

# CARES Field Campaign Overview and Report from Data Workshop

**Rahul Zaveri / PNNL  
and the CARES Team**

Fall 2010 ASR Working Group Meeting  
Boulder, Colorado  
October 12, 2010



# Carbonaceous Aerosols and Radiative Effects Study

**Overarching Goal:** Evaluate and Improve key aerosol process and property modules for use in regional and global climate models

**Objective:** Investigate evolution of carbonaceous aerosols of different types and their effects on optical and cloud condensation nuclei activation properties.

## Science Questions:

- ▶ How do anthropogenic and biogenic secondary organic aerosol (SOA) precursors interact and affect SOA yields from each type?
- ▶ How do the mixing states of different types of aerosols (esp. of light absorbing carbon) evolve with time?
- ▶ What are the roles of organics and aerosol mixing state on optical and CCN activation properties?

# Participants and Collaborators

## ***Participants (more than 70 scientists)***

- ▶ Pacific Northwest National Laboratory
- ▶ Aerodyne Research, Inc.
- ▶ American River College
- ▶ Brechtel Manufacturing
- ▶ Brookhaven National Laboratory
- ▶ DOE ARM Aerial Facility
- ▶ DOE ARM Climate Research Facility
- ▶ Droplet Measurements Technology
- ▶ Los Alamos National Laboratory
- ▶ Michigan Technological University
- ▶ Montana State University
- ▶ NASA
- ▶ Portland State University
- ▶ University of Arkansas
- ▶ University of California-Davis
- ▶ University of California-San Diego
- ▶ University of Colorado
- ▶ University of Nevada-Reno
- ▶ University of North Dakota
- ▶ Washington State University

## ***Collaborators (CalNex)***

- ▶ NOAA Twin Otter
- ▶ NOAA WP-3
- ▶ NOAA R/V Atlantis
- ▶ California Air Resources Board (CARB)

# Location and Sampling Platforms

Sacramento, June 2-28, 2010



- Mid-size City
- Regular wind pattern
- Rich biogenic emissions
- Fairly clean to the north

T0 Site at American River College, Sacramento, CA



Photo credit: Stephen Springston





T1 Site at Northside School,  
Cool, CA

Foothills of Sierra Nevada

Photo credit: Stephen Springston



Photo credit: Mikhail Pekour



# Ground Sites Instrumentation: T0 Site

## ▶ Trace Gases

■ PTR-MS & GC-MS	VOCs and SVOCs	WSU
■ CO	VUV fluorescence	WSU
■ SO <sub>2</sub>	research grade	PNNL
■ O <sub>3</sub>	research grade	WSU
■ NO, NO <sub>2</sub> , NO <sub>y</sub>	research grade	WSU

## ▶ Aerosol Size/Composition

■ SMPS, APS, CPC	particle size distribution	PNNL
■ HR-ToF-AMS + thermal denuder	non-refractory aerosol comp	PNNL
■ SPLAT-II	single-particle mass spec	EMSL
■ SP2	black carbon mass	DMT
■ Sunset OC/EC	organic/elemental carbon mass	PNNL
■ TRAC, DRUM Samplers	microspectroscopic analyses	EMSL, LBNL
■ PILS Auto-sampler	WSOC, IC	Brechtel, UC Davis
■ Hi-vol sampler	Organic functional groups	UND

## ▶ Optical Properties

■ 4-λ Photoacoustic	scattering, absorption	UNR, LANL
■ 3-λ Nephelometer, 3-λ PSAP	scattering, absorption	PNNL
■ 3-λ Cavity Ring Down	extinction, scattering	Portland State Univ., UC Davis
■ Photolysis, MFRSR	radiation	PNNL

## ▶ Hygroscopic & CCN Properties

■ CCN Counter	CCN activation	PNNL
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## ▶ Meteorology

■ Sfc. Met. Station & Radiosonde	wind velocity, P, T, RH profiles	PNNL
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# Ground Sites Instrumentation: T1 Site

## ▶ Trace Gases

■ PTR-MS	VOCs	EMSL
■ CO	VUV fluorescence	LANL
■ O <sub>3</sub>	research grade	PNNL
■ NO, NO <sub>y</sub>	research grade	LANL

## ▶ Aerosol Size/Composition

■ SMPS, APS, CPC	particle size distribution	PNNL
■ HR-ToF-AMS + thermal denuder	non-refractory aerosol comp.	Aerodyne
■ PALMS	single-particle mass spec	PNNL
■ SP2	black carbon mass	DMT
■ Sunset OC/EC	organic/elemental carbon mass	PNNL
■ TRAC, DRUM Samplers	microspectroscopic analyses	EMSL, LBNL
■ PILS Auto-sampler	WSOC, IC	Brechtel, UC Davis
■ Hi-vol Samplers	<sup>13</sup> C and <sup>14</sup> C, functional groups	Univ. of Arkansas, UND

## ▶ Optical Properties

■ 3-λ Photoacoustic	scattering, absorption	UNR, LANL
■ 3-λ Nephelometer, 3-λ PSAP	scattering, absorption	PNNL
■ 3-λ Cavity Ring Down	extinction, scattering	Portland State Univ.
■ Photolysis, MFRSR	radiation	PNNL
■ UV-MFRSR	radiation	Univ. of Arkansas

## ▶ Hygroscopic & CCN Properties

■ f(RH)	aerosol hygroscopic properties	PNNL
■ CCNc, SCCN	CCN activation	PNNL, BNL

## ▶ Meteorology

■ Sodar, Wind Profiler	wind velocity vertical profile	PNNL
■ Sfc. Met. Station & Radiosonde	wind velocity, P, T, RH profiles	PNNL

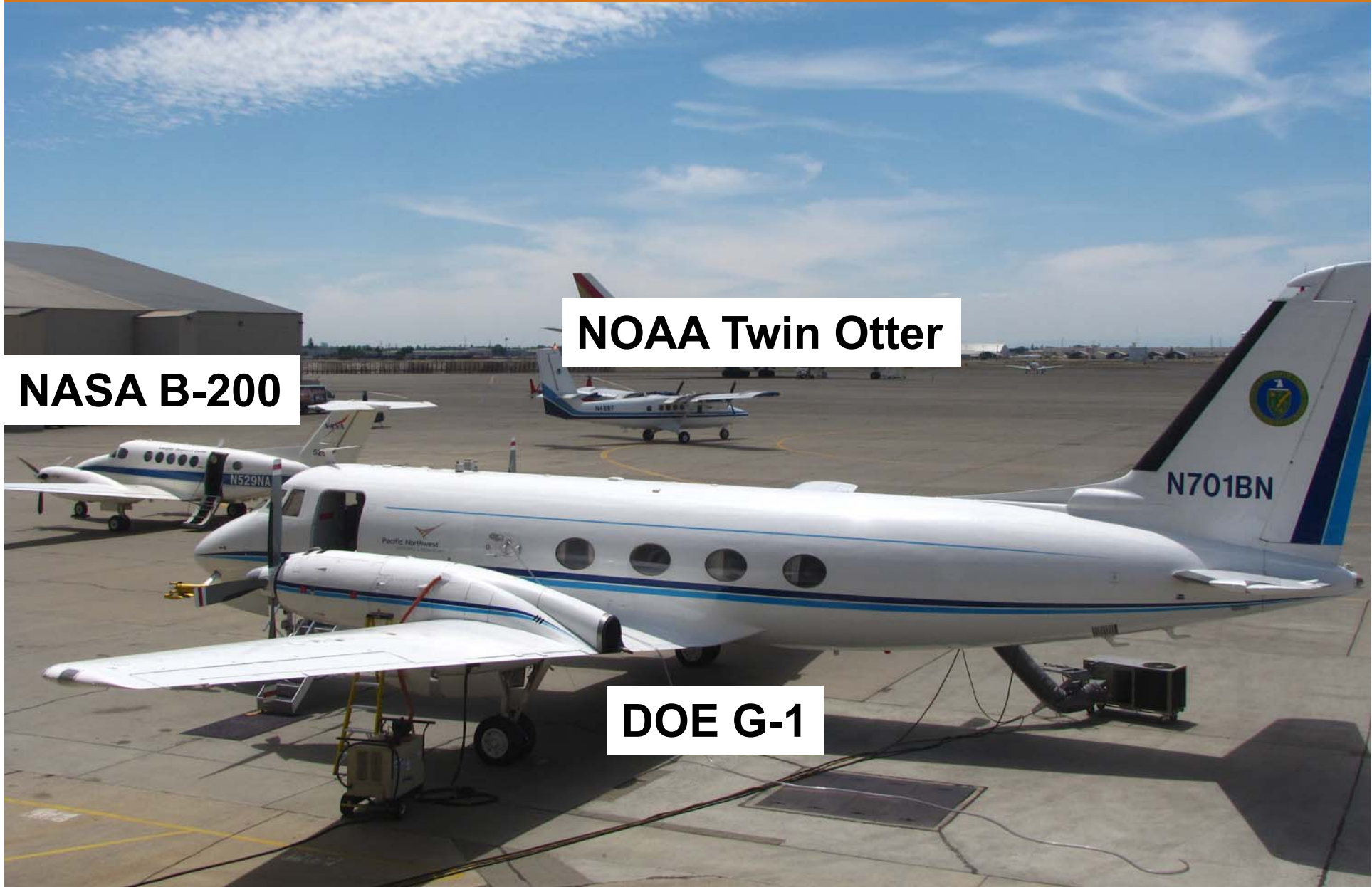


# DOE G-1, NASA B-200, and NOAA Twin Otter at McClellan Airport

**NOAA Twin Otter**

**NASA B-200**

**DOE G-1**



# DOE G-1



## ▶ Trace Gases

- PTR-MS
- CO
- O<sub>3</sub>
- SO<sub>2</sub>
- NO<sub>x</sub>, NO<sub>2</sub>, total NO<sub>y</sub>

VOCs  
VUV fluorescence  
research grade  
research grade  
research grade

PNNL  
BNL  
BNL  
BNL  
BNL

## ▶ Aerosol Size/Composition

- CPC (>3nm and >10 nm)
- FIMS (20 – 70 nm)
- UHSAS (55 – 1000 nm)
- CAPS (500 – 20000 nm)
- HR-ToF-AMS
- SP2
- ATOFMS
- TRAC Sampler
- PILS Auto-sampler

particle number concentration  
particle size distribution  
particle size distribution  
particle size distribution  
non-refractory aerosol comp.  
black carbon mass  
aerosol mixing state  
microspectroscopic analyses  
Bulk inorganic composition

