2010 CalNex public meeting
Sacramento, CA – Thursday, February 5, 2009

NOAA P-3 in CalNex 2010: capabilities, dates, and strategies

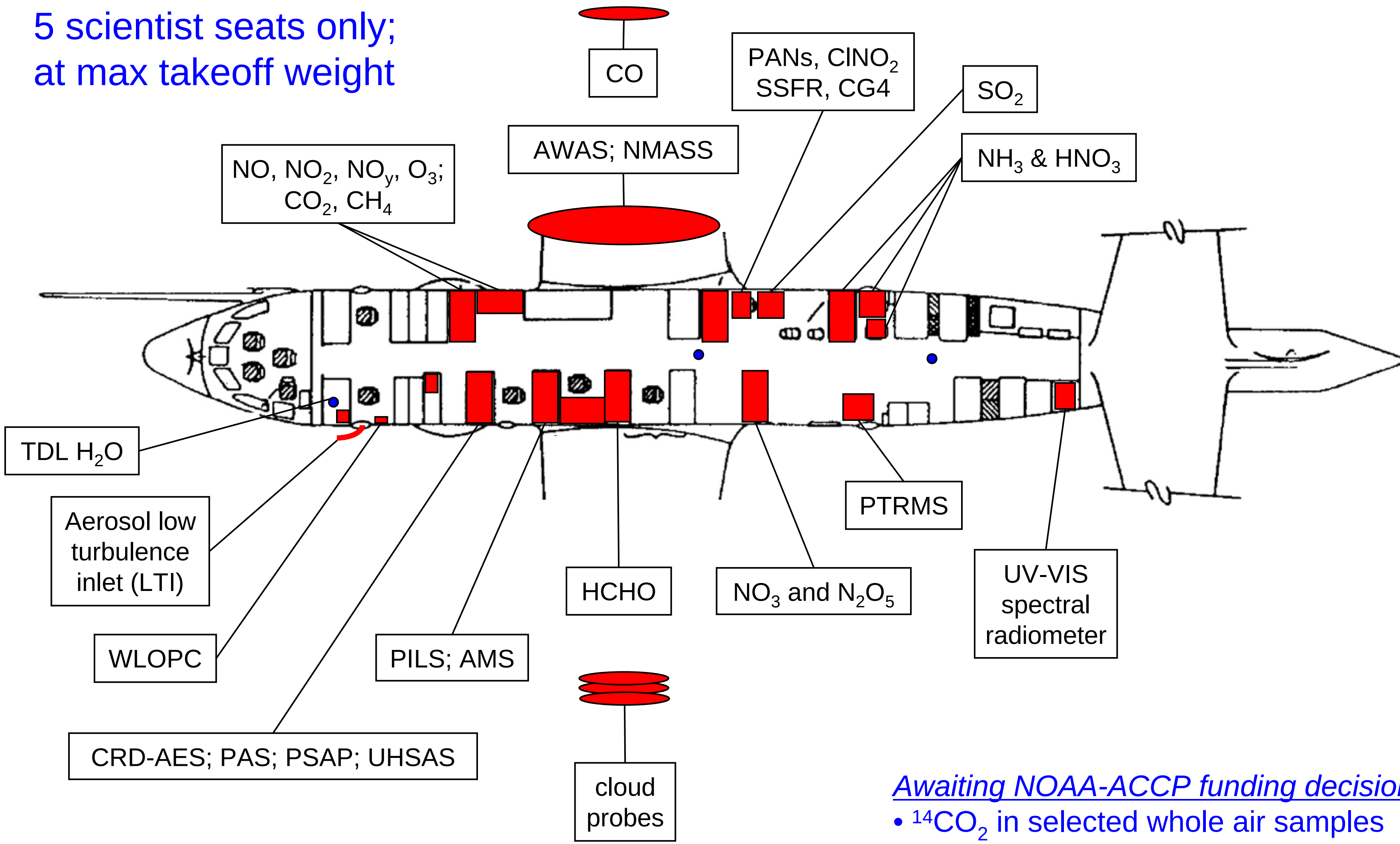
Tom Ryerson and Michael Trainer – NOAA ESRL Chemical Sciences Division

J. Cozic photo

Draft NOAA P-3 payload - CalNex 2010

subset of instruments with identified funding is shown

5 scientist seats only;
at max takeoff weight



Awaiting NOAA-ACCP funding decisions:

- $^{14}CO_2$ in selected whole air samples
- 1-Hz N_2O, CH_4, CO_2, and CO

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Instrument	Measurement	Time resolution	
O_3	ozone	1 sec	***ozone and tracers***
CO	carbon monoxide	1 sec	
SO_2	sulfur dioxide	3 sec	
CO_2 and CH_4	carbon dioxide and methane	1 sec	
AWAS	VOCs, halocarbons, alkyl nitrates	62/flight	***VOCs and products***
PTRMS	oxy-VOCs, aromatics, acetonitrile	15 sec	
HCHO	formaldehyde	1 sec	
NO, NO_2, and NO_y	nitrogen oxides	1 sec	***nitrogen species***
PANs and $ClNO_2$	peroxyacyl nitrates and nitryl chloride	1 sec	
NO_3 and N_2O_5	nocturnal nitrogen oxides	1 sec	
HNO_3	nitric acid	1 sec	
NH_3	ammonia	1 sec	
LTI	aerosol low turbulence inlet	1 sec	***aerosol size, optical properties, and composition***
NMASS/UHSAS/WLOPC	0.004 to 8 μm aerosol size distribution	1 sec	
CRD-AES	3-λ aerosol extinction as f(RH)	1 sec	
PSAP	3-λ aerosol absorption (filter)	15 sec	
PAS	3-λ aerosol absorption (photoacoustic)	5 sec	
SP2	aerosol black carbon	1 sec	
PILS	aerosol chemical composition	80/flight	
AMS	aerosol chemical composition	10 sec	
UV-VIS spectrometer	spectral actinic flux from 280-689 nm	1 sec	
TDL H_2O	water vapor	1 sec	
cloud probes	drop size and morphology	1 sec	
position and meteorology	aircraft location, T, P, winds, etc.	1 sec	

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anthropogenic

biogenic

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Emissions evaluation will be a focus in CalNex

measurements of direct emissions:

anthropogenic

biogenic

biomass burning

GHGs and soot

agricultural

Tentative NOAA P-3 CalNex deployment dates and locations

- **NOAA ESRL has requested 205 P-3 flight hours for CalNex.**

  Depending on the actual allocation, we may consider 1-2 flights from Colorado prior to transiting to California.
  - *instrument shakedown near home laboratory*
  - *investigate transport downwind of California*

- **Requested dates: May 1 through June 30, 2010 in California.**

  P-3 return date will be dictated by hurricane requirements

- **Location: LA Basin, either Ontario or Long Beach airports.**

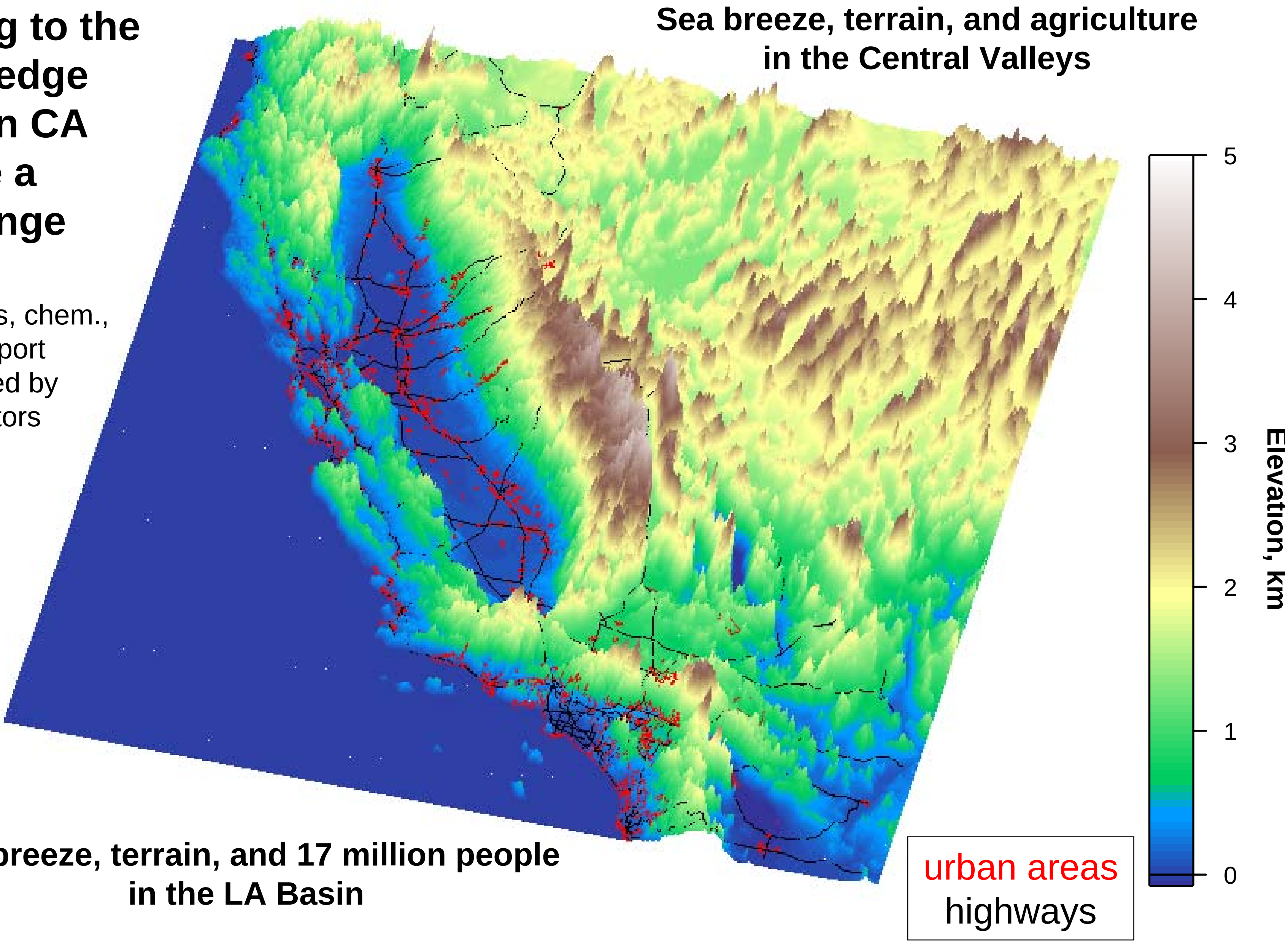
  P-3 range is sufficient to base anywhere in the State ← **!!!**
  - *co-location with NOAA and CIRPAS Twin Otters is highly desirable*

