CARES Objectives and Goal

Science Objectives:

- Investigate secondary organic aerosol (SOA) formation from anthropogenic and biogenic precursors and the potential interactions between them.
- Characterize the time scales of black carbon (BC) ageing and quantify the relative contributions of condensation and coagulation to BC mixing state evolution.
- Quantify the effect of aerosol mixing state and the role of organics on the associated optical and CCN activation properties. Perform local closure studies.
- Quantify the contribution of new particle formation and growth to CCN population.

Overarching Goal:
Evaluate and improve aerosol modules for the above mentioned processes and properties for use in regional, global climate models.
Sampling Strategy and Platforms

Sacramento, June 2-28, 2010

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

Sacramento plume serves as a meso-scale flow reactor
Two Predominant Sacramento Plume Patterns Observed

SW Flow ~15 out of 27 days

NW Flow 9 out of 27 days

SO₂ from refineries along Carquinez Strait
CO, BC, and Absorption Coeff at T0 and T1

Day of June 2010
AMS Aerosol Composition at T0 and T1

Day of June 2010

- NH4
- Org
- SO4
- NO3
- Chl

Concentration (µg m⁻³)

T0

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29

T1

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29
Time Series at T0

Day of June 2010

- Concentration (µg m\(^{-3}\))
- CO (ppbv), BC Mass (ng m\(^{-3}\) STP)
- Abs. Coeff. at 375 nm (Mm\(^{-1}\))
Organic Aerosol at T0
BC Aging and Absorption at T0

![Graph showing the relationship between PASLAN absorption coefficient at 532 nm (Mm$^{-1}$) and NO$_x$/NO$_y$ with SP2(DMT) Black Carbon Mass (ng m$^{-2}$ STP).]
Intercomparison of Optical Properties at T0

1-minute interpolated values
SPLAT II: Single Particle Composition at T0

Complex Aerosol Mixing State Changing with Time

Alla Zelenyuk, Josef Beranek
Evidence for Aged Air Mass Recirculated from the Previous Day

8:00 am – 11:00 am PST

June 15 AM Flight

Longitude

Latitude

-122.0 -121.8 -121.6 -121.4 -121.2 -121.0 -120.8
-122.0 -121.8 -121.6 -121.4 -121.2 -121.0 -120.8

38.2 38.4 38.6 38.8 39.0 39.2
38.2 38.4 38.6 38.8 39.0 39.2

NOy (ppbv)

Altitude MSL (m)

0 200 400 600 800 1000 1200 1400
0 200 400 600 800 1000 1200 1400

NOy

Altitude

UTC (h)

16.0 16.5 17.0 17.5 18.0 18.5 19.0
16.0 16.5 17.0 17.5 18.0 18.5 19.0

T0 T0 T0 T0 T1 T1 T1

T0 T0 T0 T0 T1 T1

0 2
0 2

NO3 (µg m⁻³)

Altitude MSL (m)

0 200 400 600 800 1000 1200 1400
0 200 400 600 800 1000 1200 1400

NO3

Altitude

UTC (h)

16.0 16.5 17.0 17.5 18.0 18.5 19.0
16.0 16.5 17.0 17.5 18.0 18.5 19.0

0.0 0.5 1.0 1.5
0.0 0.5 1.0 1.5

Organic Aerosol Mass (µg m⁻³)

Altitude MSL (m)

0 200 400 600 800 1000 1200 1400
0 200 400 600 800 1000 1200 1400

Organic Aerosol Mass

Altitude

UTC (h)

16.0 16.5 17.0 17.5 18.0 18.5 19.0
16.0 16.5 17.0 17.5 18.0 18.5 19.0

0 2
0 2

8:00 am – 11:00 am PST
Large Concentrations of Ultrafine Particles

![Graph showing concentrations of particles and SO2 over time and altitude.](image)
Intense Photochemical Evolution on June 28

WRF Tracer Forecast 16 PST

Sacramento Source

G-1 Data, 1341 – 1641 PST

CO (ppb)

gray = CO emission rate

consistent

peak

ozone = 124 ppb

Aerosol Volume ($\mu$m$^3$ cm$^{-3}$)

peak

WRF forecast: W. Gustafson and J. Fast
Emerging Topics

► SOA Formation
  - Dominated by biogenics
  - Biomass burning OA may be important – need PMF and multilinear regression to separate the different sources
  - Role of organic nitrates and potential interactions between anthropogenic and biogenic precursors?

► BC aging, Coarse Particles, and Light Absorption
  - Aircraft and ground based SP2 data suggest rapid aging of BC
  - SPLAT II data at T0 can give mixing state evolution
  - Specific BC absorption increases with aging
  - MFRSR data suggests substantial role of coarse mode
  - Need to investigate the effect of aerosol size and mixing state on optical properties (local closure)

► CCN Activation
  - Need to investigate the effect of mixing state on hygroscopicity and CCN activation
Papers

- Overview of CARES – Zaveri et al.
- Overview of meteorology during CARES – Fast et al.
- Evaporation kinetics of OA – Zelenyuk et al. (published in PNAS)
- Mass absorption coefficients – Flowers et al.
- Cycling of CO2 and biogenics at T1 – Flowers et al.
Overview of CARES paper outline

- **Introduction**
  - Background on the role of carbonaceous aerosols on climate
  - CARES science and modeling objectives

- **Sampling sites and aircraft**
  - Description of geographical area and sites
  - Instrument suites and payload tables

- **Overview of key data**
  - Show key time series, ratios, correlations, spatial plots to show robustness of the comprehensive CARES dataset
  - Demonstrate that the data will be able to address the stated science and modeling objectives