PNNL  
BNL  
PNNL  
PNNL  
EMSL  
BNL  
UCSD  
EMSL, LBNL  
Brechtel, UC Davis

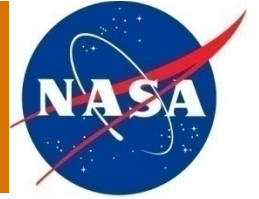
## ▶ Optical Properties

- PASS-3
- 3-λ Nephelometer
- PSAP

absorption  
scattering  
absorption

LANL  
PNNL  
PNNL

# NASA B-200 Deployment for CARES 2010



## ► Platform

- NASA Langley King Air B-200
- Nominal flight altitude: 28 kft (~ 9 km)
- Aircraft speed: 200-220 knots
- Aircraft duration: 4-5 hours



## ► Instruments

- High Spectral Resolution Lidar
- Digital Camera
- Research Scanning Polarimeter

Ferrare/Hostetler  
NASA Langley  
Cairns  
NASA/GISS)

## ► Objectives

- Support DOE G-1 operations (reconnaissance and real-time direction)
- Characterize the vertical and horizontal distribution of aerosols and aerosol optical properties
- Provide the vertical context for G-1 and ground in situ measurements
- Infer aerosol type and apportion optical depth by type
- Investigation of new active + passive (lidar + radiometer) aerosol retrieval techniques
- Characterize the PBL height and distribution of aerosols within and above PBL
- Assess aerosol model transport simulations
- CALIPSO/CALIOP & GLORY/APS Validation

# Coordinated Aircraft Flights

## **DOE G-1 (June 2 – 28)**

- Research Flights: 22
- Flight Time: 67.5 hours
- Flight Distance: ~24,000 km

## **NASA B-200 (June 3 – 28)**

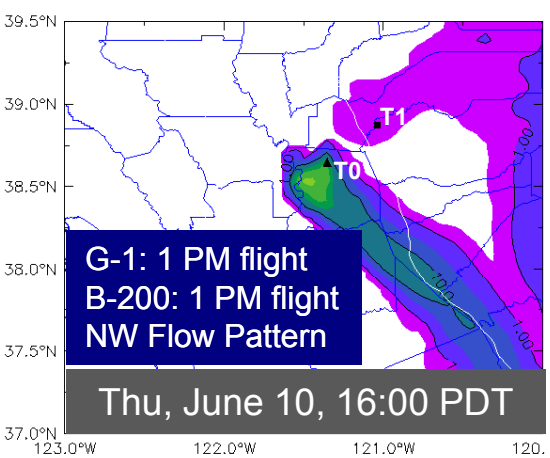
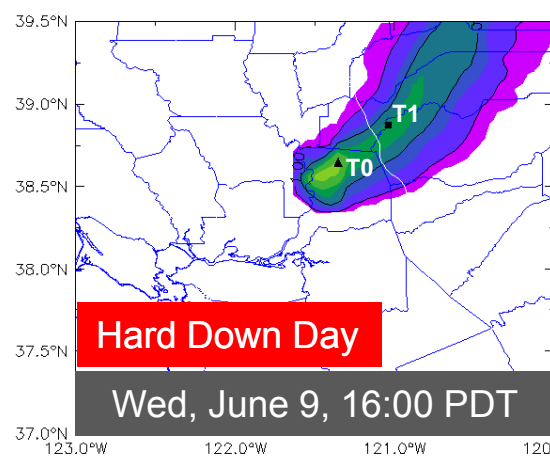
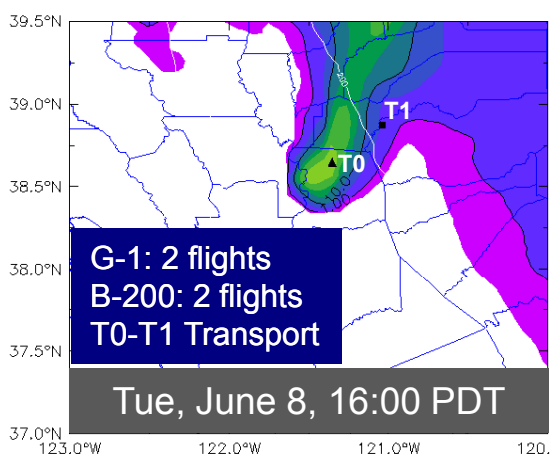
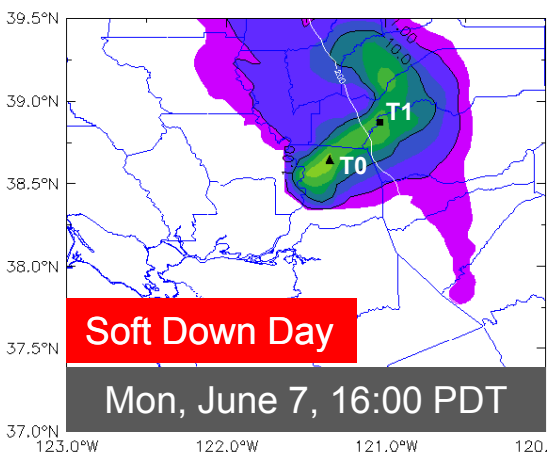
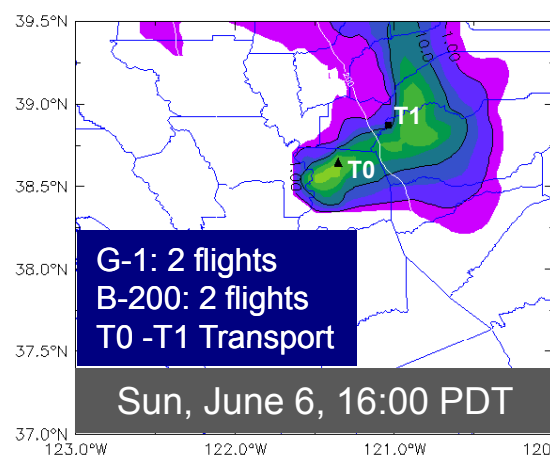
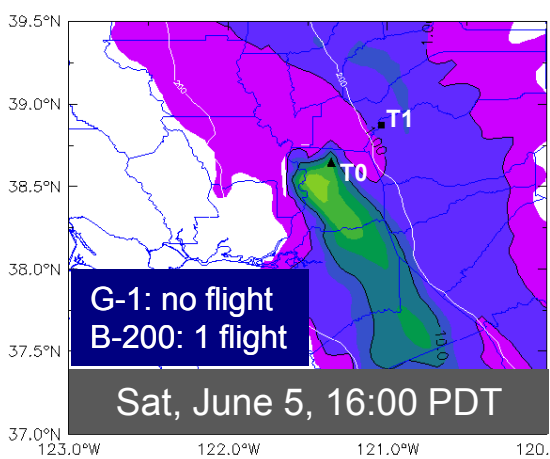
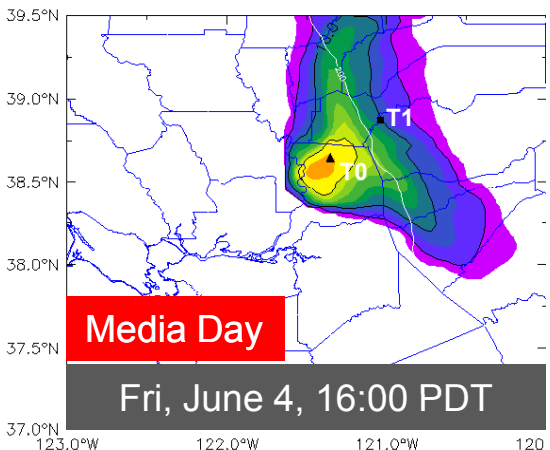
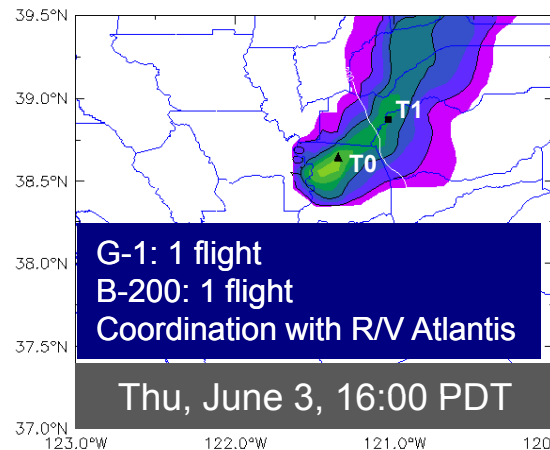
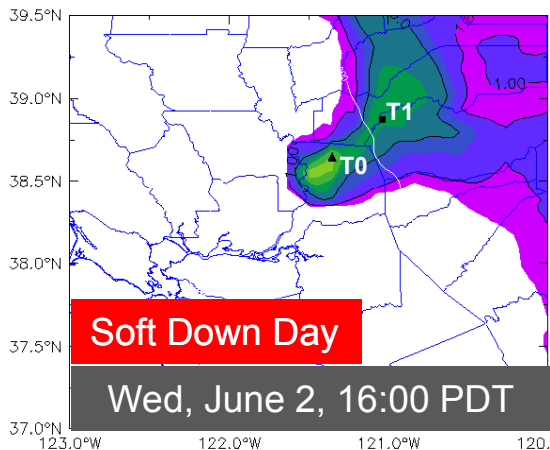
- Research Flights: 23
- Flight Time: ~68 hours