  need to avoid high/hot conditions to maximize flight duration

  24/7 operations, with no noise or takeoff restrictions after dark

Adding to the knowledge base in CA will be a challenge

Emissions, chem., and transport determined by many factors



Using the P-3 to address CalNex science questions

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C. What sources and processes contribute to atmospheric mercury concentrations in California?

Critical uncertainties remain in our understanding of 1) the processes by which primary emissions are transformed within and removed from the atmosphere, and 2) how aerosols interact with the radiation flux in the atmosphere.

Emissions studies

Anthropogenic enhancements relative to CO_2 can be compared directly to inventory values

- *VOCs, NOx, CH_4, halocarbons, N_2O*
- *use 2002, 2008, & 2010 aircraft data*
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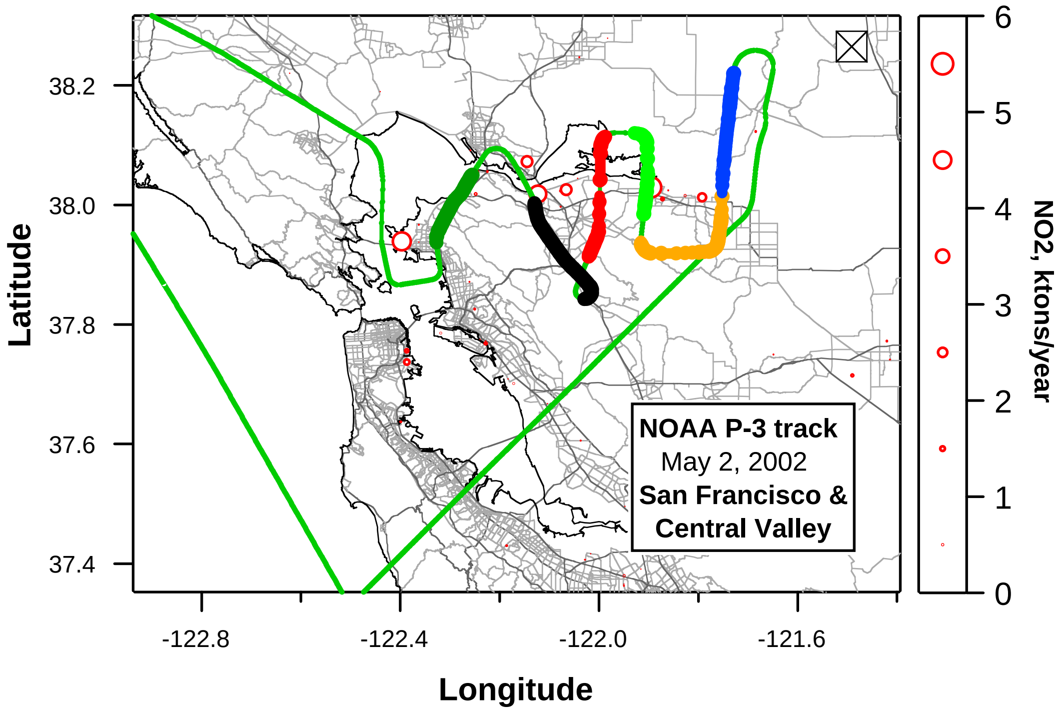

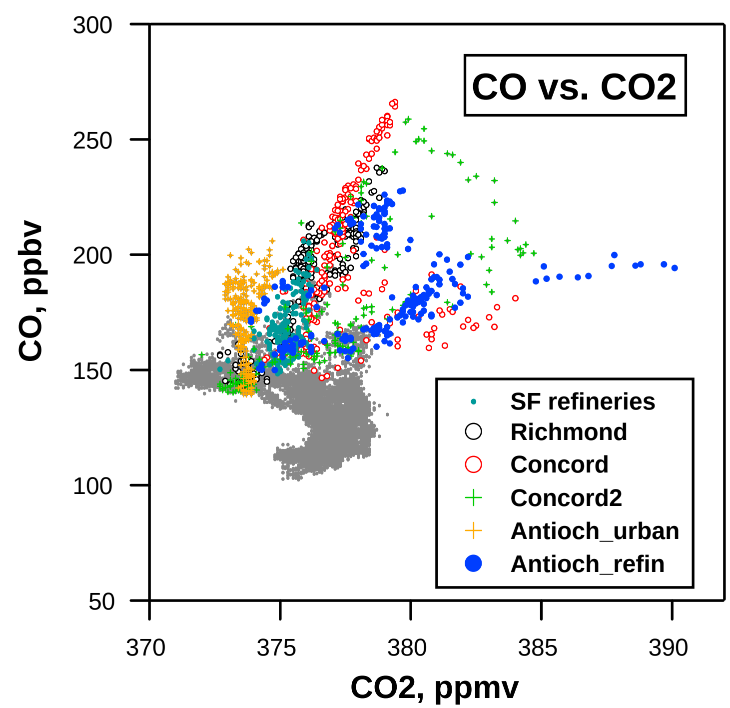

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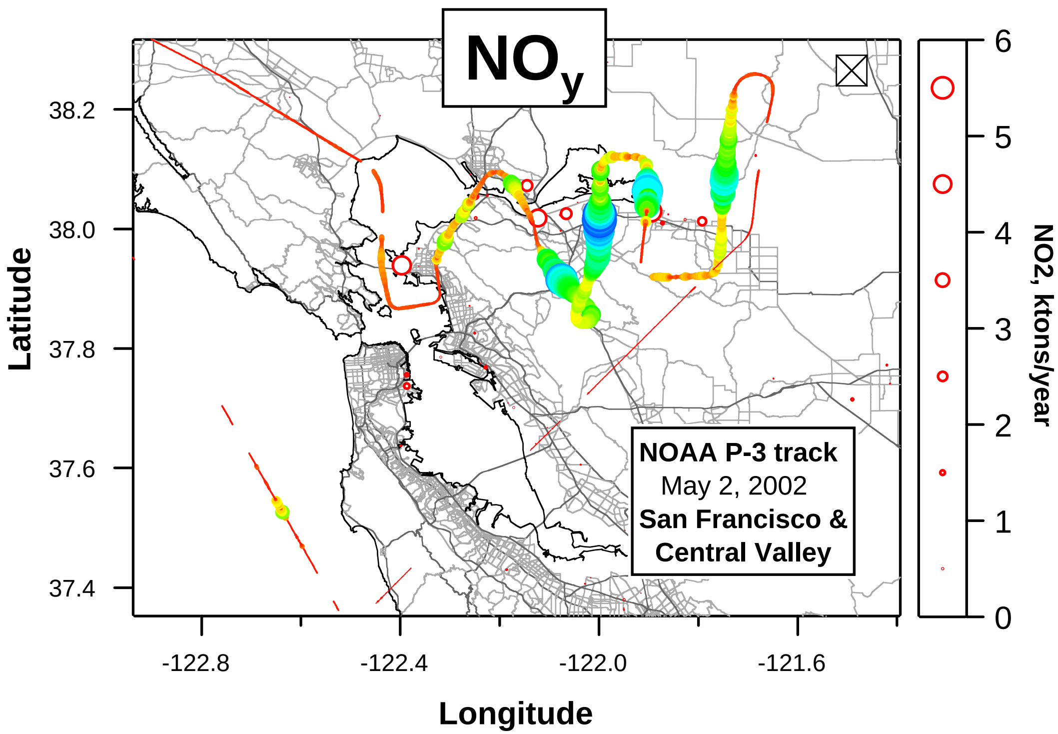

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- differentiate between sources
- differentiate transport pathways
- quantify chemical processing

