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

A. J. Sedlacek, E. R. Lewis, T. B. Onasch

BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

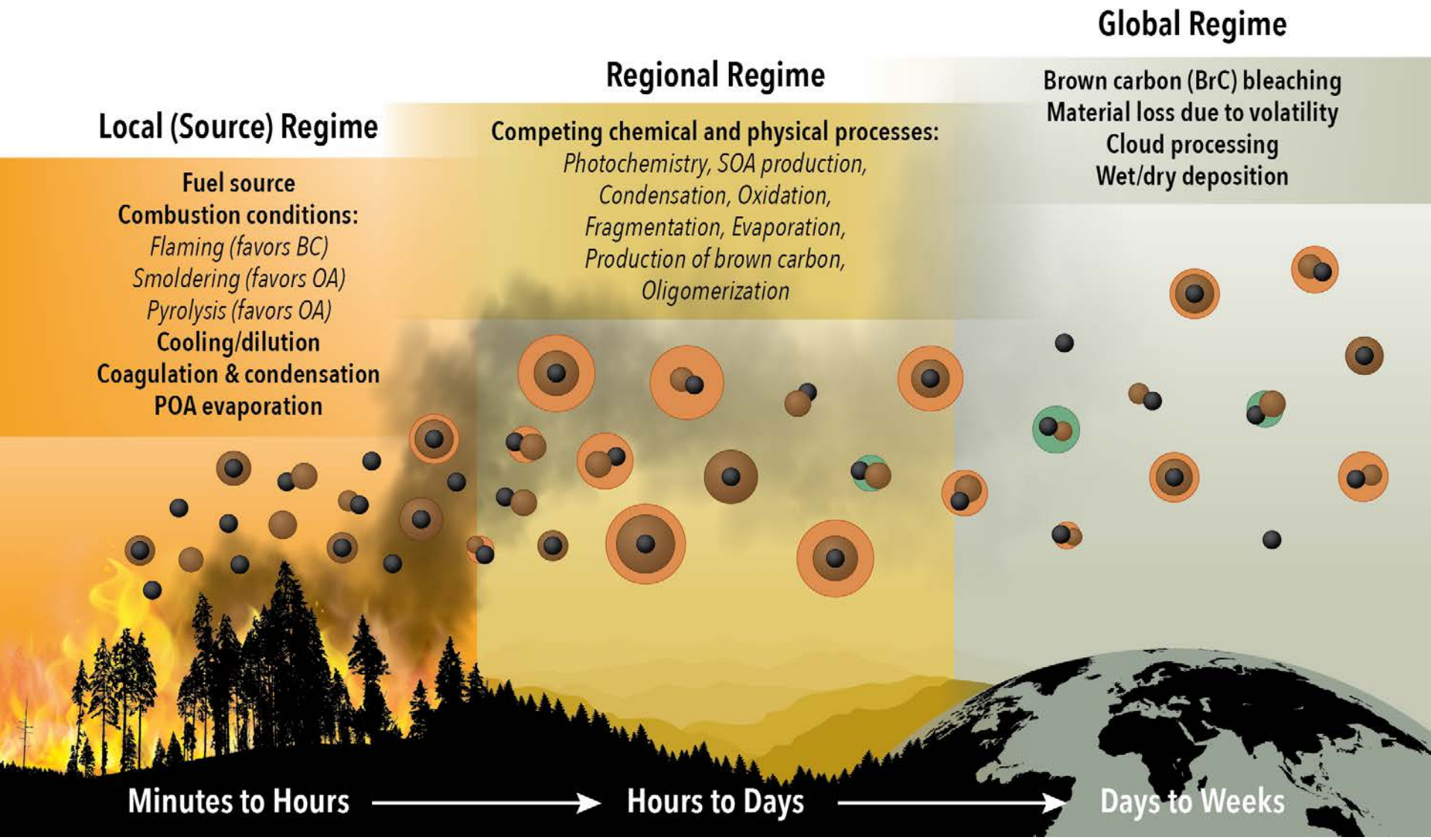
BROOKHAVEN SCIENCE ASSOCIATES

ARM CLIMATE RESEARCH FACILITY

ASR Atmospheric System Research

AERODYNE RESEARCH, Inc.

Evolution of Biomass Burning Aerosols



Sedlacek et al., in prep

Evolution of Biomass Burning Aerosols

Local (Source) Regime

Regional Regime

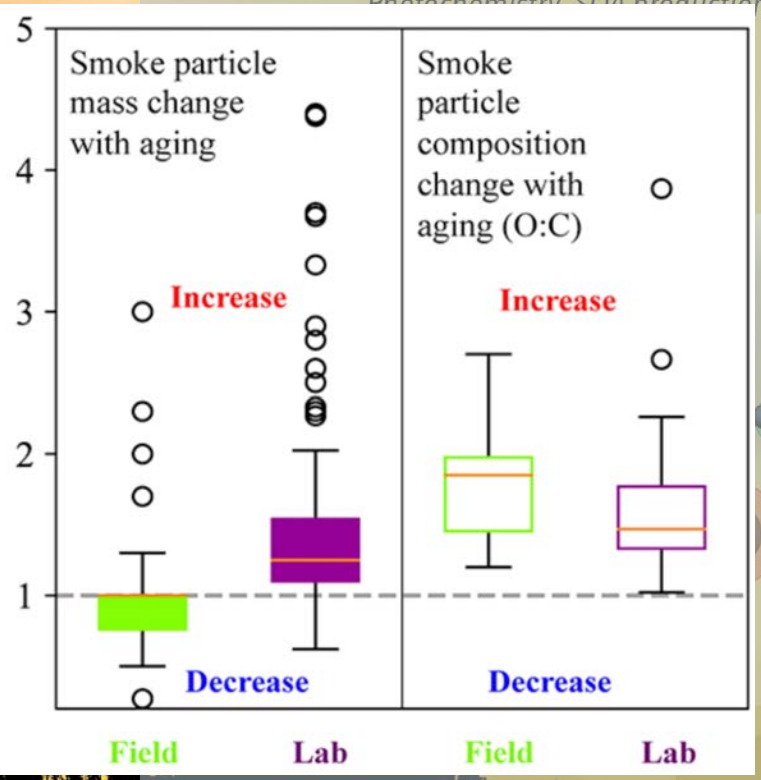
Competing chemical and physical processes:

Global Regime

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

Hodshire et al., 2019

Aged amount / Initial amount



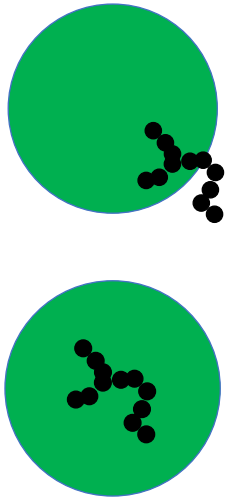
Minutes to Hours → Hours to Days → Days to Weeks

Sedlacek et al., in prep

A word on refractory black carbon (rBC) mixing state

Wildfires offer a **unique** set of **conditions** that favor a variety of rBC-containing particle morphologies.