## **NOAA Twin Otter (June 15 – 28)**

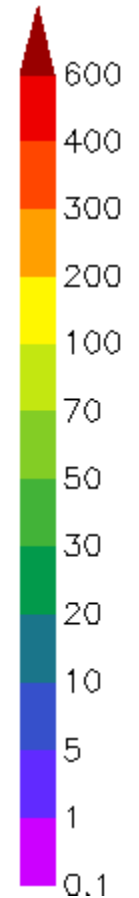
- Part of CalNex

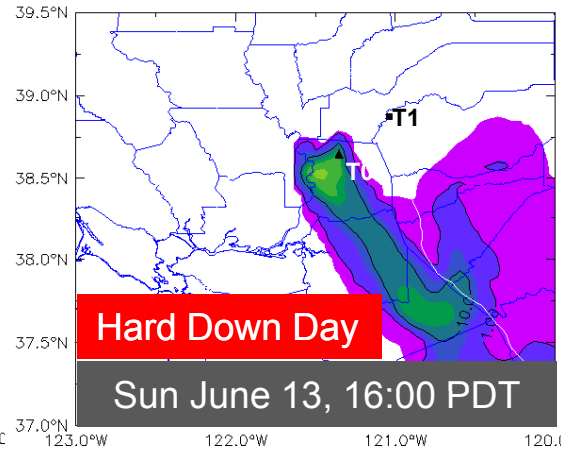
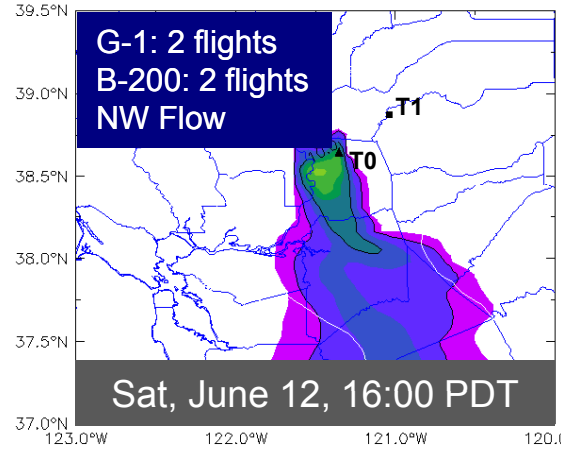
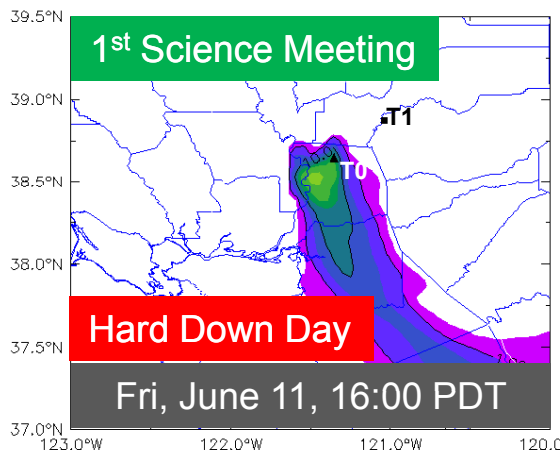
## **NOAA P-3 (June 18)**

- Part of CalNex
- Intercomparison

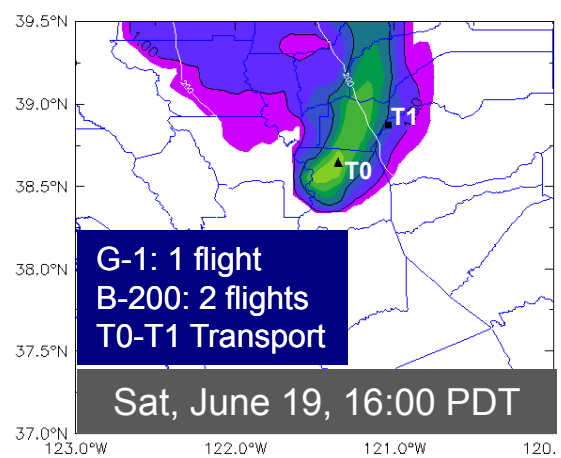
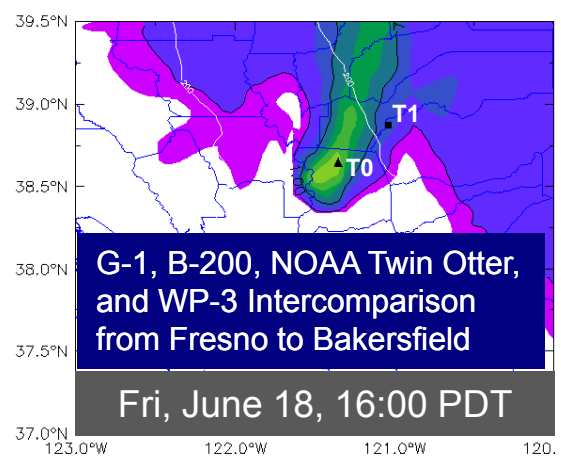
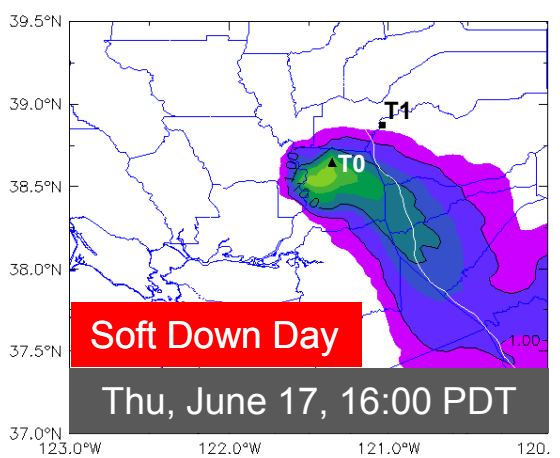
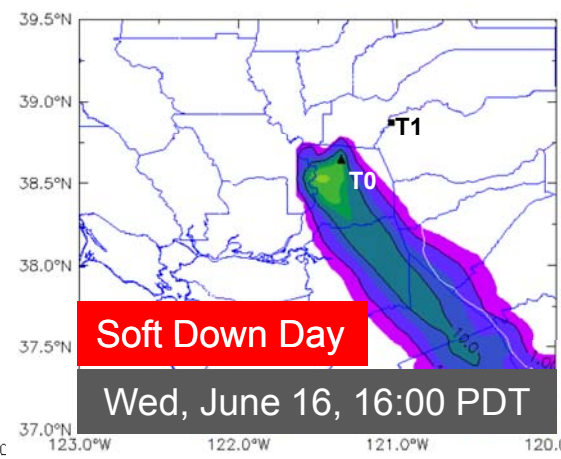
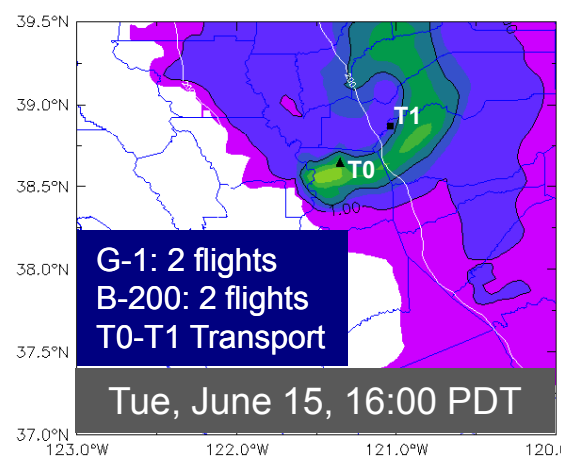
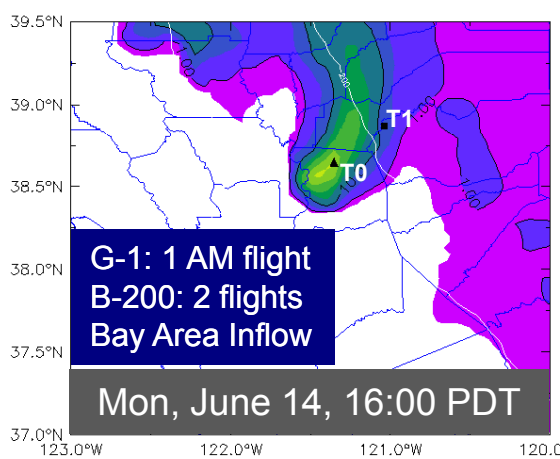
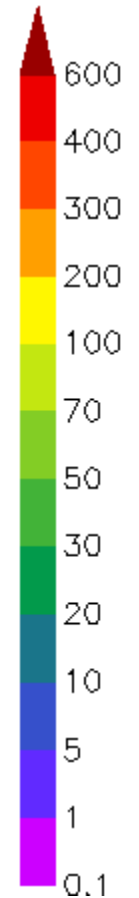


