

Biomass Burn Observation Project (BBOP)

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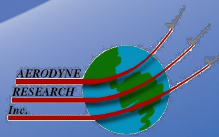
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R. Zaveri (PNNL)



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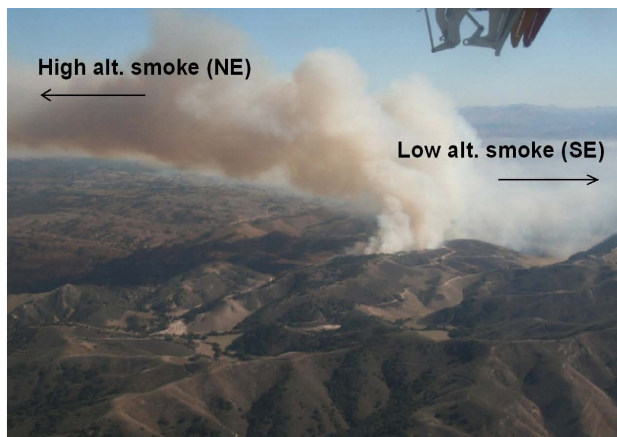
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a passion for discovery

Biomass Burn Observation Project - Motivation

Aerosols from biomass burning perturb Earth's climate through

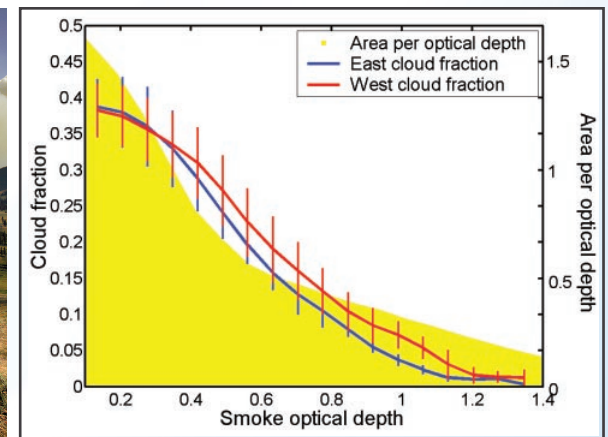
- Direct Effect (scattering and absorption)
- Indirect Effect (cloud formation and precipitation)
- Semi-direct Effect (evaporation of cloud drops)



Direct Effect
(Akagi et al., 2012)



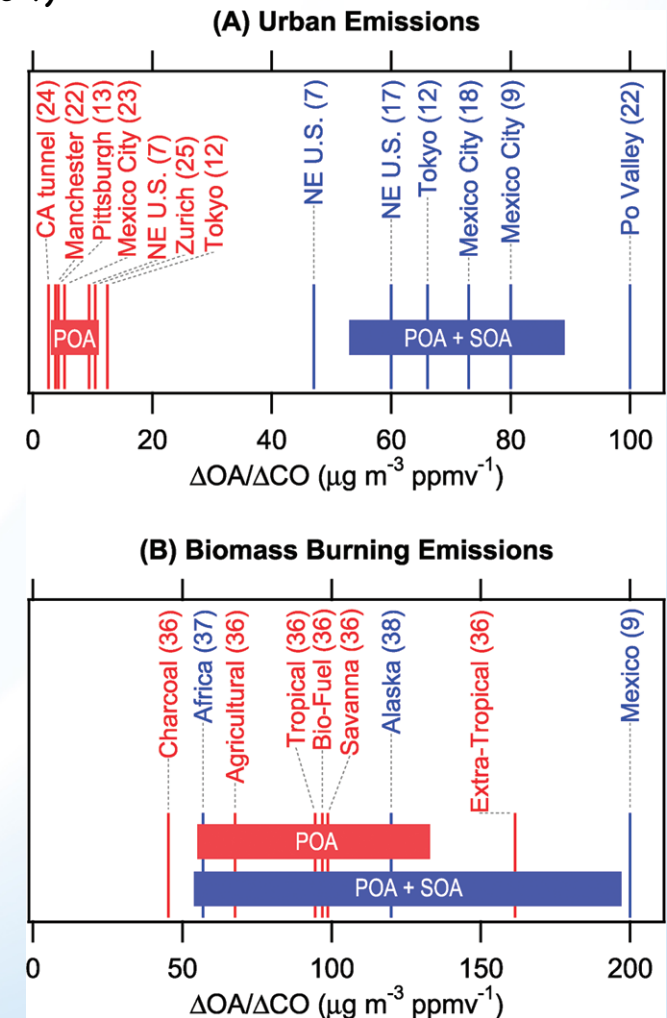
Indirect Effect
(pyrocumulus)
[Photo: B. Inaglory]