Reality

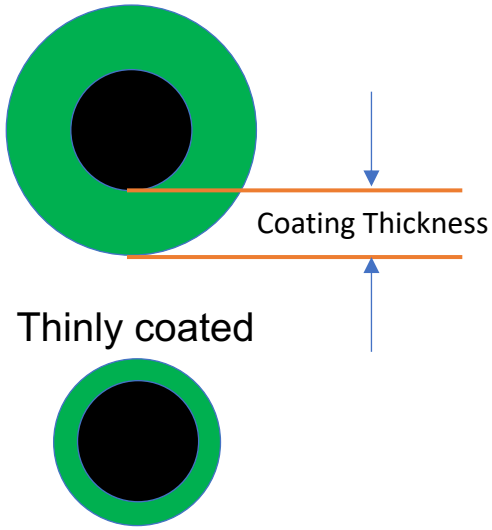


Coagulation

Condensation

Evidence for both particle types in the near field

Core-shell morphology



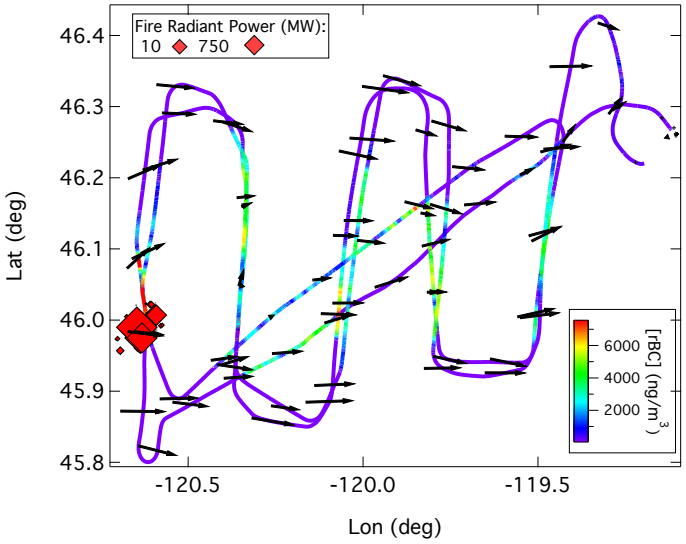
Use SP2 to derive:

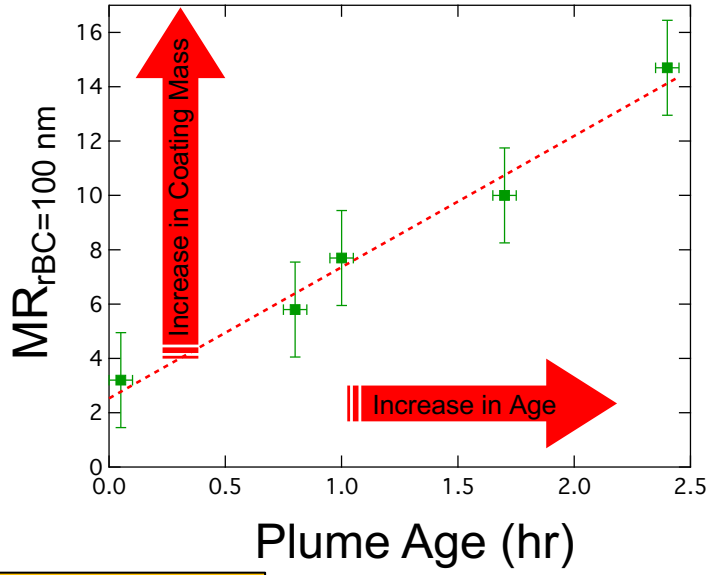
- Per particle mass ratio (MR) of non-refractory particulate material (NRPM) to rBC core mass
- NRPM aerosol mass bound to rBC particles
- Number fraction of thickly coated rBC particles ($\Delta\tau_{scat\text{-}incand}$ =1.2 μs; Moteki and Kondo, 2007)

