Regional Influence of Wildfires on Aerosols in the Western US and Insights into Emission and Aging of BBOA

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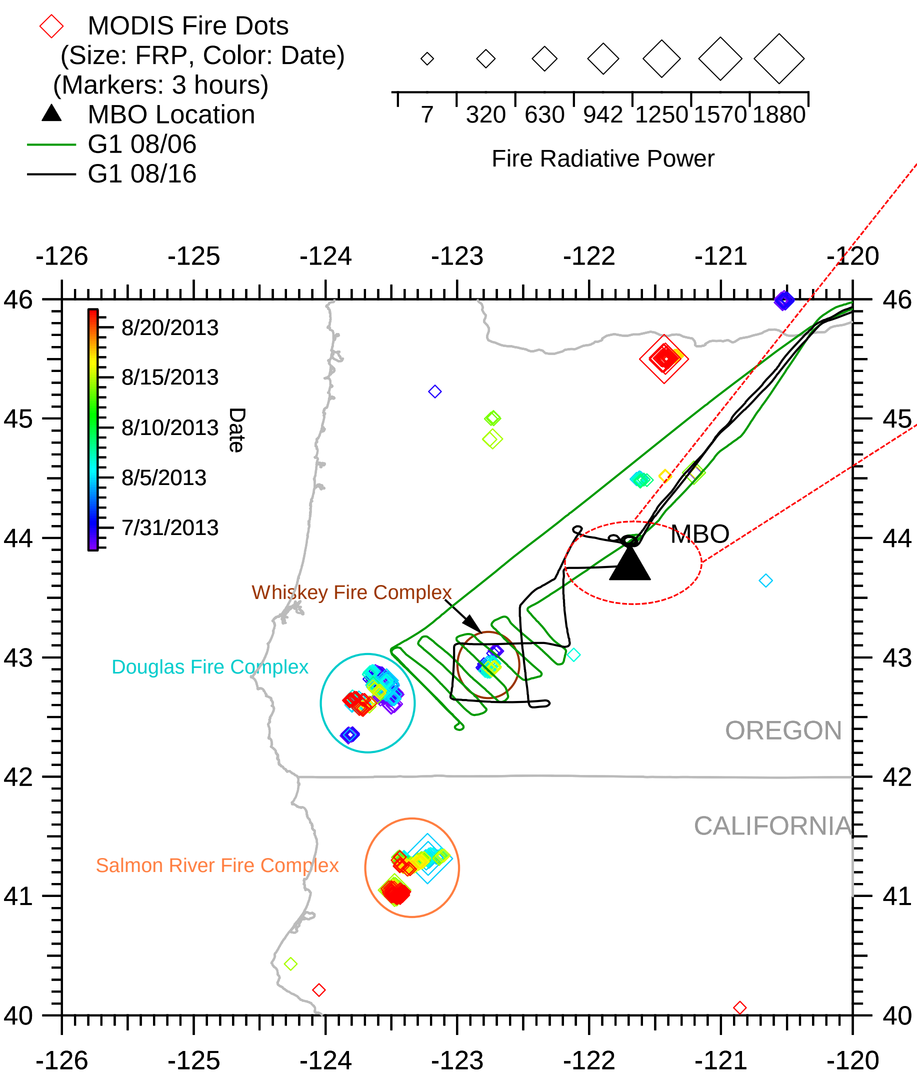
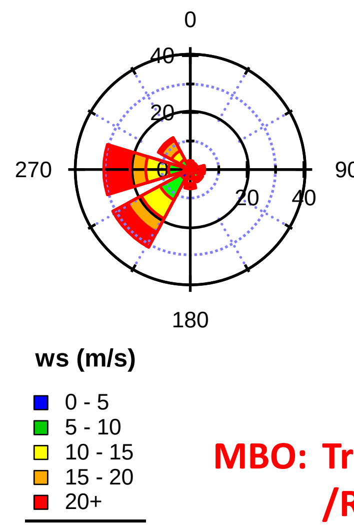
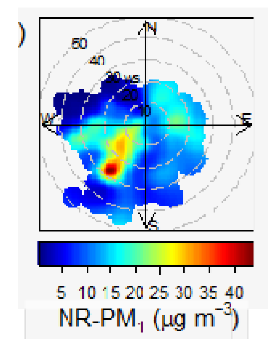
Ground-based measurements during BBOP



