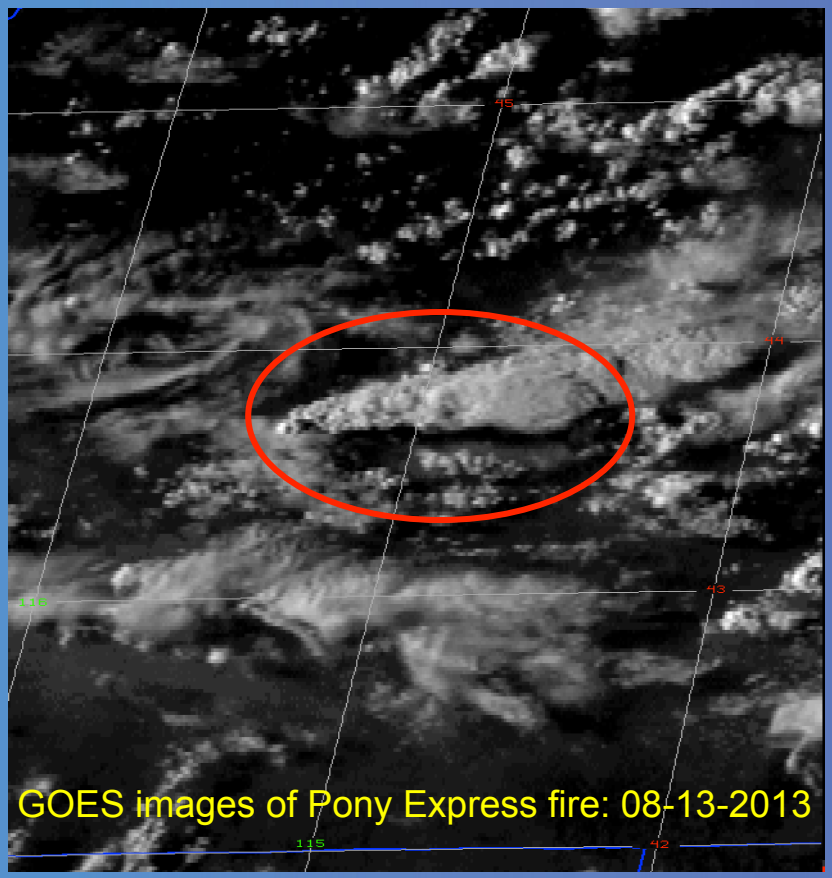
Biomass Burn Observation Project (BBOP)



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BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