Semi-direct
(Koren et al. 2004)

Biomass Burn Observation Project - Motivation

- Biomass burning estimated to account for ~60% of carbonaceous particles (Bond et al., 2004)
- Primary organic aerosol (POA) from BB comprises largest component of POA mass emissions in northern temperate latitudes (de Gouw & Jimenez 2009)
- IMPROVE network suggests that major fraction of aerosol mass and year-to-year variability is due to emissions from fires (Park et al. 2007)



Biomass Burn Observation Project – Challenge

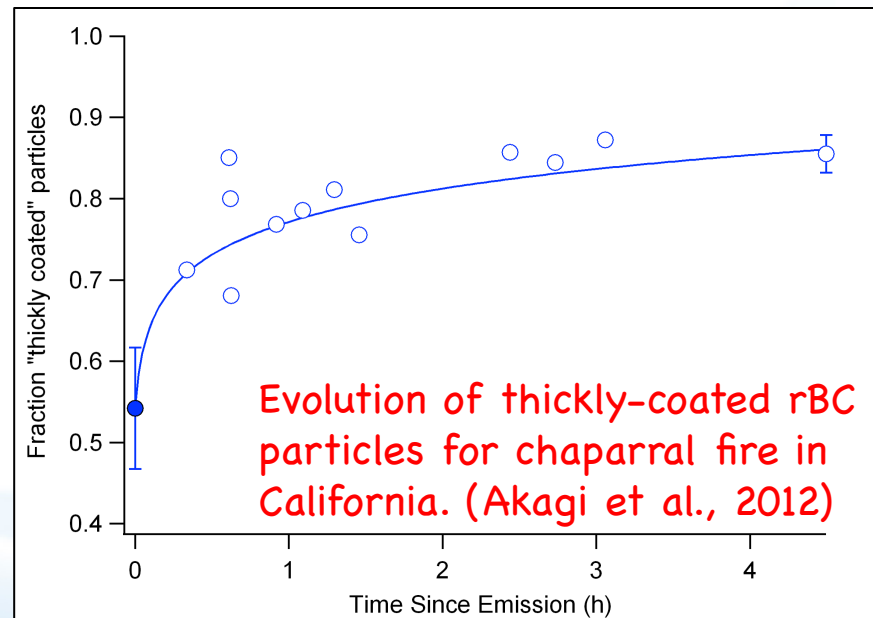
- Wildfires are sporadic and unpredictable
- Lifetime of wildfires (especially prescribed burns)
- Spatial inhomogeneity of fires (dynamic mix of flaming/smoldering)



- Wide variety of aerosol types dependent on phase of fire:
 - Flaming: primarily BC
 - Smoldering: POA (including BrC), SOA, BC, tar balls, etc.
- Where to stage for field campaign

Biomass Burn Observation Project – Unique Focus

- Most field studies have focused on tropical region (ABLE, BIBLE, PACE-5, SCAR-B, SAFARI92, SAFARI2000, TRACE-A)
- Fewer, smaller scale, aircraft-based field measurements carried out in U.S. (Yokelson)
 - Infrequent occurrence of fires contributes to the paucity of studies
- Still fewer studies have focused on the near-field evolution of BB aerosols (e.g., Akagi et al., 2012)



