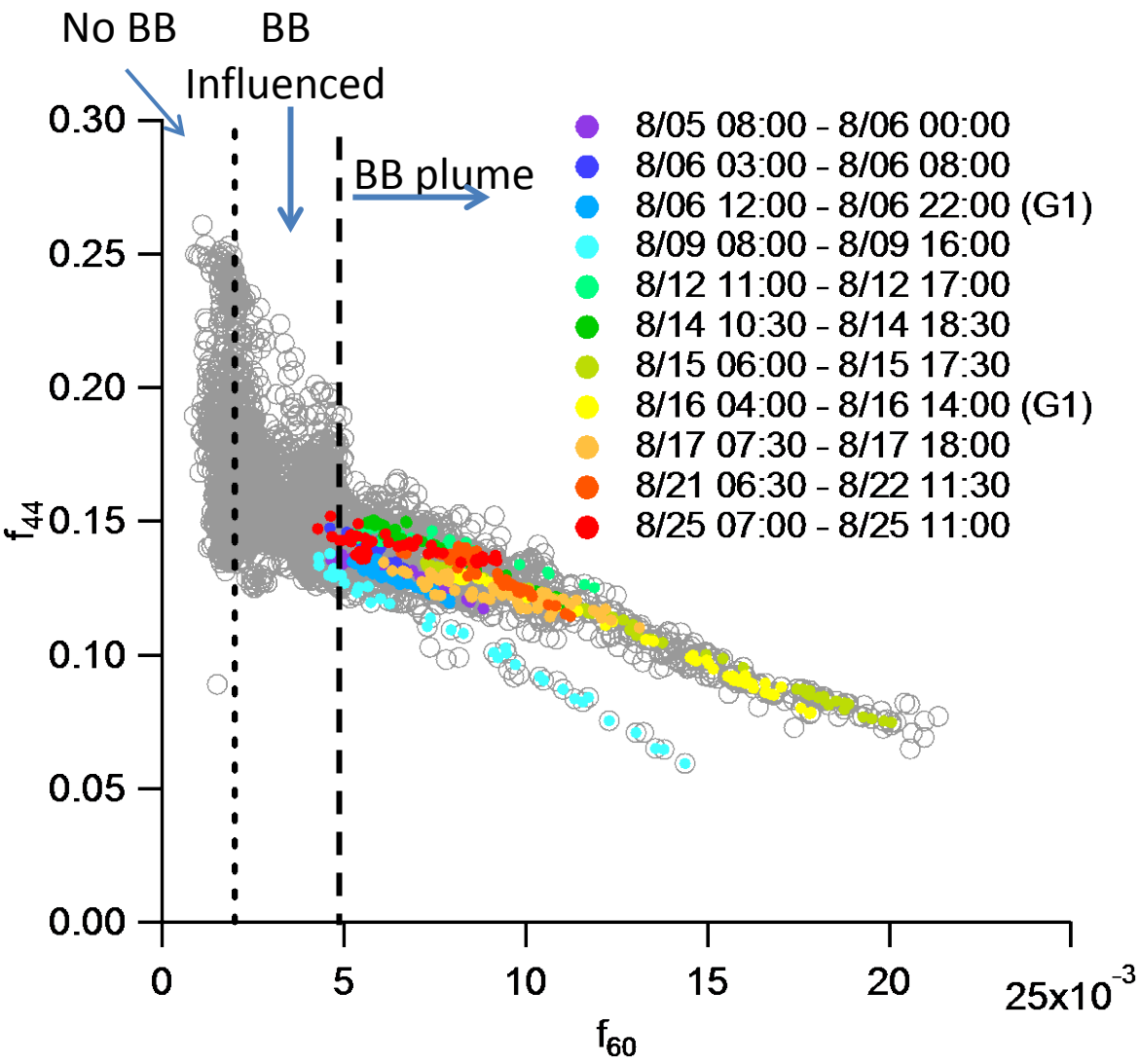
Influence of MCE on Aerosol Chemistry

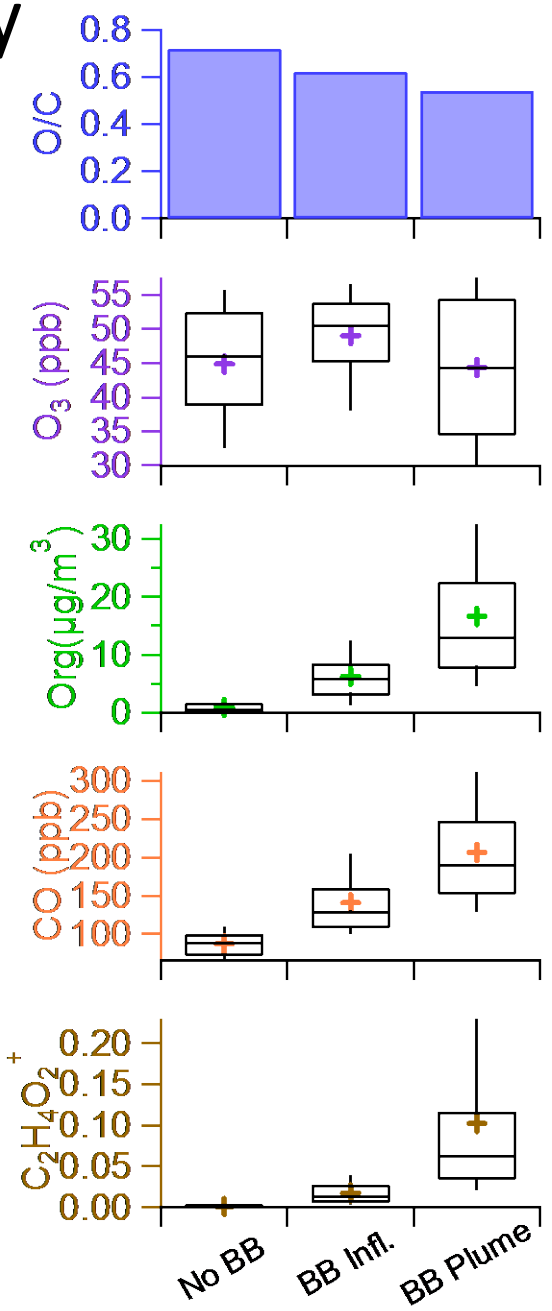
$C_2H_4O_2^+$ (m/z = 60) is an AMS tracer ion for BBOA

