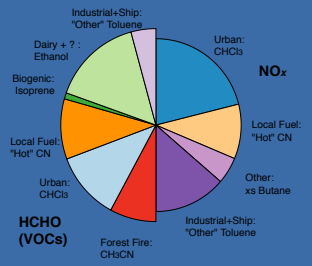


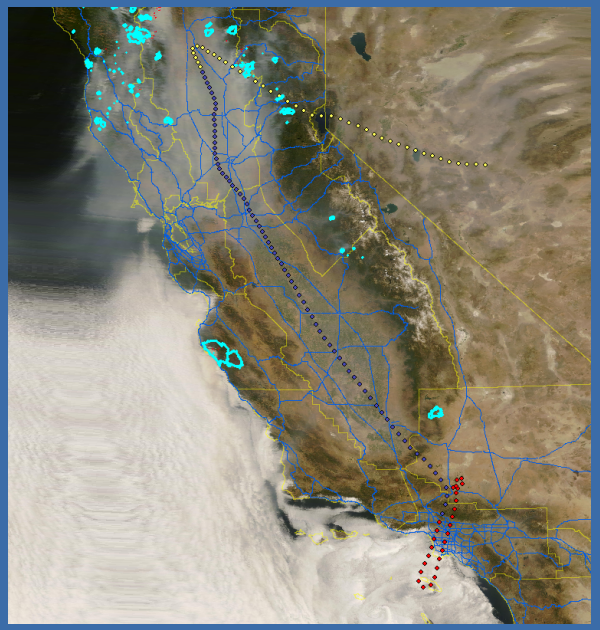
Improved Estimation of Air-Quality Impacts of Wildfires

Robert B Chatfield
NASA's
Ames Research Center
Moffett Field, CA 94035 USA

650-604-5490
Robert.B.Chatfield@nasa.gov

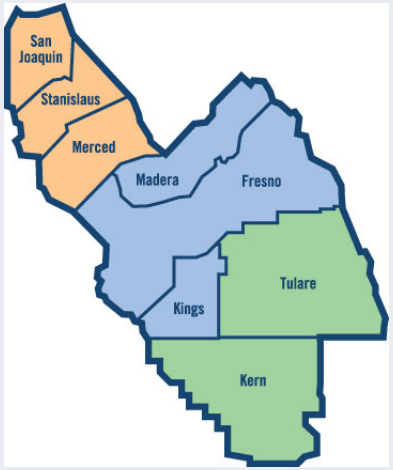
Hanwant Singh and
Laura Iraci
NASA's Ames Research Center
Moffett Field, CA 94035 USA

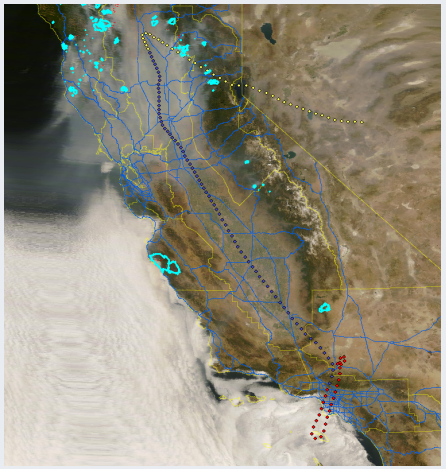
and Cal-ARB,
NRL, and Ames Partners



How do fire emissions and others interact?

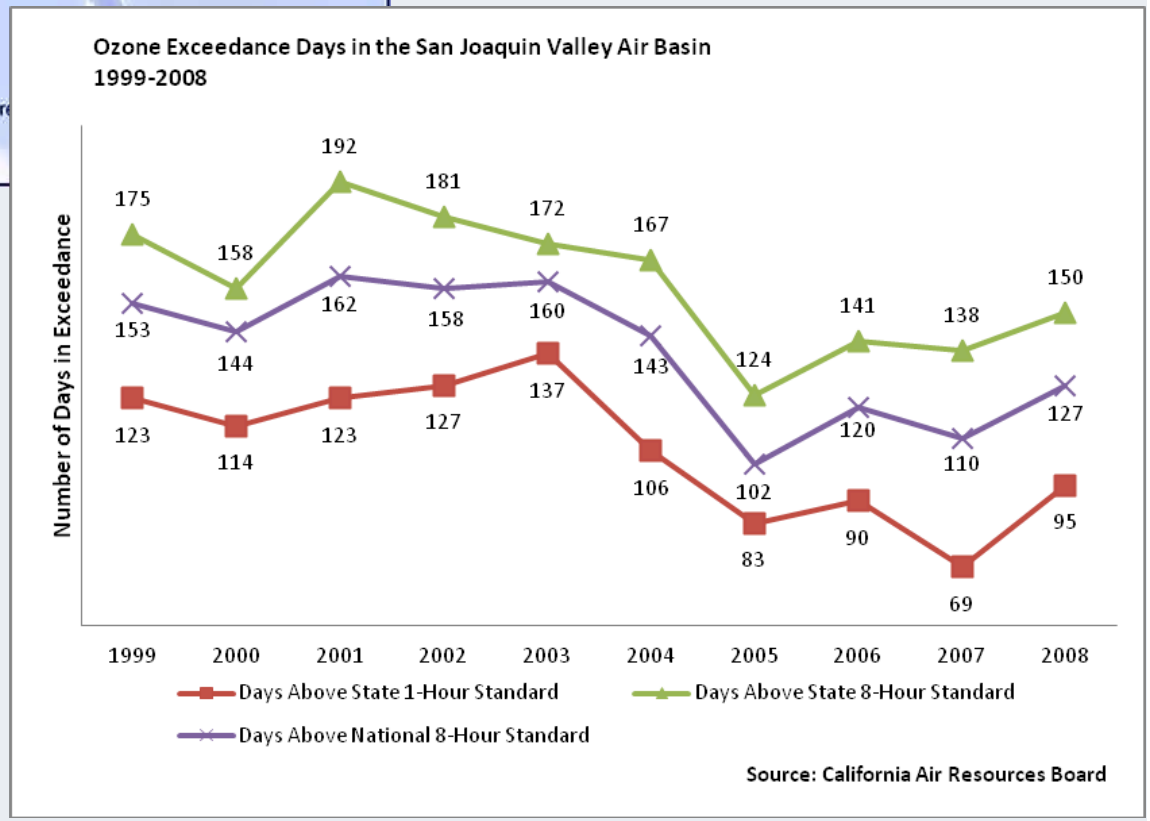
Improved Air Quality Simulations for San Joaquin Valley