Biomass Burn Observation Project – Key Objectives

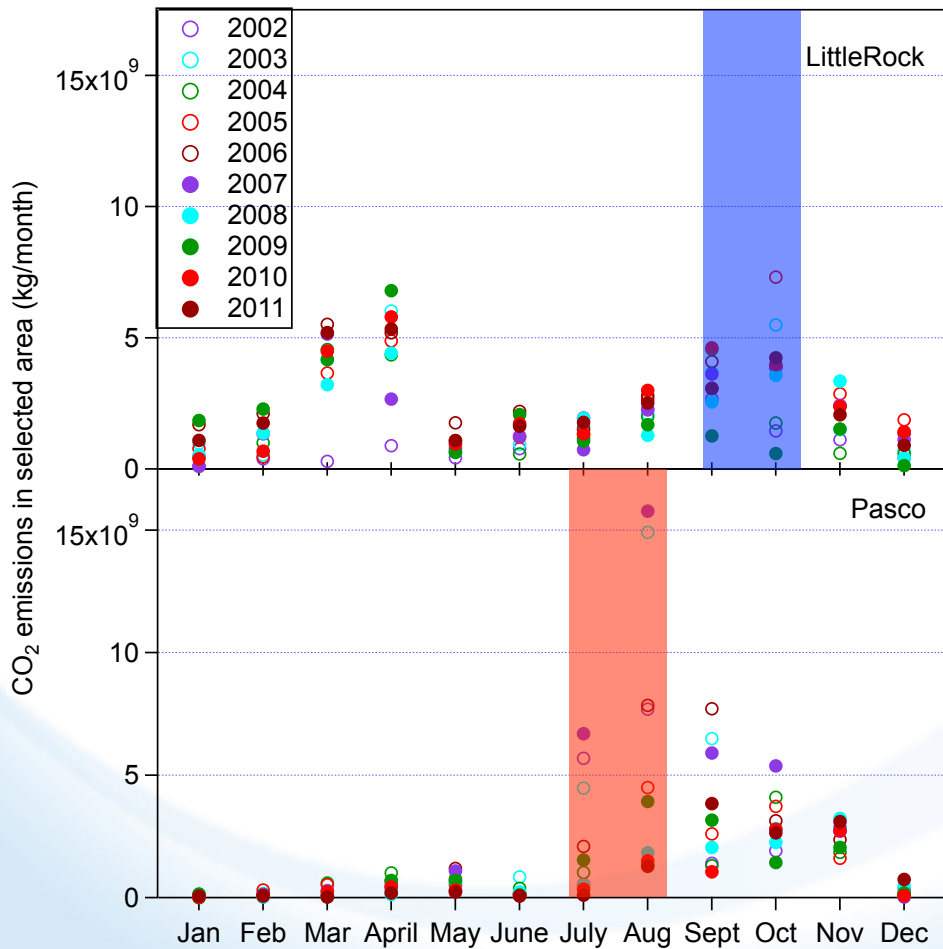
Quantify the downwind time evolution of microphysical, morphological, chemical, hygroscopic, and optical properties of aerosols generated by biomass burning

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.

Biomass Burn Observation Project – Where to Stage

Monthly BB CO emissions were examined for Little Rock (AR) and Pasco (WA). Based on MODIS fire products and FINNV1 emission inventory (Wiedinmyer et al., 2011)



Little Rock: September/October

Pasco: July/August

Biomass Burn Observation Project – 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
H₂O, CH₄, N₂O, NO, NO₂, NO_y, CO,
CO₂, O₃ and SO₂

Optical Properties

3- λ nephelometer
3- λ PSAP
1- λ PAS (355 nm)
1- λ PTI (532 nm)
1- λ CAPS (extinction, 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

BBOP– Microphysical Properties

Impacts of chemical composition/particle morphology on BC radiative forcing:

SP-AMS (Soot Particle Aerosol Mass Spectrometer):

chemical composition of non-refractory material associated with rBC

SP2 (single particle soot photometer):

using lagtime methodology probe particle morphology

Microscopy (TEM):

chemical composition and particle morphology

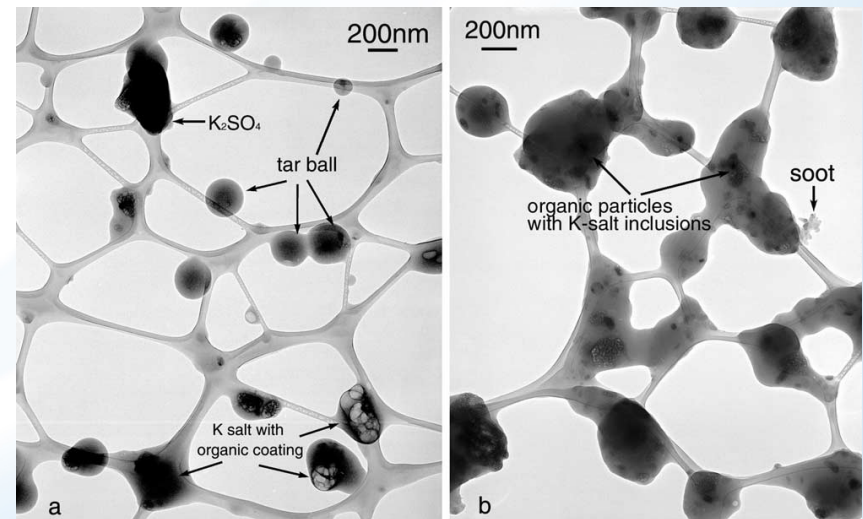
Probe the evolution of size distribution:

FIMS (Fast Integrated Mobility Spectrometer):

Range: 15 nm – 300 nm

Time response: 1-Hz

TEM images of smoke aerosols from
Timbavati fire, South Africa, 2000



(Li et al, 2003)

BBOP– Optical Properties

Black Carbon Closure Study:

3- λ nephelometer ($\lambda = 700, 550, \& 450$ nm)