More emissions study details at 1:40 in Greg Frost's talk

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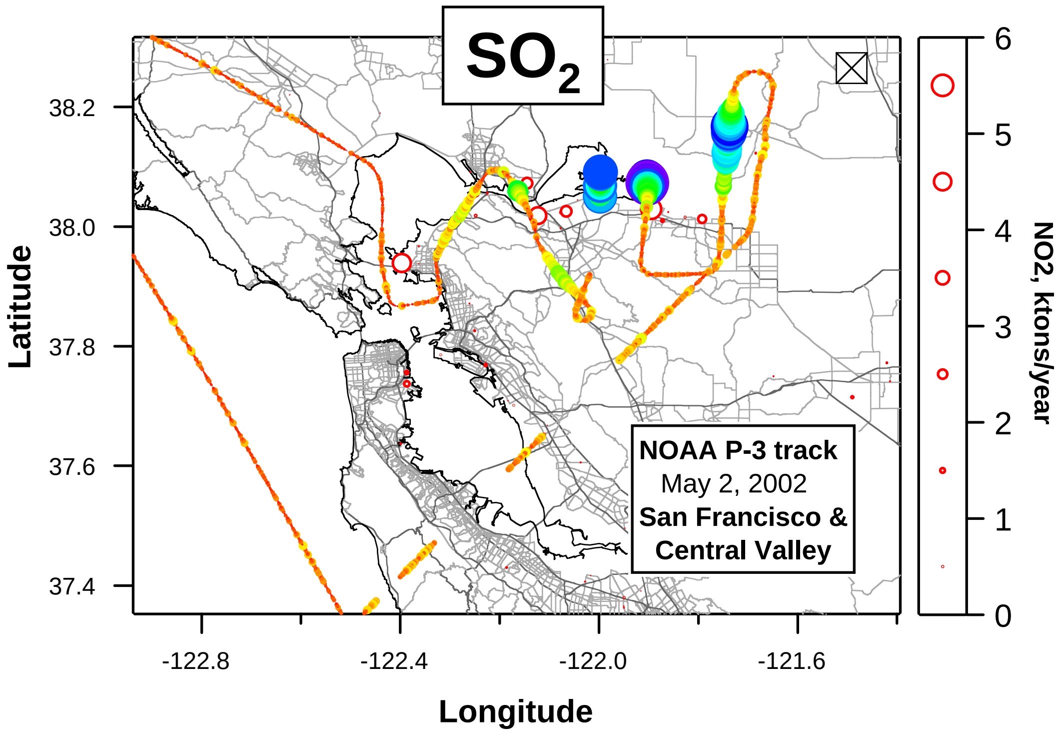

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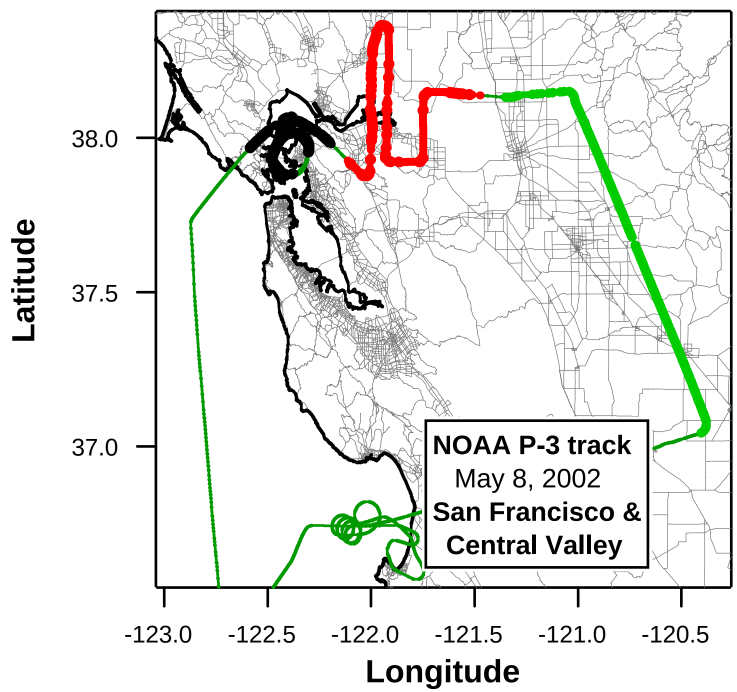
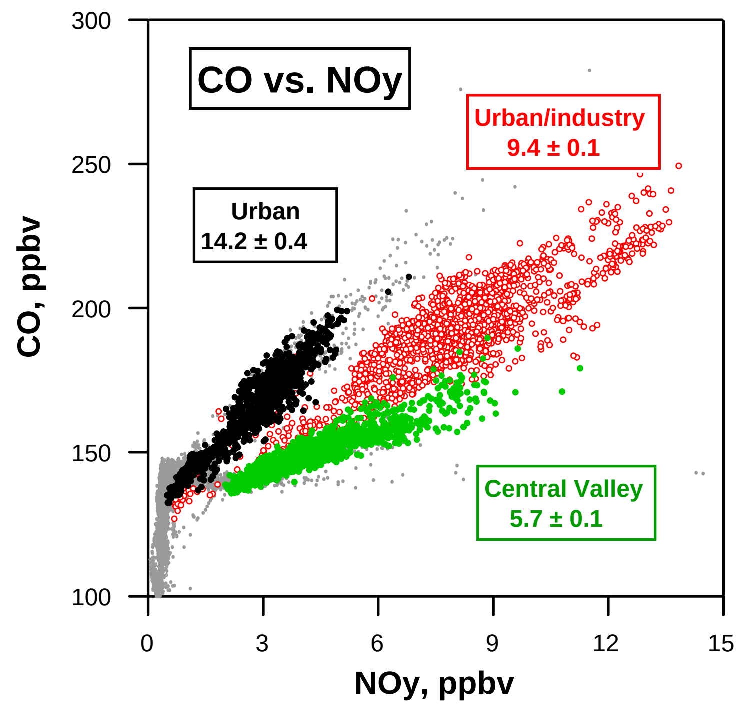
Can we quantify NO_x, NH_3, CH_4, & N_2O emissions from the agricultural sector?

include Imperial Valley flights
compare to satellite columns





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Stoichiometry of CH_4 and CO_2 flux in a California rice paddy

Andrew M. S. McMillan,[1] Michael L. Goulden,[1] and Stanley C. Tyler[1]

Received 12 March 2006; revised 27 September 2006; accepted 19 October 2006; published 3 February 2007.

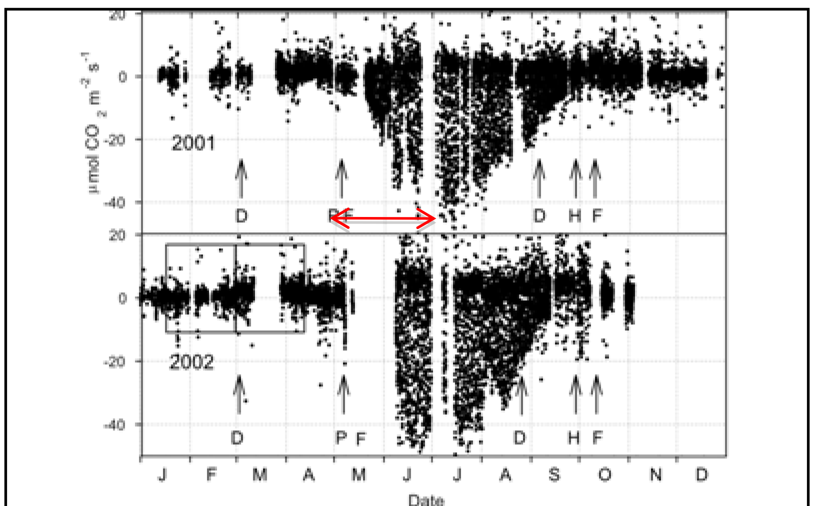

Figure 3. Half-hourly values of F_{CO2} for 2.8 years. A negative value indicates the loss of CO_2 from the atmosphere to the crop. Arrows indicate timing of planting (P), crop harvest (H), post-harvest flooding (F) and drainage prior to planting or harvest (D). The two boxes in the bottom panel indicate the 45-day period prior to drainage when the daily average of F_{CO2} was 0.3 μmol m^{-2} s^{-1} (left box) and the 45-day period after drainage when the daily average of F_{CO2} was 1.7 μmol m^{-2} s^{-1} (right box).

