Absorbing Aerosols:
Optical & Microphysical Properties

Agenda

Point Sensing of Optical and Microphysical Properties - A. Sedlacek

Aerosol Retrievals Based on Remote Sensing Measurements - R. Ferrare

A Modeling Perspective on Absorption - J. Fast

An IPCC Perspective on Absorption - S. Ghan

Absorbing Aerosols: Point Sensing of Optical & Microphysical Properties

Absorbing aerosols (black carbon and brown carbon) contribute to aerosol radiative forcing by:

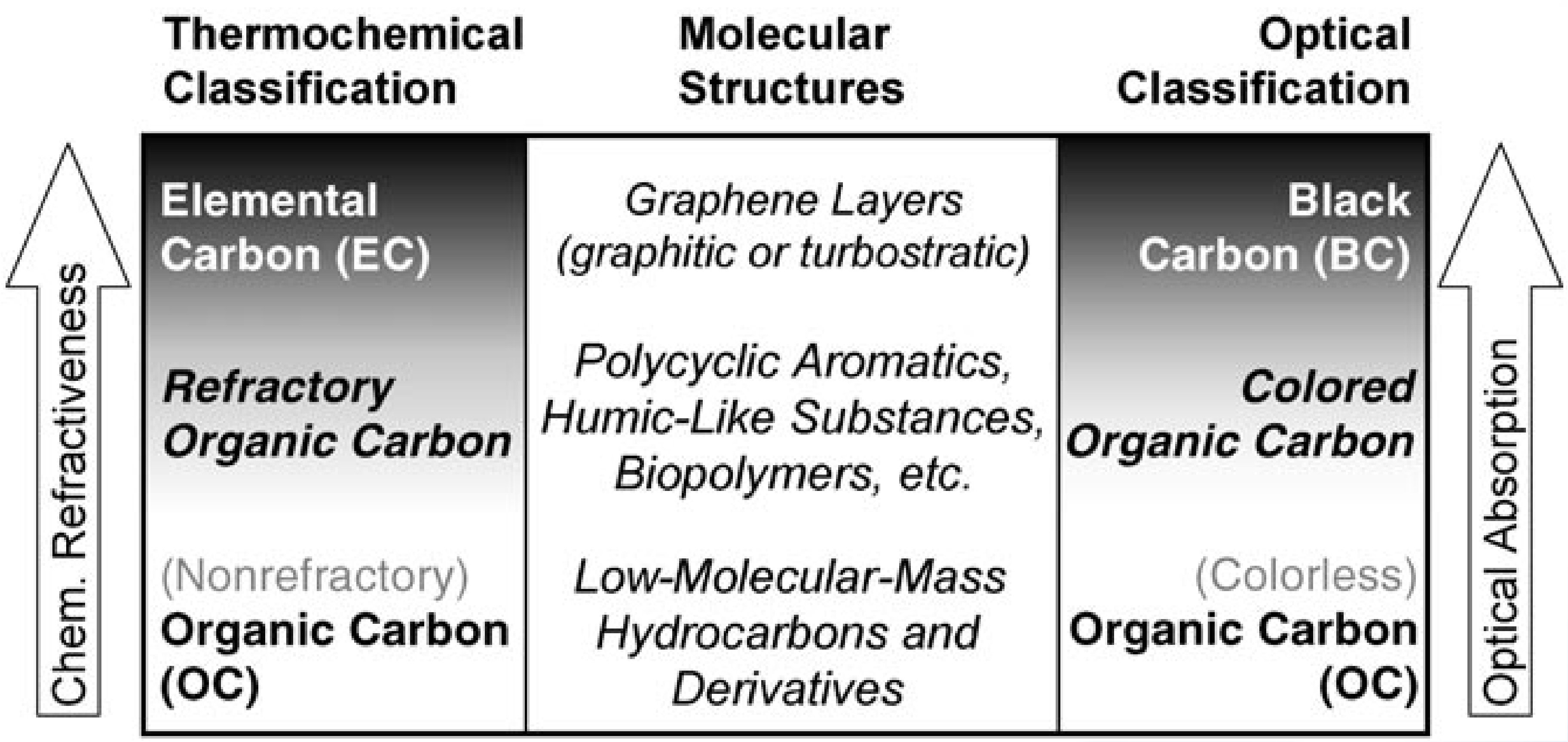
Direct Effect
- Light scattering and absorption (r^6 vs r^3 for Rayleigh particles)

Indirect Effect
- Hinder ability of CCN to activate due to increase in droplet temperature

Semi-direct Effect
- Alter temperature structure of atmosphere; influence cloud cover and precipitation

A Word on Terminology

AA (absorbing aerosol), BC (black carbon), EC (elemental carbon), rBC (refractory black carbon), BrC (brown carbon), soot, LAC (light absorbing carbon), …



Pöschl, 2003

Bond et al., (2013) *Bounding the role of black carbon in the climate system: A scientific assessment*