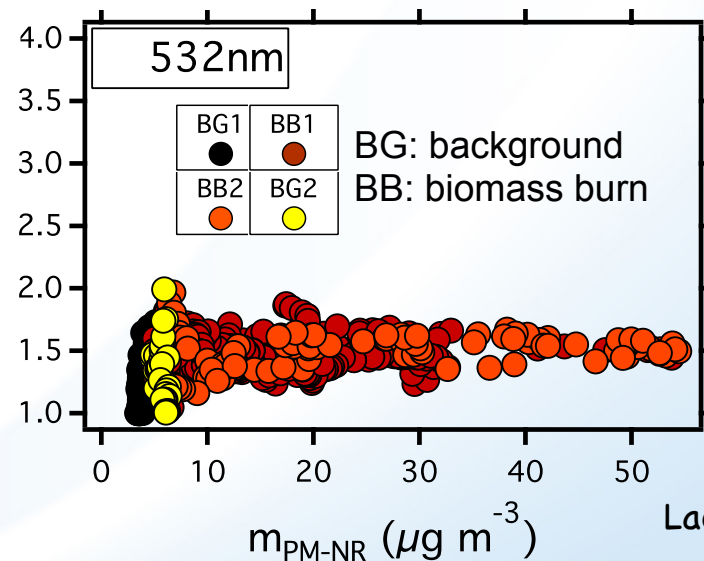
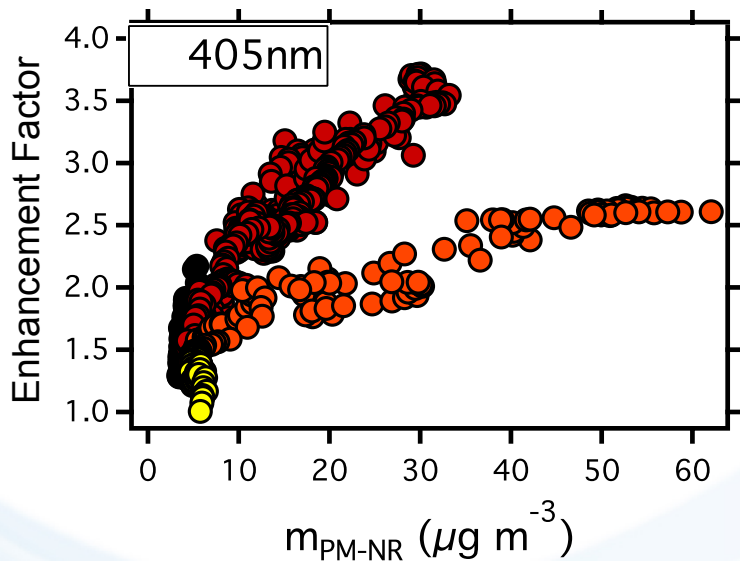
3- λ PSAP (Particle Soot Absorption Photometer; absorption; $\lambda = 650, 527, 450$ nm)

1- λ PTI (photothermal interferometry; absorption; $\lambda = 532$ nm)

1- λ CAPS (Cavity Attenuated Phase Shift; extinction; $\lambda = 628$ nm)

Brown Carbon:

1- λ PAS (Photoacoustic Spectroscopy; absorption/scattering; $\lambda = 355$ nm)



Lack, et al., 2012

BC and BrC contributions separated by wavelength dependence

BBOP– SOA Formation Rates/Evolution of CCN Activity

Investigation into SOA Formation Rates:

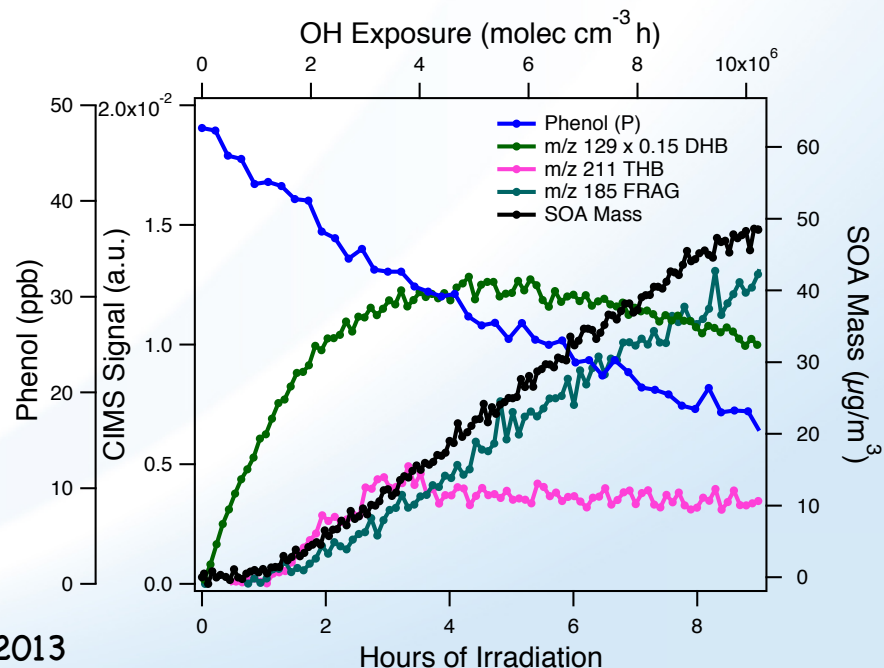
AMS (High-Resolution Aerosol Mass Spectrometry): organic aerosols
PTRMS (Proton Transfer Reaction Mass Spectrometry): trace VOCs
CO₂: ratio of OA to excess CO or CO₂ information on SOA formation rates
NO_x/NO_y: photochemical age