Local: Increase in Black Carbon (BC) Coating Mass

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

Assume core-shell configuration

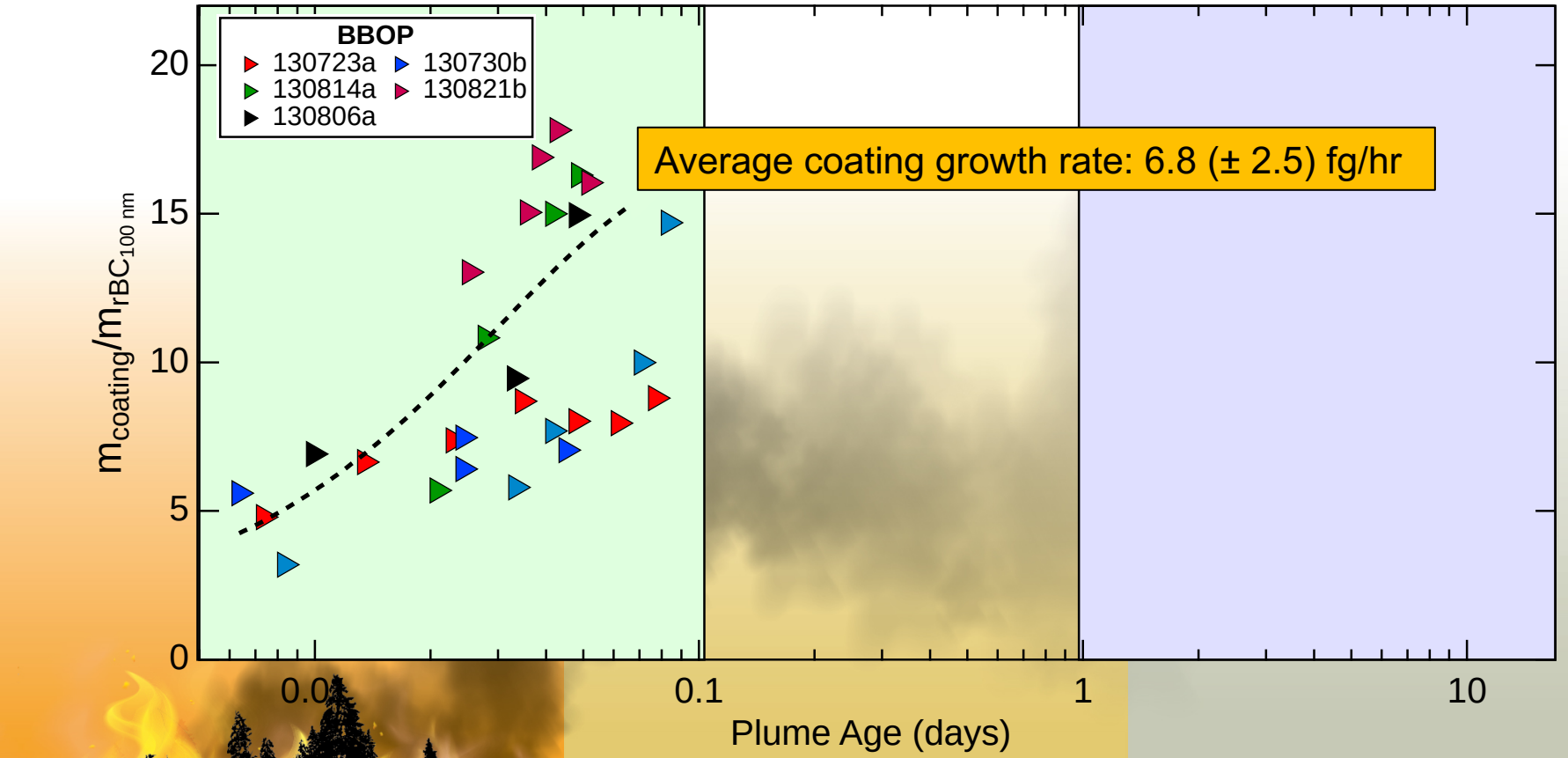




Coating Growth Rate: 4.7 (±1.1) fg/hr

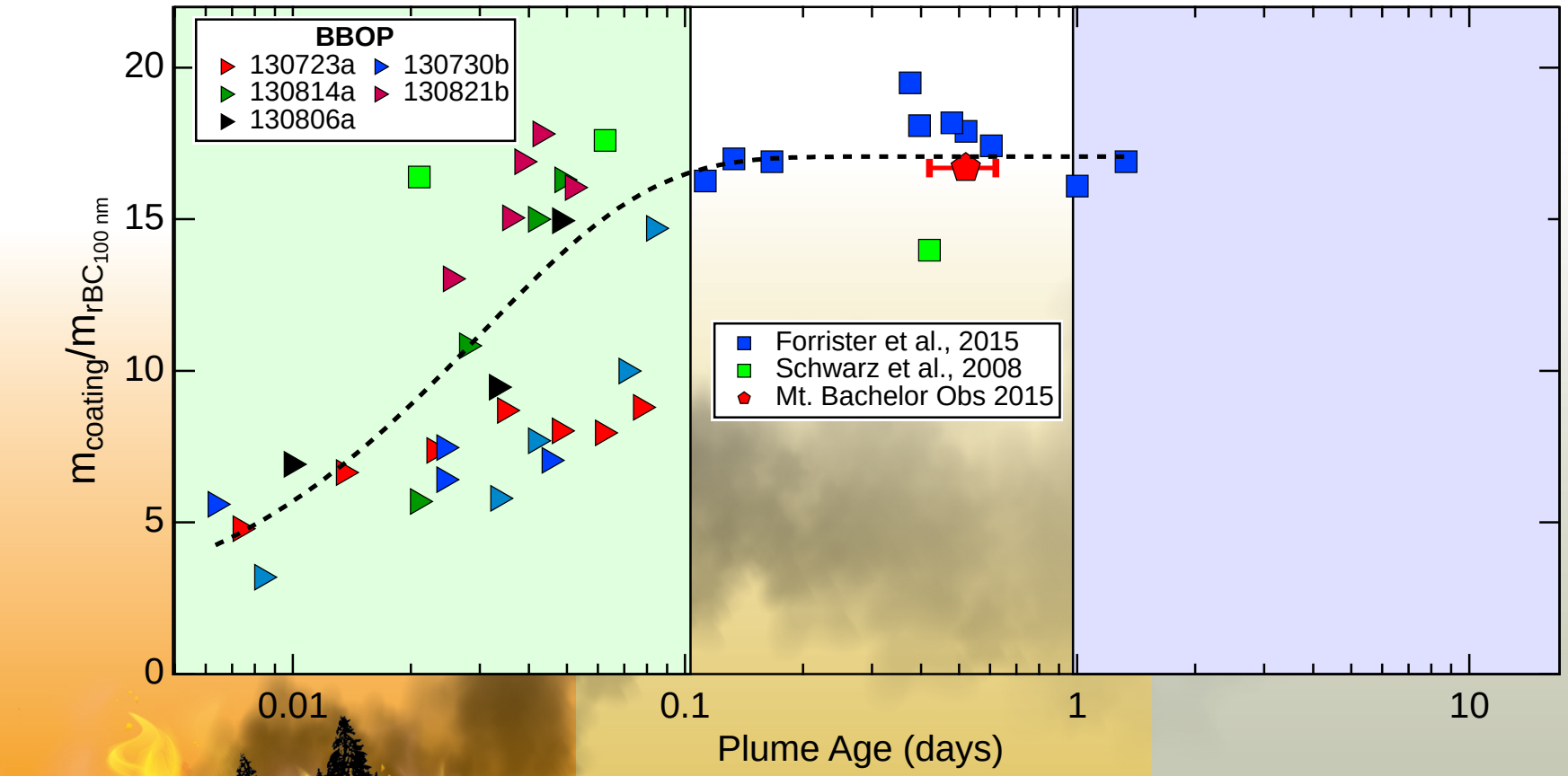
Sedlacek et al., in prep

Local: Rapid Increase in BC Coating Mass