Agricultural emissions

A wealth of existing data that we are not fully up to speed on

Blake VOC sampling grids and 2008 ARCTAS DC-8 data show the high spatial variability of sources

SJV supersite will anchor P-3 flights

repeat P-3 flights through growing season to observe increase in ag. activity over time

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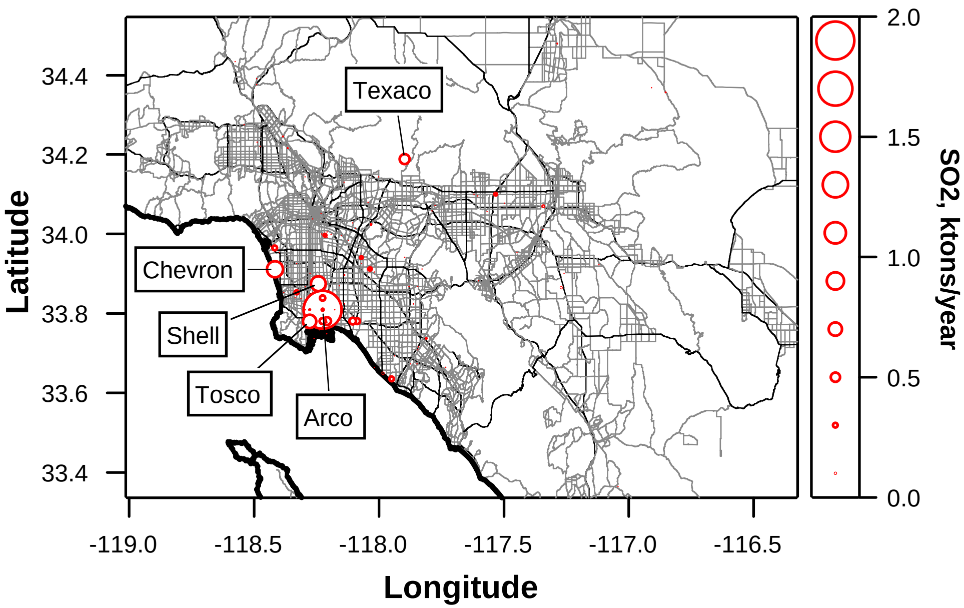
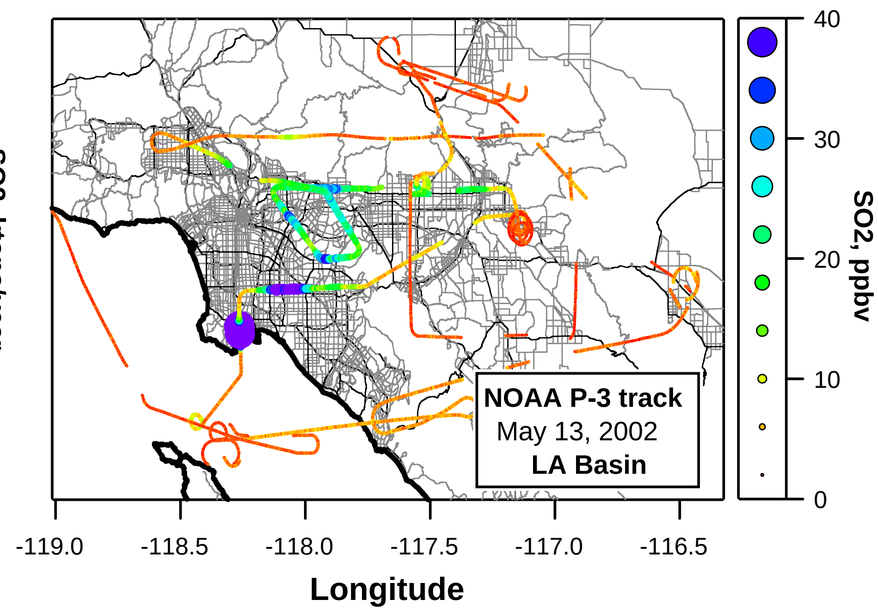
Quantifying sulfur budget of LA Basin & SF

SO_2 from shipping, industry, and mobile sources *vs.* DMS from phytoplankton





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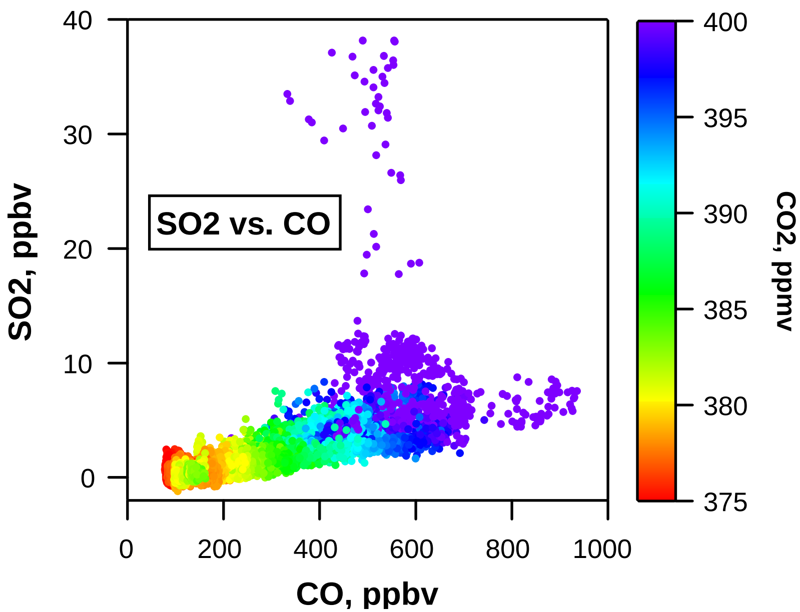

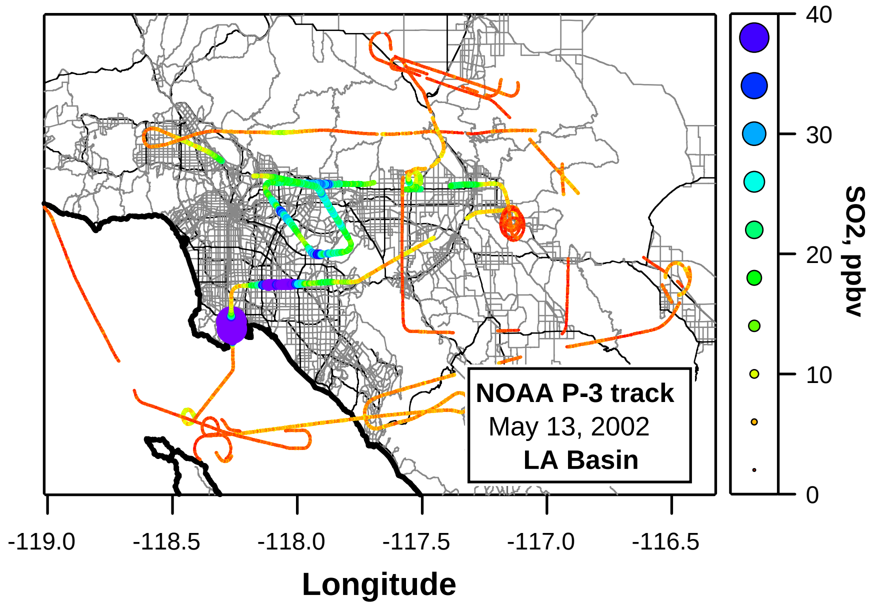

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D. How important are chemical processes occurring at night in determining transport and / or loss of nitrogen oxides, reactive VOC and ozone? Do regional models in California adequately represent these processes and their effect on air quality?

E. What are the sources and physical mechanisms that contribute to high ozone concentrations aloft that have been observed in Central and Southern California?

F. Are there significant differences between Central Valley and South Coast Air Basin precursors or ozone formation chemistry? Will meteorological and/or precursor differences between the Central Valley and the South Coast Air Basin lead to different chemical transformation processes and different responses to emissions reductions? What is the importance of natural emissions to the ozone formation process? Are there regional differences in the formation rates and efficiency for particulate matter as well?

G. What are the impacts of aerosols in California on radiative forcing and cloud formation? What are the most important precursors and formation processes for secondary

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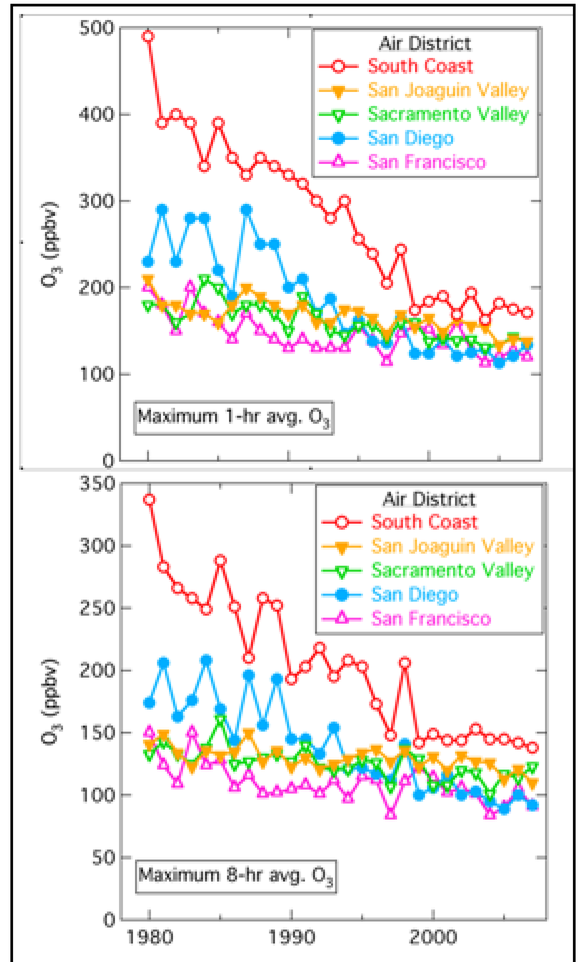
Processing studies

→ Oxidation rates and secondary product formation
LA-SJV differences?