Investigation of evolution of CCN activity:

Dual-column CCN (Cloud Condensation Nuclei counter): 0.4% and 1.0% SS
AMS (High-Resolution Aerosol Mass Spectrometry): organic aerosols

Trace Gas Measurement:

H₂O, CH₄, N₂O, NO, NO₂, NO_y,
CO, CO₂, O₃ and SO₂

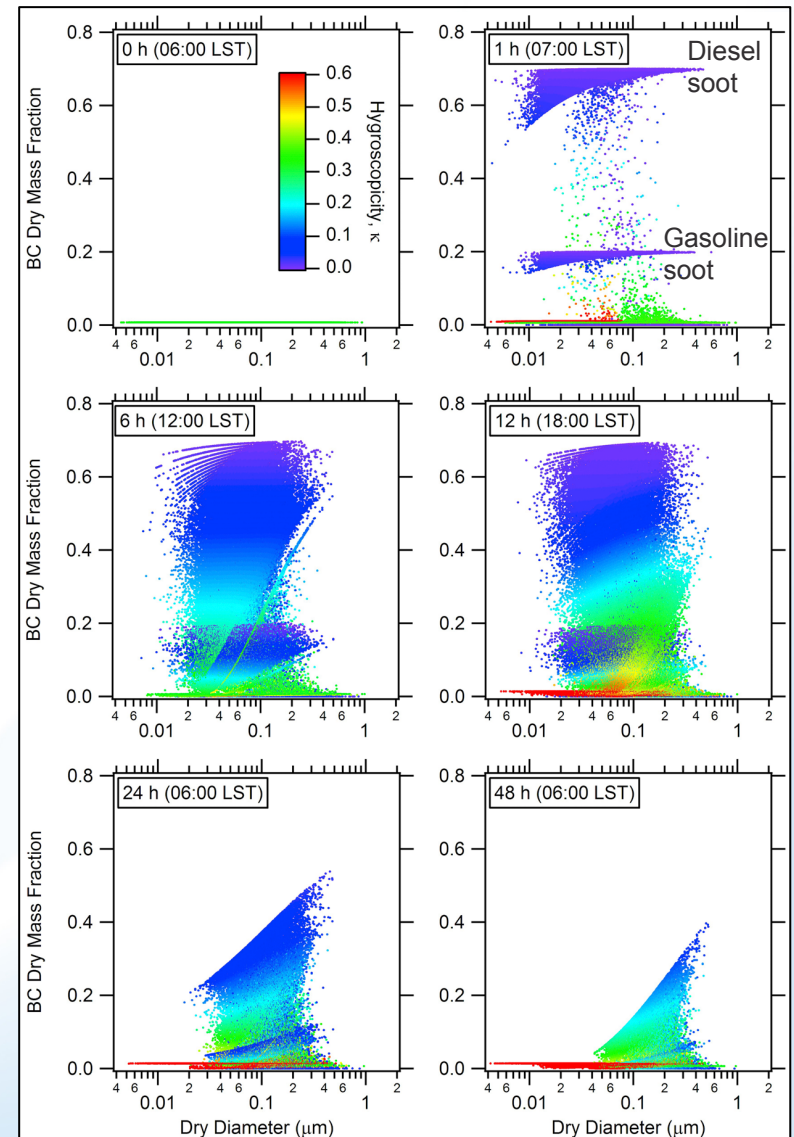


BBOP- Modeling

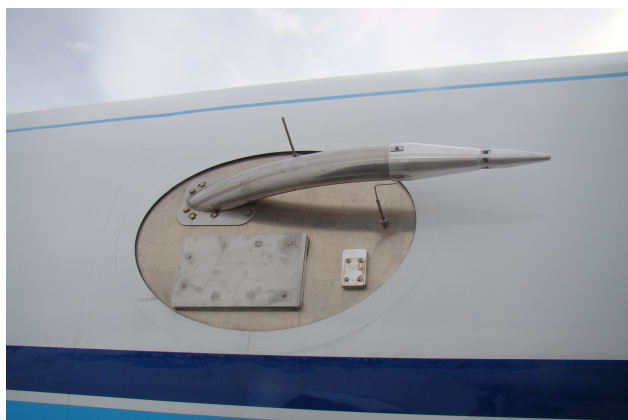