ARM CLIMATE RESEARCH FACILITY

ASR Atmospheric System Research

The University of Montana

ASU

DRI Desert Research Institute

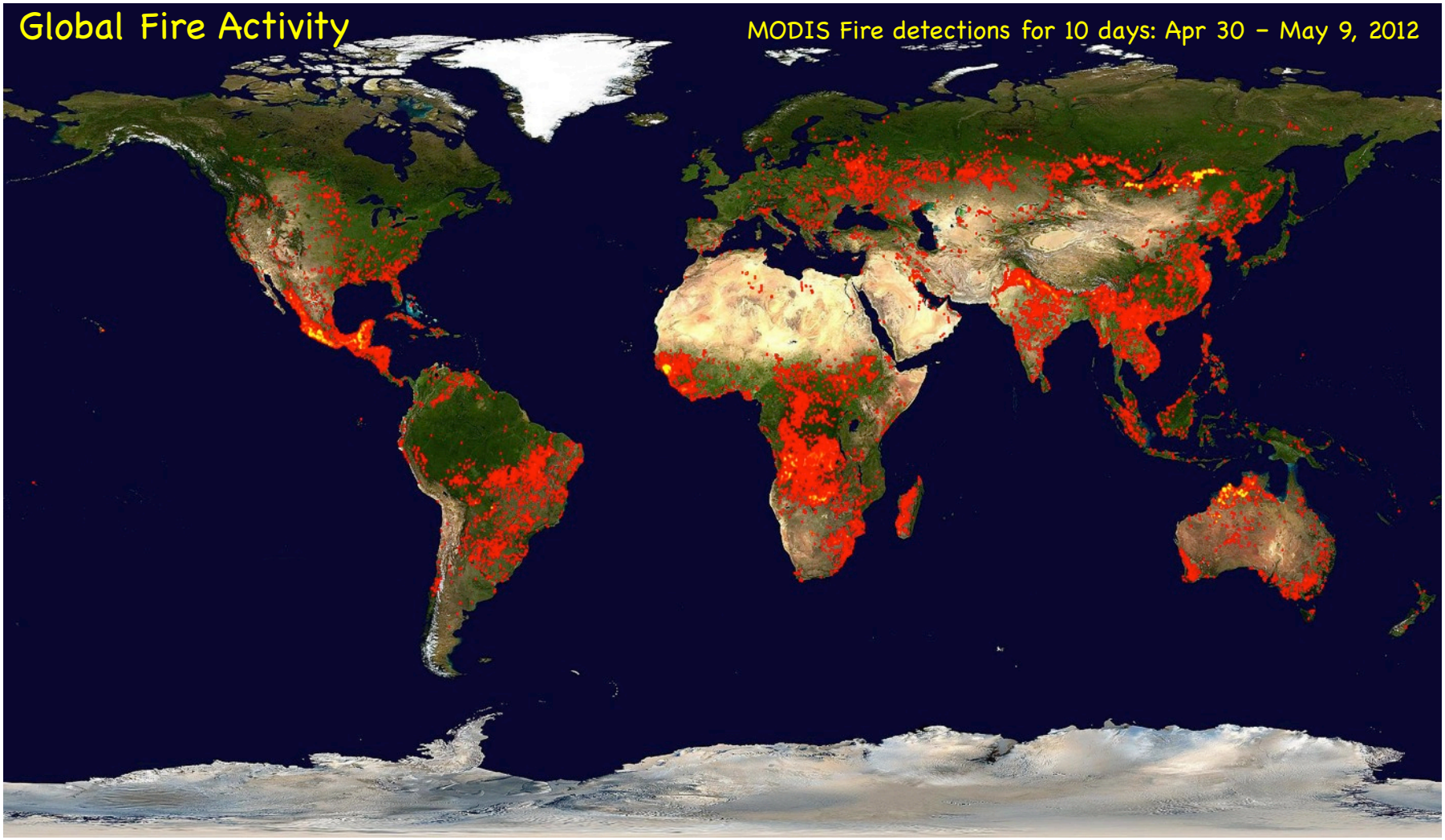
AERODYNE RESEARCH Inc.

NEVADA

Pacific Northwest NATIONAL LABORATORY

Office of Science U.S. DEPARTMENT OF ENERGY

Biomass Burning



C. Ichoku and R. Kahn

Biomass Burn Aerosols

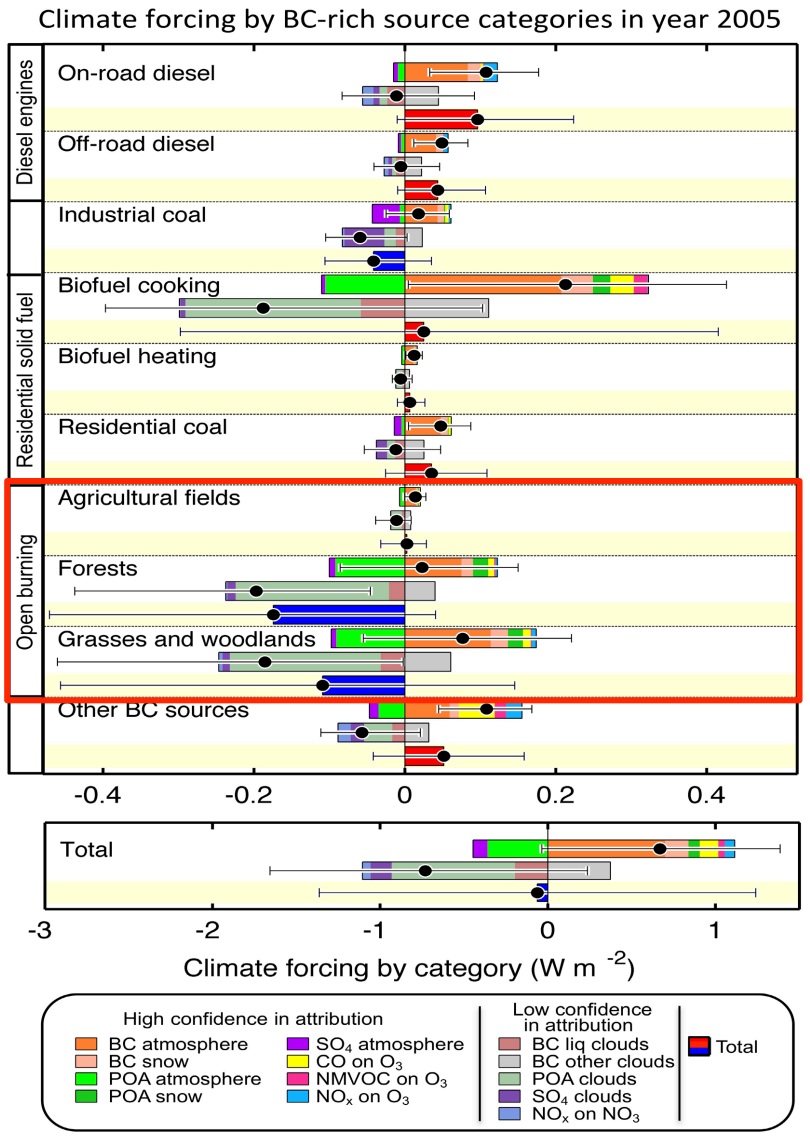
- Black carbon exerts positive aerosol forcing (warming) - second only to CO_2
- Aerosol type can vary