Several operational definitions, but issues with each

Optical Properties

Microphysical Properties

Point Sensing Aerosol Light Absorption

Filter-based

- Particle Soot Absorption Spectrometer (PSAP): standard for several years
- Continuous Light Absorption Photometer (CLAP): automated 8-filter sampling — Sheridan et al., 2011
- Multi-Angle Absorption Photometer (MAAP): corrects for scattering losses — Petzold et al., 2004

In situ

- Direct: Photoacoustic Spectroscopy (PAS)
- Direct: Photothermal Interferometry (PTI)

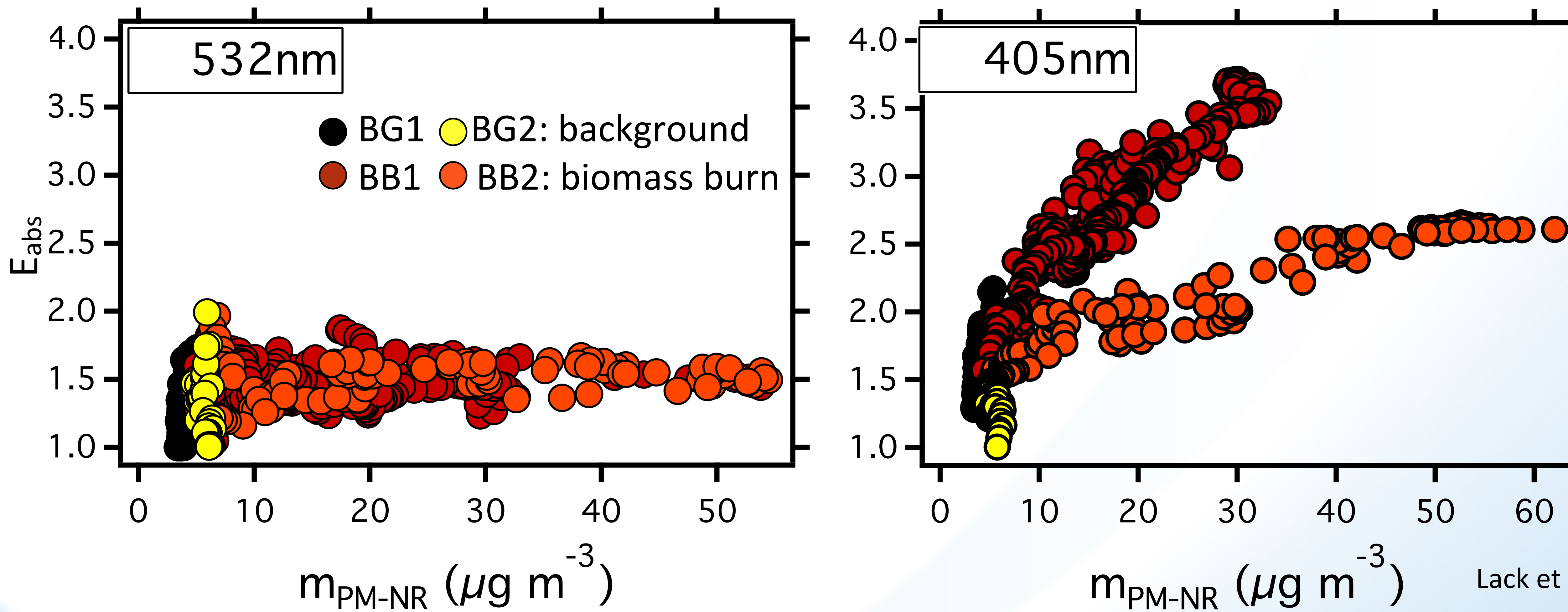
→ Light absorption heats particle → measure sound wave / measure RI change

- Indirect Cadenza: difference of extinction and scattering

How well do we need to measure B_{abs}? Measurement difficulties under high RH conditions.