Quasi-Lagrangian observations within and outside of fire plumes will be interpreted with the comprehensive sectional aerosol box model MOSAIC. (Zaveri et al., 2008)

The Rapid Radiative Transfer Model will be used to translate the observed optical properties into radiative forcing. (Mlawer et al., 1997)

Evolution of BC mass fraction as f(dry diameter)



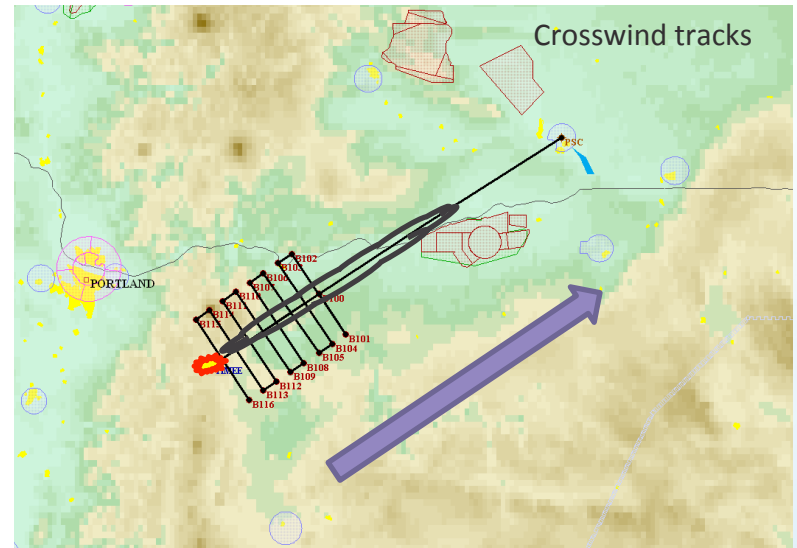
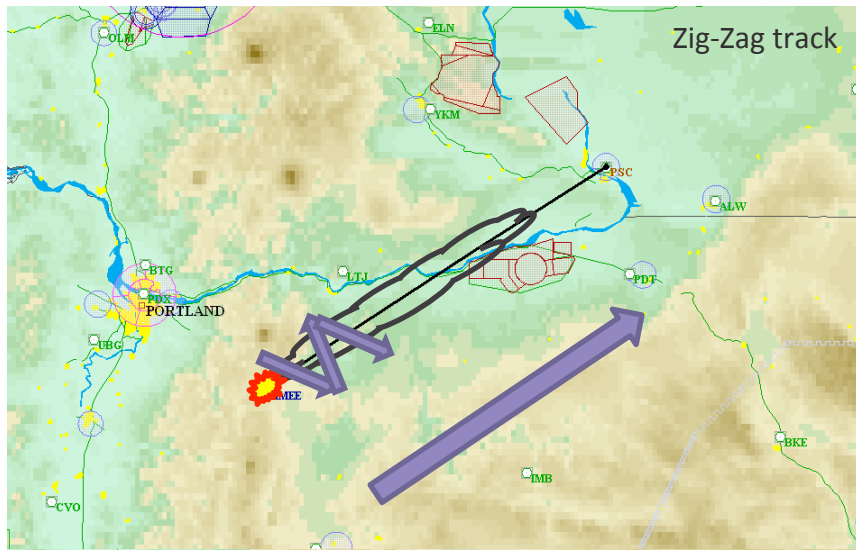
BBOP Platform: AAF Gulfstream-I