  Flaming phase favors BC production
  Smoldering phase favors organic aerosol
  Fuel source
- BB is a significant source of brown carbon (BrC)

  Exhibits pronounced λ dependence in absorption
  Role at CCN (in contrast to BC)
- Total climate forcing due to BB is estimated to be:

  -0.11 (-0.46 to +0.15) W m^{-2} (Bond et al. 2013)

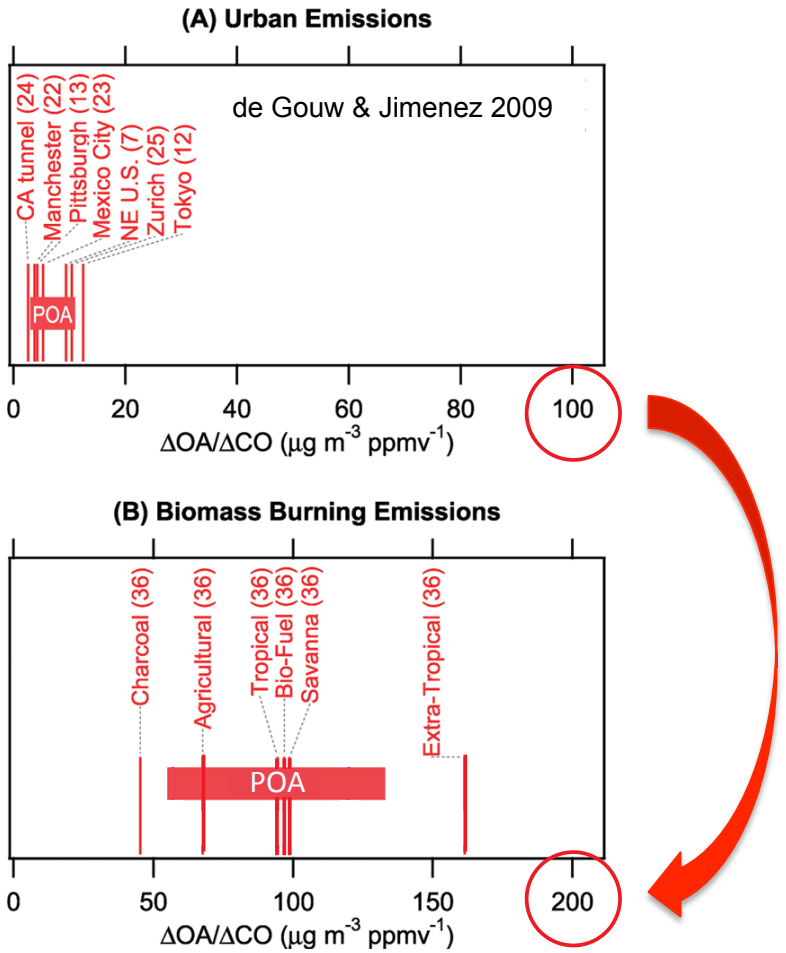
  Uncertainly reflects knowledge gaps in BC-cloud interactions & BC interactions with co-emitted organic carbon



Bond et al. 2013

Biomass Burn Aerosols – Primary Organic Aerosol (POA)

- BB is the largest component of POA mass emissions in northern temperate latitudes
  (de Gouw & Jimenez 2009)
- Biomass burning estimated to account for ~60% of carbonaceous particles
  (Bond et al., 2004; de Gouw & Jimenez 2009)
- Number concentration from biofuel/biomass burning comparable to sulfate on a global average
  (Chen et al., 2010)
- IMPROVE network suggests that major fraction of aerosol mass and year-to-year variability is due to emissions from fires
  (Park et al. 2007)