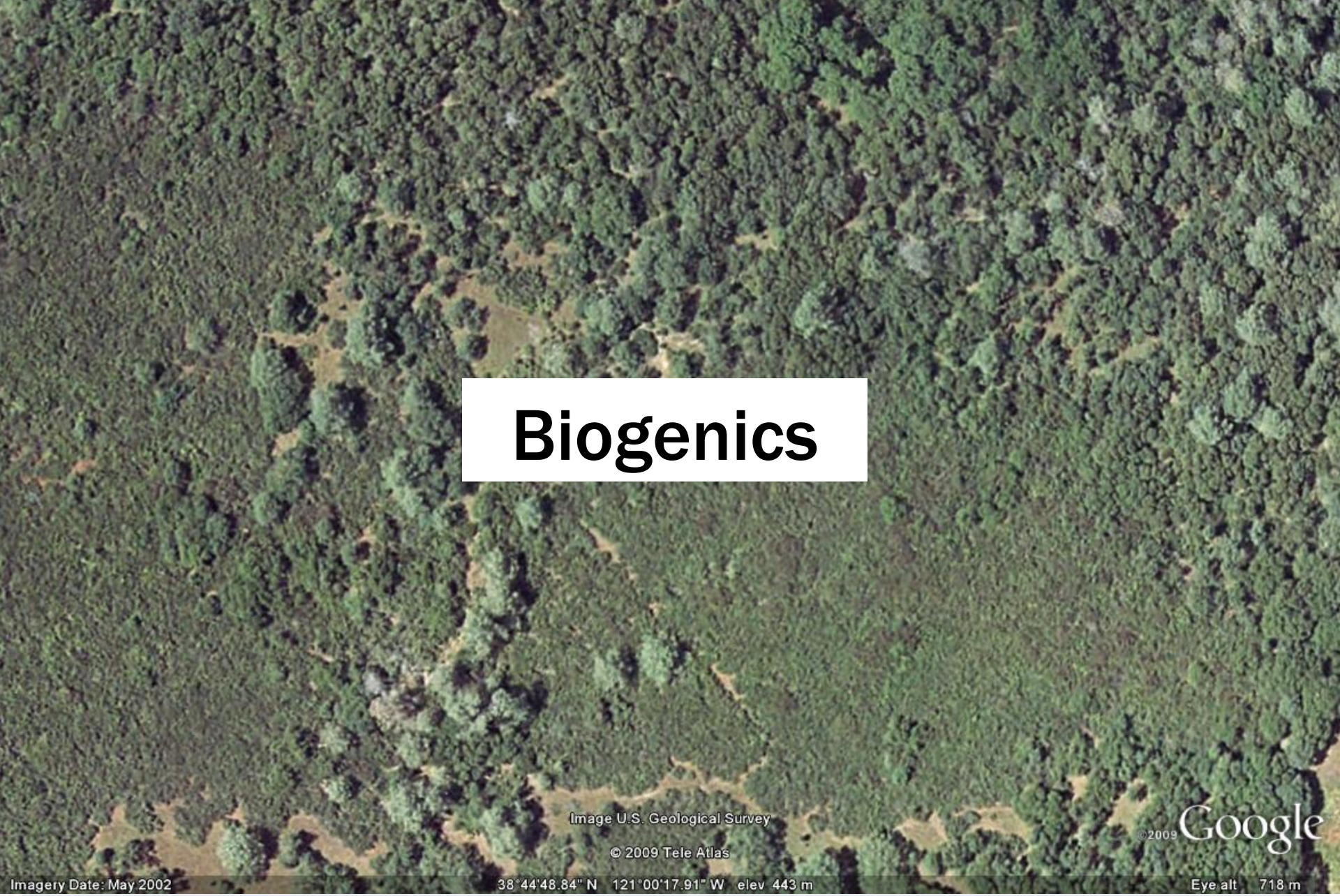


- Significant challenges air pollution and health for "SJq." Air quality has resisted some improvements seen in LA and S. Coast
- Poor pulmonary health in the central cities (Fresno) is well known
- Out-of-compliance for both ozone and particles ($PM_{2.5}$)
- A very large amount of time, effort (and confusion) is taken in assessing "exceptional events," particularly with fires (these situations can combine some fire with other influences)

- While the number of ozone exceedance days are gradually decreasing on average, the San Joaquin Valley continues to have the highest proportion of people at risk. When coupled with poor air quality that is often worse than other California regions, people in the San Joaquin Valley experience the highest proportional decline in health overall.