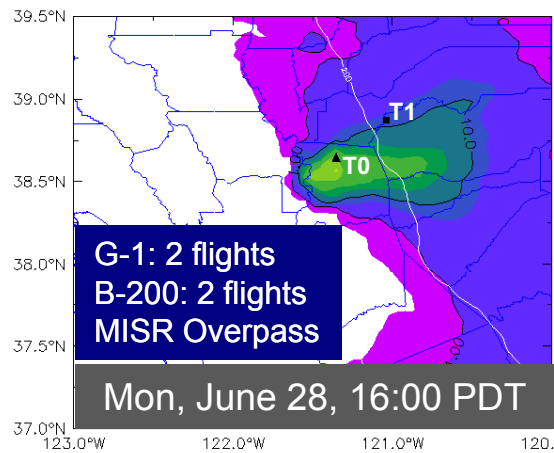
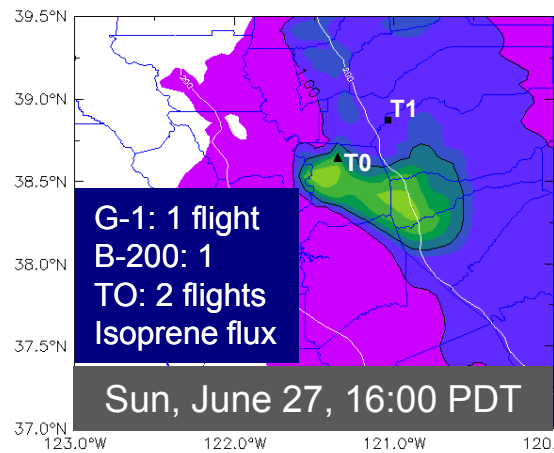
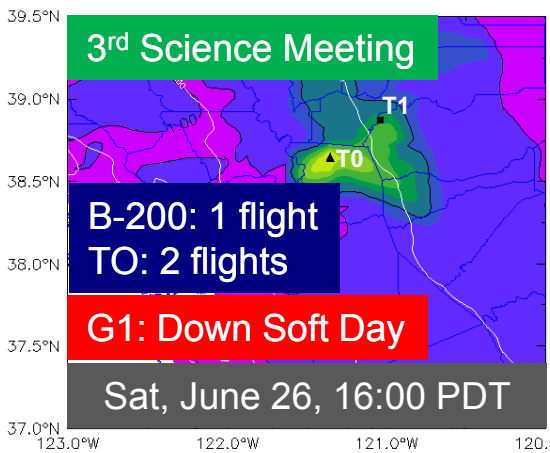
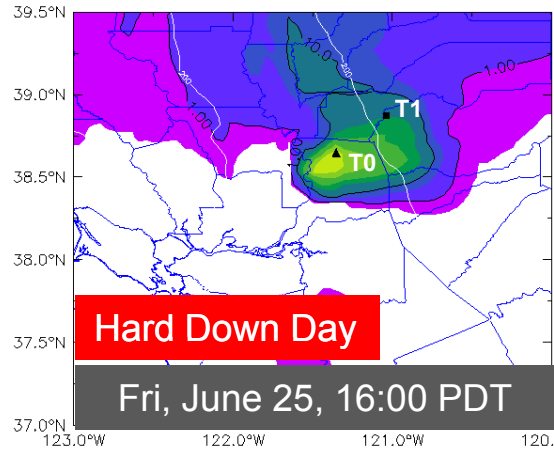
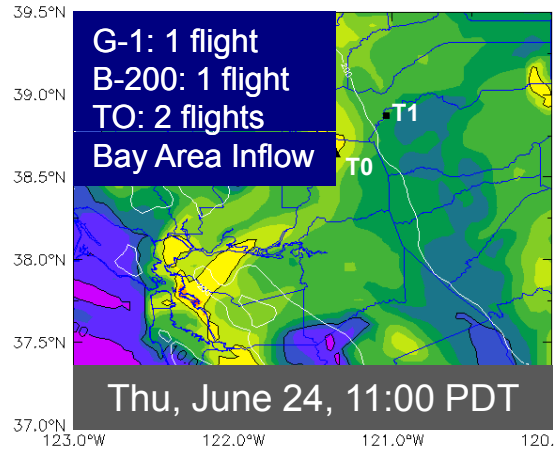
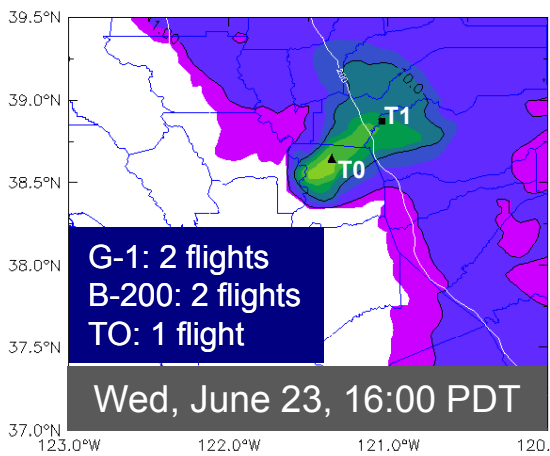
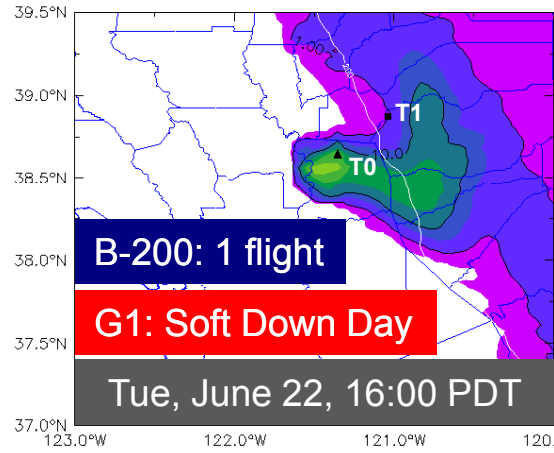
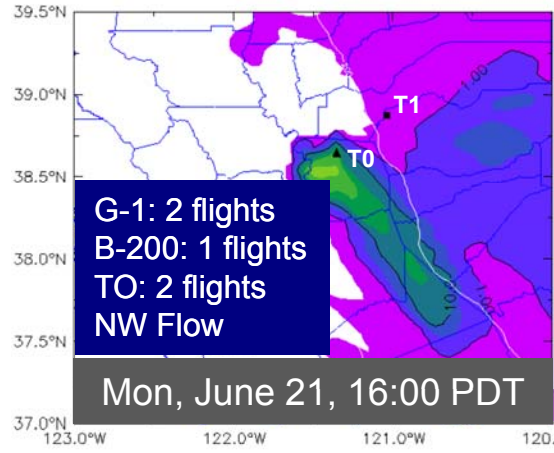
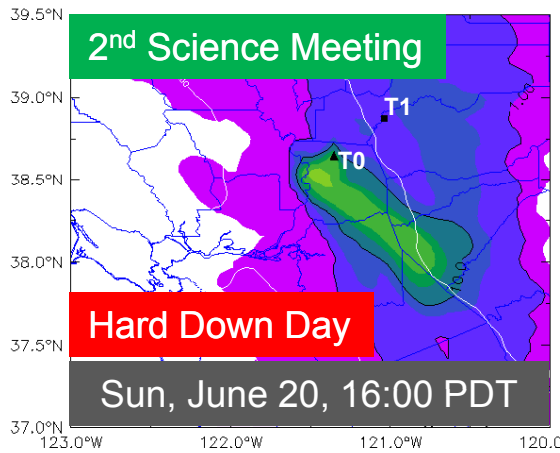
CO (ppbv)



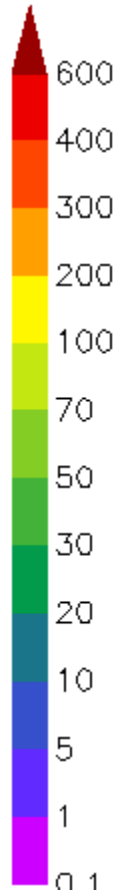


CO (ppbv)



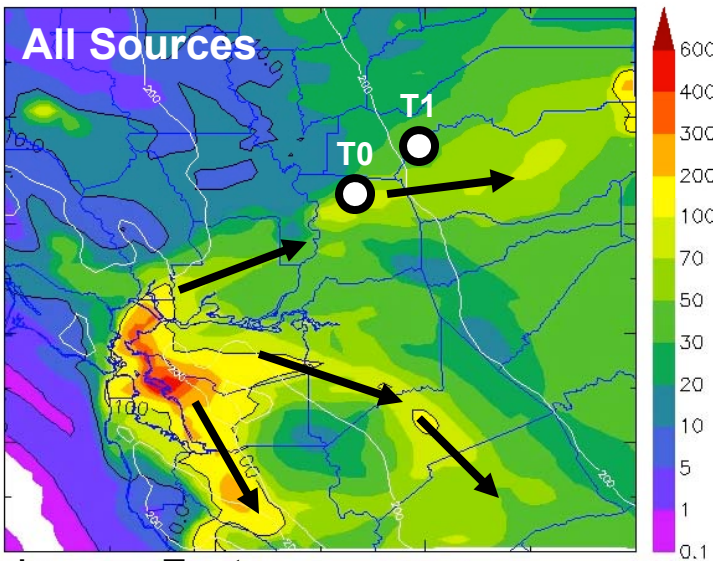
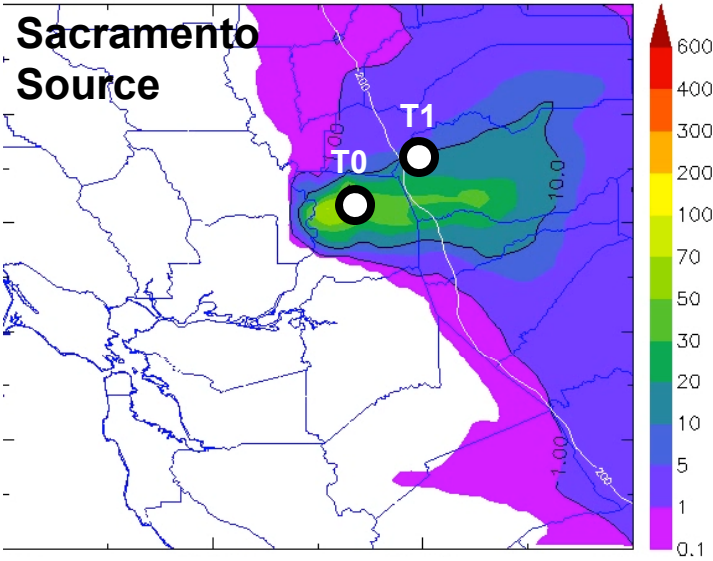


CO (ppbv)