Wavelength dependence of enhancement factor (E_{abs}) for plumes containing BrC

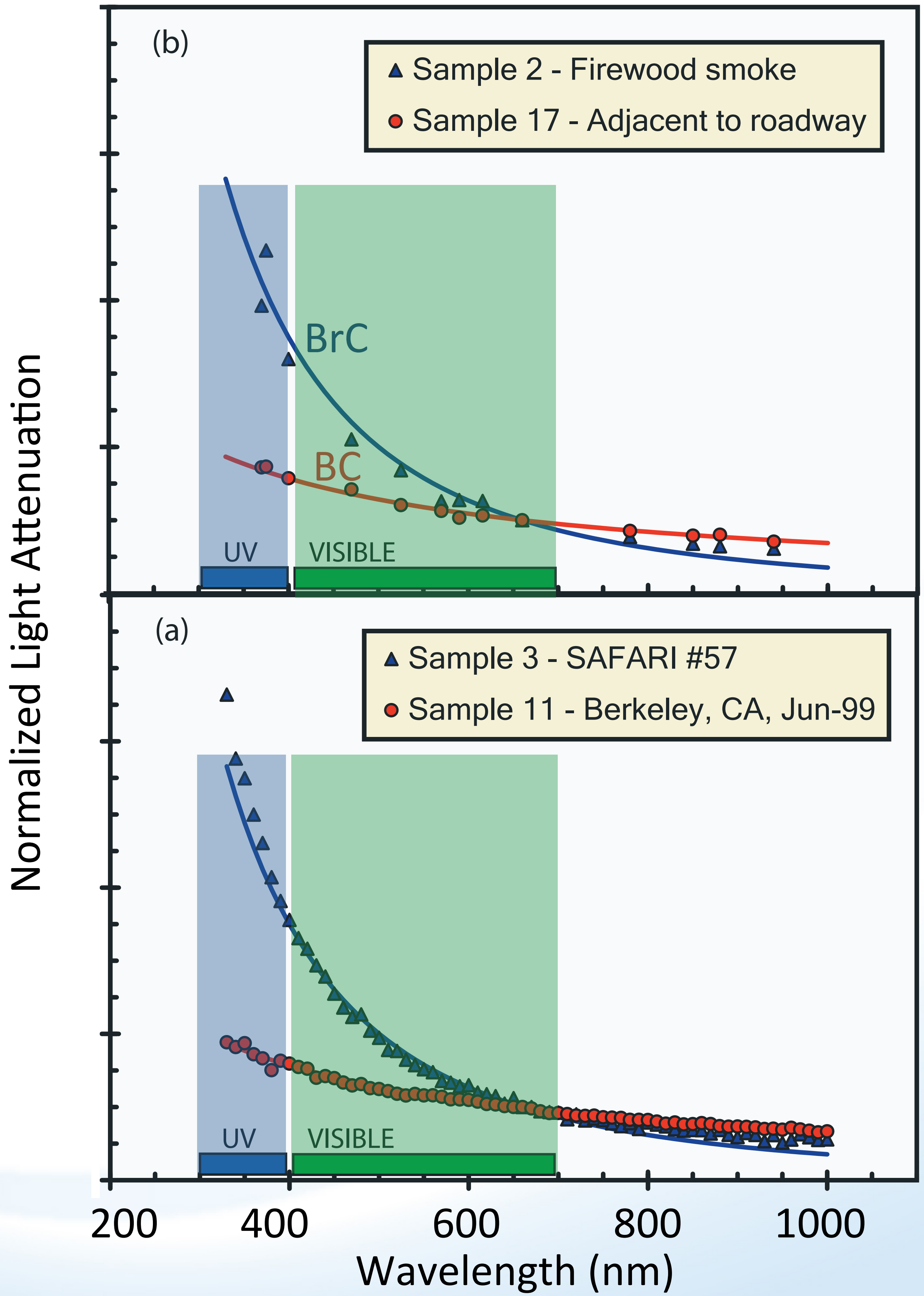
Biomass burns provide an important source of BrC as well as BC



Lack et al., 2012

What are the relative contributions of BrC and BC to radiative forcing?