Wild Fires


Biogenics
Image U.S. Geological Survey
© 2009 Tele Atlas
©2009 Google
Imagery Date: May 2002
38°44'48.84" N 121°00'17.91" W elev 443 m
Eye alt 718 m

Courtesy

Improved Air Quality Simulations for San Joaquin Valley

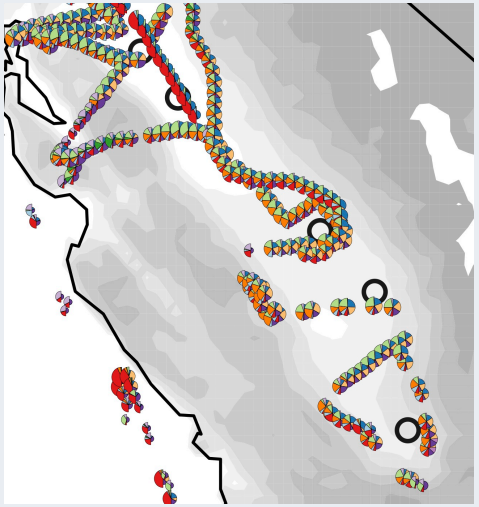
- Ames has a Space Act Agreement with the San Joaquin Valleywide Air Quality Study Agency to improve modeling of fire emissions effects on O_3

Study Agency Contacts
Jennifer Ridgway
Air Quality Specialist/Forecaster
San Joaquin Valley APCD

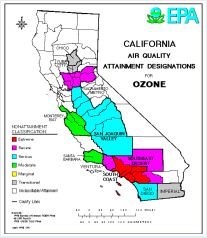
Ajith Kaduwela, Cal-ARB

The Agency has governmental (SJVAPCD, Cal-ARB) and non-governmental members, so the S.A.A/ was the vehicle

  - However …
- The control district does run some simulations, but depends on the central California Air Resources Board ("Cal-ARB") for formulation and simulation
- So, our direct client is at Cal-ARB
- Results will extend to all of CA, perhaps Western US



Our main cooperatinging client is California-Air Resources Board



Ajith Kaduwela
Manager Regional Air Quality Modeling Section
California Air Resources Board
Sacramento, CA

ARB Team
Ajith Kaduwela, lead modeler
Chenxia Cai*
principle CMAQ modeler
Sarika Kulkarni, developing WRF

(Works from Southern California)

Clearly, most collaboration is by video-con

Ames Team
… Robert Esswein, analyst/programmer
Hanwant Singh, analysis/emissions-composition
Laura Iraci – lofting, editing
Vince Ambrosia, James Brass – fire behavior
Robert Chatfield - "Lord High Everything Else"

Other advisors/providers:
Edward Hyer (Monterey NRL – emissions)
Christine Wiedenmyer, NCAR – FinnV1 emissions

Our measurement basis: July, 2008 Flights

- Red tracks show DC-8 sampling, all altitudes for June 18, 20, 22, 24, 28 June + 13 July