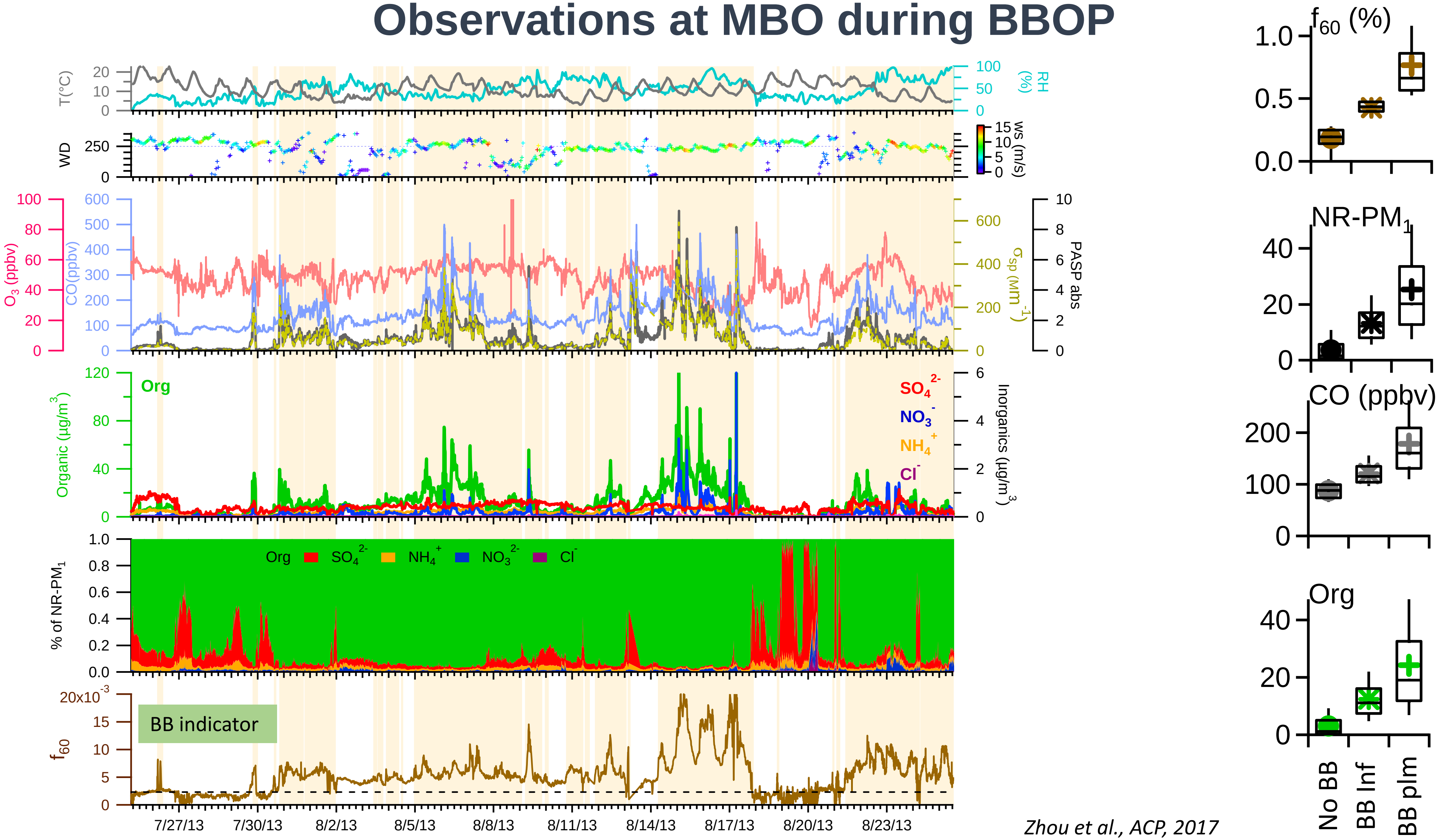




MBO: Transported (6 – 48hr) /Regional

G1: Near field (~1 ~ 10 hr)

Observations at MBO during BBOP

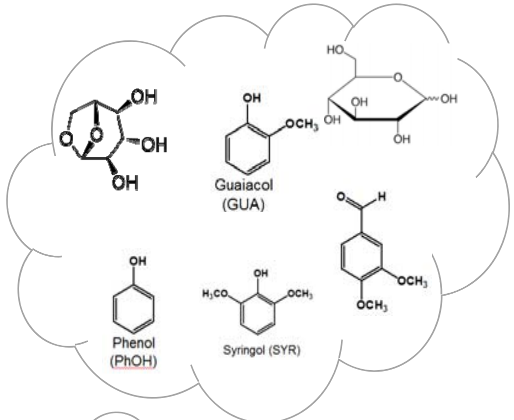


Zhou et al., ACP, 2017

Modified Combustion Efficiency (MCE)

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

SOA Precursors



Smoldering combustion:
CO, CH_4, OVOC, OC, etc.

Flaming combustion:
NO, CO_2, EC, etc.