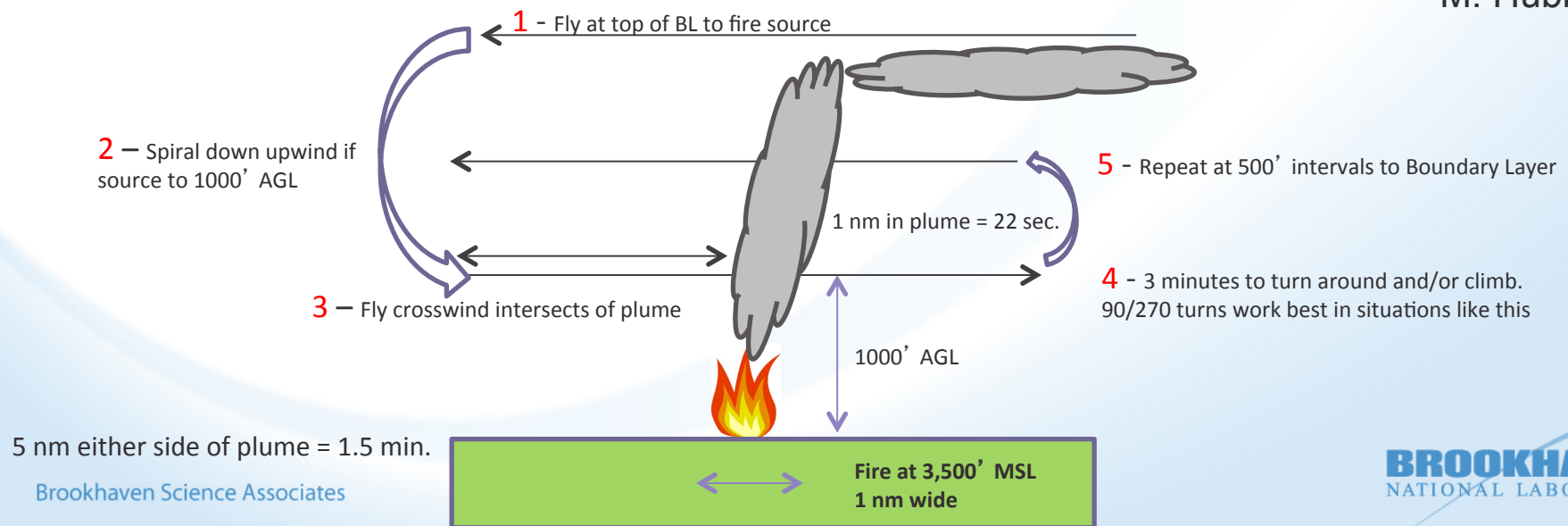
120 flight hours

BBOP- Platform: Sampling Patterns

Discussions recently initiated - No patterns finalized or rejected



M. Hubbell

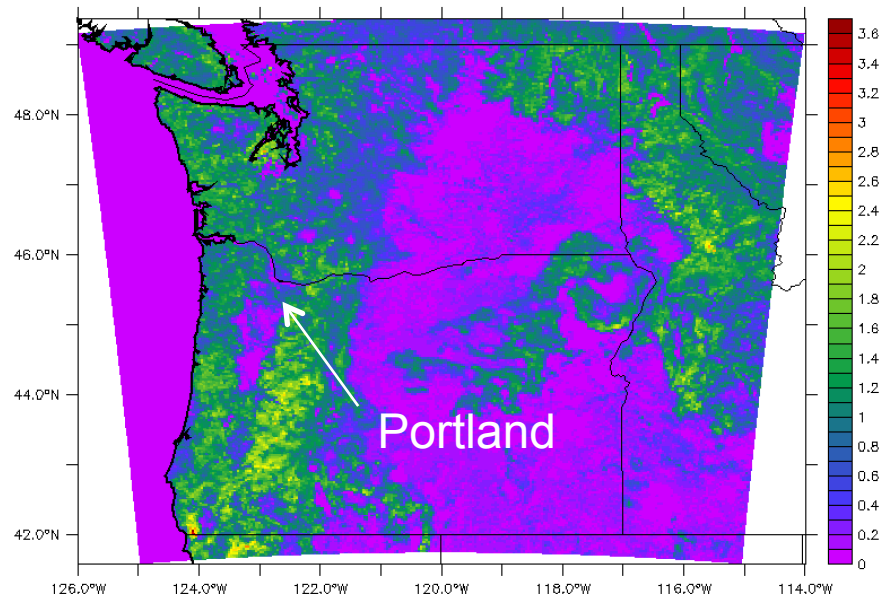


BBOP: What?! No fires!

Plan 'B'

Urban flights for A-B interactions

Comparison of Portland Plume (terpene forest) with Sacramento plume (isoprene forest: CARES)



Terpene emission rate,
02 UTC July 04.
A MEAGEN-WrfChem
calculation by J. Fast

Collaborate with the Southern Oxidants and Aerosol Study (SOAS) & Southeast Nexus (SENEX).