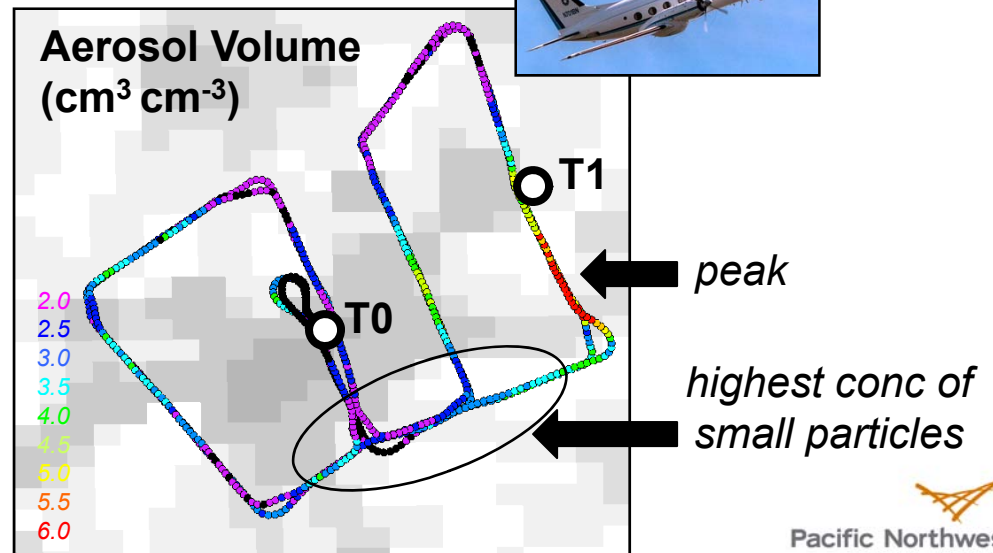
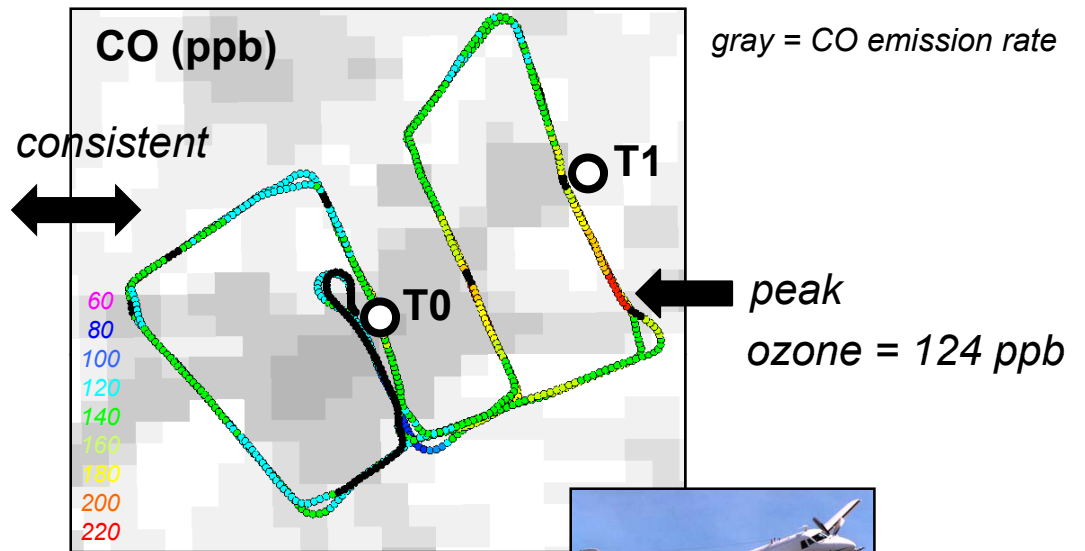
# G-1 Sample Flight Plan: June 28

WRF Tracer Forecast 16 PST



Jerome Fast

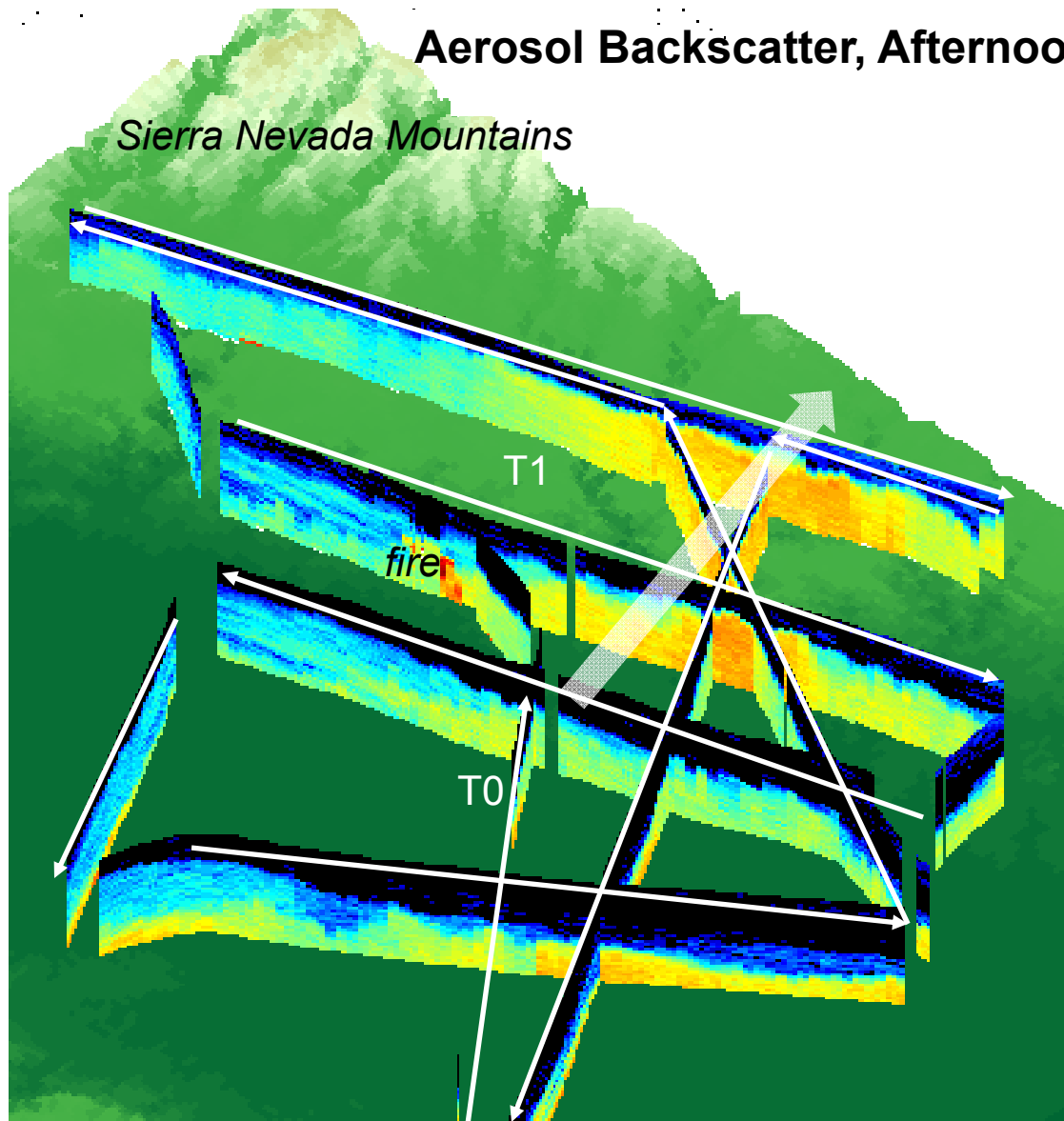
G-1 Data, 1341 – 1641 PST





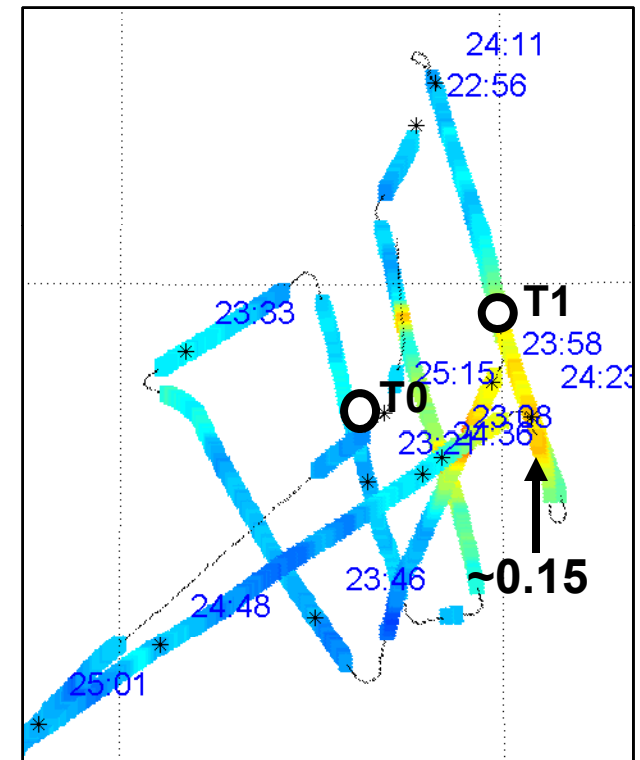
# NASA B-200 HSRL Data: June 28

## Aerosol Backscatter, Afternoon June 28



Rich Ferrare

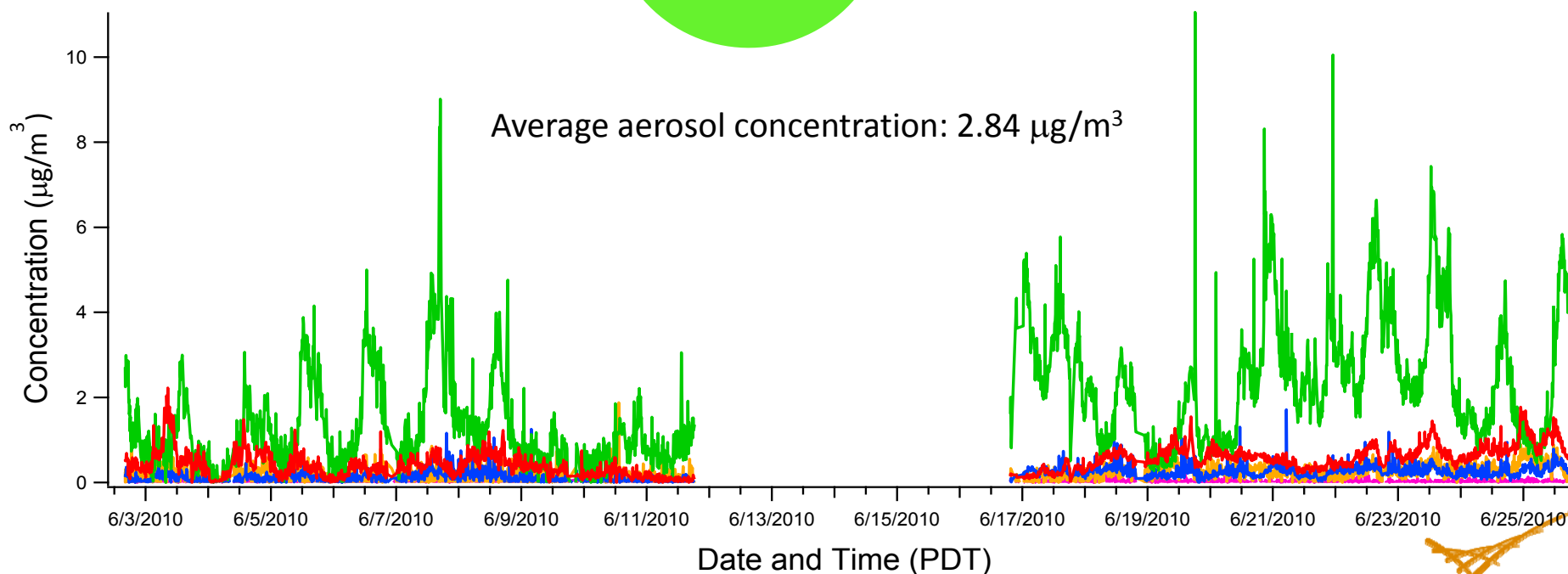
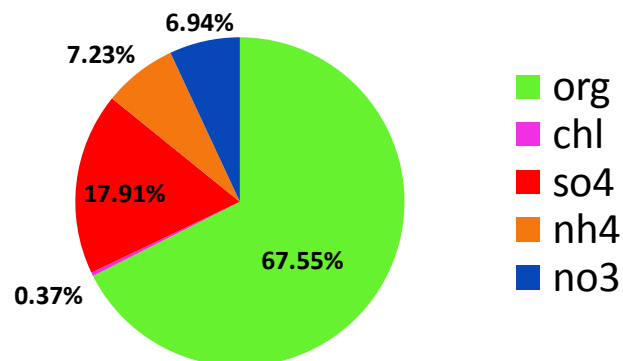
## Aerosol Optical Depth (532 nm)