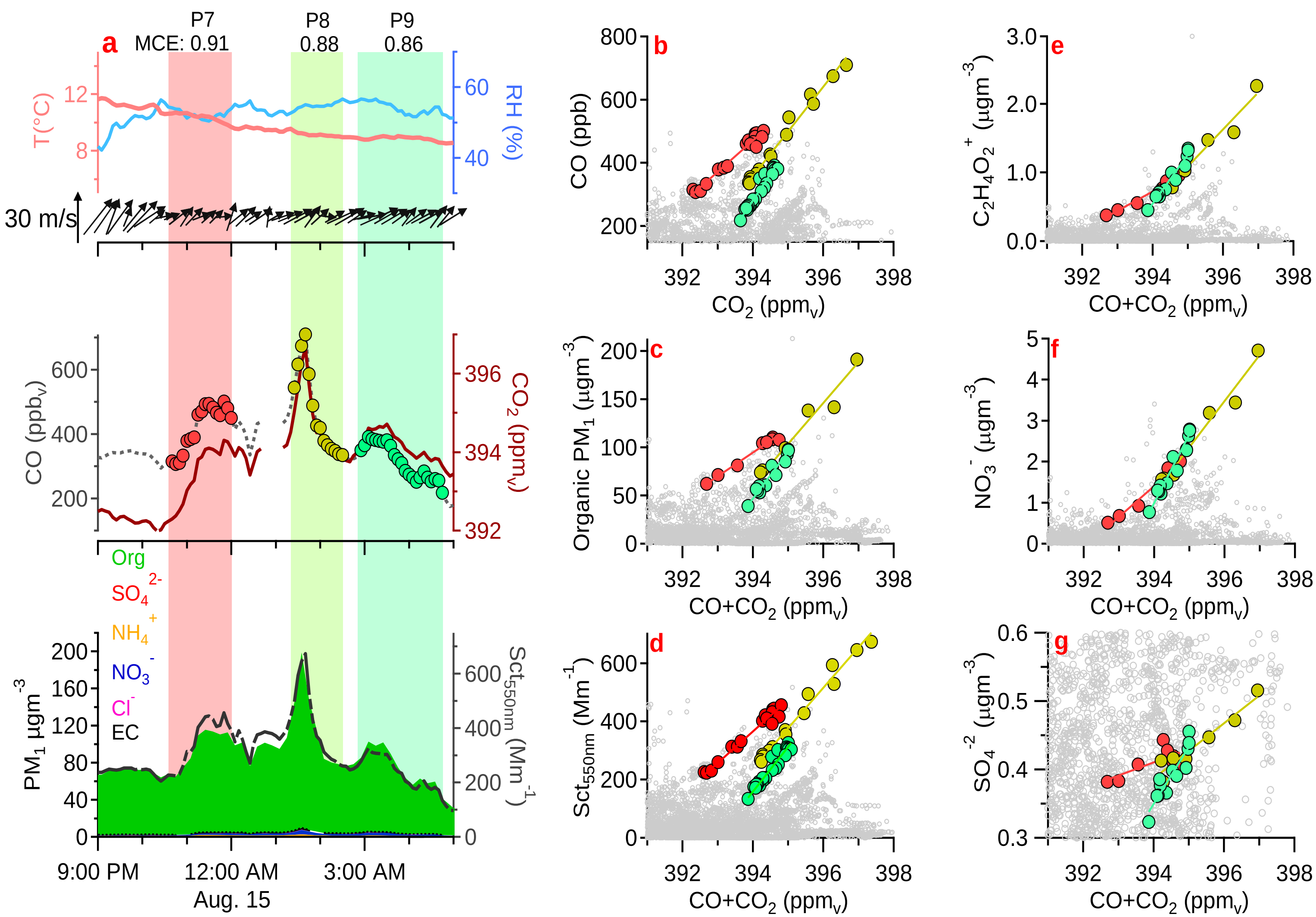
smoldering
MCE ~ 0.80

wildland fires vary along
spectrum over time

flaming
MCE ~ 1.00

Low MCE →Greater emissions of oxygenated VOCs → Greater SOA formation

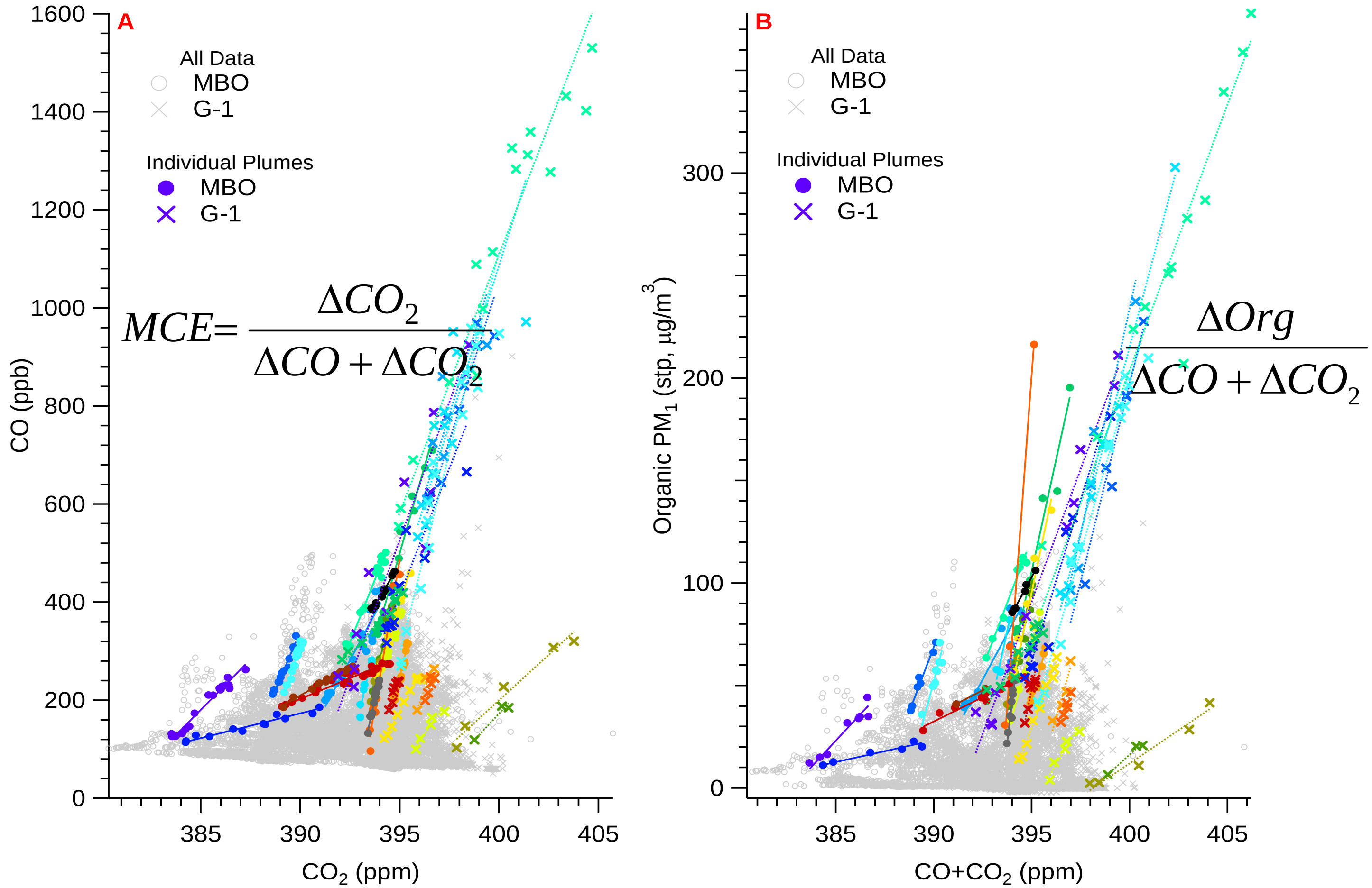
Influence of MCE on Aerosol Chemistry: A Case Study



- Plume selection criteria:
  - Tight correlation between CO and CO_2
  - Tight correlation beween Org and ΣC (= CO+CO_2)
- Fire source identified using satellite imagery and model
- Calculate transport time using HYSPLIT trajectories
  - 3 consecutive plumes, evolving burn conditions
  - ↓ of MCE over time is consistent with burning condition change

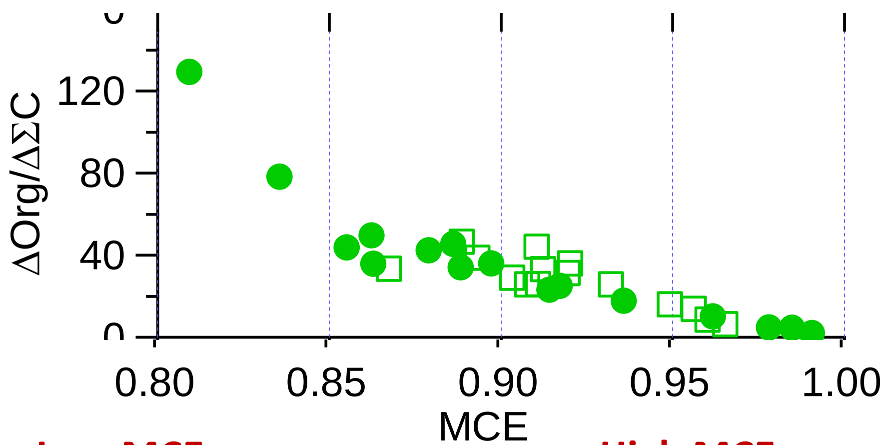
Collier et al., ES&T, 2017

Enhancement of OA in Wildfire Plumes



- Enhancement of OA relative to amount of fuel combusted ($\Sigma C = CO + CO_2$) varies significantly from plume to plume.

OA Enhancements in Wildfire Plumes: MCE vs. Aging



Low MCE: more smoldering combustion ⟷ **High MCE: more flaming combustion**

Collier et al., EST, 2016

ER of BBOA: ΔOrg/Δ($CO+CO_2$)