- Use P-3 to connect LA and SJV supersite observations during CalNex
- Emissions mixes are quite different between the two basins
- How will this be reflected in differences between secondary photoproducts?
  P-3: *O_3, HCHO, CH_3CHO, OVOCs, $RONO_2$, PANs, (PAN/HNO_3), etc.*

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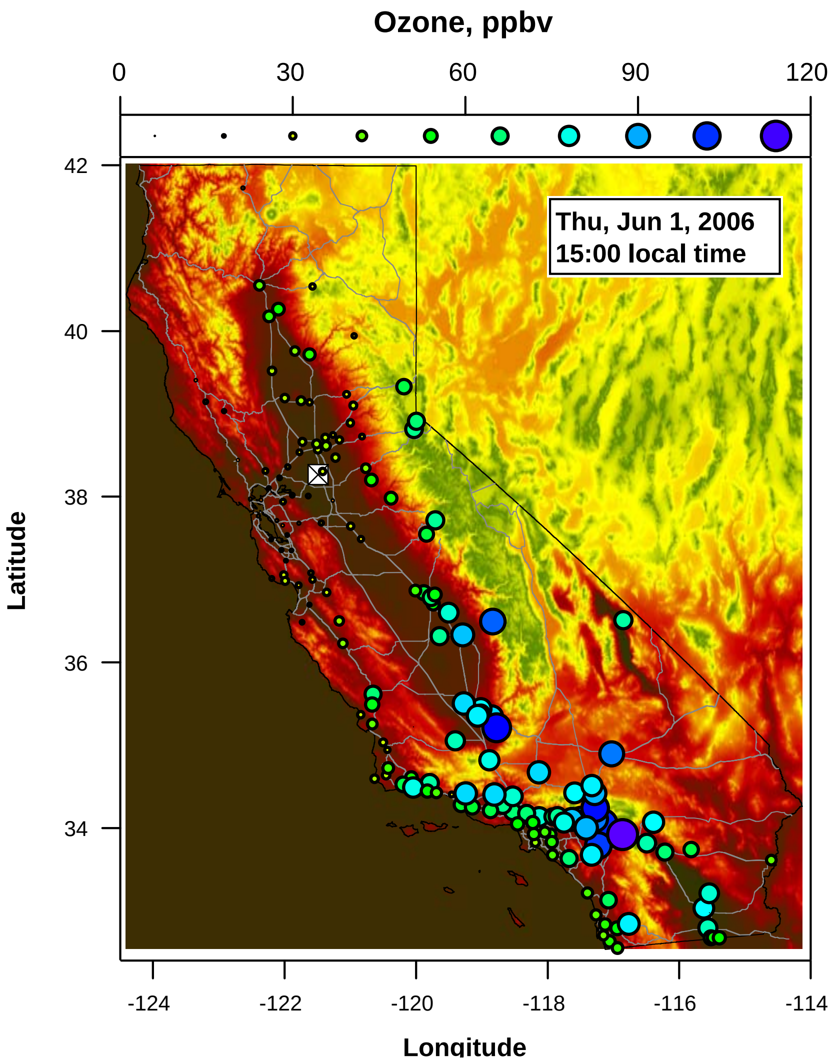

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Nocturnal chemistry and transport

Aerosol-cloud interactions

Central Valley aging and layers aloft

Repeatedly sample fresher vs. more oxidized air within South Coast and Central Valleys in the mixed layer & aloft (day and night flights)

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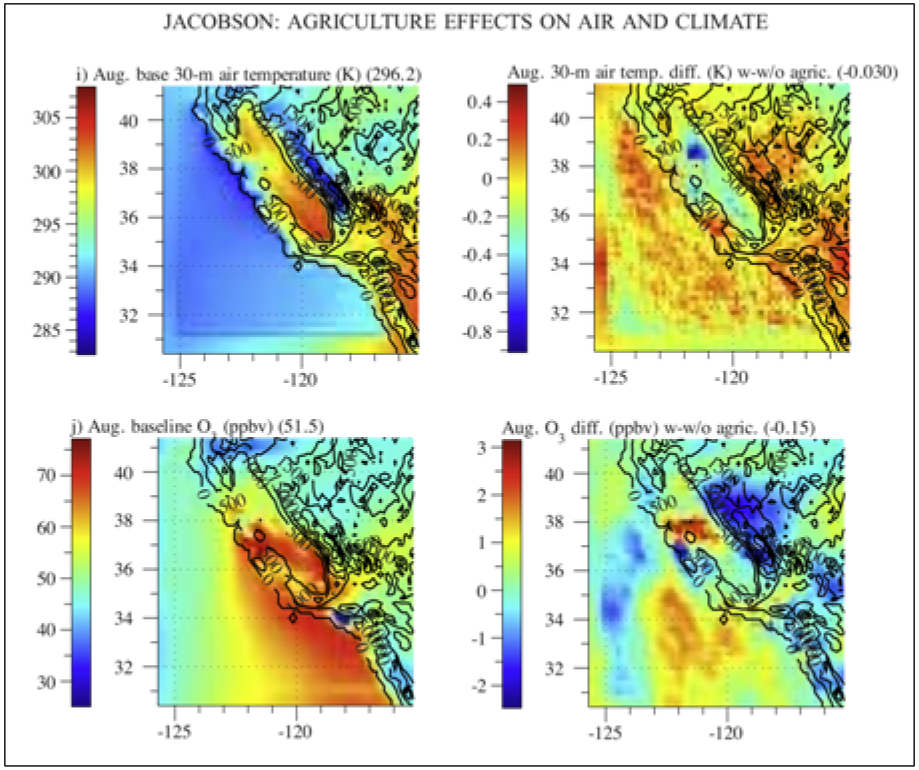

Opportunity for studying multiday events (day – night – day studies)

Frontal passage (rare, but they do happen) gives a chance to observe pollutant buildup after clearing out

Basin exchange times from multiple looks

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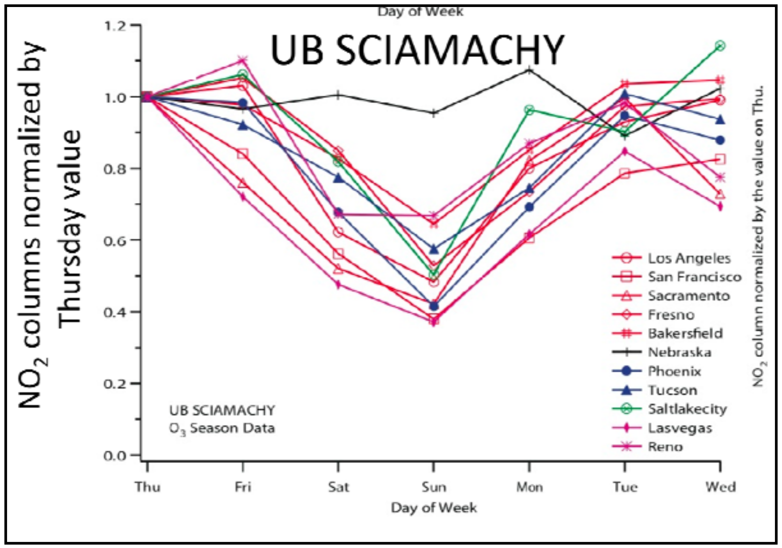
Satellite-derived day-of-week differences in California urban total NO_2 columns



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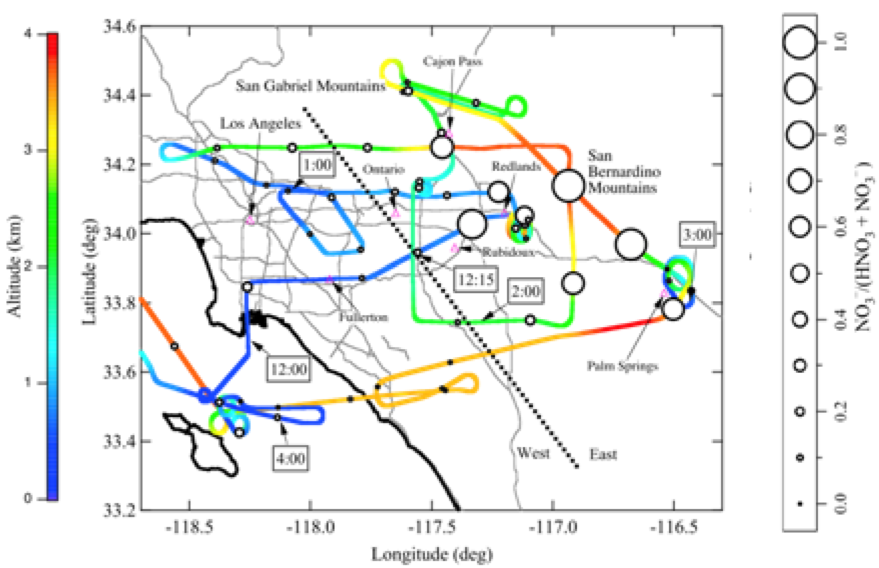
NEUMAN ET AL.: PARTICLE FORMATION OVER CALIFORNIA