Sedlacek et al., in prep

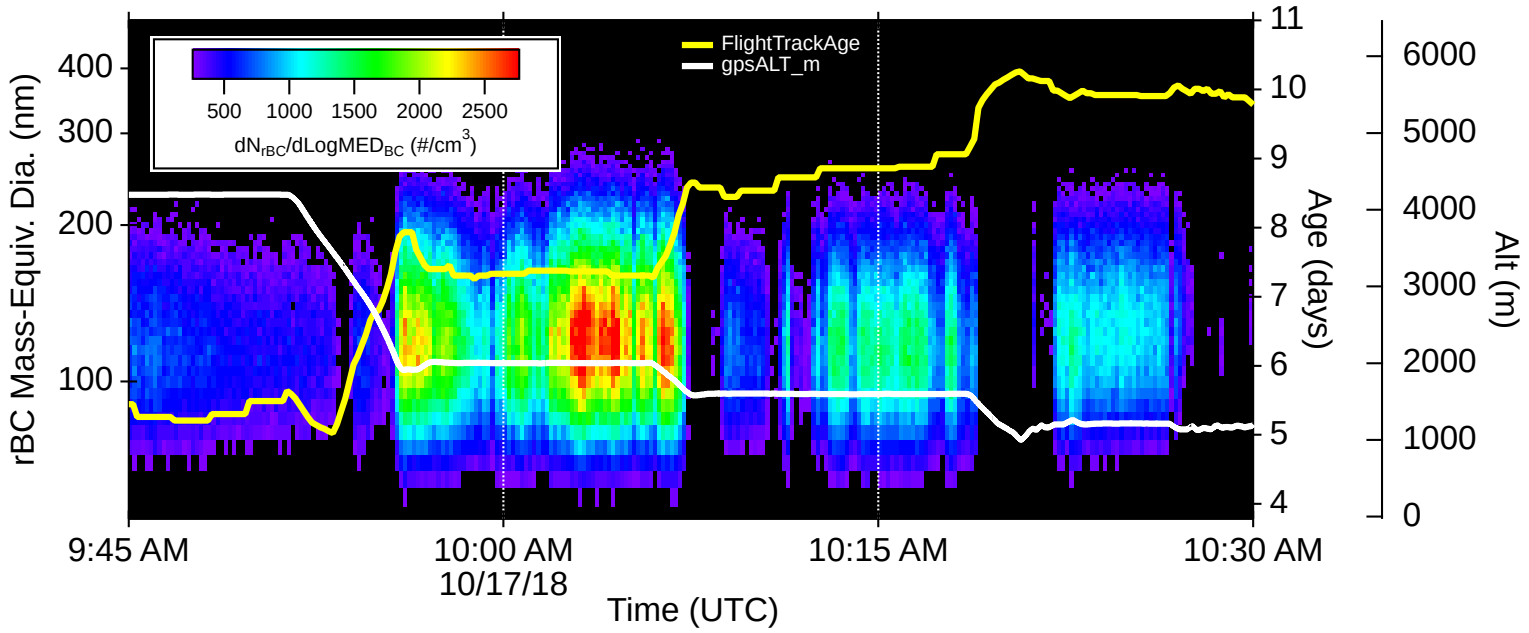
Regional: Growth in BC Coating Appears to Plateau



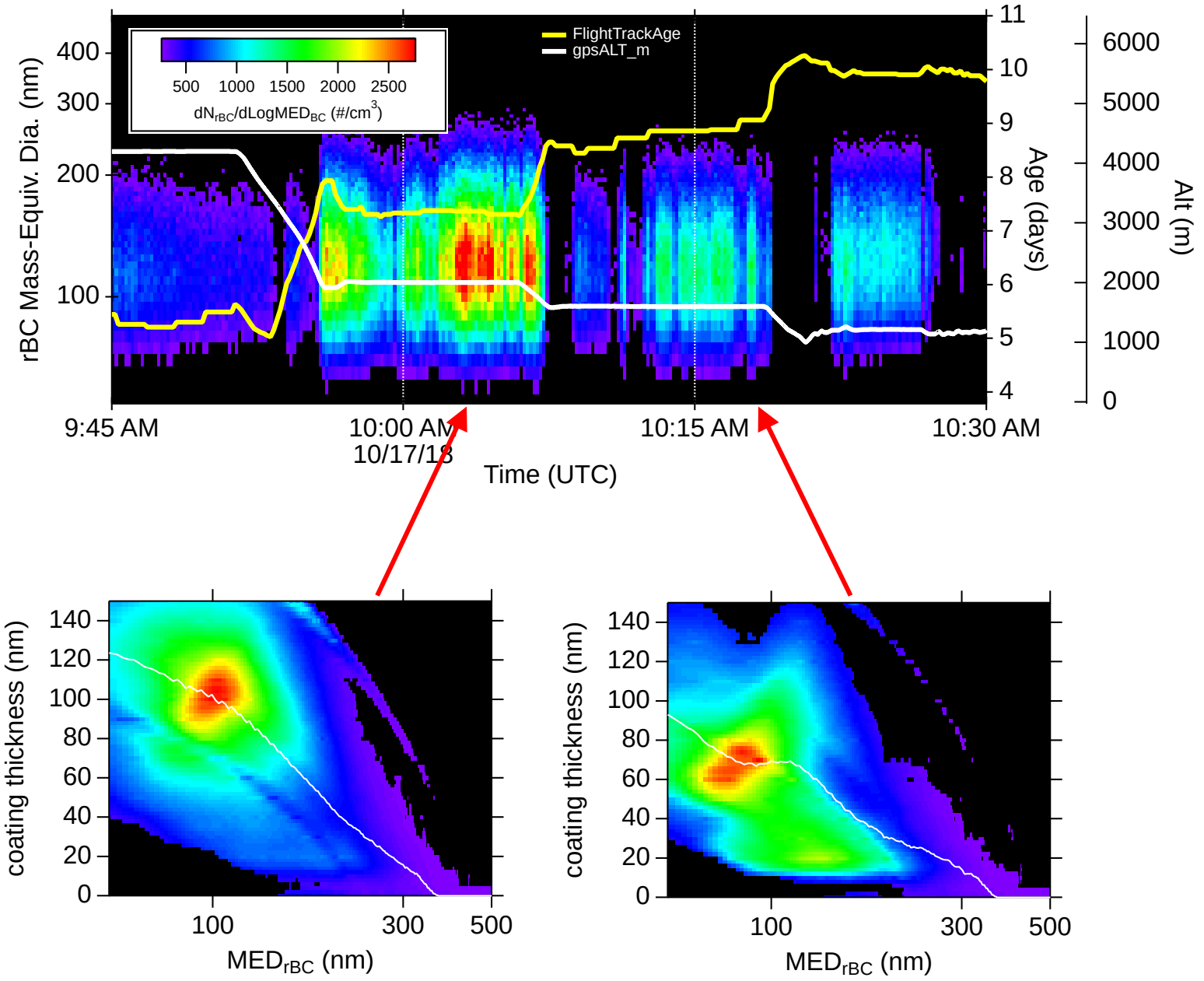
Sedlacek et al., in prep

Combining BBOP, ORACLES, and LASIC provides an unprecedented opportunity to examine the complete lifecycle of BB aerosols.