1) Negatively correlates with MCE

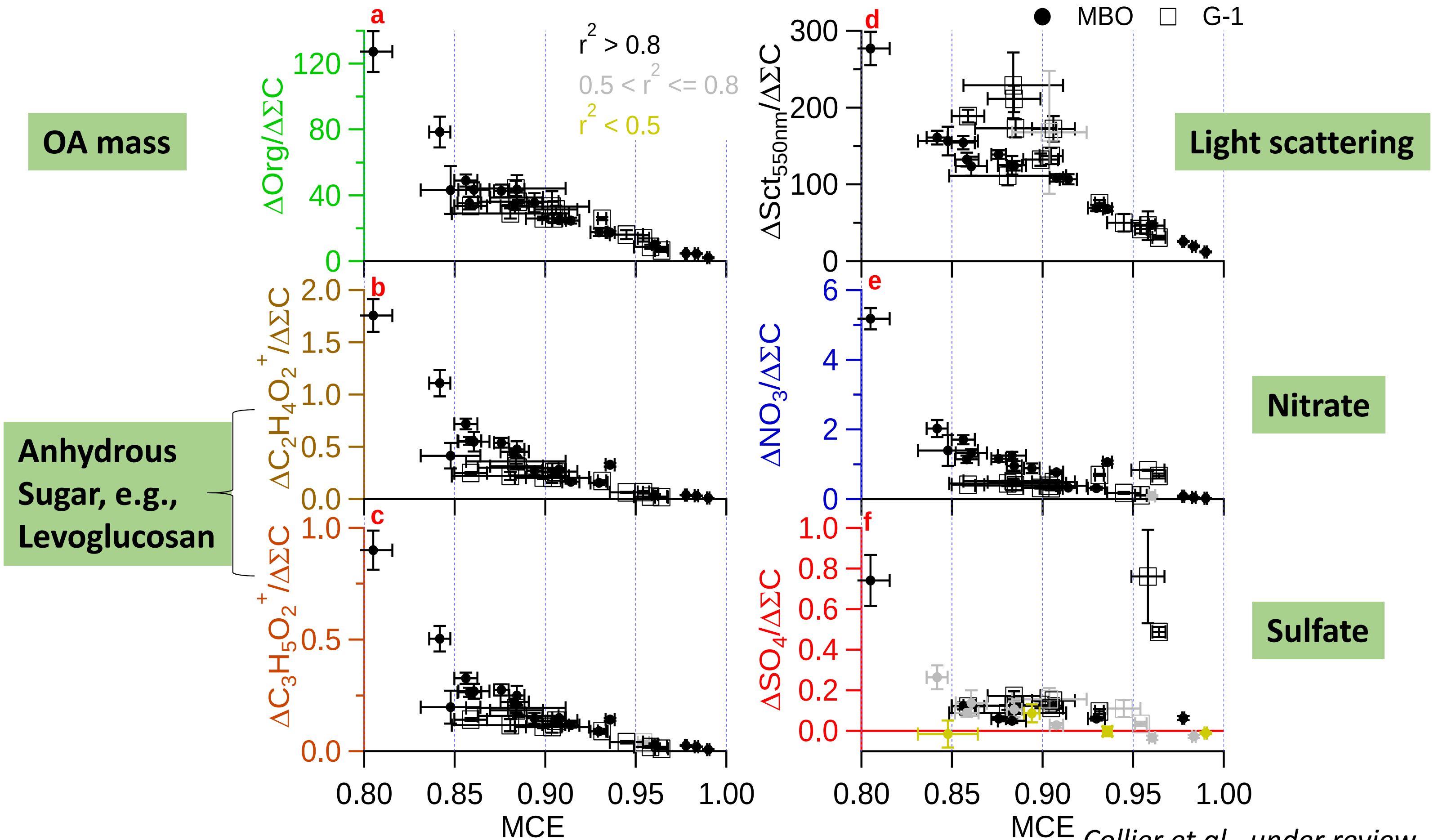
→ Greater primary aerosol emissions at low MCE

2) G1 and MBO data overlap

- MBO: aged fire plumes (6 – 48hr)
- G1: fresh + aged fire plumes (< 1 – 11 hr)

→ Aging has little influence on ΔOrg/Δ($CO+CO_2$)

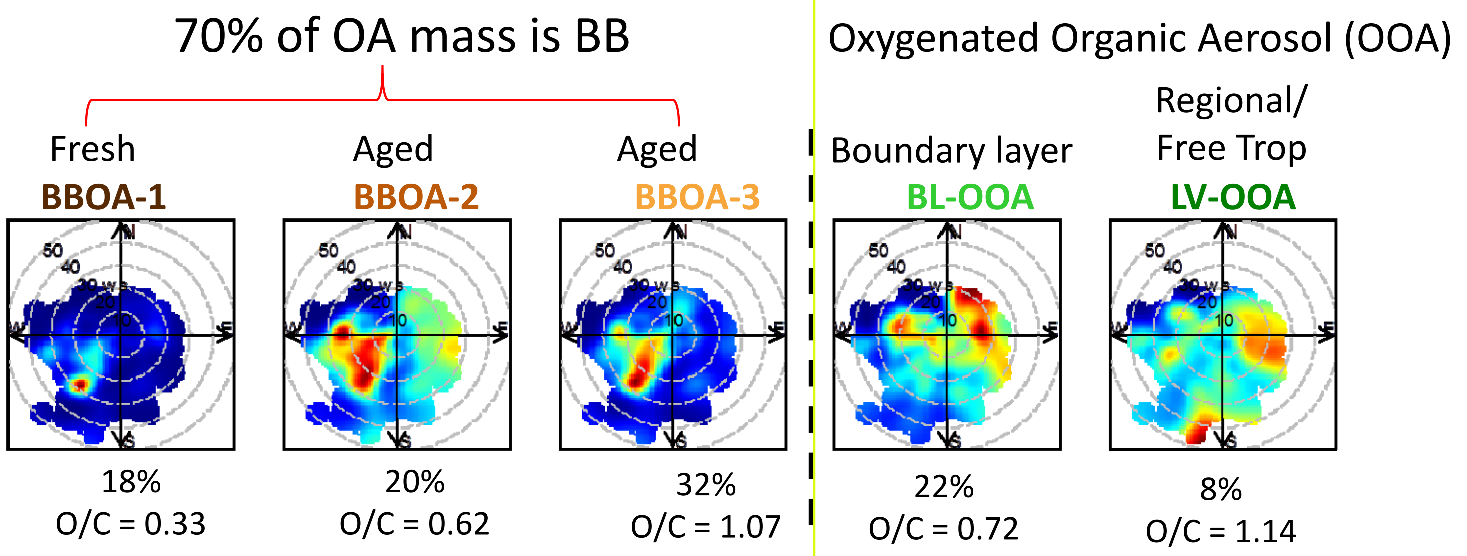
Regional Influence Shows Strong Dependence on MCE

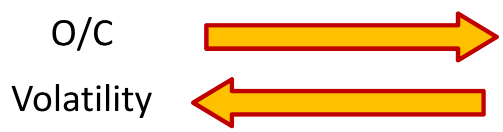


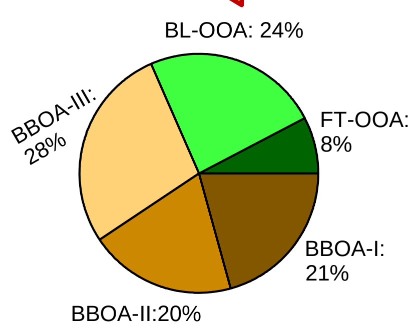
Collier et al., under review

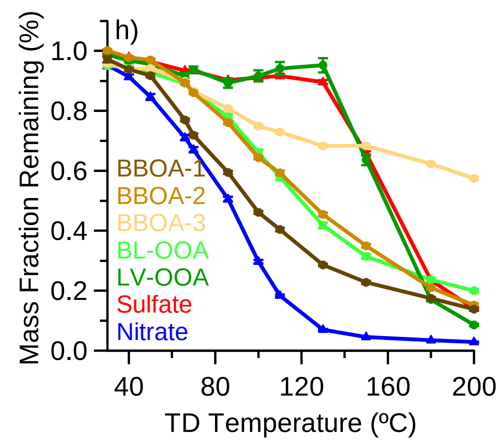
Why might regional PM chemistry and optics be controlled by MCE rather than atmospheric processing? → What happened on a shorter time frame?