Optical Properties

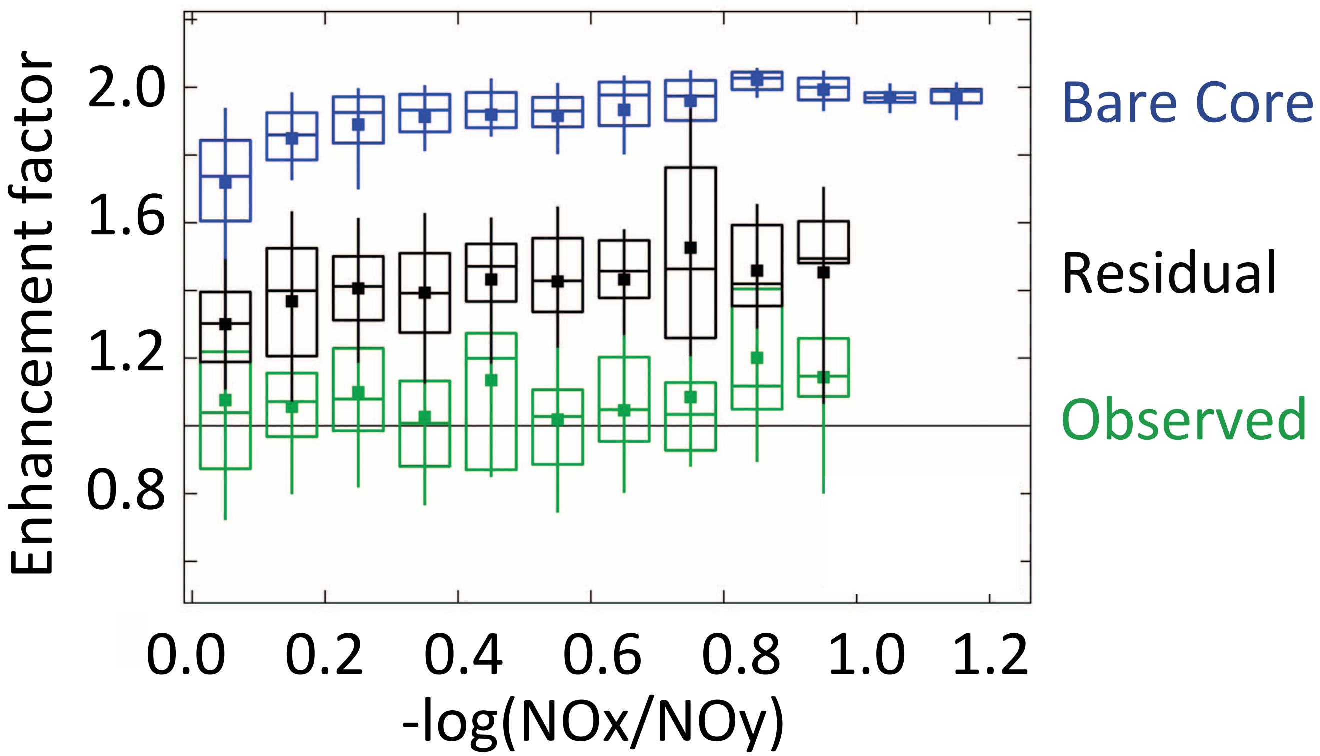


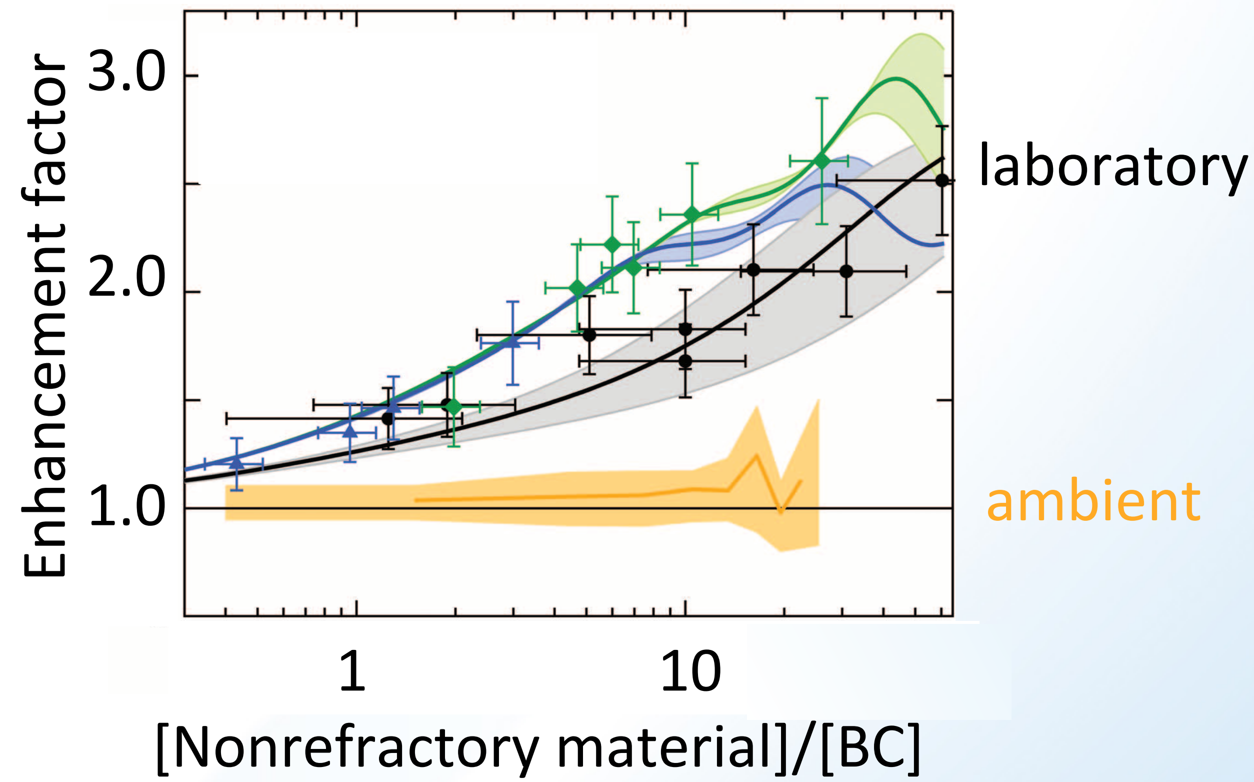
Kirchstetter et al., 2004

Optical Properties

Microphysical Properties

What is the role of BC-containing particle morphology (configuration) on light absorption?