- Consistent with in-situ data collected by G-1

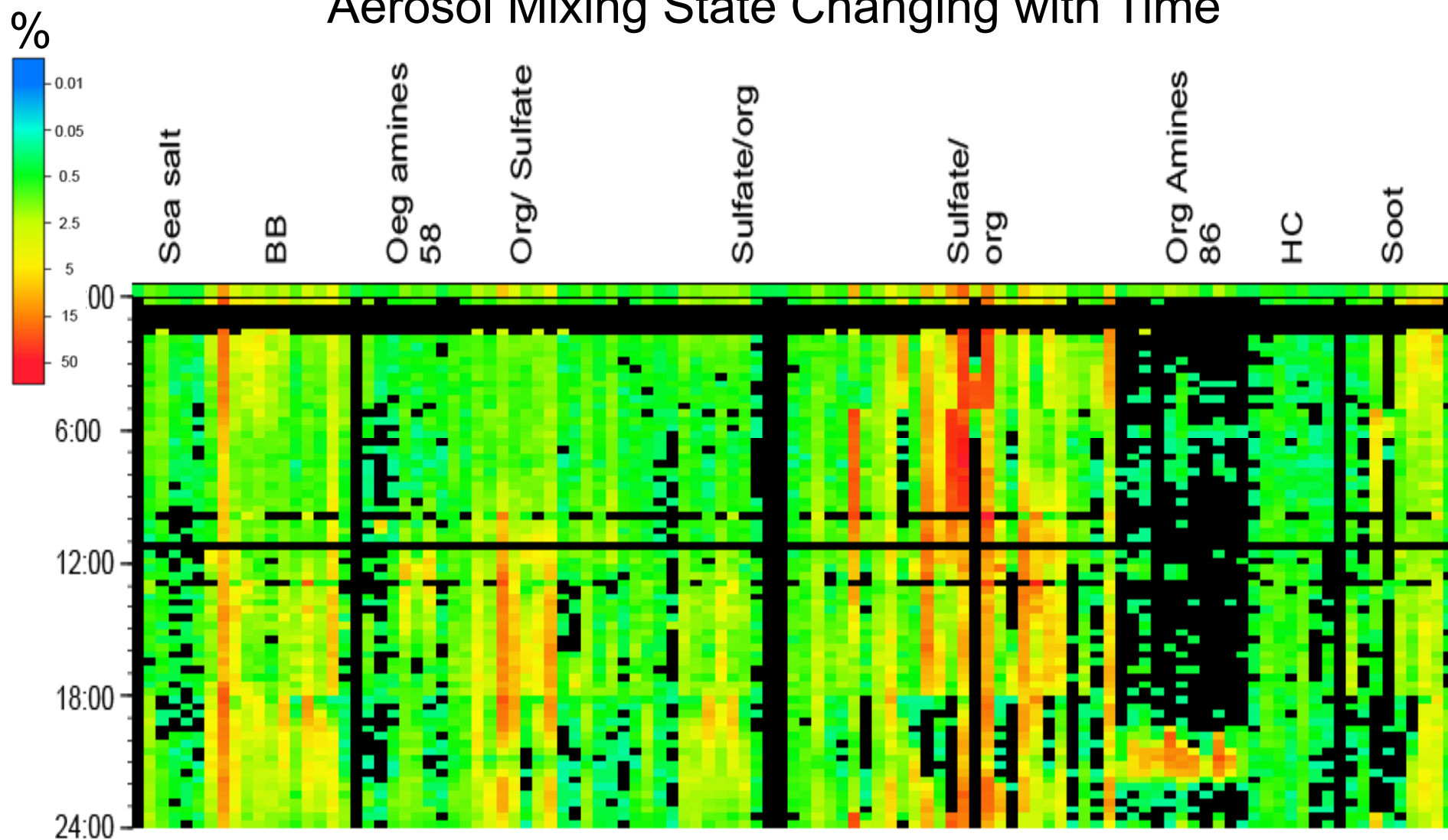
# AMS: Aerosol Composition at T0

Average Aerosol Composition at T0

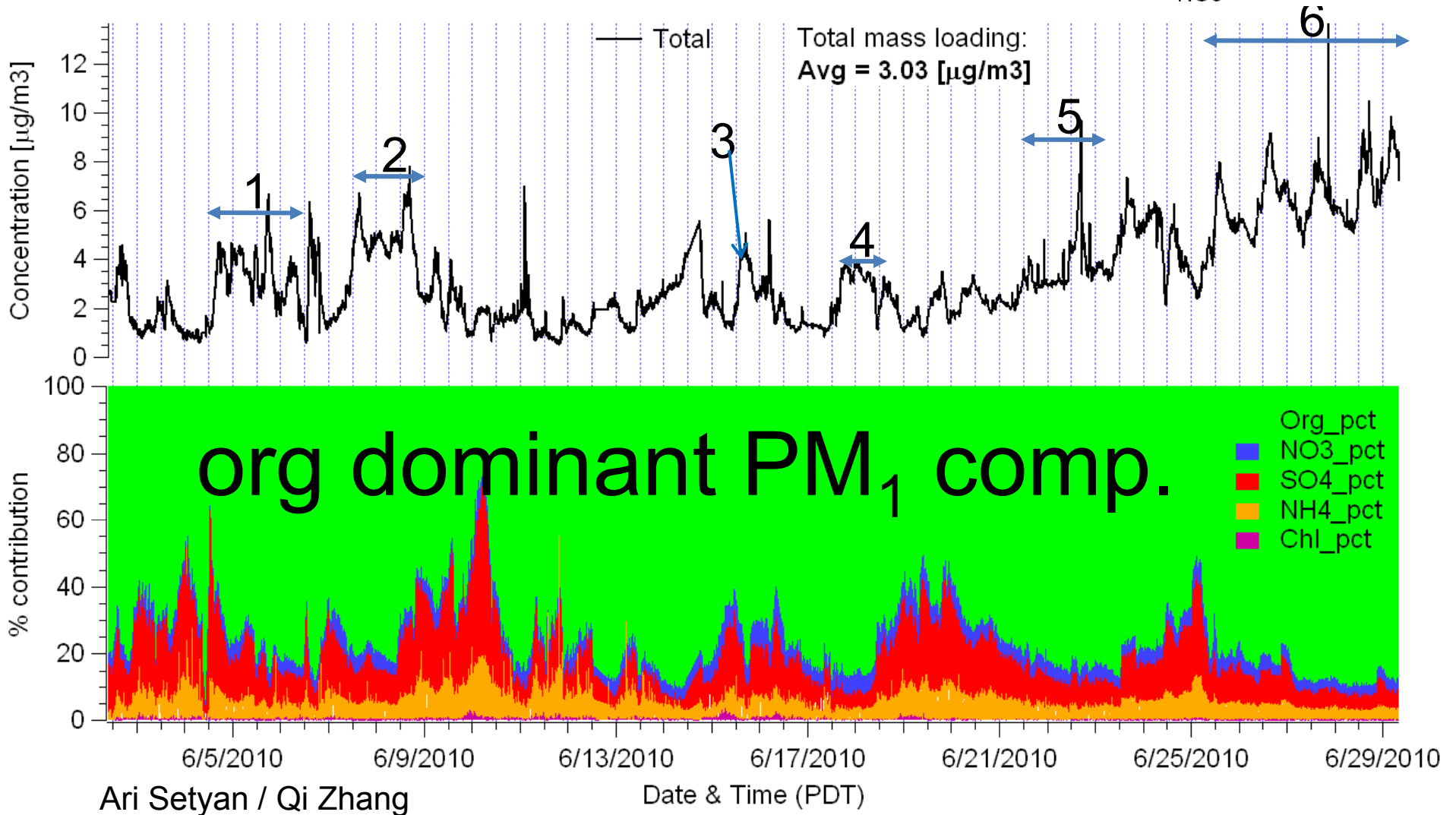
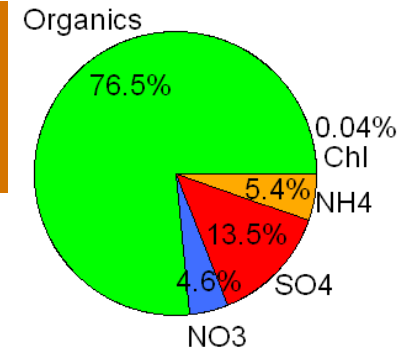