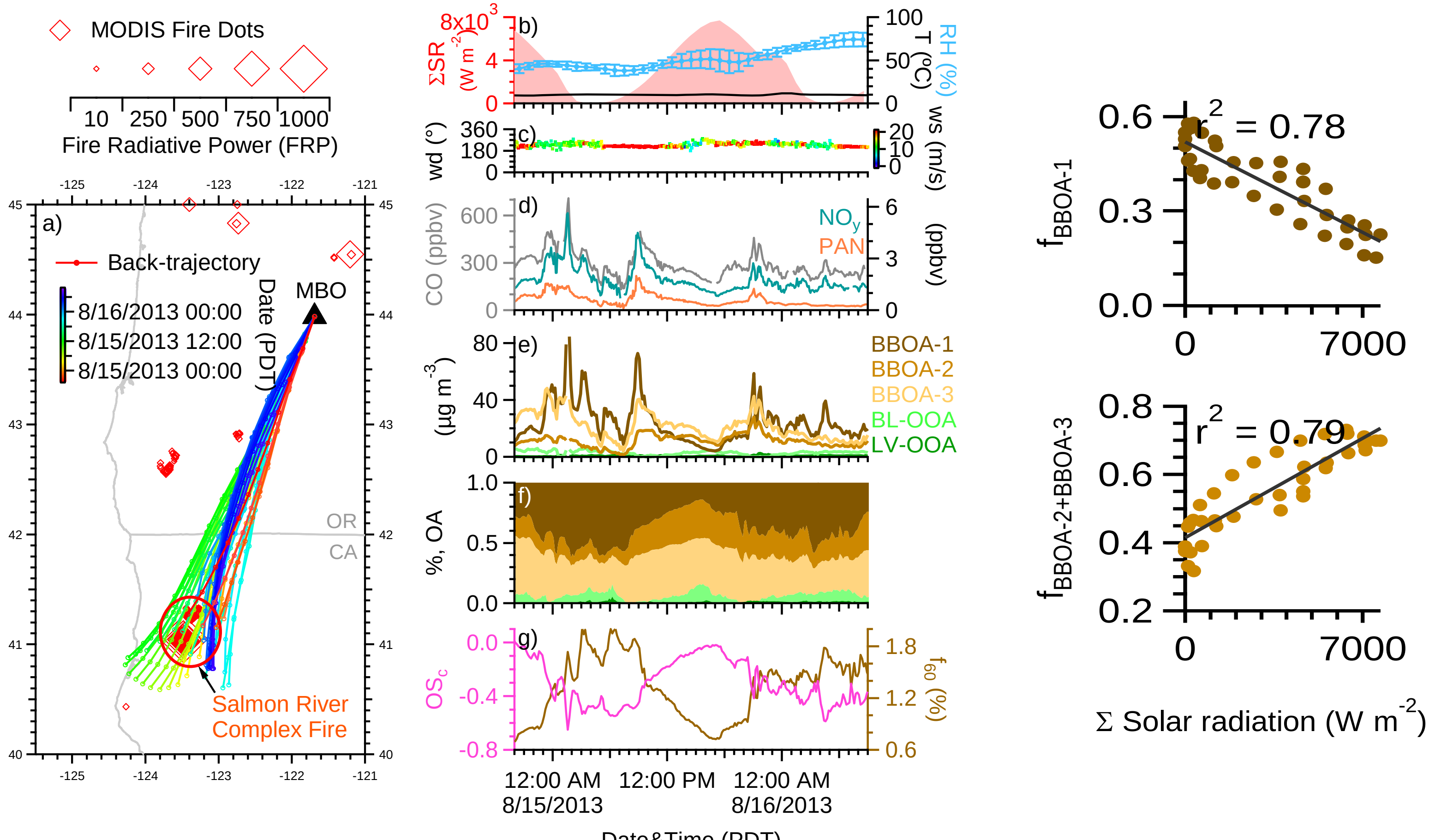
Unravel BBOA Chemistry at MBO



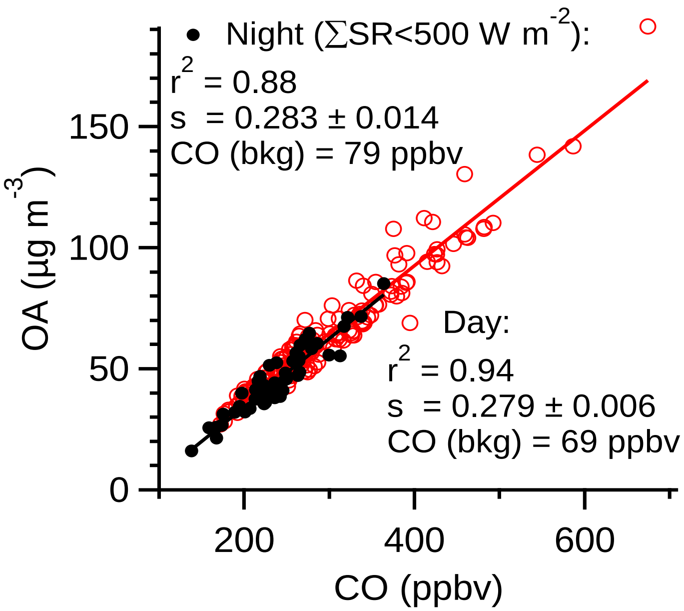


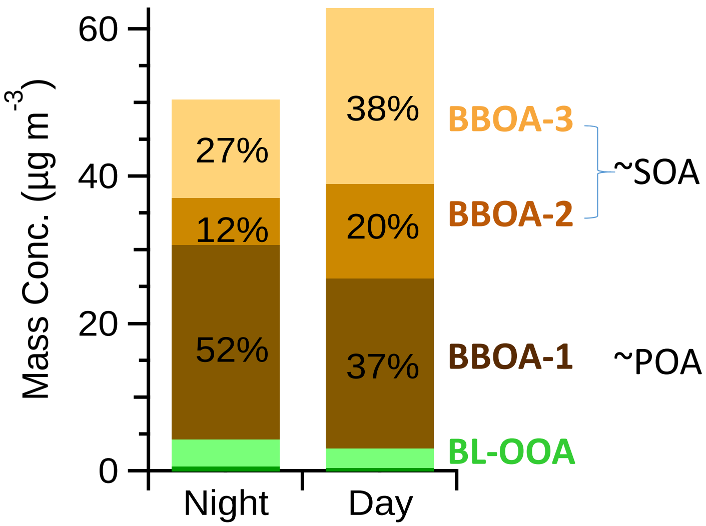


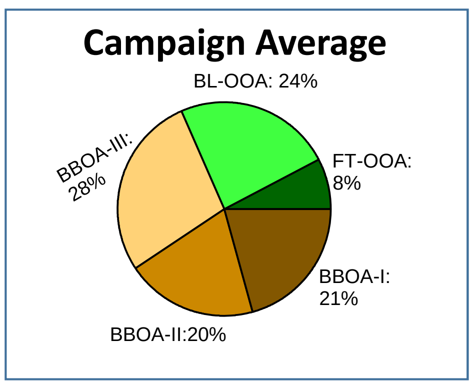


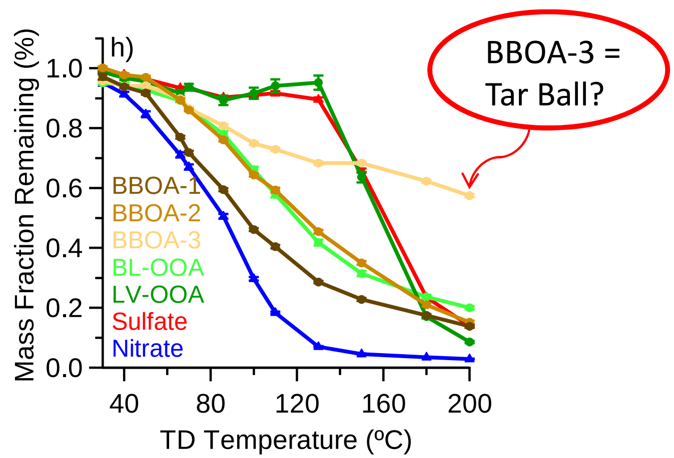


- A case study of BBOA evolution : constant SW wind during 36 hours
- Determine solar exposure (ΣSR) of BBOA based on backtrajectory analysis.
- ↑ of %BBOA-1 (fresh, POA) and ↓ of % aged BBOA with SR



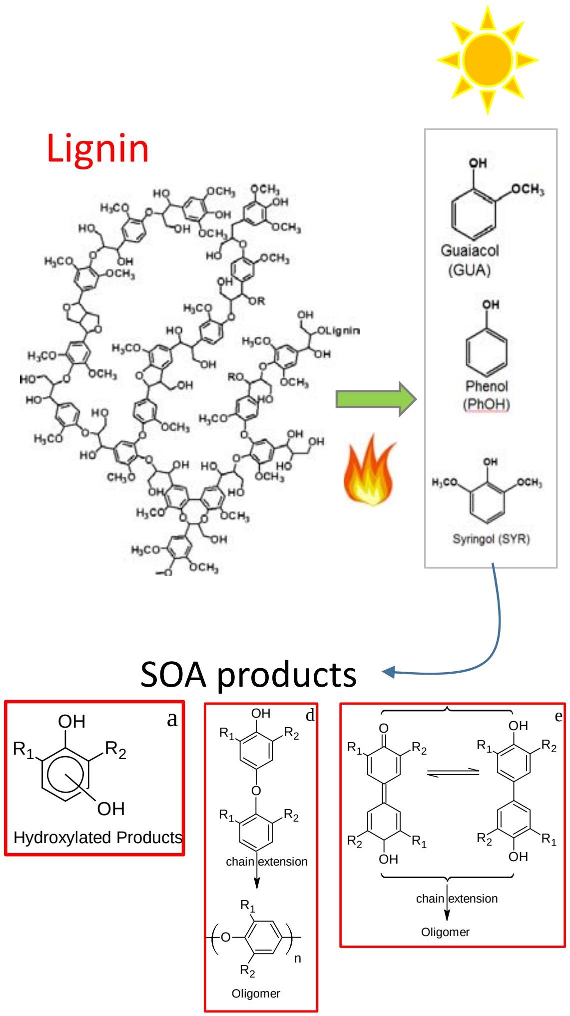


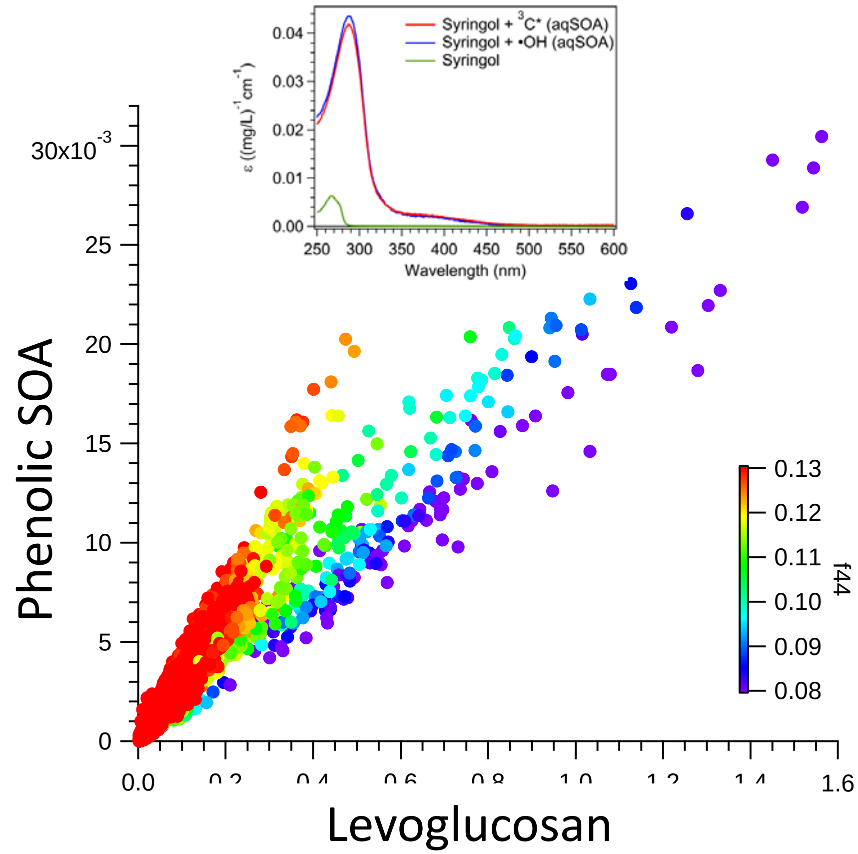




- Nearly constant OA/CO with aging due to offsetting SOA formation and POA evaporation.
- SOA accounts for ~ 2/3 of BBOA in regional airmass influenced by wildfire emissions

Secondary BrC Formation in BB Plumes





Sun et.al., ACP, 2010; Yee et al., ACP, 2013, Yu et al., ACP, 2014

Larger enhancement of BB SOA tracer relative to levoglucosan in more aged BB plumes, evidence of SOA production in BB emissions

→ BrC ↑ with aging

Summaries

- Biomass burning: forest fires (wild, prescribed), ag. burning, residential heating and cooking
  - ubiquitous and increasing globally
  - important sources of gas and particle-phase pollutants
  - Impact air quality, health, climate, ecosystems
- BB emissions strongly influence ambient PM loading and composition.
- Gas and PM components in BB vary dynamically
  - Burn conditions, transport, fuel type
  - SOA formation → transform BB aerosols from a positive radiative forcing agent (warming) to a negative forcing agent (cooling).