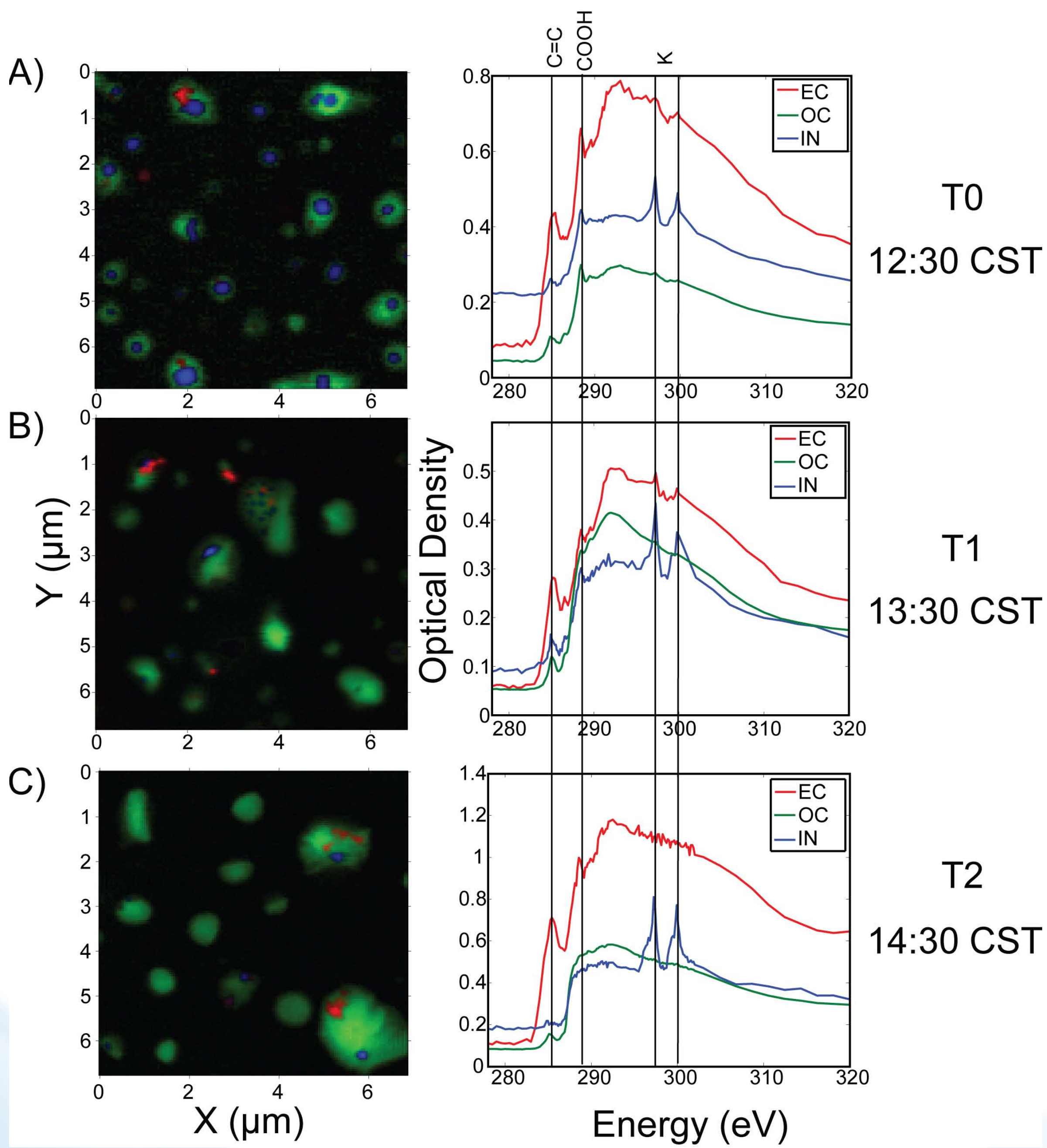


Cappa et al., 2012

Most Laboratory studies have focused on chemical composition impact of binary systems

How representative are laboratory measurements?

Microscopy provides unprecedented detail into individual particle chemical composition and morphology.



Moffet et al., 2010

STXM (scanning transmission x-ray microscopy)

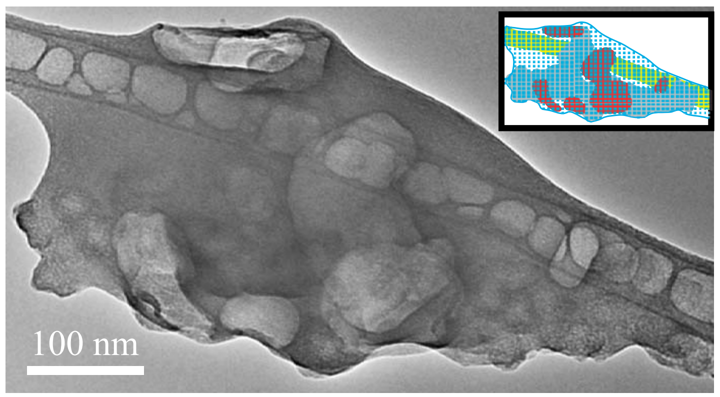
NEXAFS (near edge x-ray Absorption fine structure spectroscopy) used to probe samples