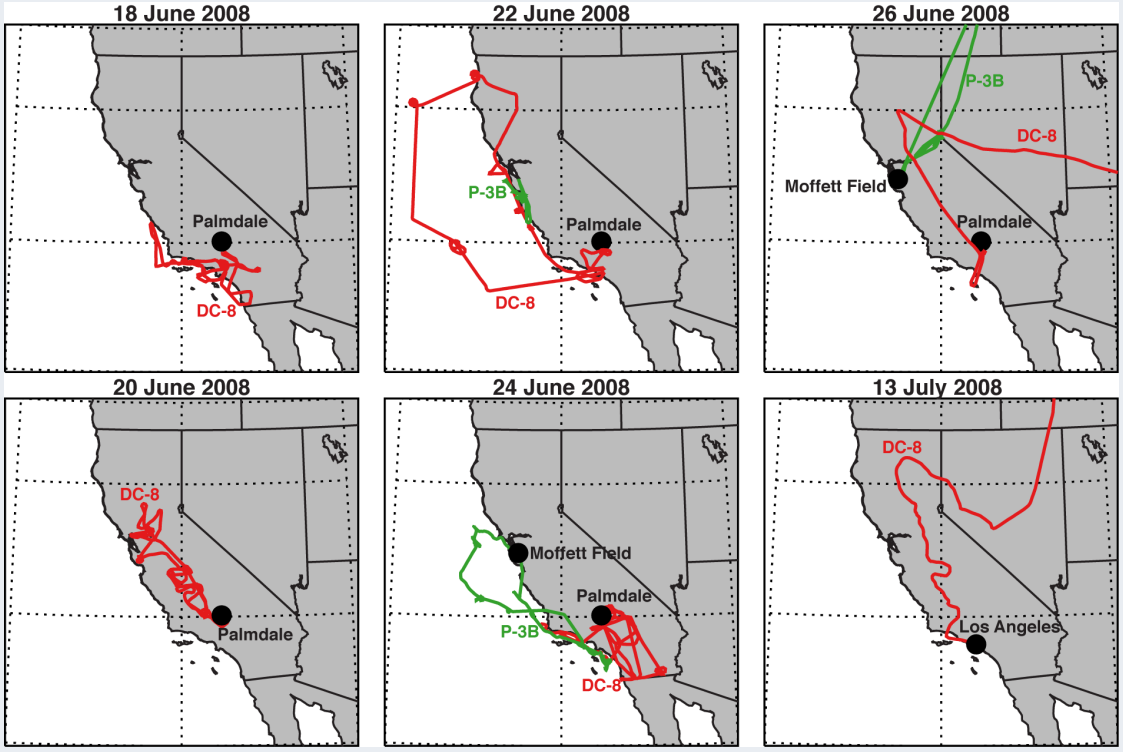
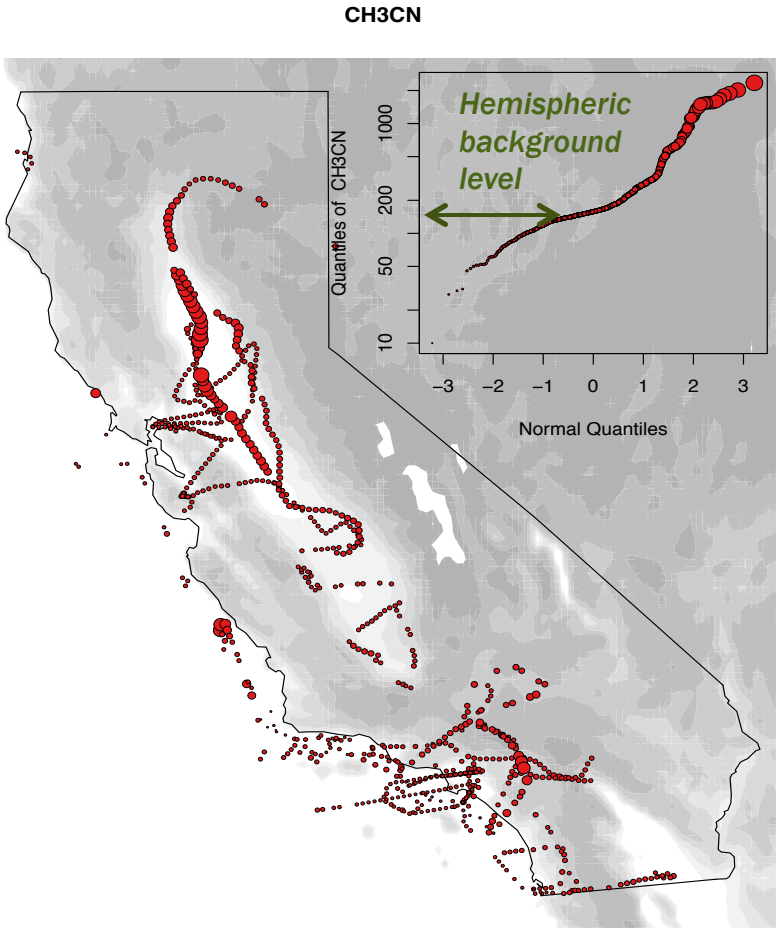
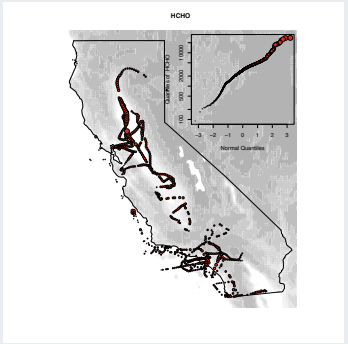
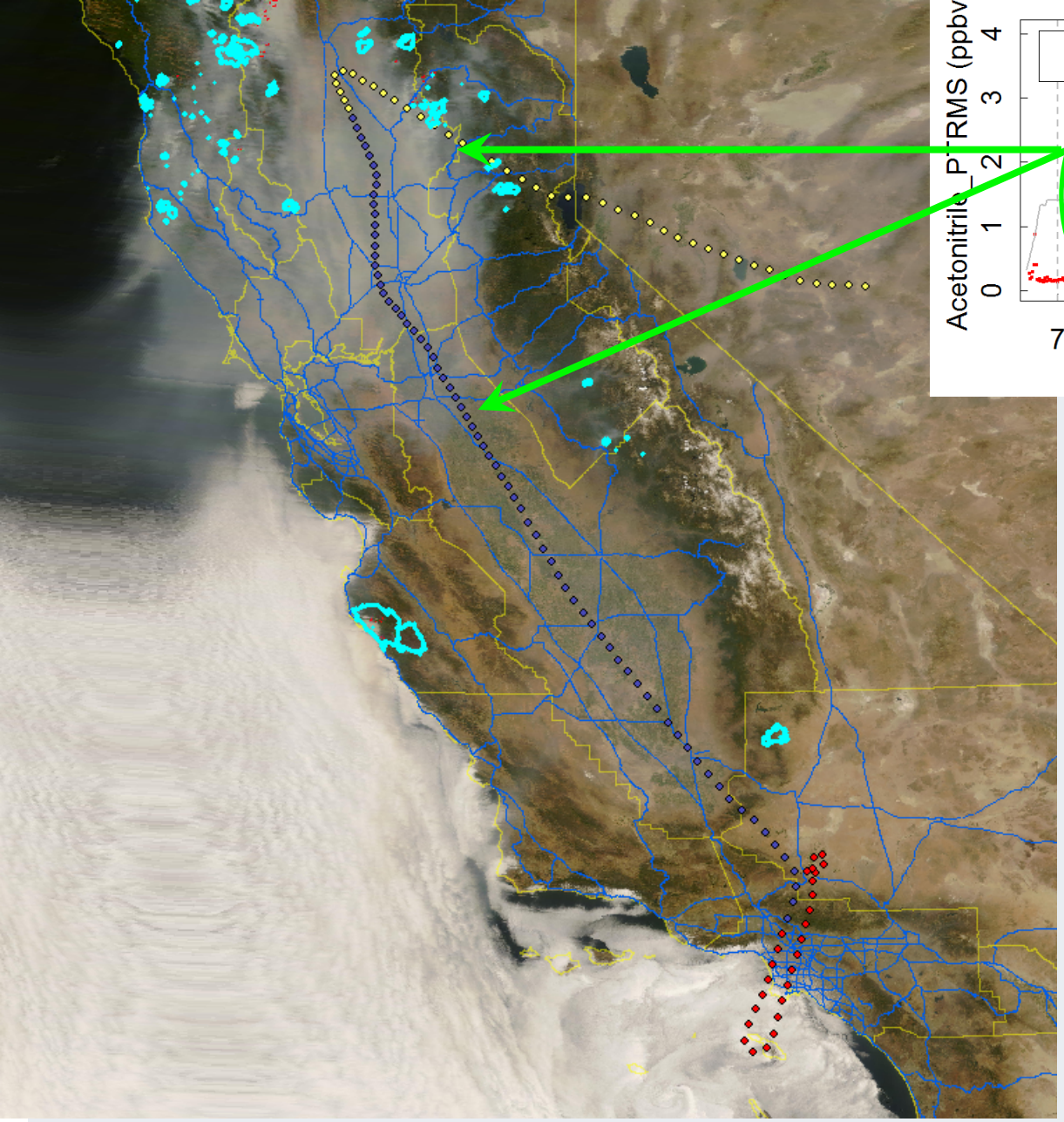


Fig. 1c. Flight tracks for the ARCTAS-CARB deployment (Tables 5a–b).

