Biomass Burning BC Mixing State Lifecycle: BBOP, ORACLES, and LASIC

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Evolution of Biomass Burning Aerosols

**Local (Source) Regime**
- Fuel source
- Combustion conditions:
  - Flaming (favors BC)
  - Smoldering (favors OA)
  - Pyrolysis (favors OA)
  - Cooling/dilution
  - Coagulation & condensation
  - POA evaporation

**Regional Regime**
- Competing chemical and physical processes:
  - Photochemistry, SOA production,
  - Condensation, Oxidation,
  - Fragmentation, Evaporation,
  - Production of brown carbon,
  - Oligomerization

**Global Regime**
- Brown carbon (BrC) bleaching
- Material loss due to volatility
- Cloud processing
- Wet/dry deposition

Minutes to Hours  -->  Hours to Days  -->  Days to Weeks

Sedlacek et al., in prep
Evolution of Biomass Burning Aerosols

Local (Source) Regime

Hodshire et al., 2019

Regional Regime

Competing chemical and physical processes:
- Photochemistry
- SOA production
- Smoke particle mass change with aging
- Smoke particle composition change with aging (O:C)

Increase

Decrease

Field
Lab
Field
Lab

Global Regime

Brown carbon (BrC) bleaching
Material loss due to volatility
Cloud processing
Wet/dry deposition

Minutes to Hours
Hours to Days
Days to Weeks

Sedlacek et al., in prep
Wildfires offer a unique set of conditions that favor a variety of rBC-containing particle morphologies.

A word on refractory black carbon (rBC) mixing state

Use SP2 to derive:
- Per particle mass ratio (MR) of non-refractory particulate material (NRPM) to rBC core mass
- NRPM aerosol mass bound to rBC particles
- Number fraction of thickly coated rBC particles ($\Delta t_{\text{scat-incand}} = 1.2 \ \mu s$; Moteki and Kondo, 2007)
Local: Increase in Black Carbon (BC) Coating Mass

How does black carbon mixing state evolve in the local regime?

Coating Growth Rate: 4.7 (±1.1) fg/hr

Sedlacek et al., in prep
Local: Rapid Increase in BC Coating Mass

Average coating growth rate: 6.8 (± 2.5) fg/hr
Regional: Growth in BC Coating Appears to Plateau

Sedlacek et al., in prep

2012

Plume Age (days)

m_{coating}/m_{BC,100 \text{nm}}

BBOP

130723a 130730b
130814a 130821b
130806a

Forrister et al., 2015
Schwarz et al., 2008
Mt. Bachelor Obs 2015

Sedlacek et al., 2013
Combining BBOP, ORACLES, and LASIC provides an unprecedented opportunity to examine the complete lifecycle of BB aerosols.
Composition Budget: 20-60% NRPM Bound to rBC

Mass ratio enables estimation of NRPM mass bound to core

$$\phi_{rBC-NRPM} = \text{mass fraction of NRPM bound to rBC to total NRPM (via AMS)}$$

Much or most of NRPM can be bound to BC-containing particles!
Composition Budget: 20-60% NRPM Bound to rBC

Mass ratio enables estimation of NRPM mass bound to core

$\phi_{rBC-NRPM} = \text{mass fraction of NRPM bound to rBC to total NRPM (via AMS)}$

Much or most of NRPM can be bound to BC-containing particles!
Loss of Coating as rBC Particles Age

Mass ratio enables estimation of NRPM mass bound to core

\( \phi_{rBC-NRPM} = \) mass fraction of NRPM bound to rBC to total NRPM (via AMS)

Number fraction of thickly coated rBC particles

NRPM bound to rBC (budget & coating thickness) decreases with age
Comparison Between ORACLES and LASIC

\[ \Phi_{\text{rBC-RNPM}} = 0.51 \pm 0.05 \]
\[ \Phi_{\text{rBC-RNPM}} = 0.30 \pm 0.03 \]
\[ \Phi_{\text{rBC-RNPM}} = 0.19 \pm 0.01 \]

Increase in thin:thick number ratio, decrease in MR100 with age
Local – Regional – Global: Bringing it all together

~ 1 day

Sedlacek et al., in prep
Closing Thoughts

Observations:
- Mass ratio of NRPM to rBC core increases, plateaus and then decreases with age
- NRPM bound to rBC varies from 60-20%, with indication of decreasing with age in global regime
- Number fraction of thickly coated rBC particles decreases with age

Future Directions:
- NRPM budget
  - SP2 analysis suggests much of the OA mass is bound to rBC cores.
    - BB plume is the most extreme case of this
- How do we connect ground-based measurements at LASIC with flight-based measurements during Oracles/CLARIFY?
- Is there a seasonality-dependence of the rBC mixing state between two observed biomass burning periods?