POA includes brown carbon (BrC), a source of light absorbing carbon in the near UV

Radiative Forcing Contribution of Biomass Burn (BB) Aerosols

Scientific Challenge:

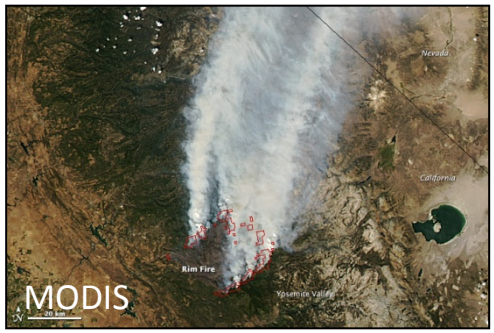
To understand and quantify the role of BB in aerosol forcing (heating/cooling)

- *Investigate the **evolution** of chemical, hydroscopic, microphysical, and optical properties of biomass burn aerosols in the near field*

*What is the **minimum knowledge** needed to accurately parameterize the contribution of biomass burn aerosols to radiative forcing?*

Laboratory scale

Near-field scale



Meso scale

Challenges of Conducting Field Measurements of BB

- Wildfires are sporadic and unpredictable
- Lifetime of wildfires (especially prescribed burns)
- Spatial inhomogeneity of fires (dynamic mix of flaming/smoldering)



- Where to stage for field campaign?
  - Target wildfires in the northwest
  - Target agricultural burns in the Mississippi valley

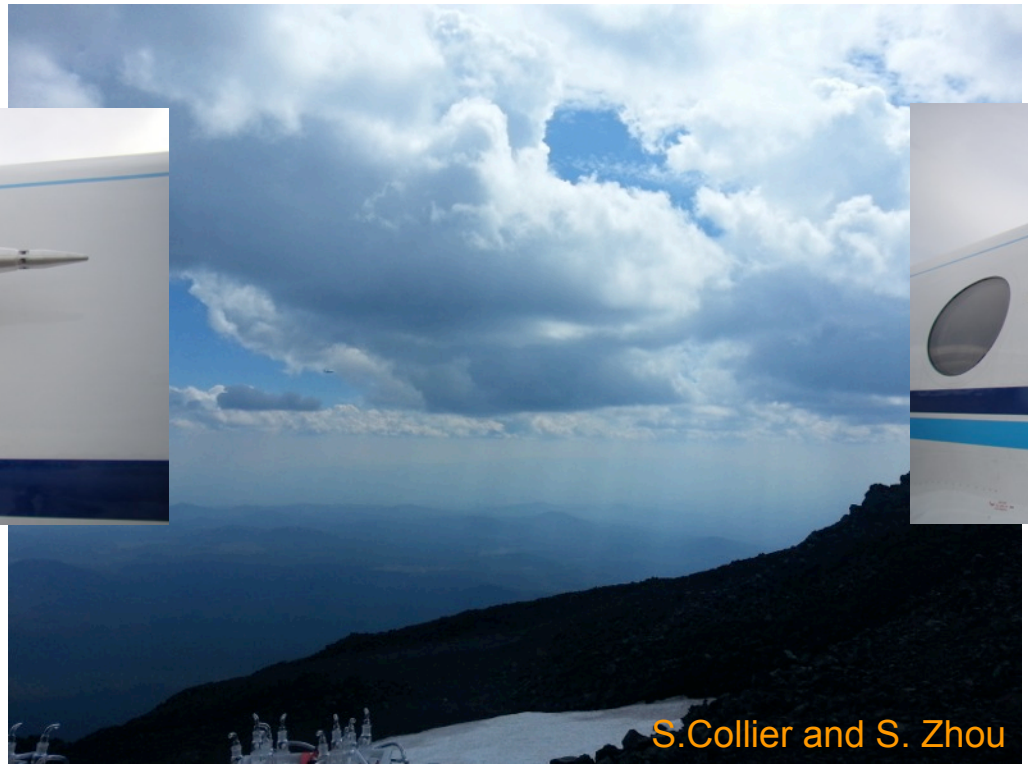
Biomass Burning Observation Project (BBOP)

~ 30 Scientists from 12 National Labs,
Universities, and Companies

120 hours of G-1 Flight Time
July – September: Wildland fires in the Pacific NW
October: Prescribed agriculture burns in the
lower Mississippi River Valley

- 17 wildfires sampled (ID, OR, & WA)
- 3 dozen agricultural burns sample (AR)
- 7 urban plumes (emission contrast)