Our major concern: effect of fire is very clearly signaled by CH_3CN, "acetonitrile" or methyl nitrate

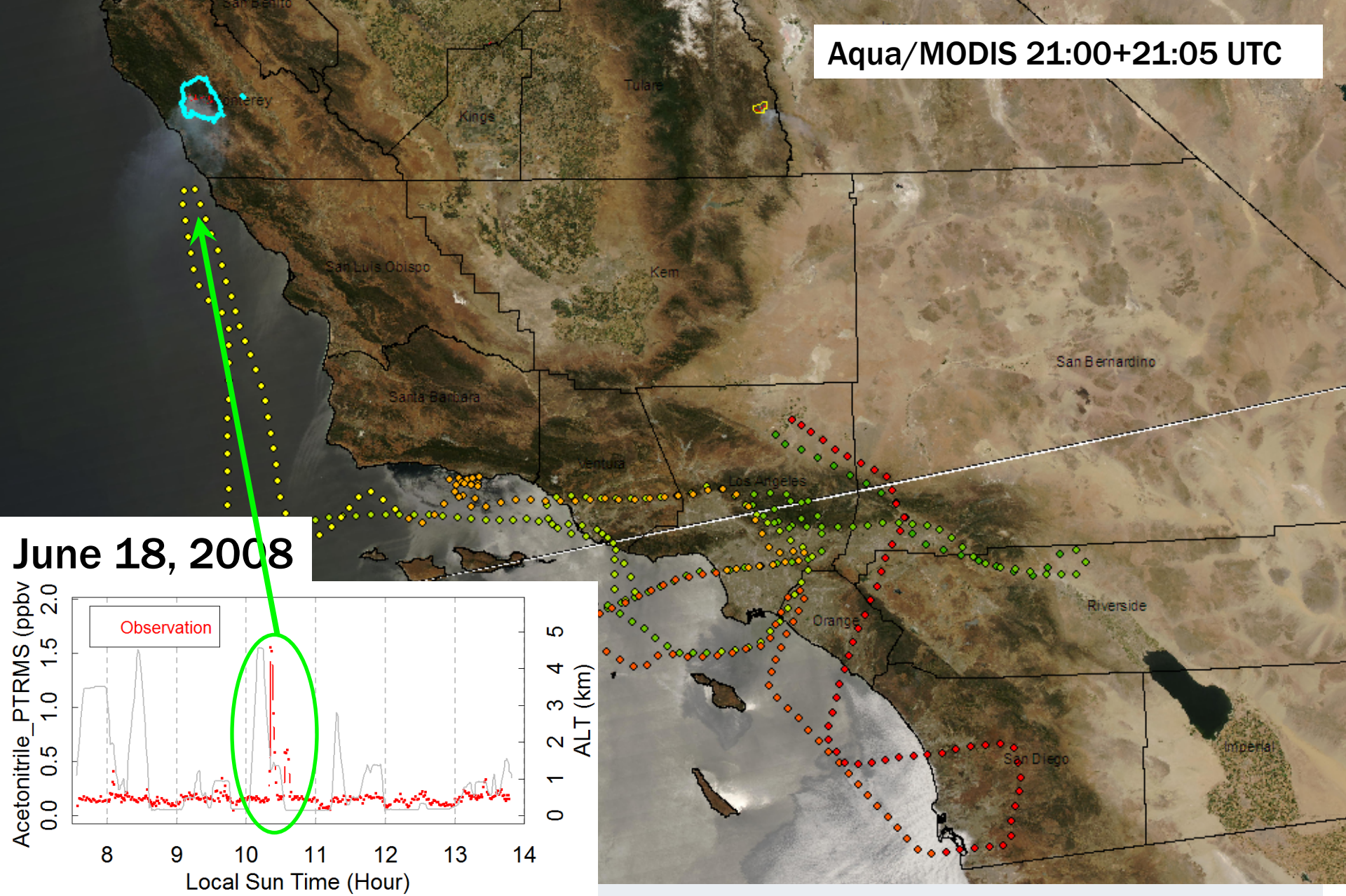


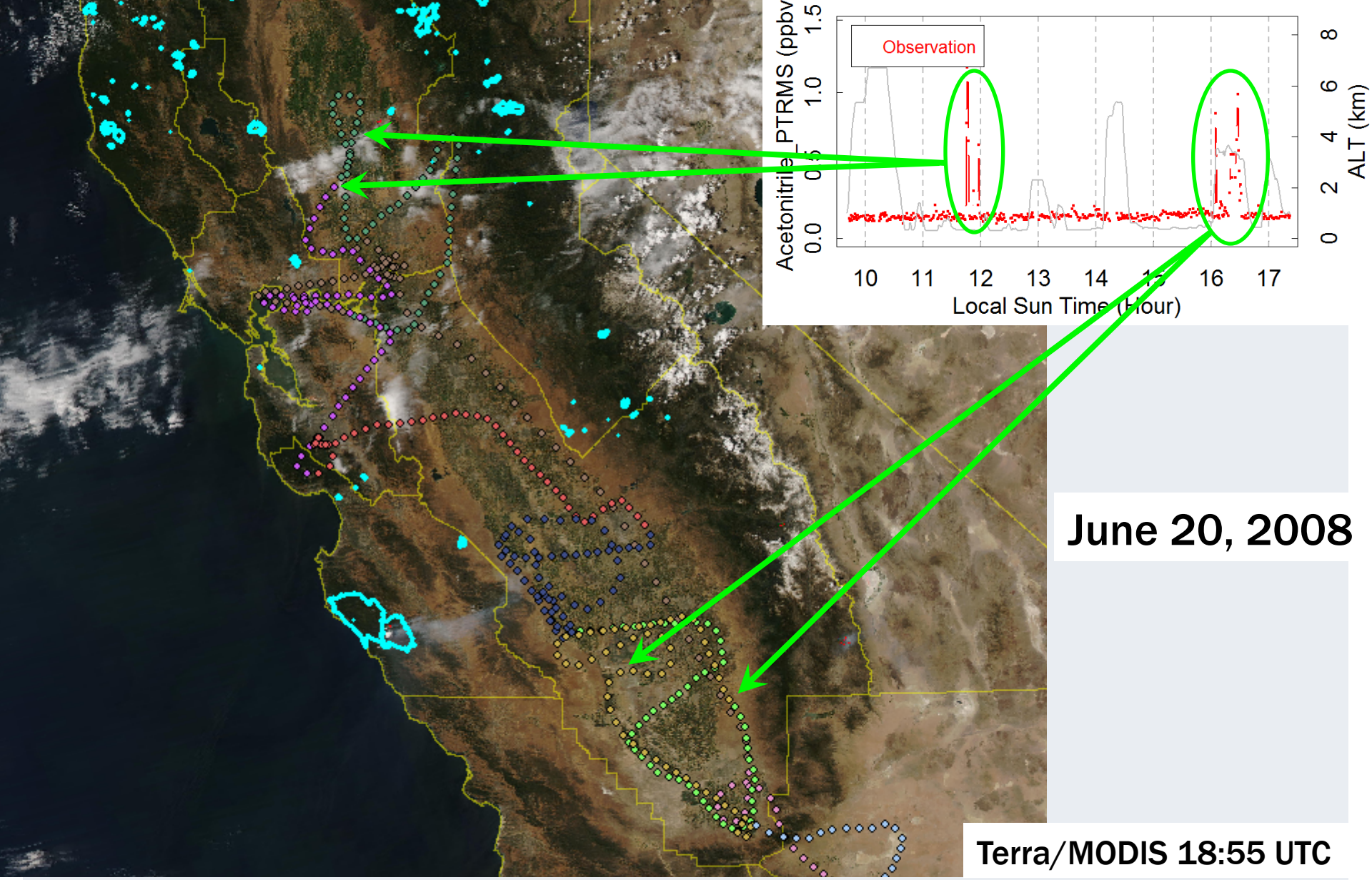




June 26, 2008

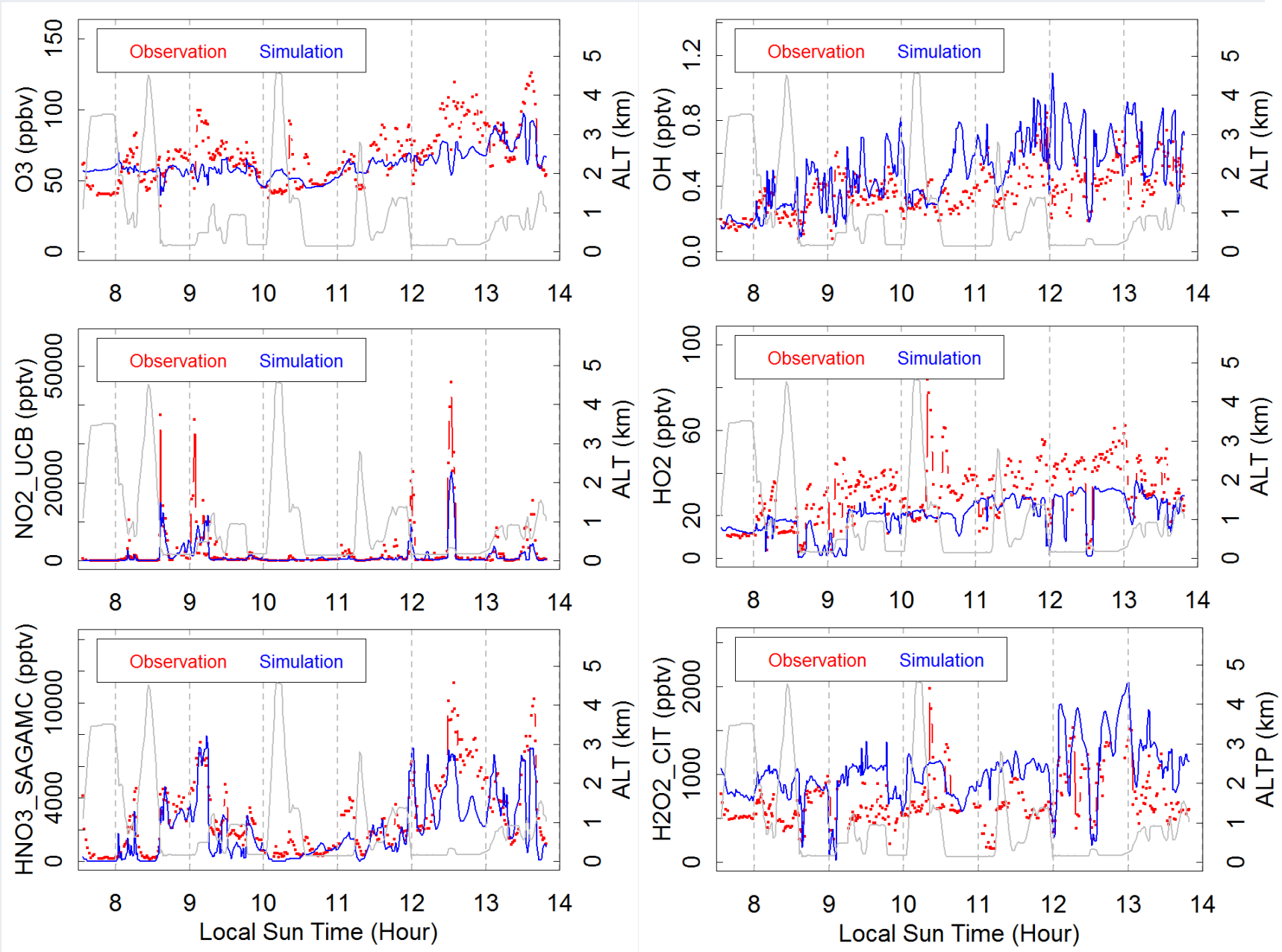
Terra/MODIS 18:30 UTC


Aqua/MODIS 21:00+21:05 UTC
Tulare
Kings
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
June 18, 2008
Observation
Acetonitrile_PTRMS (ppbv
0.0 0.5 1.0 1.5 2.0
ALT (km)
0 1 2 3 4 5
8 9 10 11 12 13 14
Local Sun Time (Hour)


Observation
Acetonitrile_PTRMS (ppbv)
0.0
0.5
1.0
1.5
0
2
4
6
8
ALT (km)