LA aerosol and ozone formation

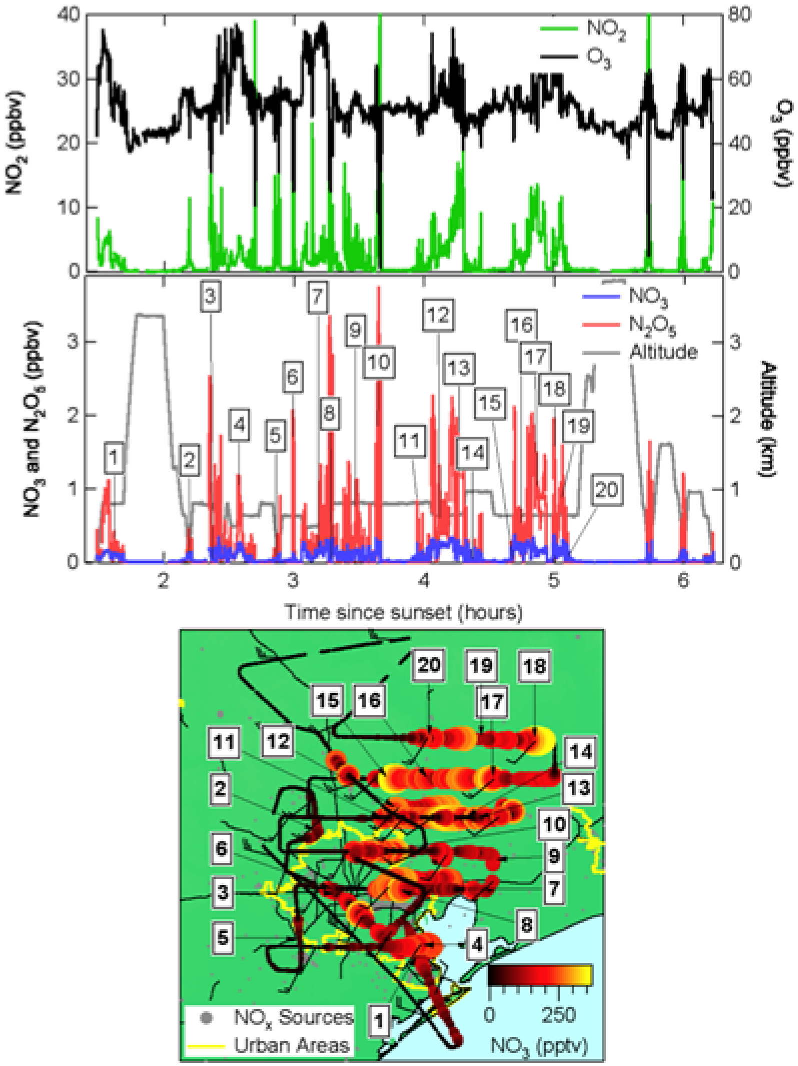
Transects upwind and above LA ground site; continue through Riverside and downwind

Should have measurements that fully constrain
$NH_3 + HNO_3 \Leftrightarrow NH_4NO_3$

The P-3 in 2010 will bring aerosol extinction, absorption, and soot mass to this classic aging experiment

Using the P-3 to address CalNex science questions

Example of nighttime data
(Houston, 2006)



Processing studies

Oxidation rates and secondary product formation
LA-SJV differences?

Gas-to-particle conversion of HNO_3 and NH_3

→ Nocturnal chemistry and transport

Aerosol-cloud interactions

Nighttime chemistry of NO_3 and N_2O_5

Sample urban plumes aloft after dark

determine $\gamma(N_2O_5)$ on NH_4NO_3 particles

evaluate NO_x and O_x loss vs. transport

study VOC sinks and halogen activation

Details at 10:50 in Steve Brown's talk

Using the P-3 to address CalNex science questions

Transport and Meteorology

H. **What are proper oceanic boundary conditions** for coastal and regional atmospheric chemistry modeling? Are there variations in oceanic boundary conditions in northern and central California vs. the southern part of the state? What physical and chemical changes occur as a parcel of air moves from off-shore, through the shore zone, and inland?

I. **How best can we characterize and model air flow** over coastal waters and the complex terrain of California? For example: what is the best representation of air flow in the southern San Joaquin Valley, particularly with respect to flow between the San Joaquin Valley and South Coast Air Basin versus recirculation north along the Sierra Nevada and Coastal ranges?

J. **What are the major deficiencies in the representation of chemistry and meteorology in research and operational models** and how can models be improved through the collection of additional measurements? What physical and chemical processes are not captured well by available models? Is there an optimum grid resolution to capture all of the relevant physical and chemical processes that occur?

K. **What are the important transport corridors for key chemical species** and under what conditions is that transport important?

L. **What are the relative roles of regional (North American) sources and long range transport (from East Asia) on aerosol forcing over California?**

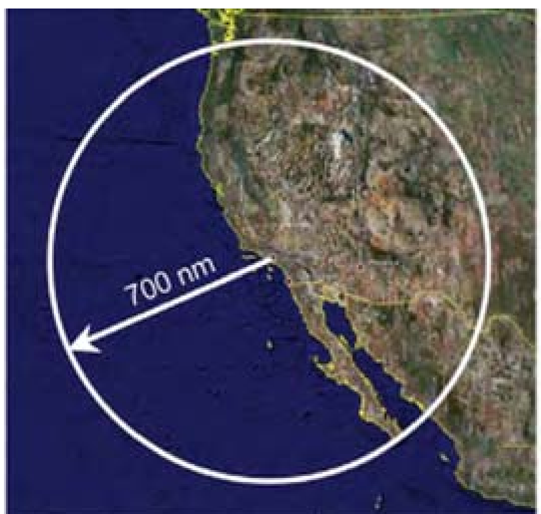
Climate change and air quality problems have both global and regional scale aspects that interact through atmospheric transport. Critical uncertainties remain in our understanding of these interactions.

Transport studies

→ use chemical measurements to define pathways for export of LA Basin and Central Valley pollution

characterize residual layers aloft after dark

quantify relative contributions of orographic lifting and gap flows to transport within California



P-3 research mission range

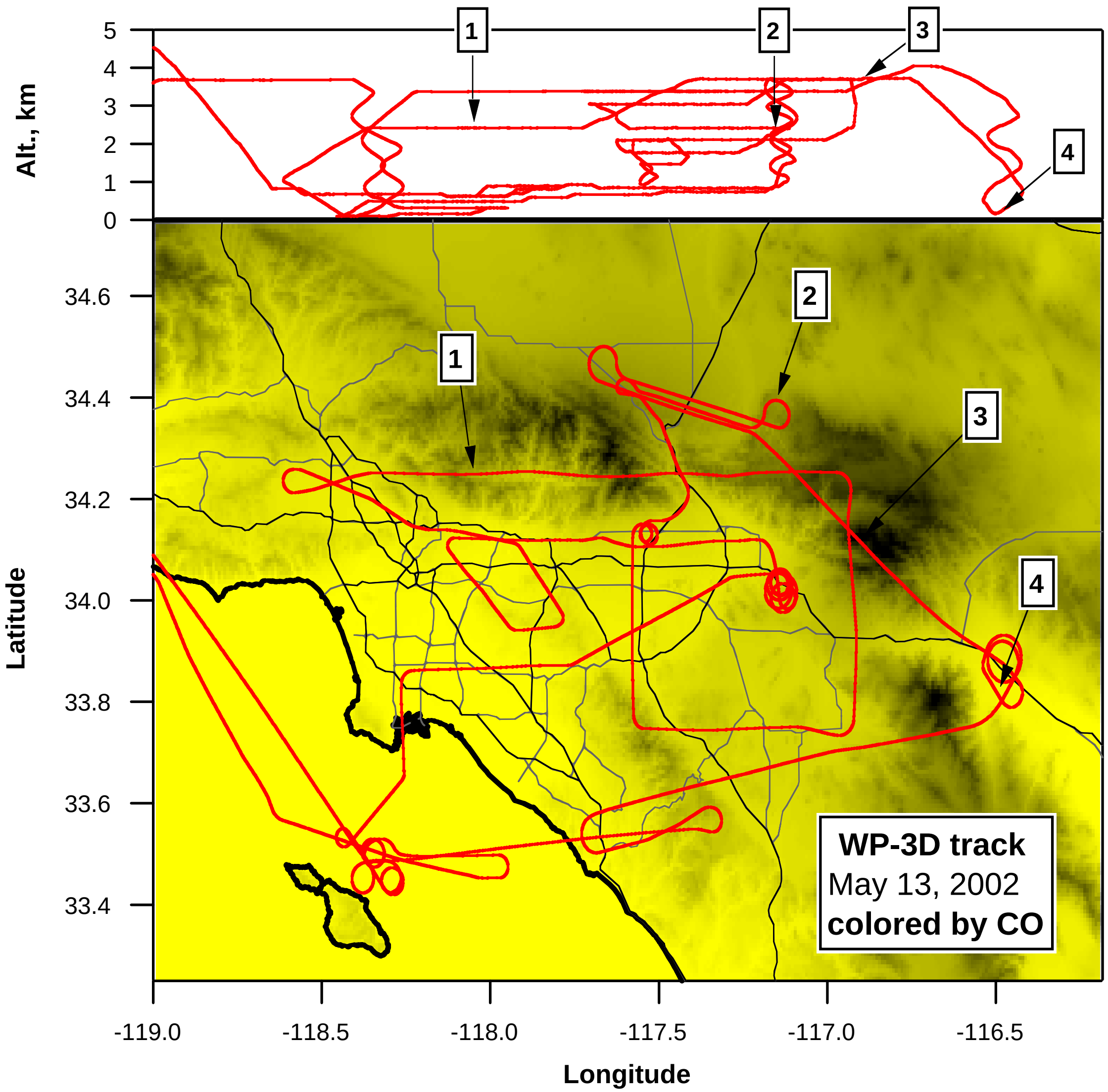
8+ hours endurance

700 nm radius

(including vertical profiles)

We plan to repeatedly visit most of California, as science goals dictate (not just an LA Basin experiment)