G-1 Platform



BBOP: Collaborations

Mount Bachelor Observatory (MBO)
Dan Jaffe (U. Washington
Lat: 43.979 N / Long: 121.687 W
Elevation: 9000 Ft a.s.l. (2.7 km)

Core measurements:
CO, CO2, H2O, Scat, Abs, Hg

Qi Zhang (U. California/Davis)

HR-AMS and SMPS

Studies of Emissions & Atmospheric Composition, Clouds & Climate Coupling by Regional Surveys (SEAC4RS) - Coordinated flight on August 6, 2013

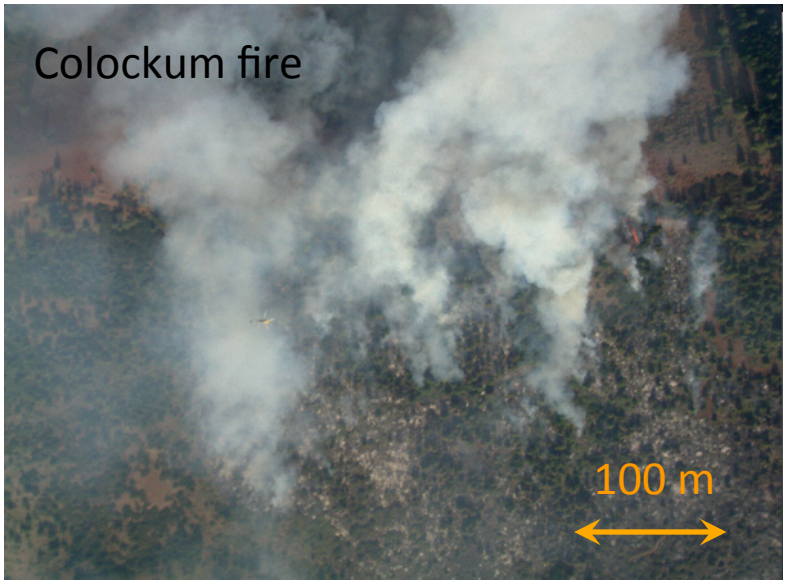
Several missions coincided with over flights of Aqua and/or Terra. BBOP will provide *in situ* measurements for satellite retrievals

Scenes from BBOP: Wildfires

G1 was outfitted with two cameras: forward-looking and Nadar

Government Flats fire (2013-08-21) was one of the larger fires sampled during BBOP. Over the course of 24-hrs, size increased by > 2500 acres

Forward-looking



Nadar

Org loading: ~ mg/m^3
rBC loading: 10s-100s µg/m^3
Bscat ~10000 Mm^{-1} and Babs ~ 1000 Mm^{-1}

Scenes from BBOP: Agricultural Burns

Agricultural burns provide distinct advantage of being a single source burn. However, fire lifetime (flame/smoldering phase) much shorter duration than wildfires

MODIS no help in identifying potential sites. Most efficient approach: fly high and look fires

2013-10-20: largest Ag-burn sampled.

Forward-looking

Nadar

BBOP Instrument Suite

This field campaign will leverage the capabilities of several new instruments or instrument combinations that have not been previously used in aircraft.

Microphysical Properties:

- SP-AMS
- FIMS
- Microscopy (TEM)
- SP2
- Dual column CCN
- UHSAS/PCSAP
- Particle counter

Trace gas

- PTRMS
- H_2O, CH_4, N_2O, NO, NO_2, NO_y, CO, CO_2, O_3 and SO_2

Optical Properties

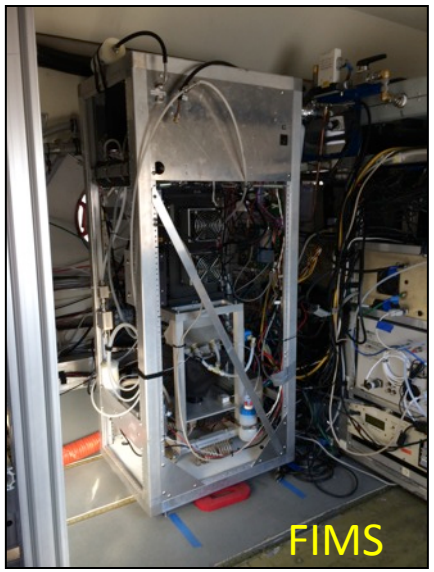
- 3-λ nephelometer (scat; 450, 550, & 700 nm)
- 3-λ PSAP (abs; 461, 523, & 648 nm)
- 1-λ PAS (abs; 355 nm)
- 1-λ PTI (abs; 532 nm)
- 1-λ CAPS (ext; 628 nm)