# SPLAT II: Single Particle Composition at T0

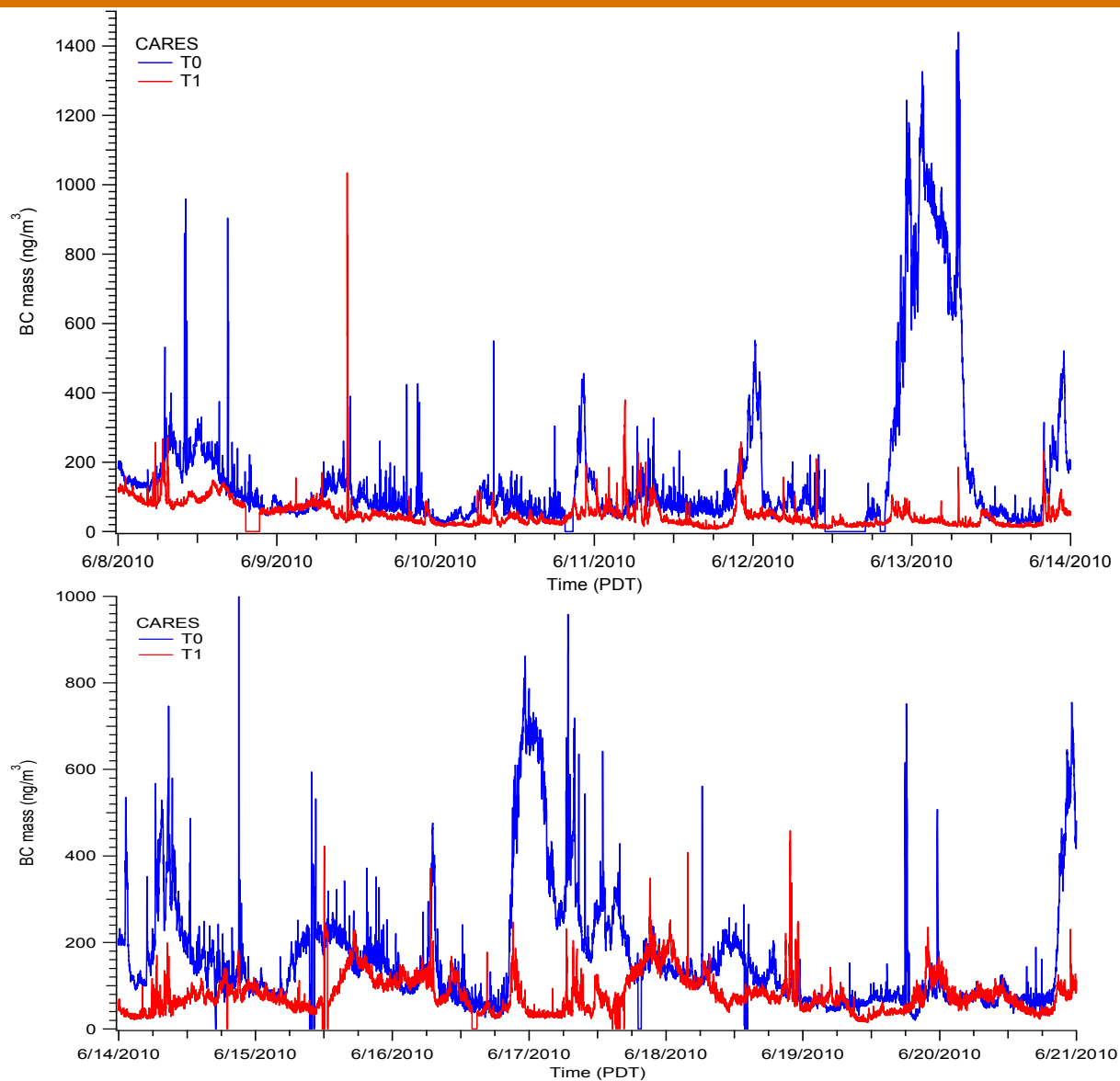
## Aerosol Mixing State Changing with Time