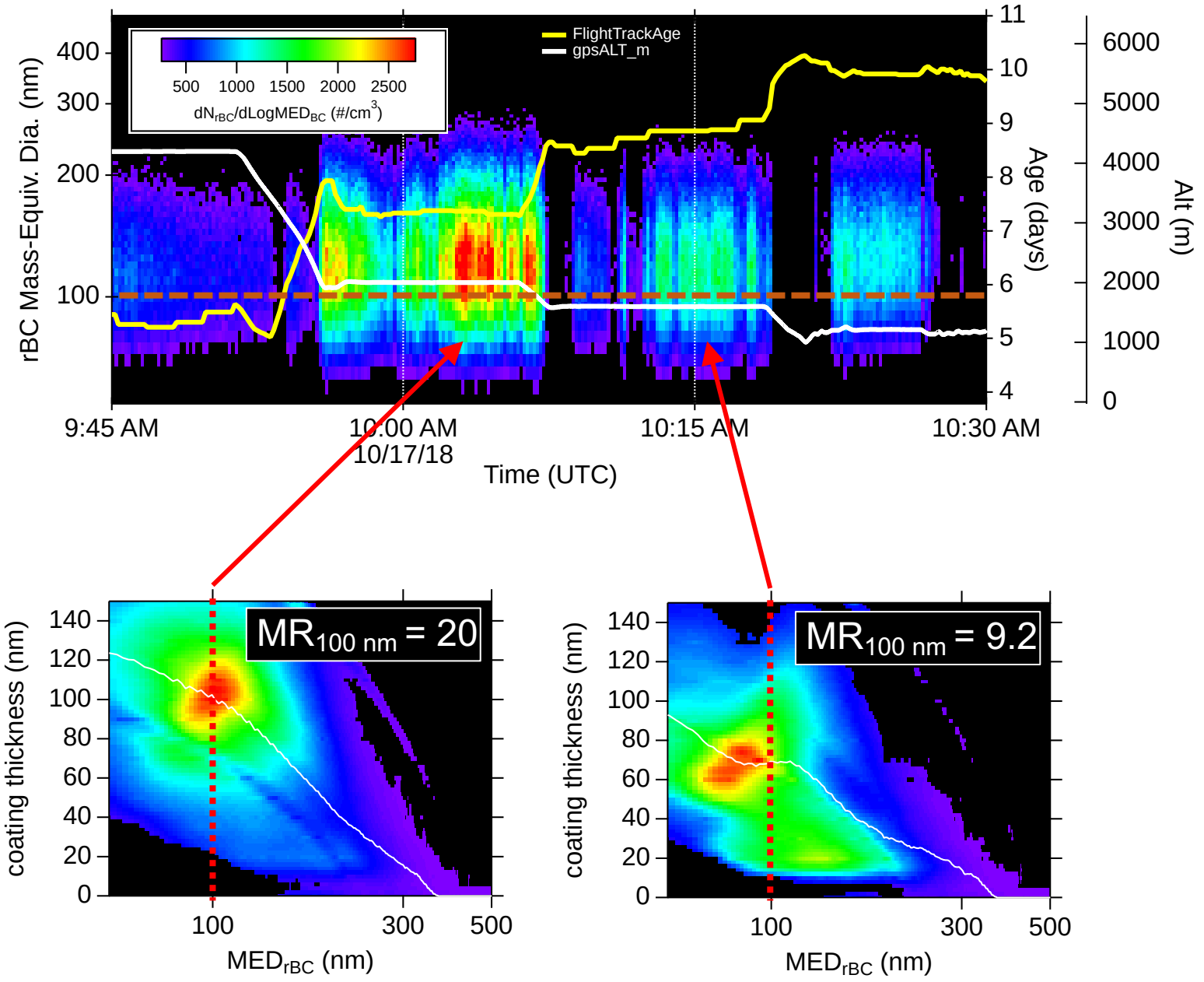
ORACLES: Detection of thickly coated rBC Particles



ORACLES: Detection of thickly coated rBC Particles



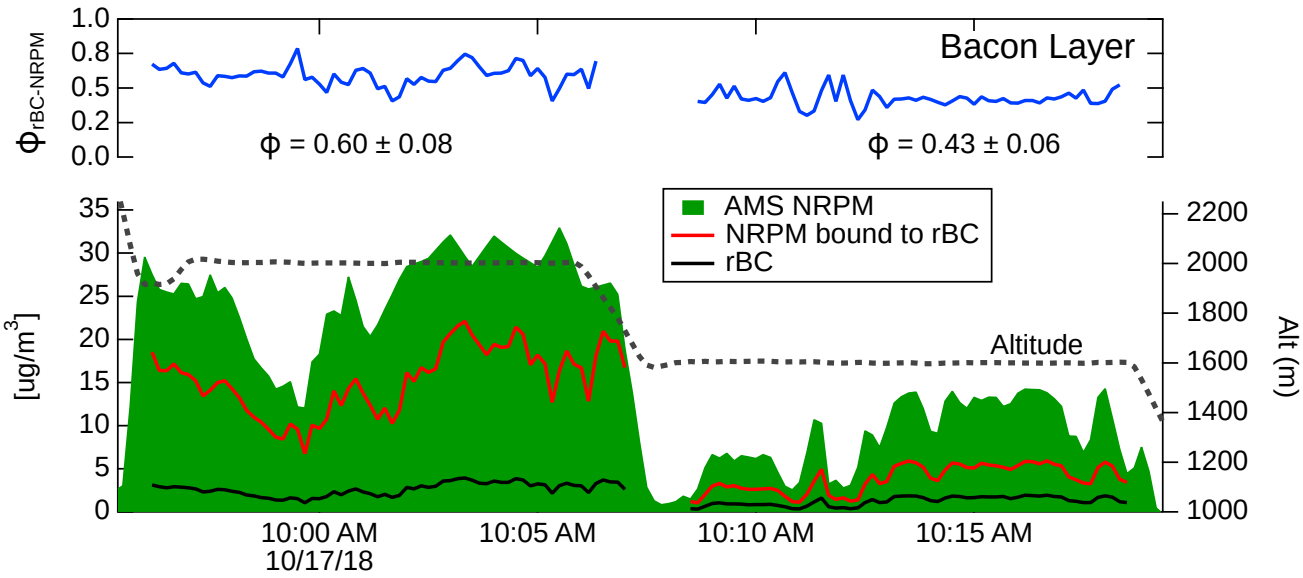
ORACLES: Detection of thickly coated rBC Particles