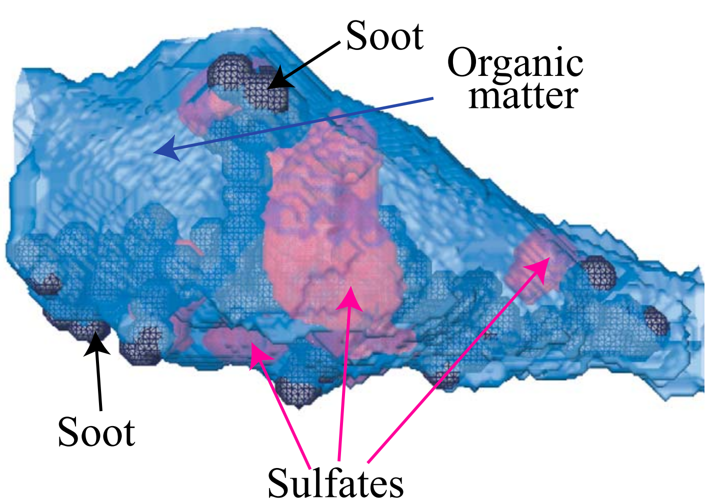
Note that T0 particles are dominated by inorganic material ('IN') in center of particle.

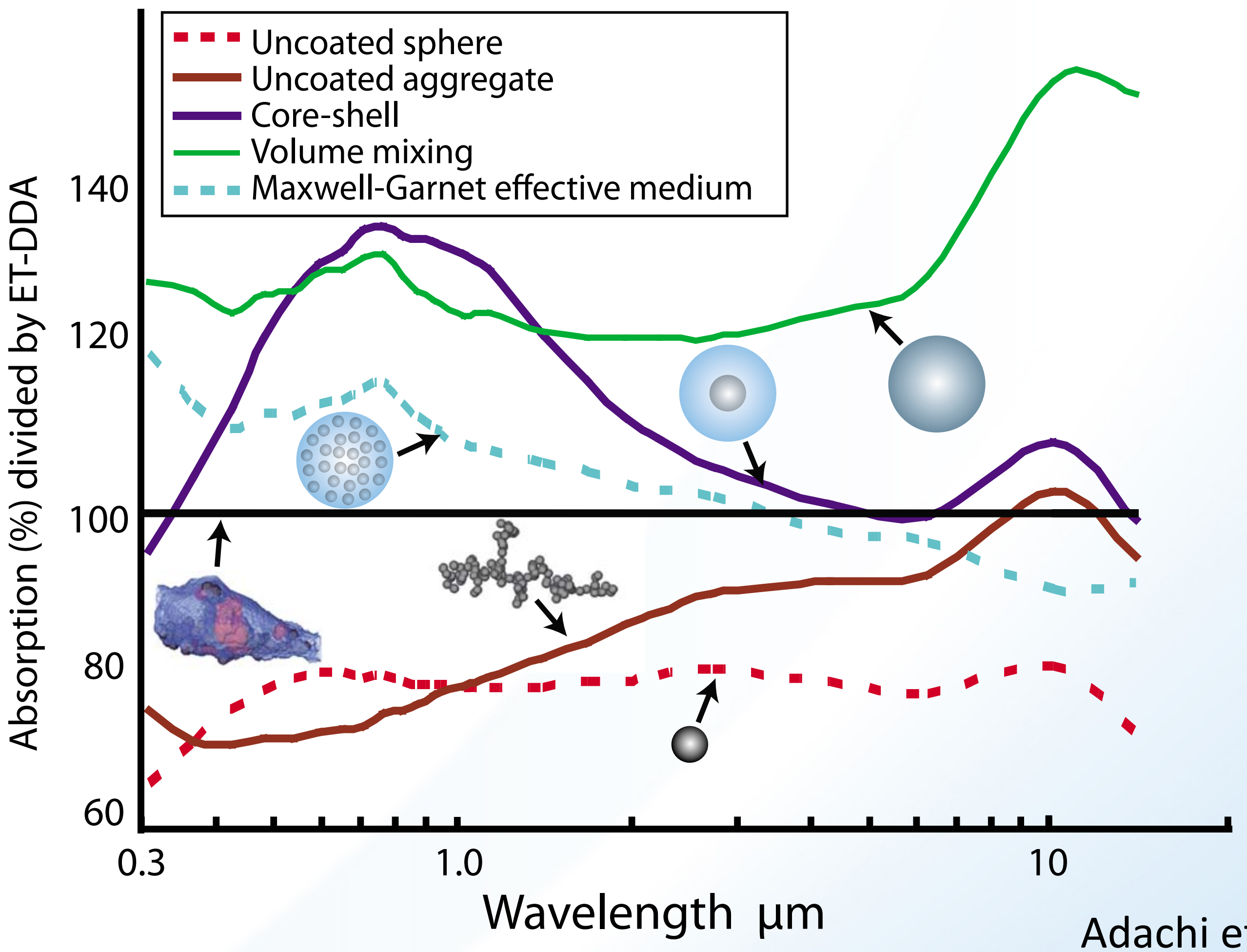
'EC' is found off-center

Microscopy is the standard for analysis of particle chemical composition and morphology