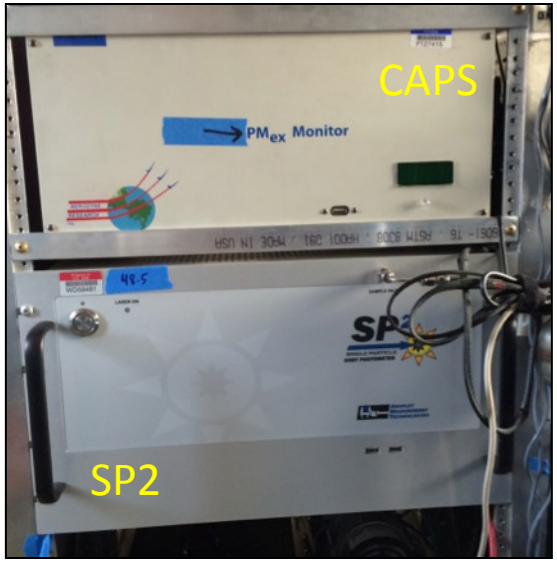
Radiation

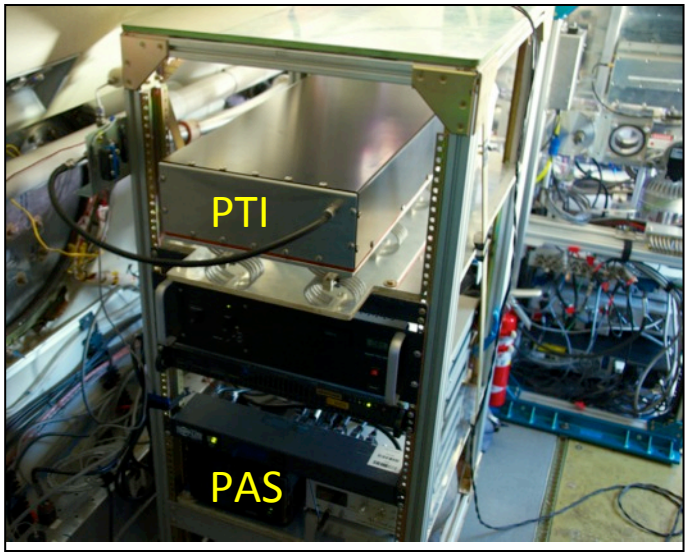
- SW, Upwelling hemispheric, spectral
- SW, Upwelling hemispheric, broadband
- IR. Surface Temperature
- SW, Down-welling hemispheric, broadband, global and diffuse
- SW, Down-welling hemispheric, broadband, diffuse

New instruments Not Previously Deployed on an Aircraft

Several new/upgraded instruments are being deployed during BBOP







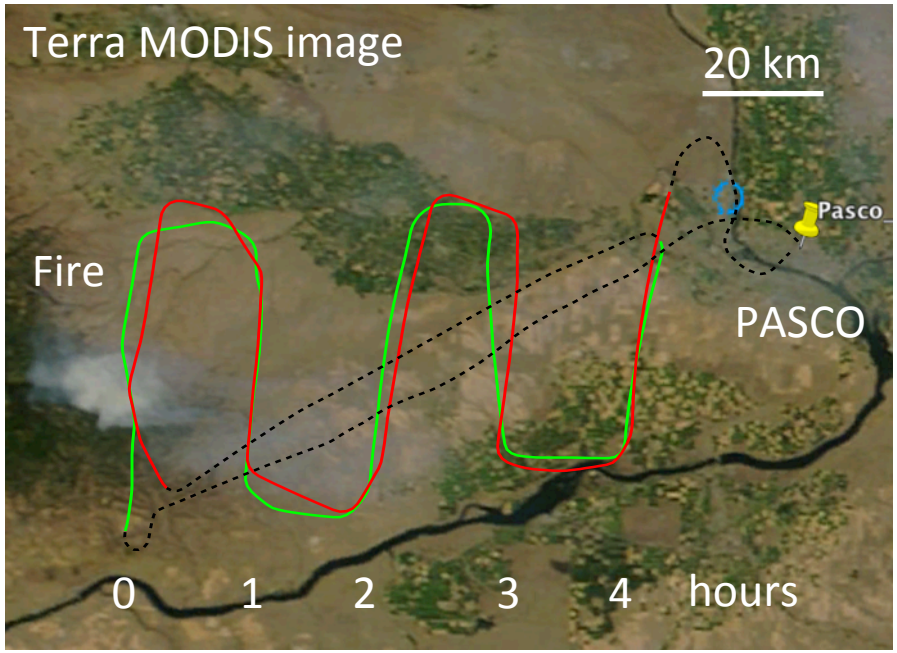
Objective of BBOP: capture near-field evolution