Composition Budget: 20-60% NRPM Bound to rBC

Mass ratio enables estimation of NRPM mass bound to core

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

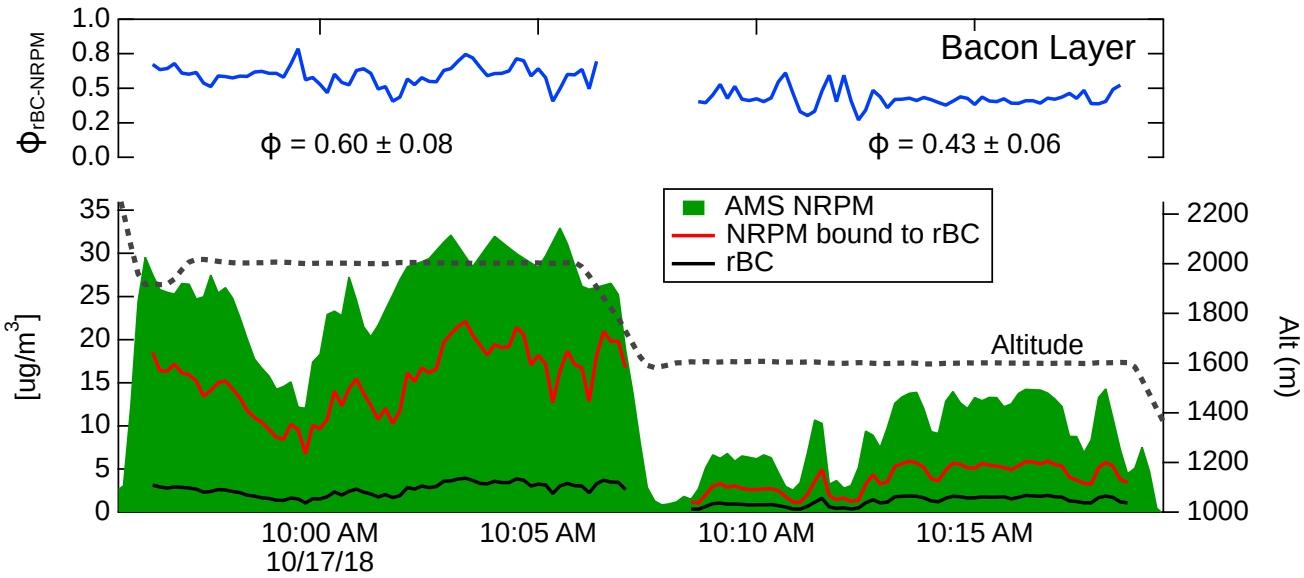


Much or most of NRPM can be bound to BC-containing particles!

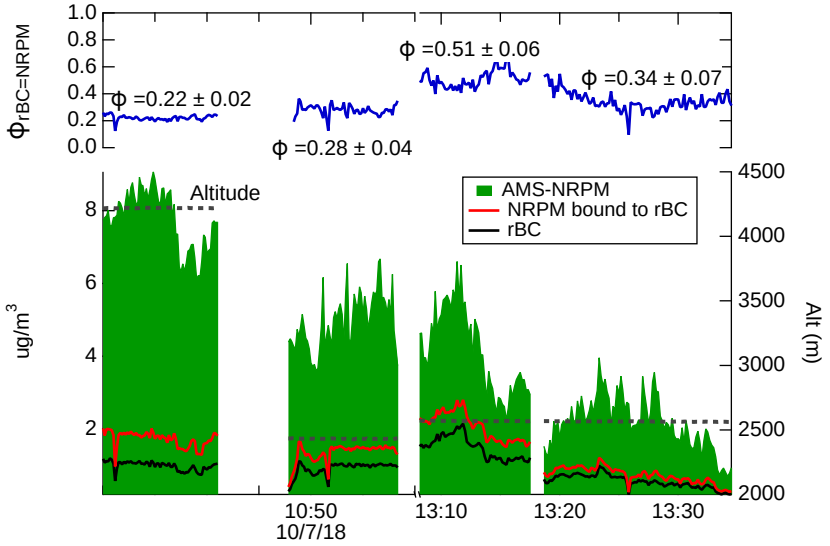
Composition Budget: 20-60% NRPM Bound to rBC

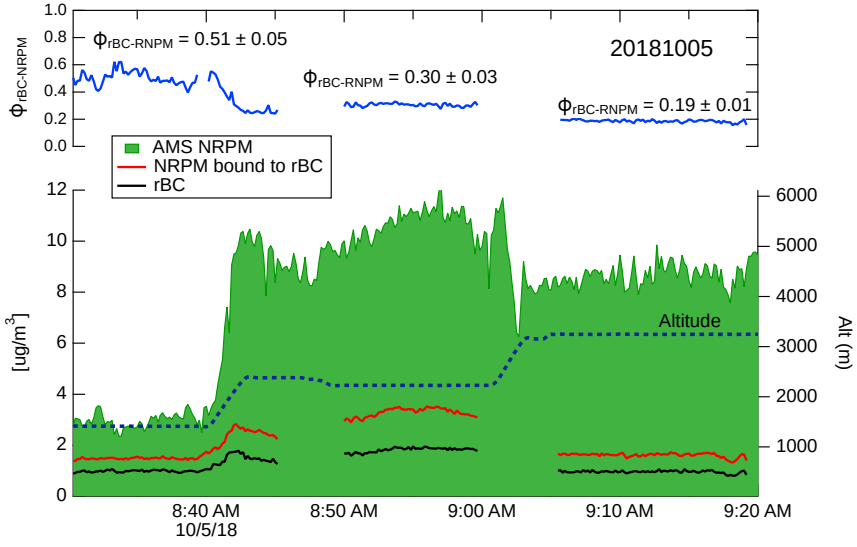
Mass ratio enables estimation of NRPM mass bound to core

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



Much or most of NRPM can be bound to BC-containing particles!