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doi:10.5194/acp-17-2477-2017

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Regional influence of wildfires on aerosol chemistry in the western US and insights into atmospheric aging of biomass burning organic aerosol

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Regional Influence of Aerosol Emissions from Wildfires Driven by Combustion Efficiency: Insights from the BBOP Campaign

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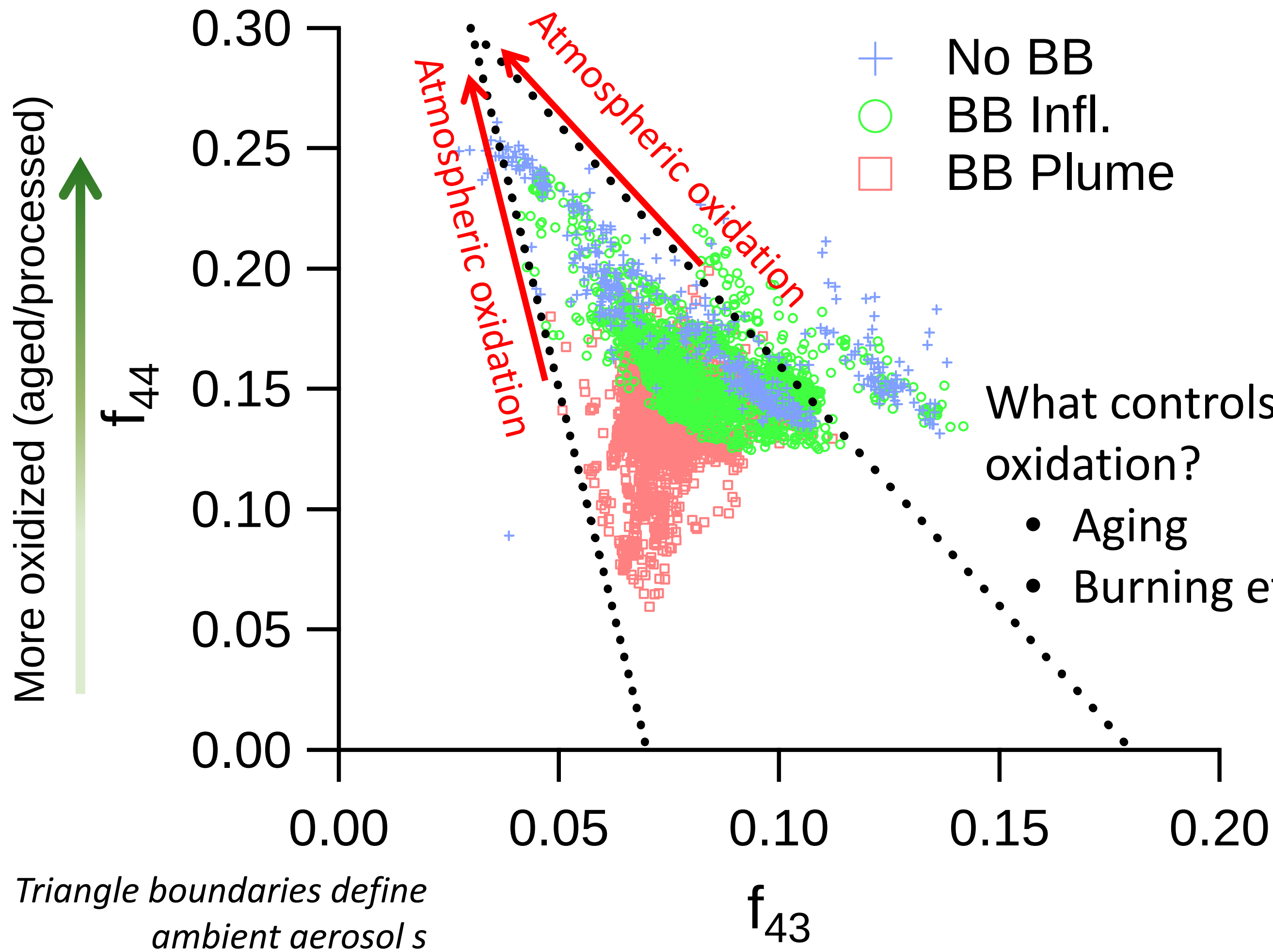
Influence of BB on Aerosol Chemistry

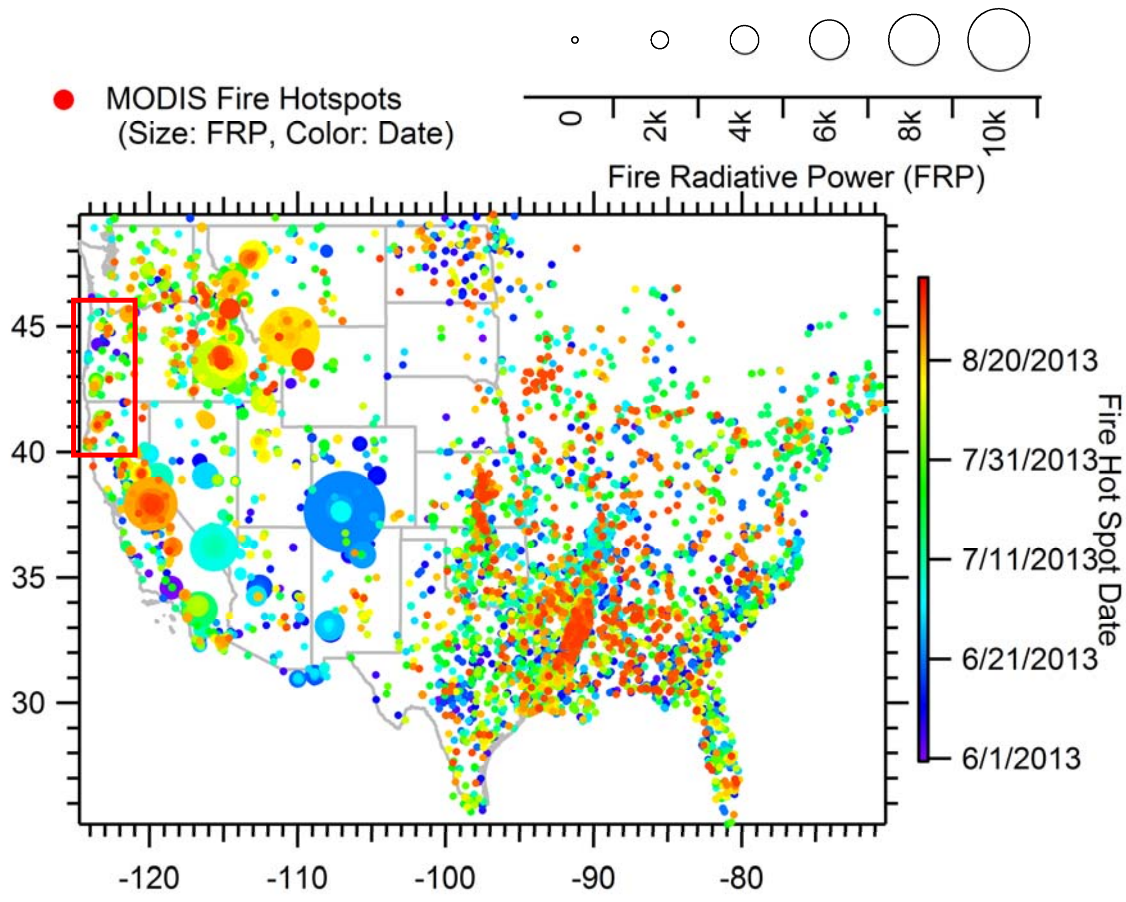


What controls BBOA oxidation?