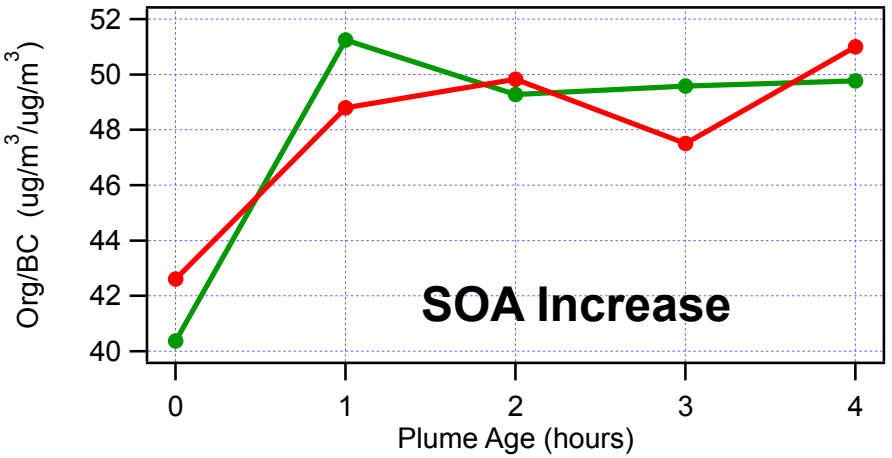
Two *very preliminary* examples showing that BBOP successfully captured this evolution

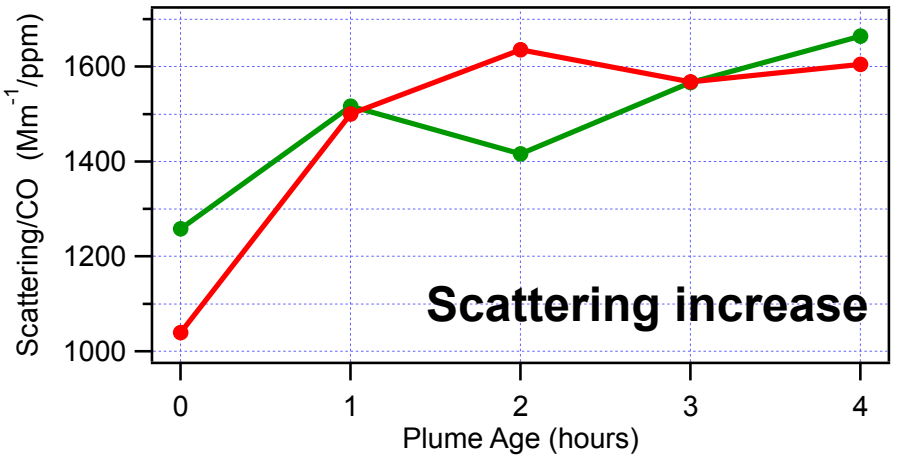
BBOP: Near-Field Evolution of Smoke Aerosol Properties

"28 Mile Marker" Fire sampled at source and 1, 2, 3, 4 hour downwind

Targeted 07-26-2013







Repeatable

Rapid increase within 1st hour in SOA (25%) and scattering (50%)