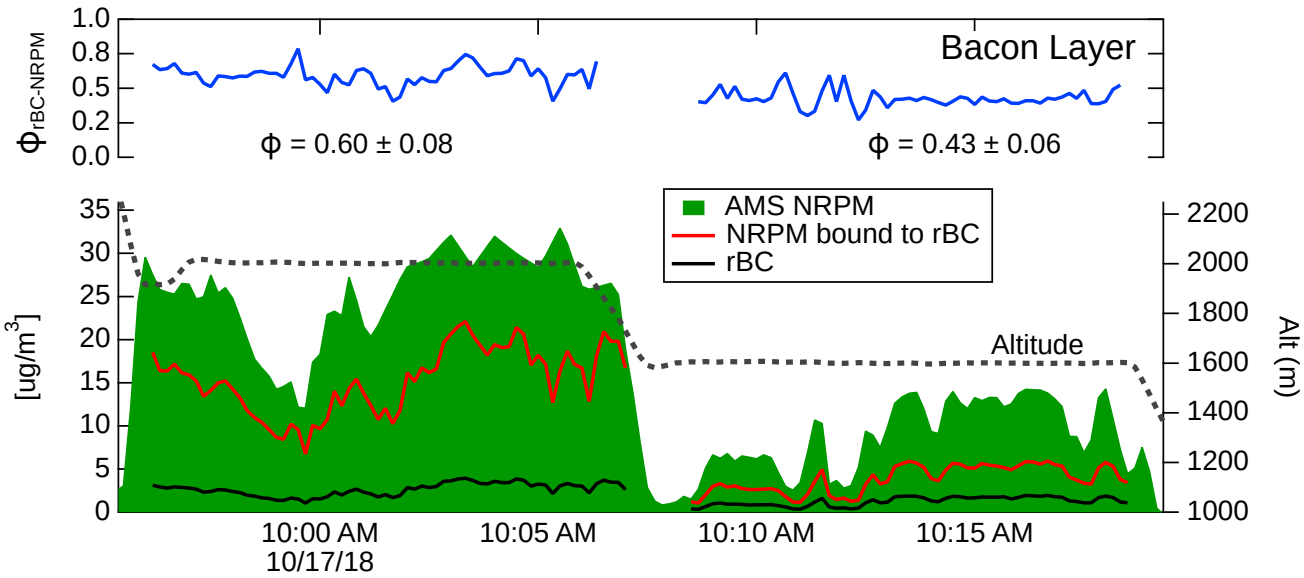




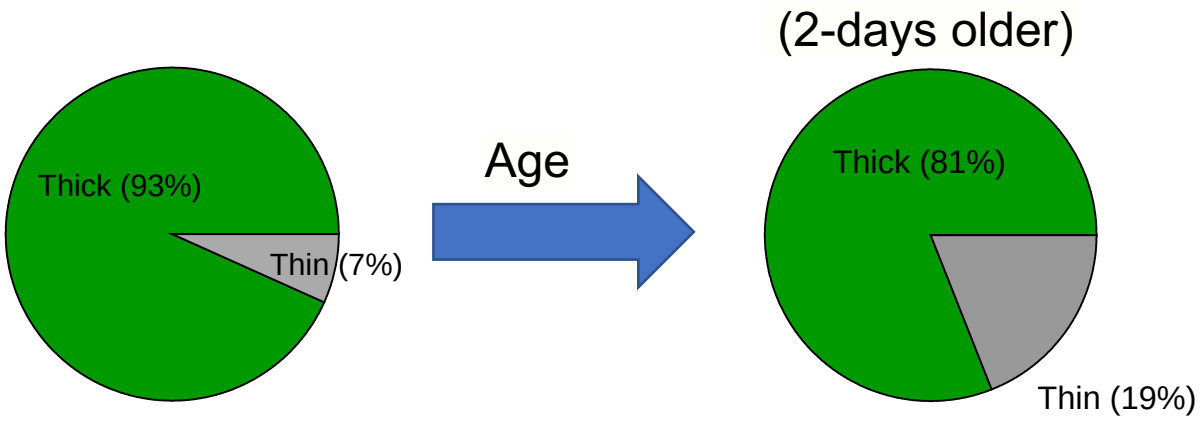
Loss of Coating as rBC Particles Age

Mass ratio enables estimation of NRPM mass bound to core

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

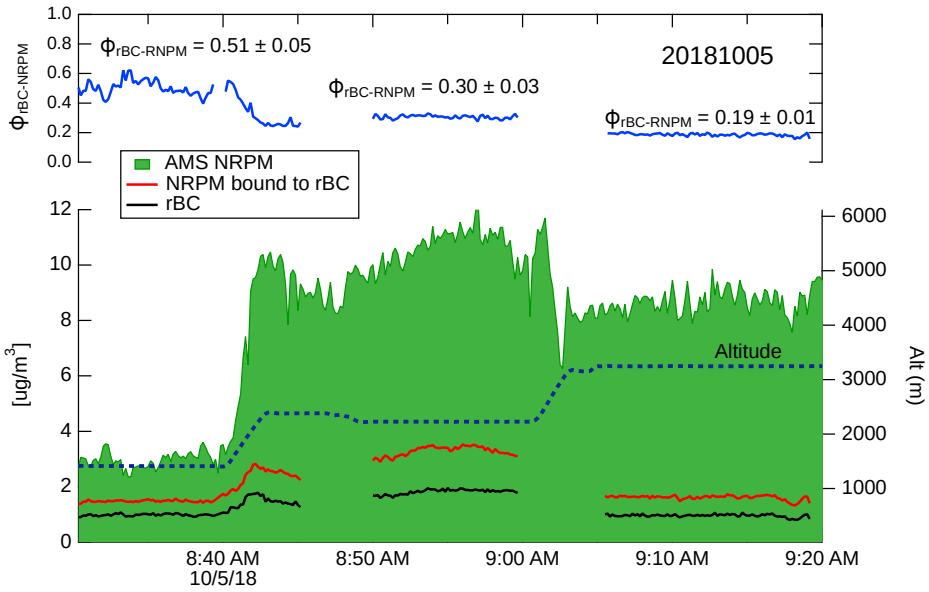


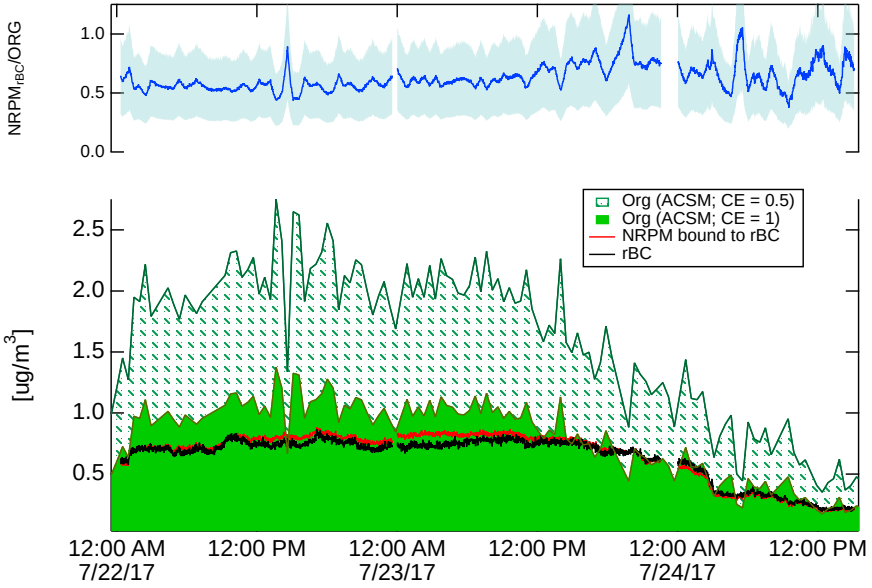
Number fraction of thickly coated rBC particles