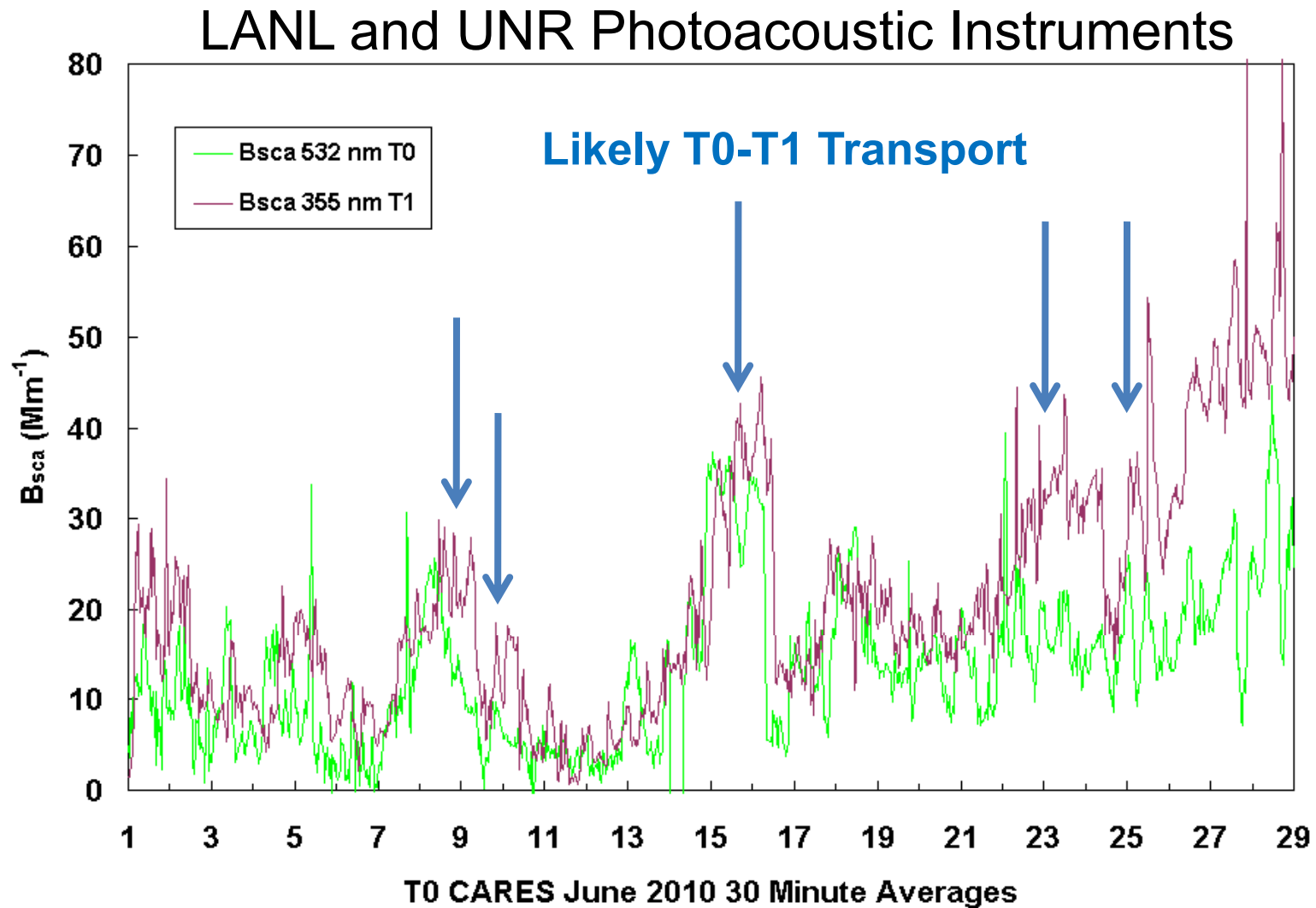
# AMS: Aerosol Composition at T1



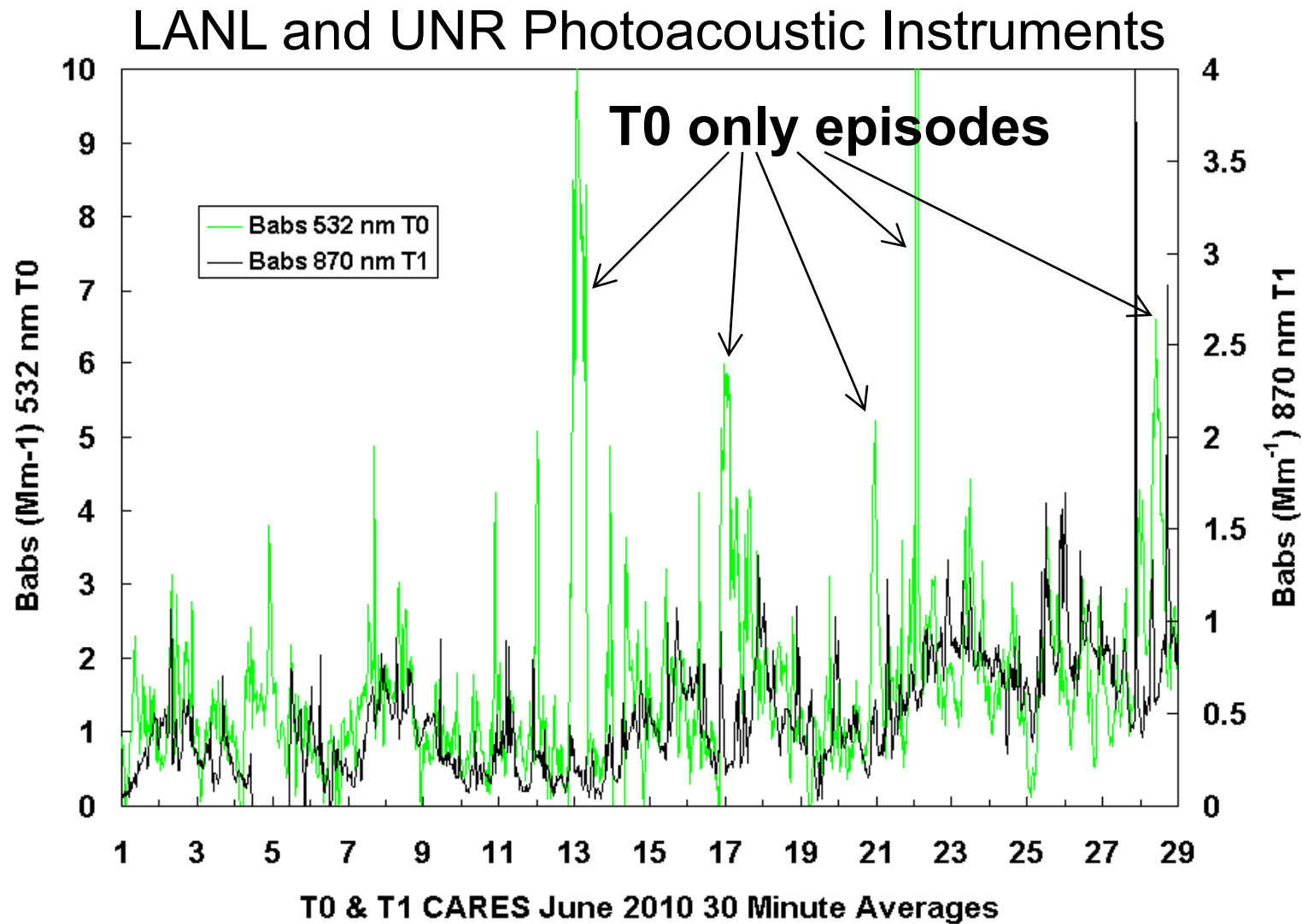
# SP2: Comparison of BC at T0 and T1



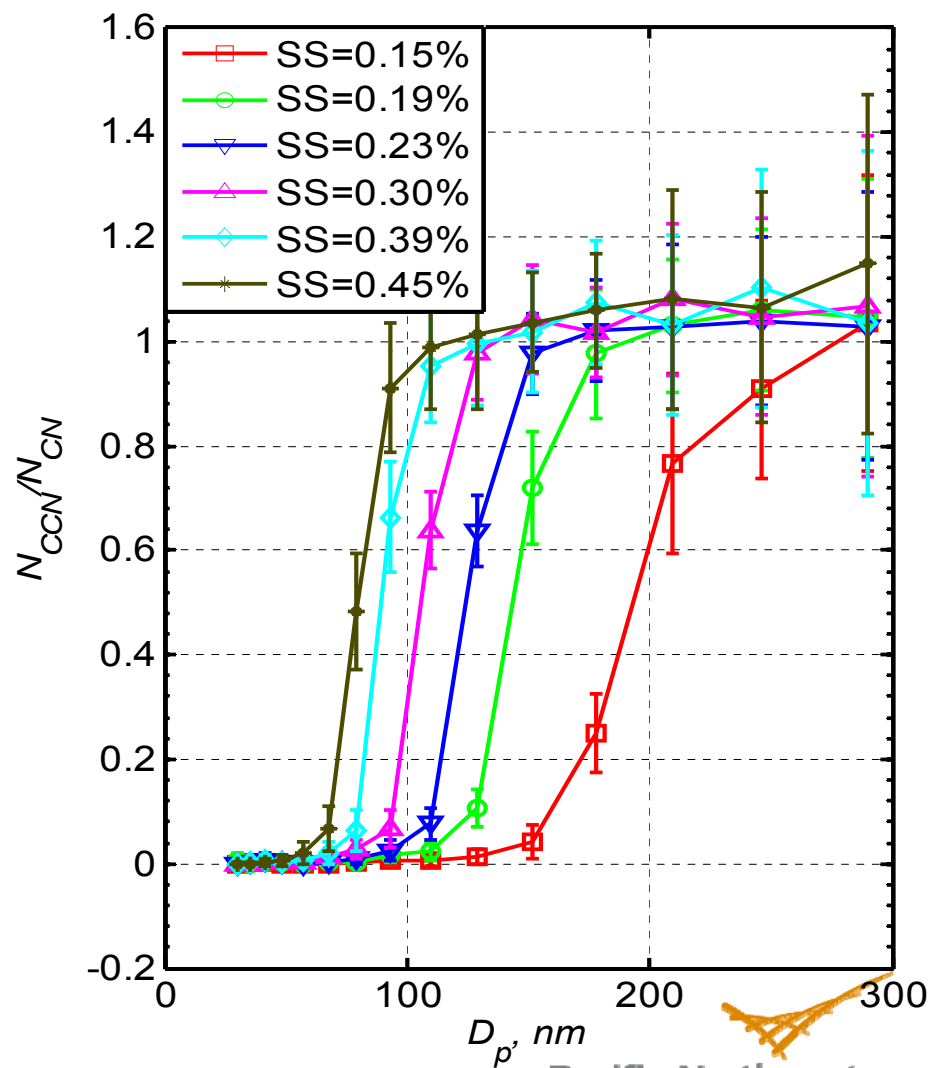
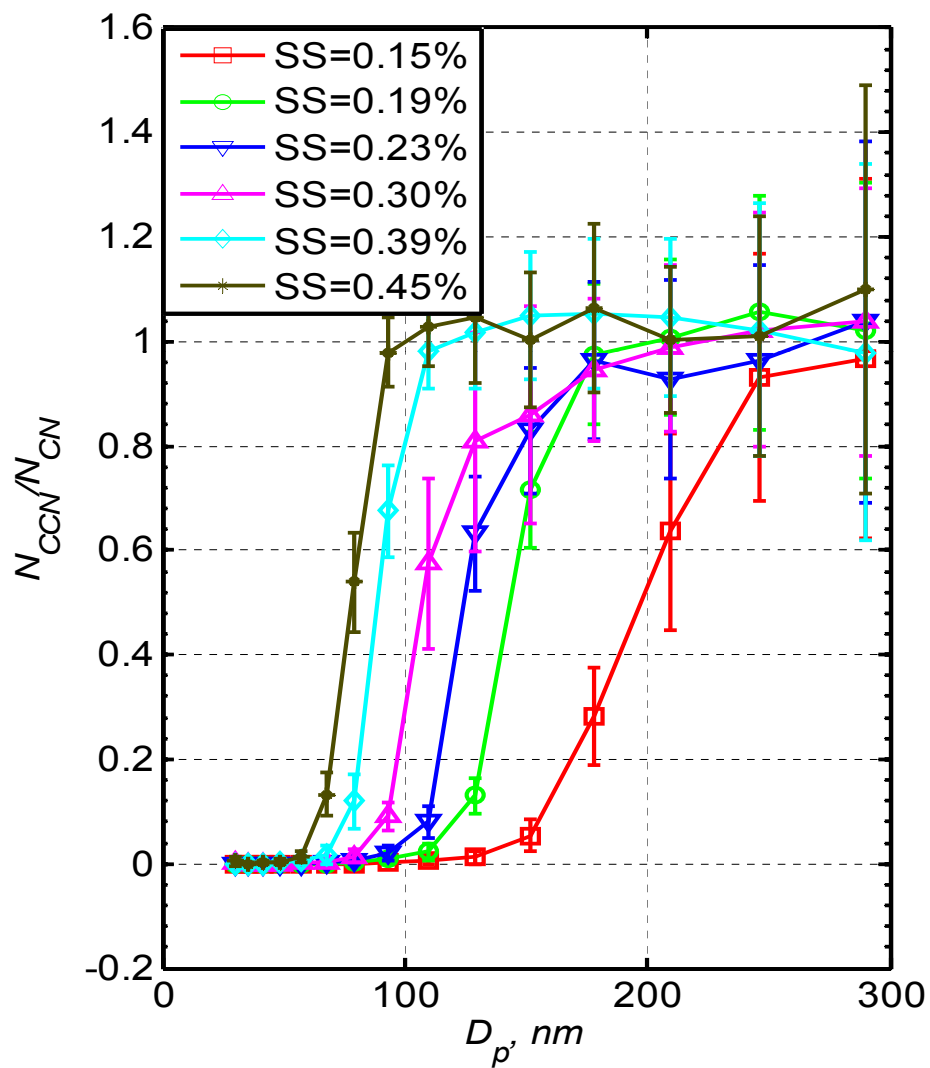
# PAS: Comparison of Light Scattering at T0 and T1



# PAS: Comparison of Absorption at T0 and T1



# Size-Resolved CCN Spectra at T1

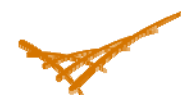




# Envisioned Analyses

**We have developed a very rich data set useful for improving and evaluating aerosol process models**

- ▶ **Observational analyses**
  - Instrument characterization
  - Understand the limitations of measurements
  - Identify interesting episodes for detailed analyses
- ▶ **Constrained modeling analyses (MOSAIC Aerosol Module)**
  - Local optical and CCN closures using aerosol mixing state data
  - SOA formation and mixing state evolution
  - Improve aerosol process and property representations
- ▶ **Urban to regional scale modeling analyses (WRF-MOSAIC)**
  - Test new and improved aerosol processes
  - Impact of process improvements on direct radiative forcing



## At McClellan Jet Services Hangar



# Outside Homewood Suites in Roseville



## 3<sup>rd</sup> Science Meeting on June 26, 2010



# Outreach

- CARES website <http://campaign.arm.gov/cares/>
- Blog sites
  - [http://www.pnl.gov/atmospheric/programs/CARES\\_campaign.stm](http://www.pnl.gov/atmospheric/programs/CARES_campaign.stm)
  - <http://earthobservatory.nasa.gov/blogs/fromthefield/category/urban-aerosols-who-cares/>
- Photos on Flickr: <http://www.flickr.com/photos/armgov/sets/72157624042722124/>
- Press
  - **ARM Climate Research Facility:** *Field Campaign Begins in Sacramento to Study Aging Aerosols*  
<http://www.arm.gov/news/stories/post/8968>
  - **Science Daily:** *Airplanes, Ground Instruments, & Weather Balloons to Study Effect of Airborne Particles on Climate*  
<http://www.sciencedaily.com/releases/2010/06/100602121056.htm>
  - **Enviro-News:** *US Aerosol Climate Effects Study*  
<http://www.enviro-news.com/news/us-aerosol-climate-effects-study.html>
  - **NASA:** *Who CARES About Carbonaceous Aerosols?*  
<http://www.nasa.gov/topics/earth/features/cares-cali.html>
  - **FOX 40 KTXL Sacramento:** *Scientists Begin Air Sampling* (video)  
<http://www.fox40.com/videobeta/14bdea6e-4fd4-4119-beab-3c429ad19349/News/Scientists-Begin-Air-Sampling>
  - **The Sacramento Bee:** *Scientists Launch Air Study in Sacramento*  
<http://www.sacbee.com/2010/06/05/2800024/scientists-launch-air-study-in.html>

# Acknowledgements

## **Funding and Personnel Support**

- ARM Climate Research Facility
- ARM Aerial Facility
- Atmospheric System Research Program
- Environmental Molecular Sciences Laboratory

## **CARES Team**

- Scientists, post-docs, students, collaborators
- Support staff

## **Our Hosts**

- CARB (staff and forecasting team)
- McClellan Jet Services, Sacramento
- American River College, Sacramento
- Northside School, Cool