10
11
12
13
14
16
17
Local Sun Time (Hour)
June 20, 2008
Terra/MODIS 18:55 UTC

Precursor Limitations

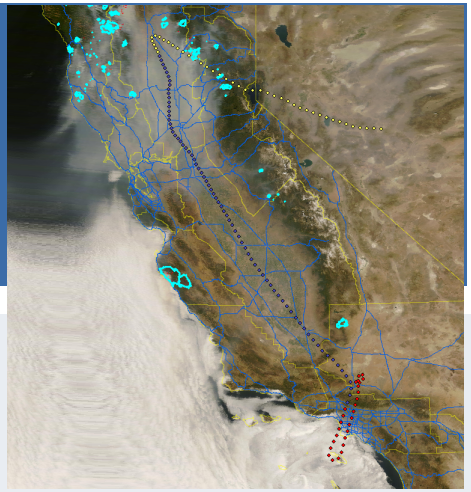
June 18, 2008



VOC and/or NOx Limitations

- Obtained an unprecedented suite of measurements that would allow one to probe inner-workings of chemistry
- Aircraft measurements are not really Lagrangian
- Is the model predicting the correct VOC and/or NOx sensitivity of O_3?
  - Are we now able to test the validity of indicator ratios (or something related to that)? If not, what are we missing (and should be measured during 2010 CalNex)?