Study anthropogenic – biogenic interactions that foster production of SOA
Investigate season variations in biogenic emissions and properties of
anthropogenic and biogenic aerosol

BBOP: Collaborations

Satellite Analysis of Biomass Burning: Charles Ichoku and Ralph Kahn

Mount Bachelor Observatory (MBO; 43.98-N, 121.69-W, 2763 m asl)

Dr. Dan Jaffe

Couple ground and aircraft measurements

Historical emission measurements in the July - Sept. time frame

SOAS/SENEX (Plan 'B')

Examine changes in biomass emissions between the SOAS/SENEX deployment (mid-June to July) and BBOP (late Sept. to October)

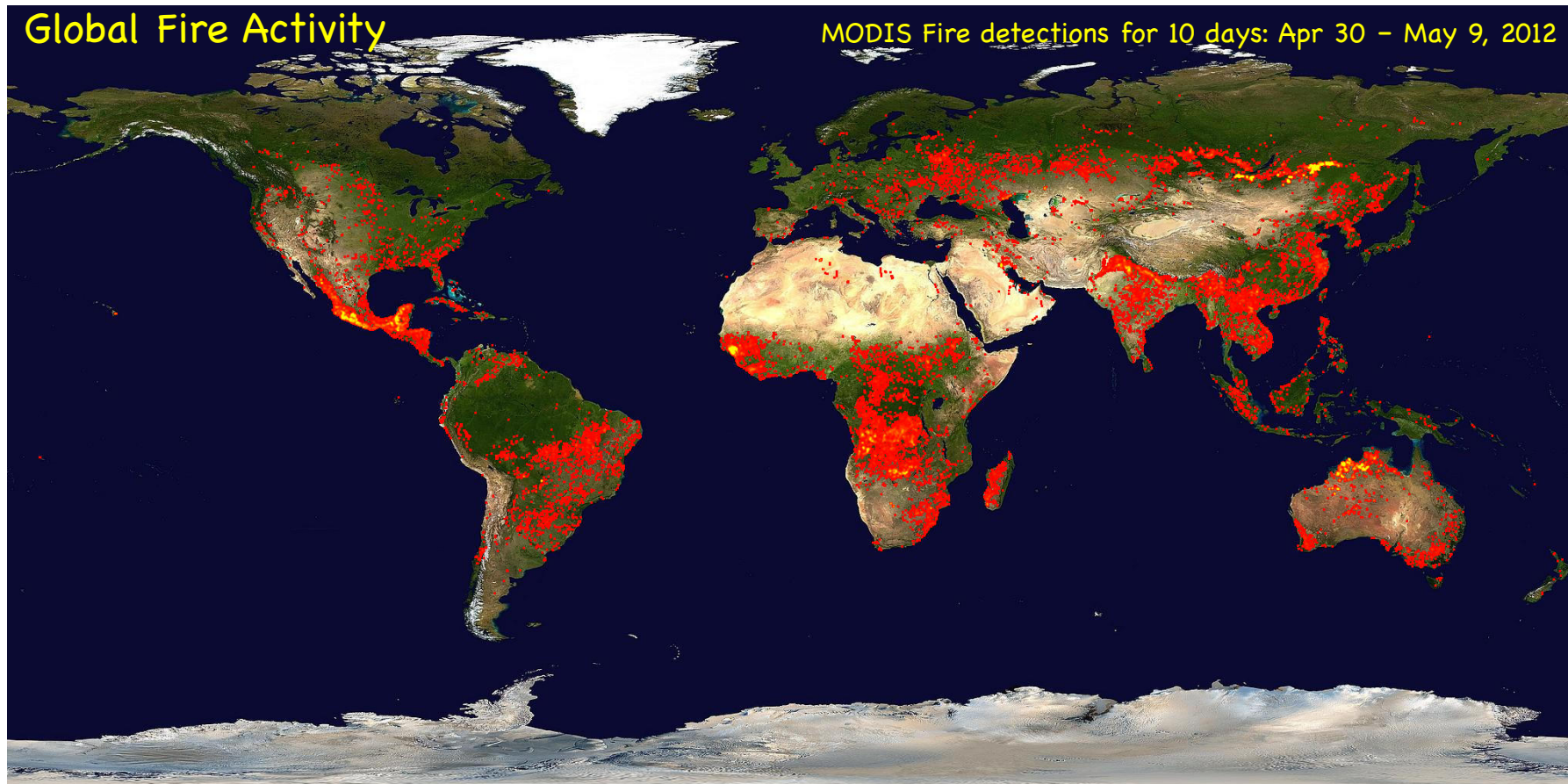
Discussions with SEAC⁴RS (Southeast Asia Composition, Cloud, Climate Coupling Regional Study) team on potential combined flight opportunities (DC-8/ER-2)

Summary



Global Fire Activity

MODIS Fire detections for 10 days: Apr 30 - May 9, 2012



C. Ichoku and R. Kahn

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