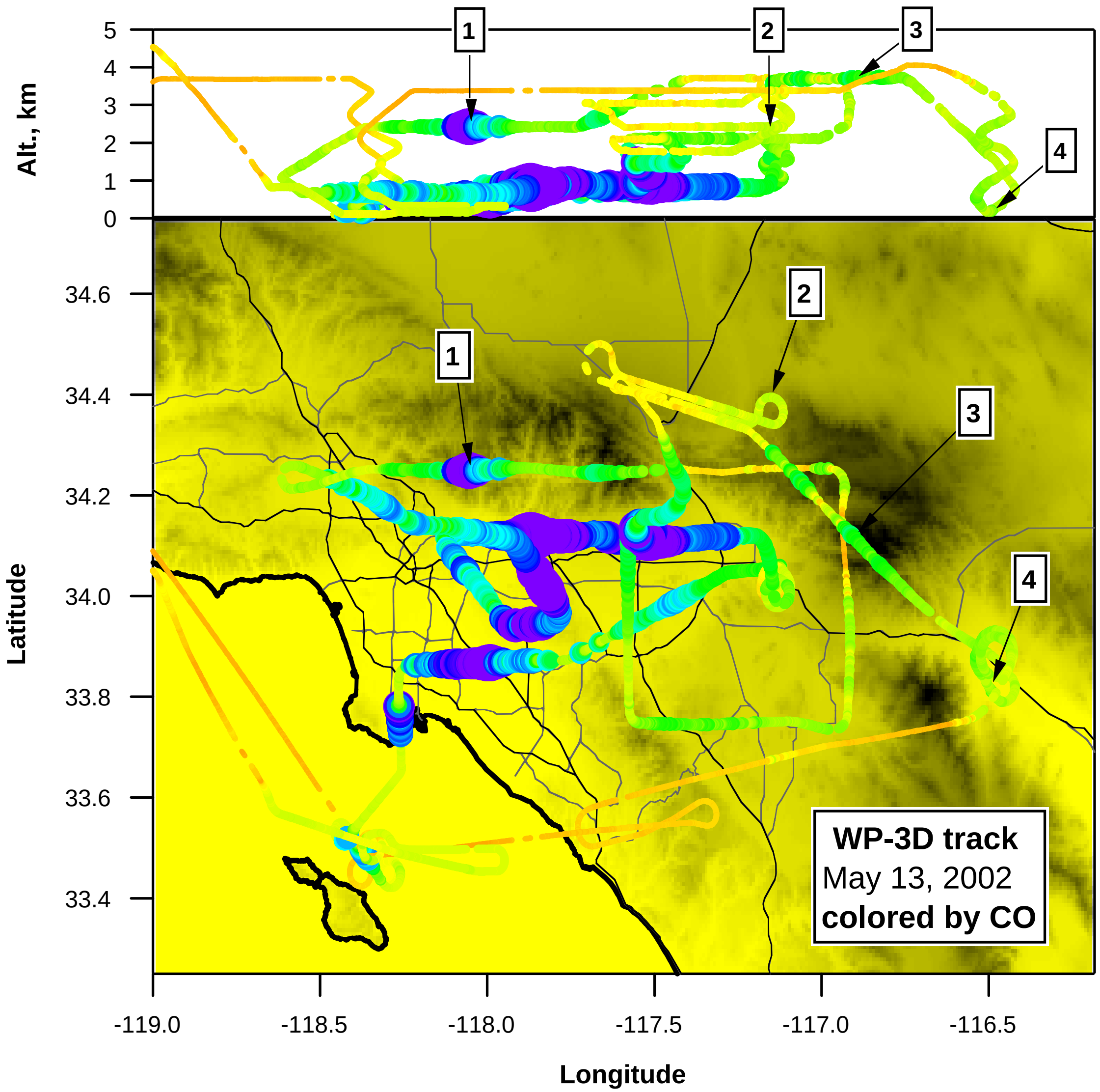
Using the P-3 to address CalNex science questions



Transport studies

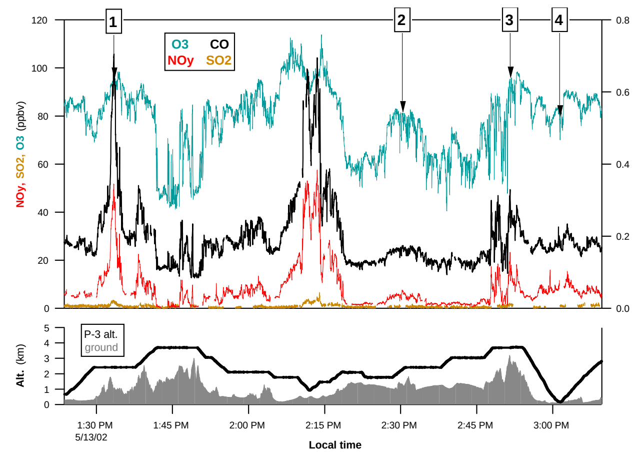
use chemical measurements to define pathways for export of LA Basin and Central Valley pollution

Using the P-3 to address CalNex science questions



Transport studies

use chemical measurements to define pathways for export of LA Basin and Central Valley pollution



Chem. data shows export is highly variable in time

- need vertical profiles over same locations at different times e.g., near Catalina & over San Bernardino Mountains

Repeat often to build stats; even better with several aircraft

Using the P-3 to address CalNex science questions

Lidar Observation of Elevated Pollution Layers over Los Angeles*

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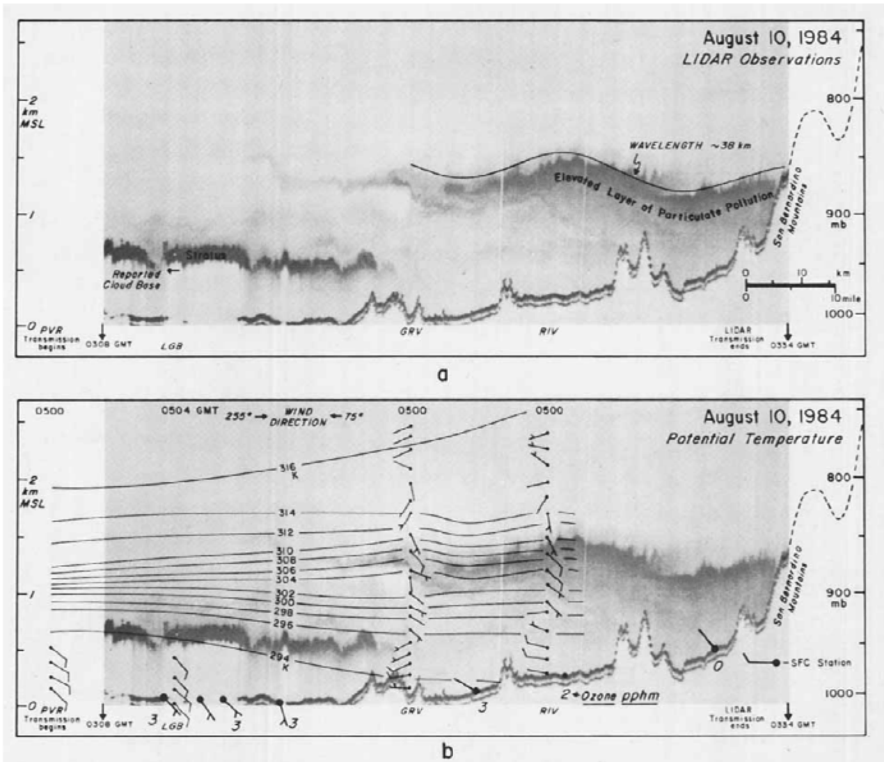
(Manuscript received 25 January 1986, in final form 26 April 1986)

ABSTRACT

Elevated pollution layers are observed over Los Angeles with an aircraft equipped with a downward-looking lidar. For the first time, detailed ancillary upper-air kinematic and thermodynamic data were collected simul-

NOVEMBER 1986 ROGER M. WAKIMOTO AND JAMES L. MCELROY 1595



Transport studies

use chemical measurements to define pathways for export of LA Basin and Central Valley pollution

- Long history of studying transport aloft in the LA Basin:

- 1984 UCLA/EPA airborne lidar

Using the P-3 to address CalNex science questions

Airborne analysis of the Los Angeles aerosol

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4162 D.R. Collins et al. / Atmospheric Environment 34 (2000) 4155–4173