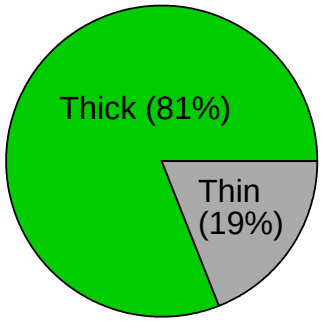


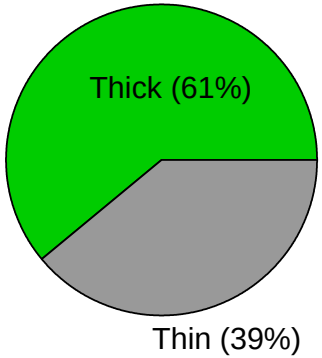
NRPM bound to rBC (budget & coating thickness) decreases with age

Comparison Between ORACLES and LASIC







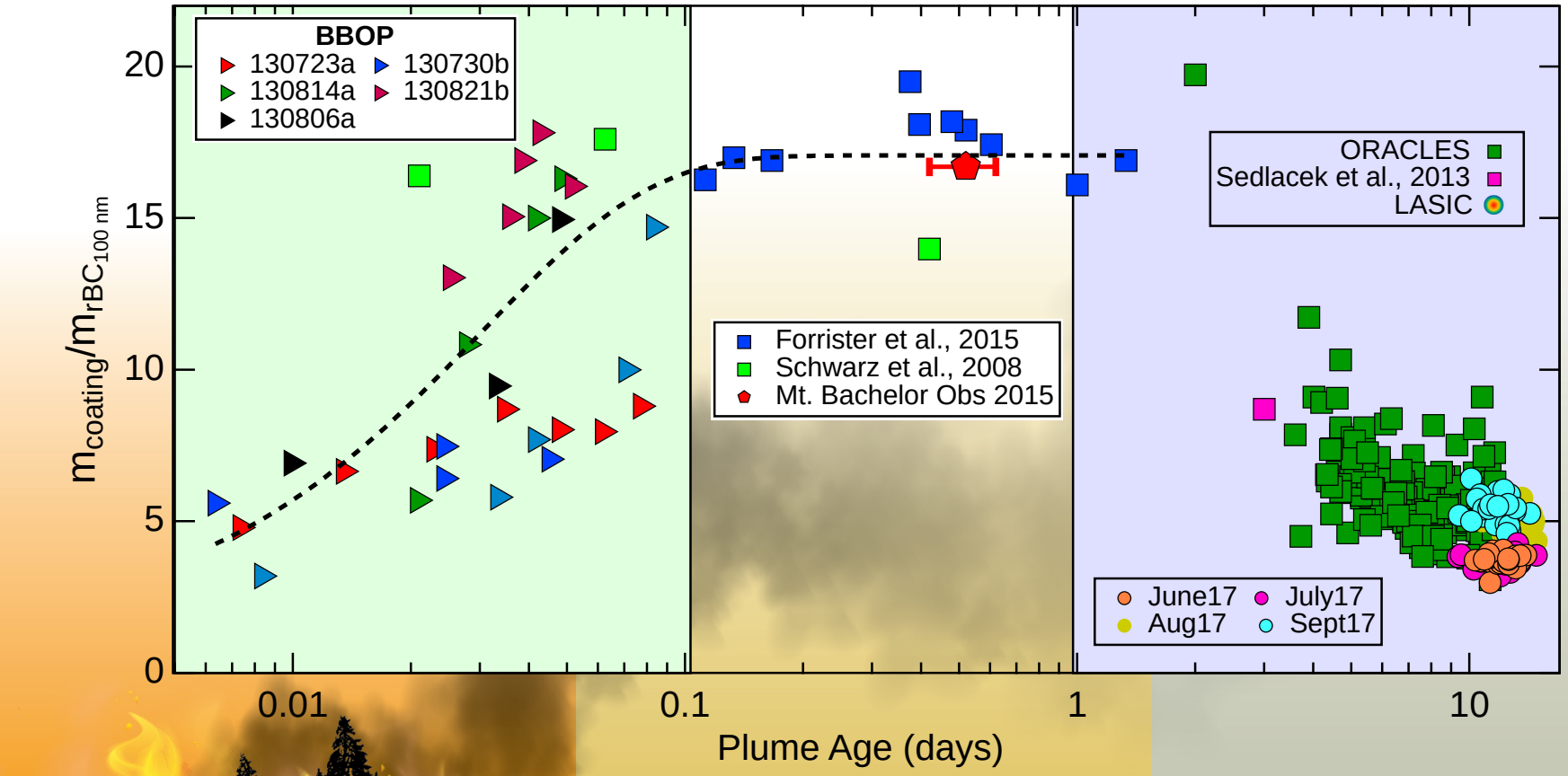


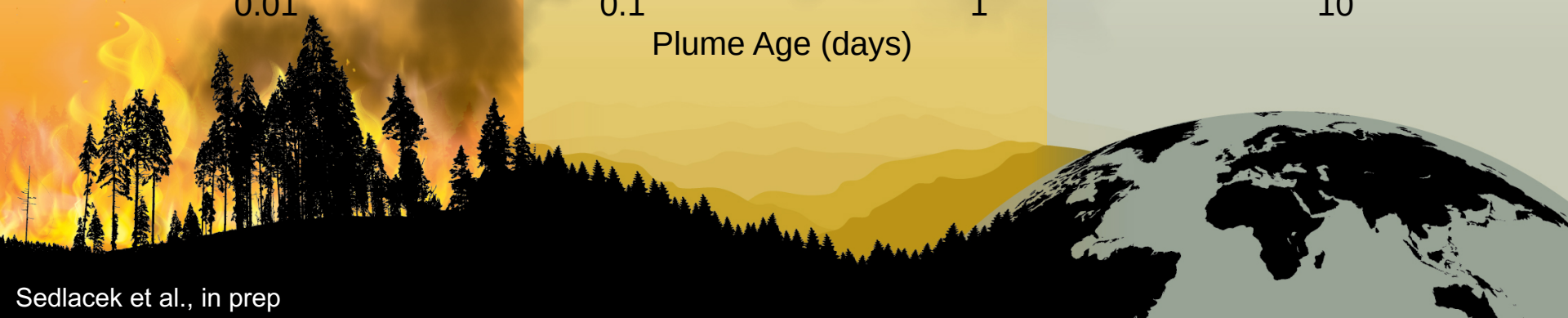
$MR_{100\ nm}$ = 5.9 ± 0.5

$MR_{100\ nm}$ = 3.9 ± 0.6

Increase in thin:thick number ratio, decrease in MR100 with age

Local – Regional – Global: Bringing it all together





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?