- Aging
- Burning efficiency

Triangle boundaries define ambient aerosol s (Ng et al., ACP, 2010)

Intense Wildfire Activities during Summer

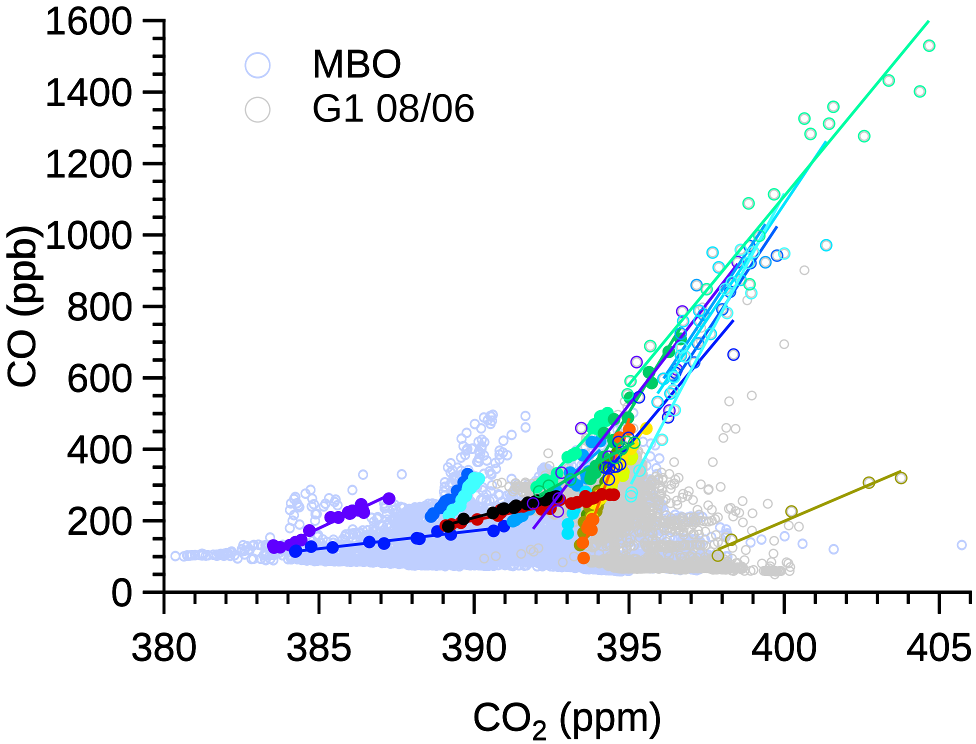


BBOP (G-1 + MBO): July 25 – Aug. 25, 2013

Identification of BB Plumes and Calculation of MCE

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

	MCE	Estimated transport time
MBO:	0.81 – 0.98	6 – 48
G1:	0.86 – 0.96	~1 – 10



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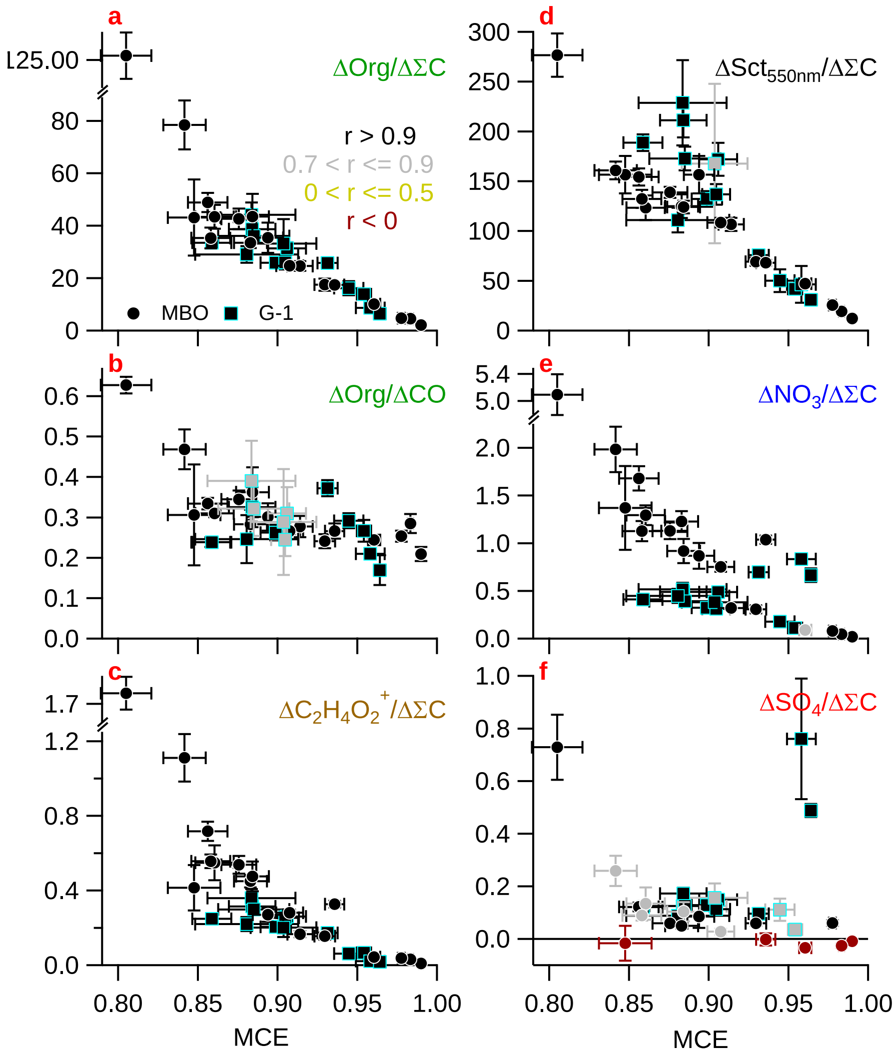

a
ΔOrg/ΔΣC
r > 0.9
0.7 < r <= 0.9
0 < r <= 0.5
r < 0
MBO
G-1
b
ΔOrg/ΔCO
c
ΔC2H4O2+/ΔΣC
MCE
d
ΔSct550nm/ΔΣC
e
ΔNO3/ΔΣC
f
ΔSO4/ΔΣC
MCE