$$f_{60} = \frac{\text{Signal}_{m/z=60}}{\text{overall OA mass}}$$

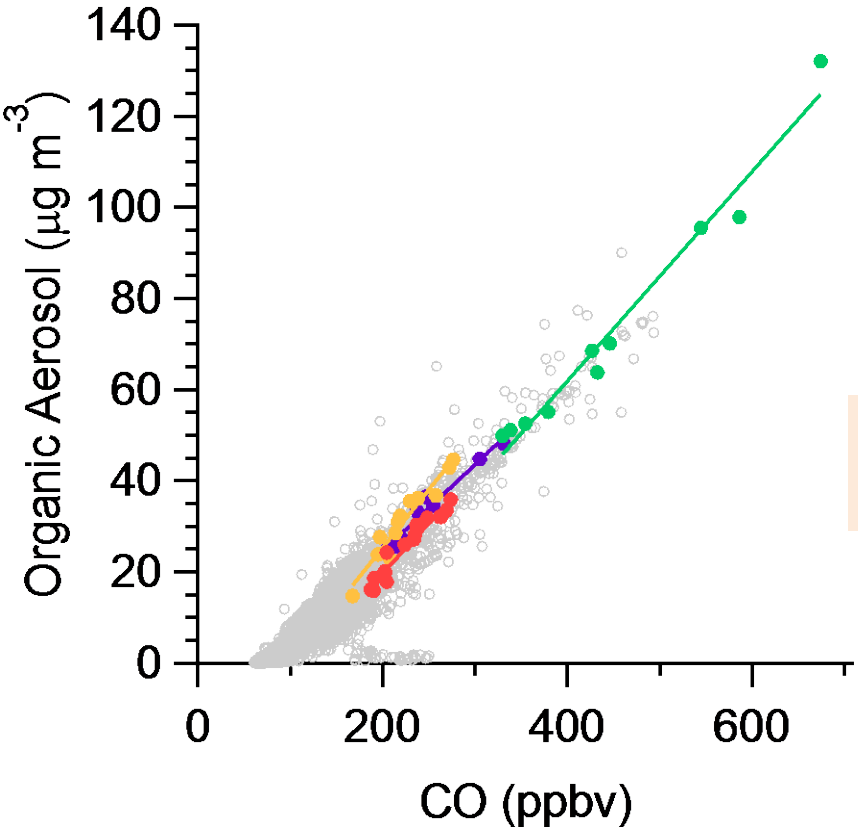


Influence of BB on Aerosol Chemistry





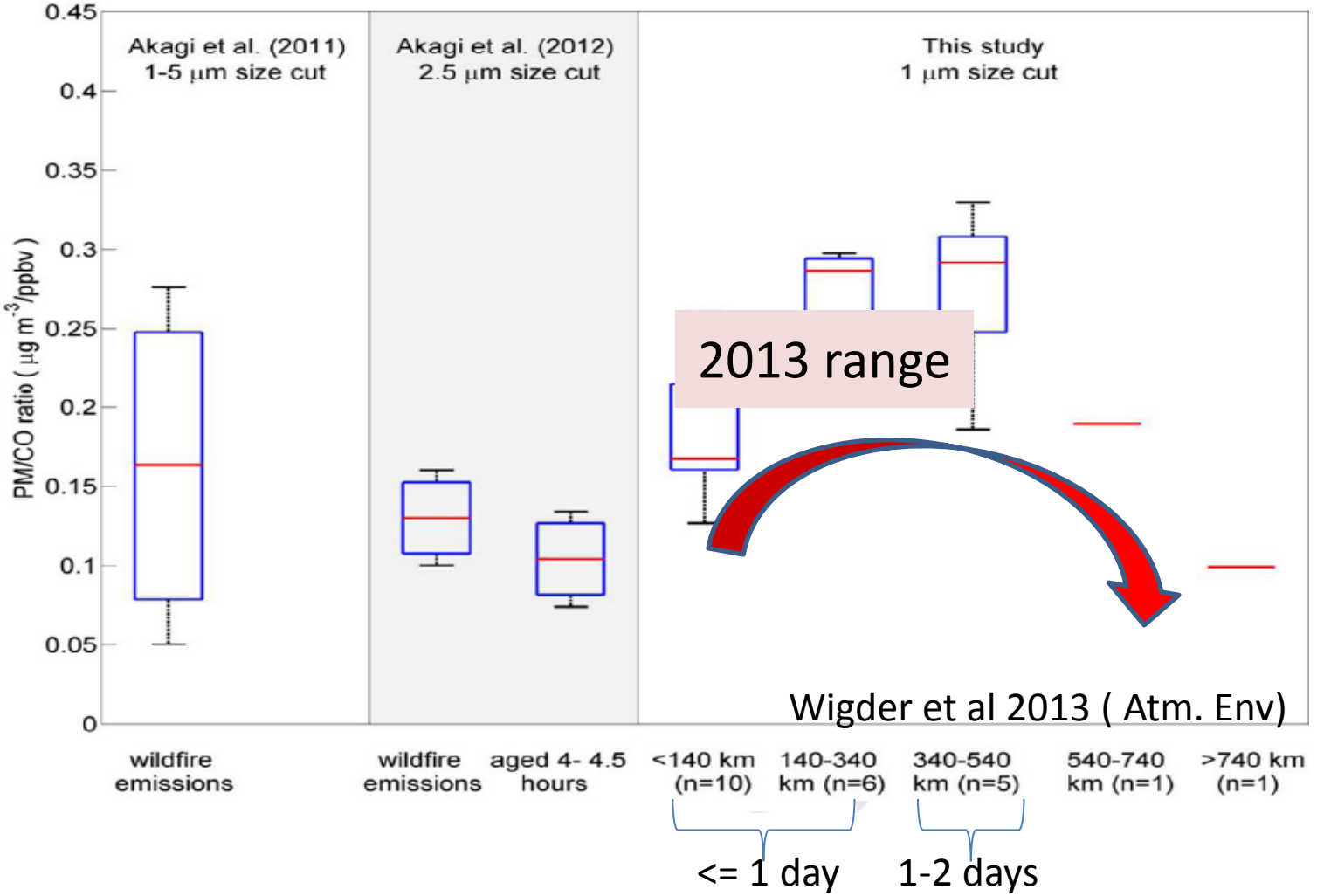
PM enhancement ($\Delta PM_1/\Delta CO$) in BB Plumes



	ΔOrg/ΔCO (μg m^{-3} ppb^{-1})	Transport time (hr)	MCE
P18	0.19	14 - 34	0.93
P21	0.23	10 - 12	0.89
P22	0.25	10 - 12	0.86
P23	0.22	25 - 45	0.98

Fresh plume (G1) ~ 0.17

PM enhancement ($\Delta PM_1/\Delta CO$)



- 32 fire plumes observed in 2004-2011
- $\Delta PM_1/\Delta CO$ ratio varied from 0.06-0.42 $\mu g/m^3$ ppb^{-1}
- Initial emissions → Near-field → More distant transport

Conclusions

- Wild fire plumes were frequently observe at Mt. Bachelor summit
- Wild fire plumes characteristics
  - > 90% of PM is organic
  - Variable MCE
  - MCE correlates well with $\Delta PM/\Delta CO_2$, O/C
- Significant ↑of $\Delta PM/\Delta CO$ 1-2 days downwind compared to at sources → indicating SOA formation .