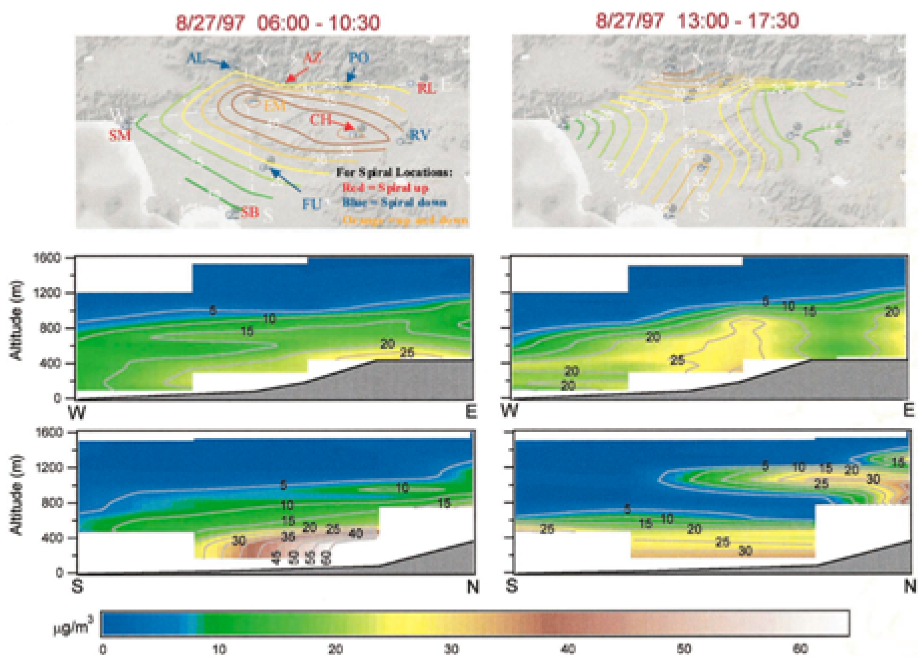


Fig. 3. Distribution of PM2.5 throughout the Los Angeles basin as sampled during morning and afternoon flights on 27 August. The top plots show contours of near-ground-level aerosol mass as well as the east–west (E–W) and north–south (N–S) cross sections used in the image plots shown below. As indicated in the 27 August contour plot, spiral locations are Altadena (AL), Azusa (AZ), Chino (CH), El Monte (EM), Fullerton (FU), Pomona (PO), Rialto (RL), Riverside (RV), Santa Monica (SM), and Seal Beach (SB). Represented in the image plots is PM2.5 interpolated from adjacent spirals. The solid gray area at the bottom of each of the image plots represents the approximate ground level.

Transport studies

use chemical measurements to define pathways for export of LA Basin and Central Valley pollution

- Long history of studying transport aloft in the LA Basin:

- *1984 UCLA/EPA airborne lidar*

- *1997 Caltech/CIRPAS in-situ aerosol measurements*

- Hope to extend existing studies by joint work with NOAA Twin Otter airborne lidar, CIRPAS Twin Otter aerosol, and combined aerosol and gas-phase data from the NOAA P-3

Using the P-3 to address CalNex science questions

The P-3 can address many CalNex study goals independently.

- emissions characterization
- chemical processing
- transport and mixing

However, most or all of the planned P-3 studies will <u>greatly</u> benefit from:

- close coordination with other mobile platforms and ground sites
- vertical context provided by remote sensing data
- temporal context provided by longer-term ground site data & modeling
- <u>input from the experienced CA research community</u>
  e.g., local meteorology, agricultural emissions,
  3D CTMs, ...

Our aim is to maximize joint efforts without undue strain on anyone.

CalNex Proposal from Caltech: CIRPAS Twin Otter

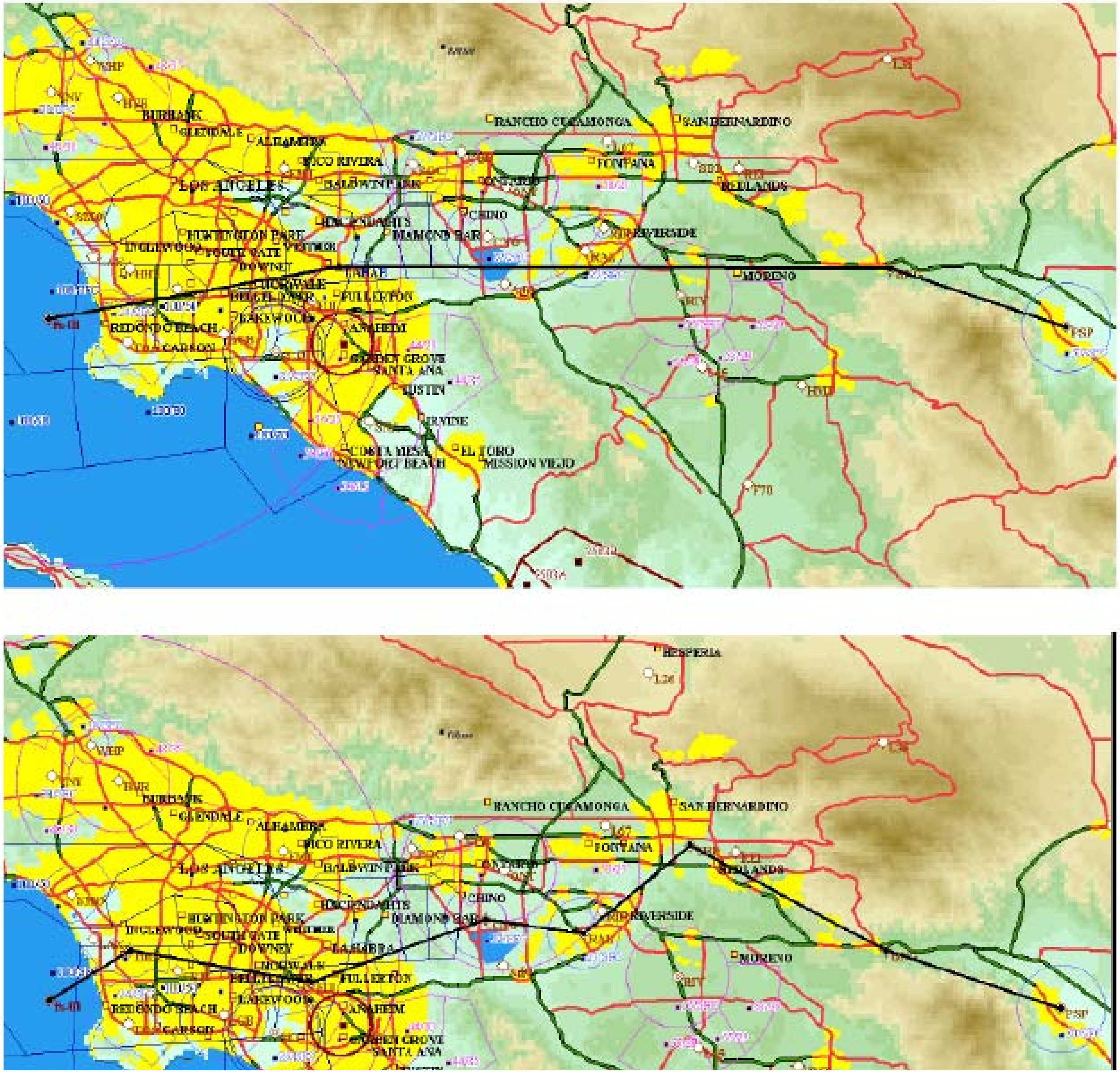
John Seinfeld, P.I.

"very likely" to be funded through NOAA ACCP extramural grants program

focus on SOA formation

Table 1. Proposed CalNex 2010 Twin Otter instrument payload

Parameter	Instrument	Time Resolution	Detection Limit	Size Range
Particle Number Concentration	Condensation Particle Counter (TSI CPC 3010)	1 s	0-10,000 cm^{-3}	$D_p \geq 10$ nm
	Condensation Particle Counter (TSI CPC 3025)	1 s	0-100,000 cm^{-3}	$D_p \geq 3$ nm
Aerosol Size Distribution	Scanning differential mobility analyzer	73 s	N/A	10-700 nm
	Radial differential mobility analyzer		N/A	
	Passive Cavity Aerosol Spectrometer Probe (PCASP)	1 s	N/A	0.1-2.6 μm
Aerosol Bulk Ionic Composition and Soluble Organic Composition	Particle-Into-Liquid Sampler (PILS)	5 min	0.02-0.28 $\mu g/m^3$	1 μm
Aerosol Bulk Composition (non-refractory species)	Aerodyne Compact Time-of-Flight Aerosol Mass Spectrometer (CToF-AMS)	1 s or 15 s	$\leq 0.25\ \mu g/m^3$	40 nm $\leq D_{p,va} \leq 1\ \mu m$
Mass and Coating Thickness of Black Carbon	Single Particle Soot Photometer (SP2)	Particle-by-particle	6×10^{-16} g BC < 5000 cm^{-3}	90-600 nm
Aerosol Hygroscopicity	Differential Aerosol Sizing and Hygroscopicity Spectrometer Probe (DASH-SP)	15 – 100 s	N/A	135 nm $\leq D_p \leq 1\ \mu m$
CCN Distribution	CCN spectrometer (DMT)	~ 1s		
Soot Absorption	Particle Soot Absorption Photometer (PSAP)	≥ 1 s	N/A	N/A
Aerosol Refractive Index and Shape	Mutiangle Light Scattering Spectrometer (MLS)			
Aerosol Absorption Coefficient	Photoacoustic Soot Spectrometer (PASS-1) (DMT)	1 s	50 ng/m^3 1 Mm^{-1}	10 nm – 5 μm
Aerosol Single Particle Composition	Aerosol Time of Flight Mass Spectrometer (ATFOMS)	Particle-by-particle	m/z 2000	70 nm – 1 μm



Anticipate Caltech/ CIRPAS Twin Otter operations from an LA Basin airport during May-June 2010

Joint work with other aircraft TBD

Caltech/CIRPAS bring critical experience, measurements, and analysis tools to the CalNex study

Figure 1. Two potential flight paths over the greater Los Angeles area. Each path could include "touch and go" maneuvers at a number of small airports, in order to obtain vertical profiles of aerosol properties.