Microscopy suggests that core-shell configuration is rarely realized in ambient data





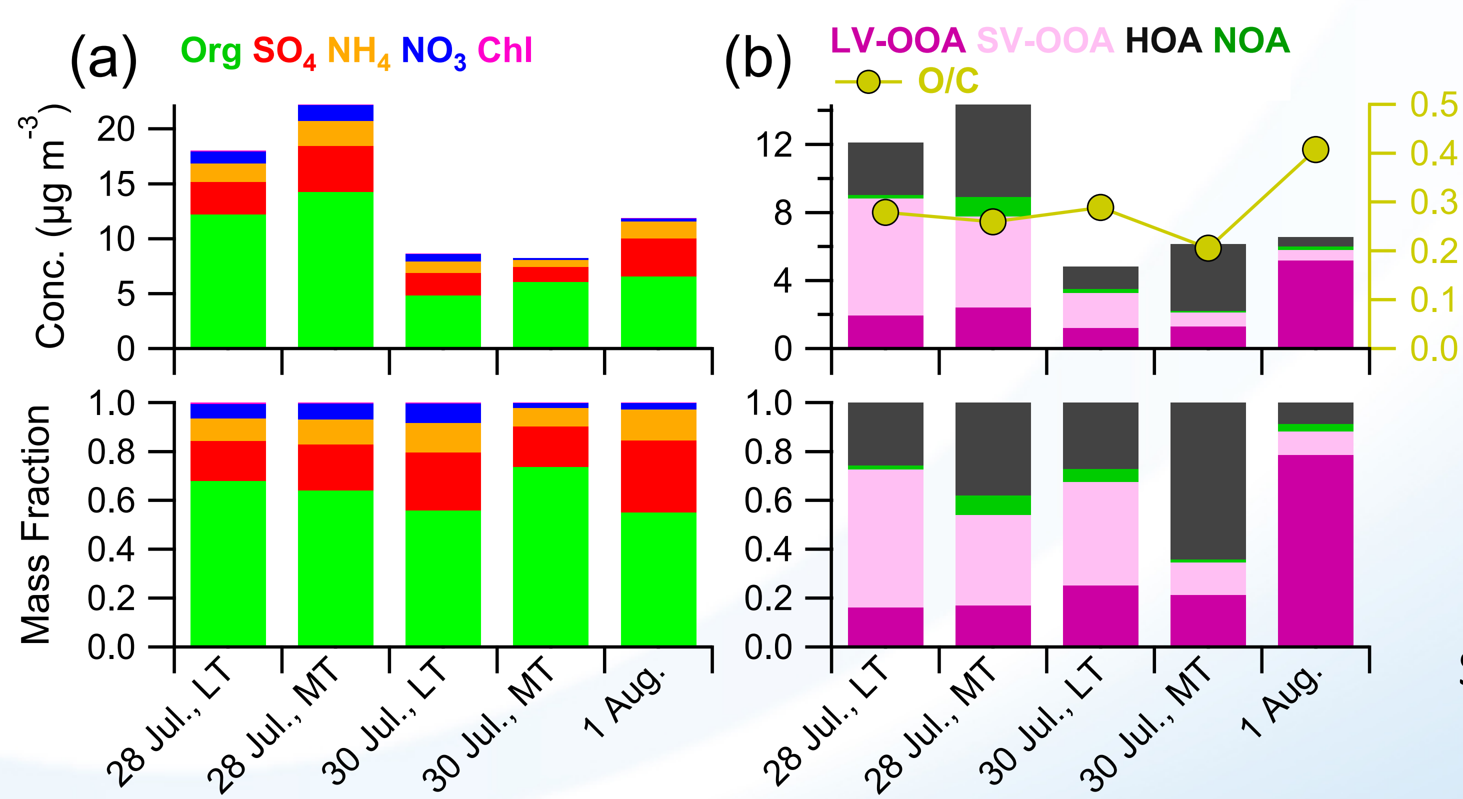


Adachi et al., (2010)