Soot Particle-AMS, Onasch

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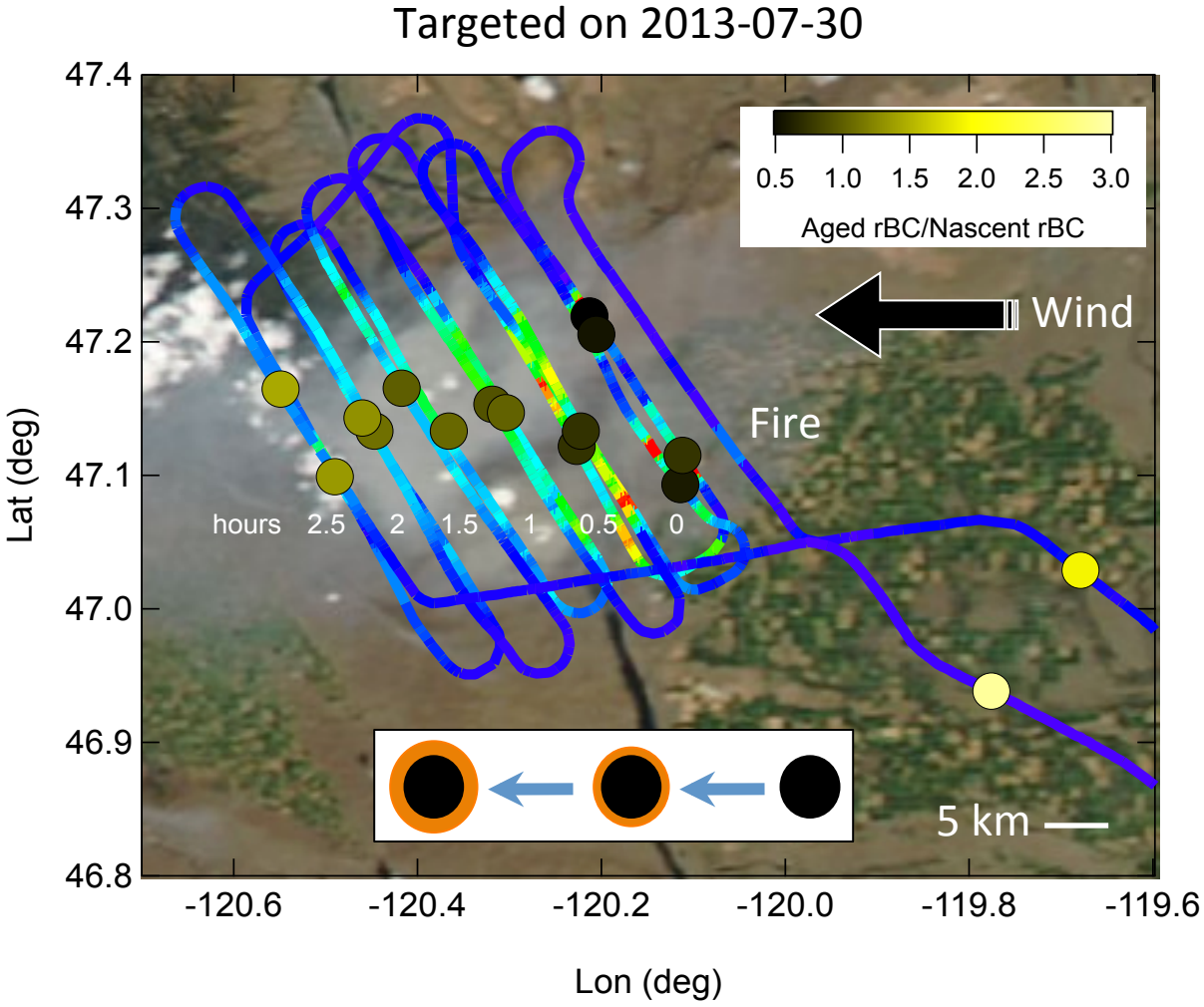
BBOP: Near-Field Evolution of rBC Mixing State

"Colockum Tarp" Fire sampled at source and 1 - 5 hours downwind



Rapid increase in fraction thickly coated rBC

BBOP: Relevance in Community

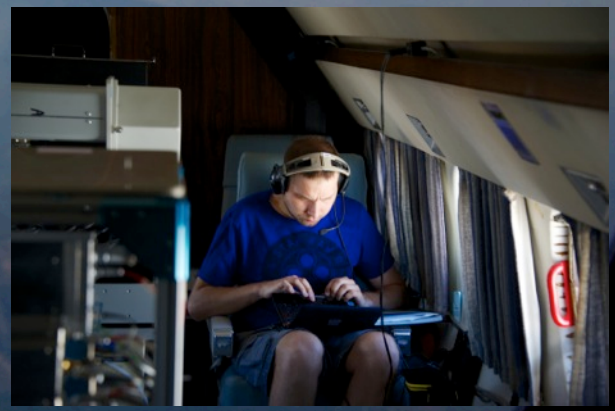
Quantify the downwind time evolution of microphysical, morphological, chemical, hygroscopic, and optical properties of aerosols generated by biomass burning

Use the time sequences of observations to constrain processes and parameterizations in a Lagrangian model of aerosol evolution

Incorporate time evolution information into a radiative transfer model for determining forcing per unit carbon burned.

BBOP bridges the gap between laboratory studies (nascent particles) and previous field campaigns of BB (older particles)

Big Thanks for the folks that made BBOP a success!



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