Mixing state can have profound impact on BC light absorption

Probing Chemical Composition with in situ, online techniques

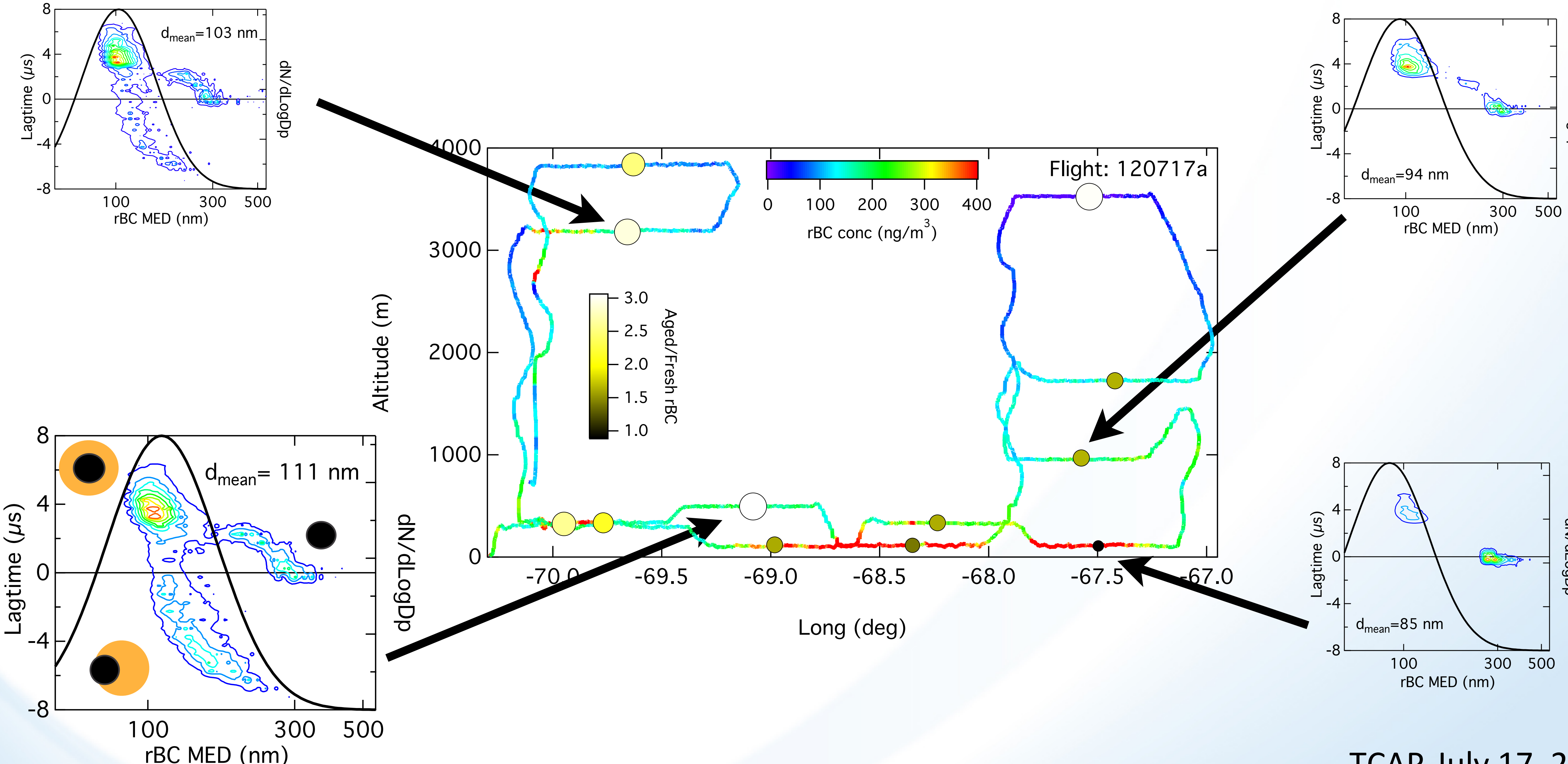
- Aerosol time of flight mass spectrometer (AToF-MS): Gard et al., 1997
- Aerosol Mass Spectrometer (AMS): Jayne et al., 2000
- Particle Analysis by Laser Mass Spectrometry (PALMS): Thomson et al., 2000
- Single Particle Laser Ablation TIme-of-Flight Mass Spectrometer (SPLAT): Zelenyuk & Imre 2005
- Aerosol Chemical Speciation Monitor (ASCM): Ng et al., 2011
- Soot Particle - Aerosol Mass Spectrometer (SP-AMS): Onasch et al., 2012



Sun et al., 2012

Mass Spectrometry is sufficiently mature enough that it can be considered ‘core’ measurement

Probing rBC-containing particle configuration using SP2 Lagtime analysis



TCAP-July 17, 2012

New SP2 analysis routine may offer insight into particle configuration

Optical Properties Microphysical Properties

Research questions from a point sensing perspective:

What are the relative importances of chemical composition versus particle structural? Are there conditions under which one aspect or the other is dominant?

What is the time evolution of absorbing aerosols (concentration) and aerosol particles (oxidation to make more brown)?

What are the vertical and horizontal distributions of absorbing aerosols and how do they vary with source?

How do absorbing aerosols affect the atmospheric heating (i.e. Broadband Heating Rate Profile)?

Absorbing Aerosols: Optical & Microphysical Properties

How suitable are the current parameterizations of radiative forcing by absorbing aerosols?

1) What measurements are needed to improve these parameterizations?

2) How accurately do we need these measurements?

3) To what extent are measurement capabilities we have sufficient?

Would a field-based intercomparison provide answers on either instrument capabilities or science issues that a laboratory-based intercomparison would not?