  - Is there anything else we can look at?

Current Status and Costing



- Waiting for new Cal-ARB simulations with CMAQ expected by end of month.
- Chenxia Cai has seen unexpected delays in updating CMAQ (new SAPRC reaction set and other modernizations)

CMAQ for California requires integration of both national and California experience: unique meteorological and some emissions challenges

- Publications:

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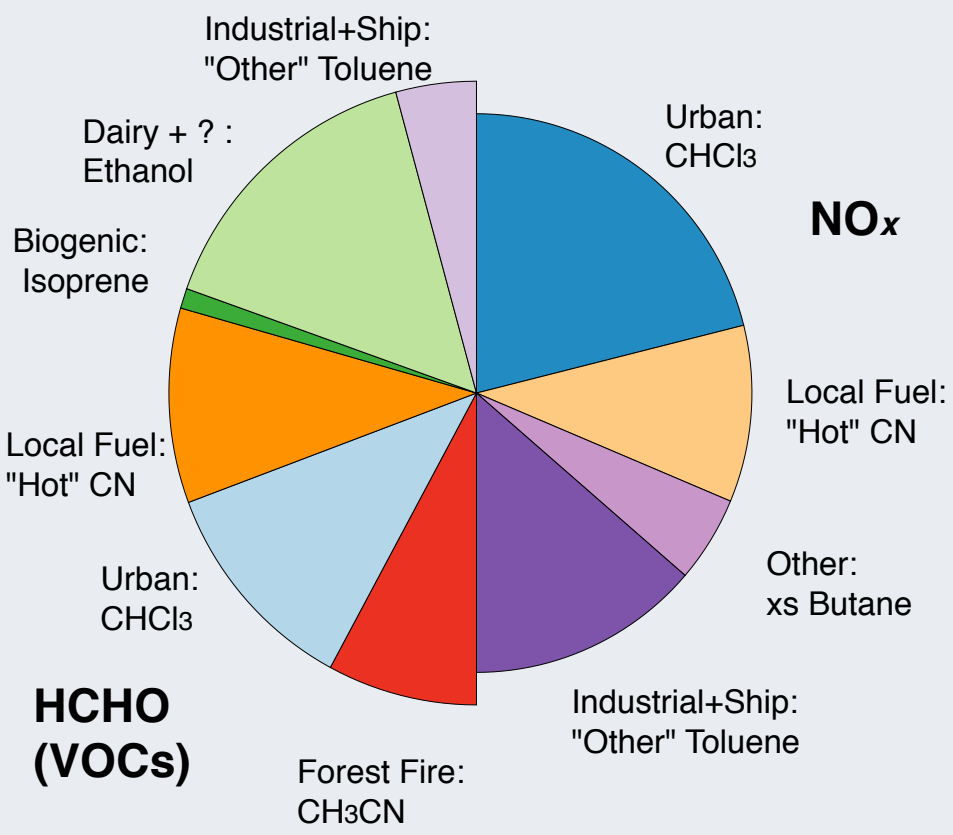
- Costing: Salary support only from Applications:

  Costed $83,387 of $86,654 or 96%

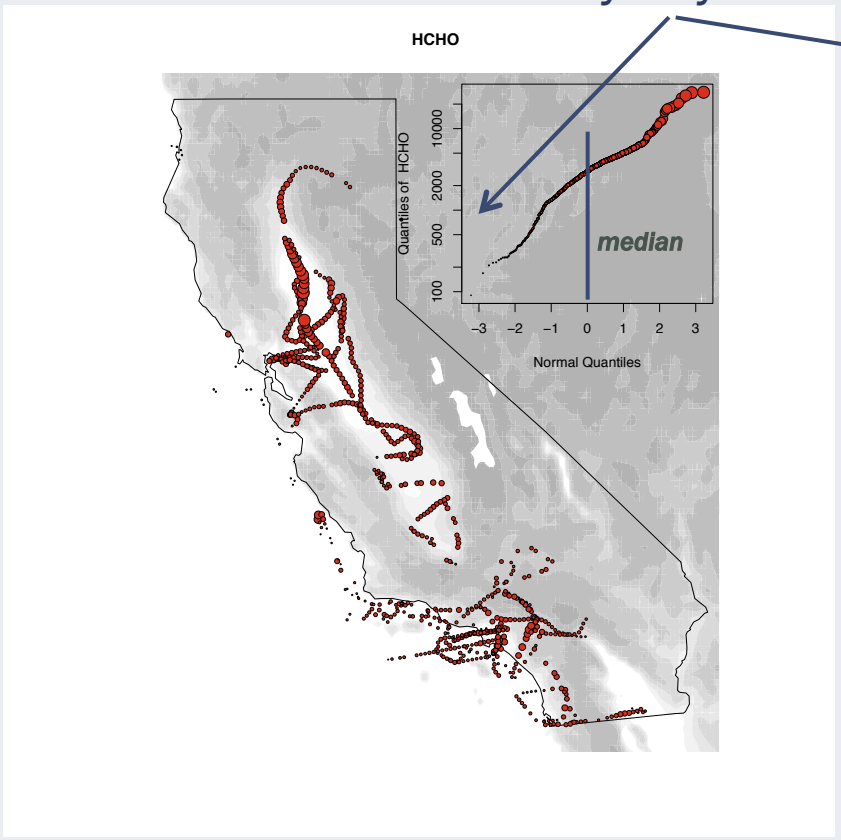
Where we are going: Attributions for both NOx and also VOC "Activity" for Smog O_3

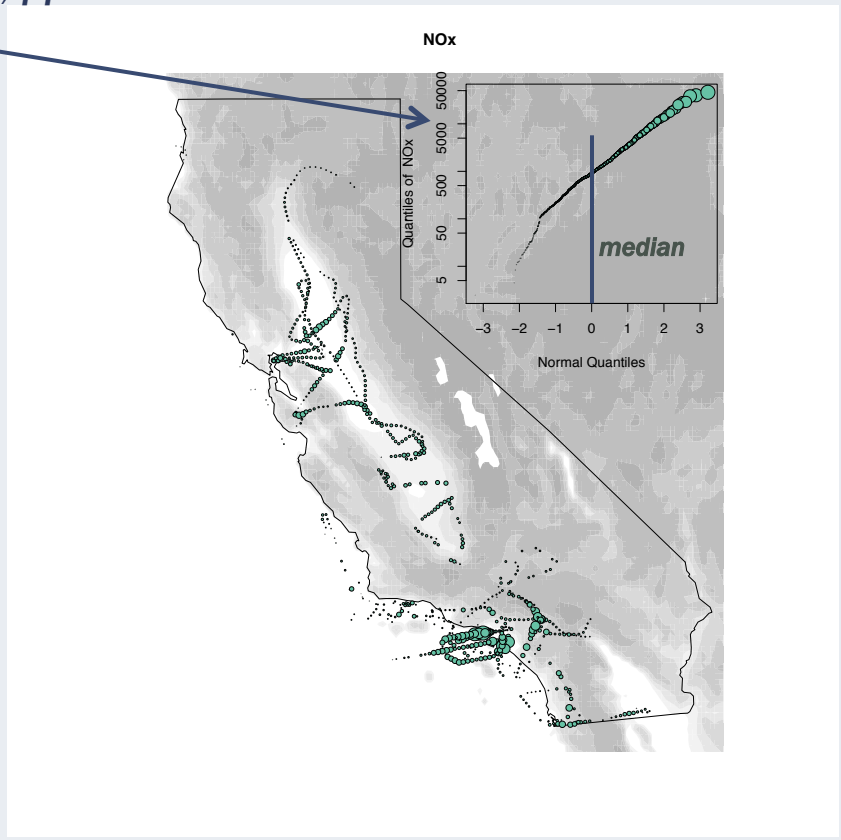


- Both reacting VOC's and NOx are required to produce ozone.
- Size of semicircle suggests balance of these contributors … this is slightly NOx limited
- All identified tracers/influences contribute … *rare!*

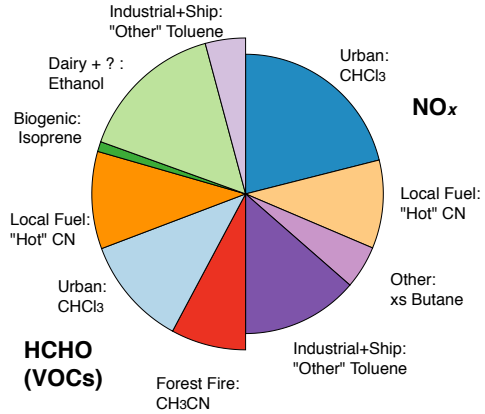
Formaldehyde and NOx are signals for smog O_3 production … change slowly for several hours after emissions

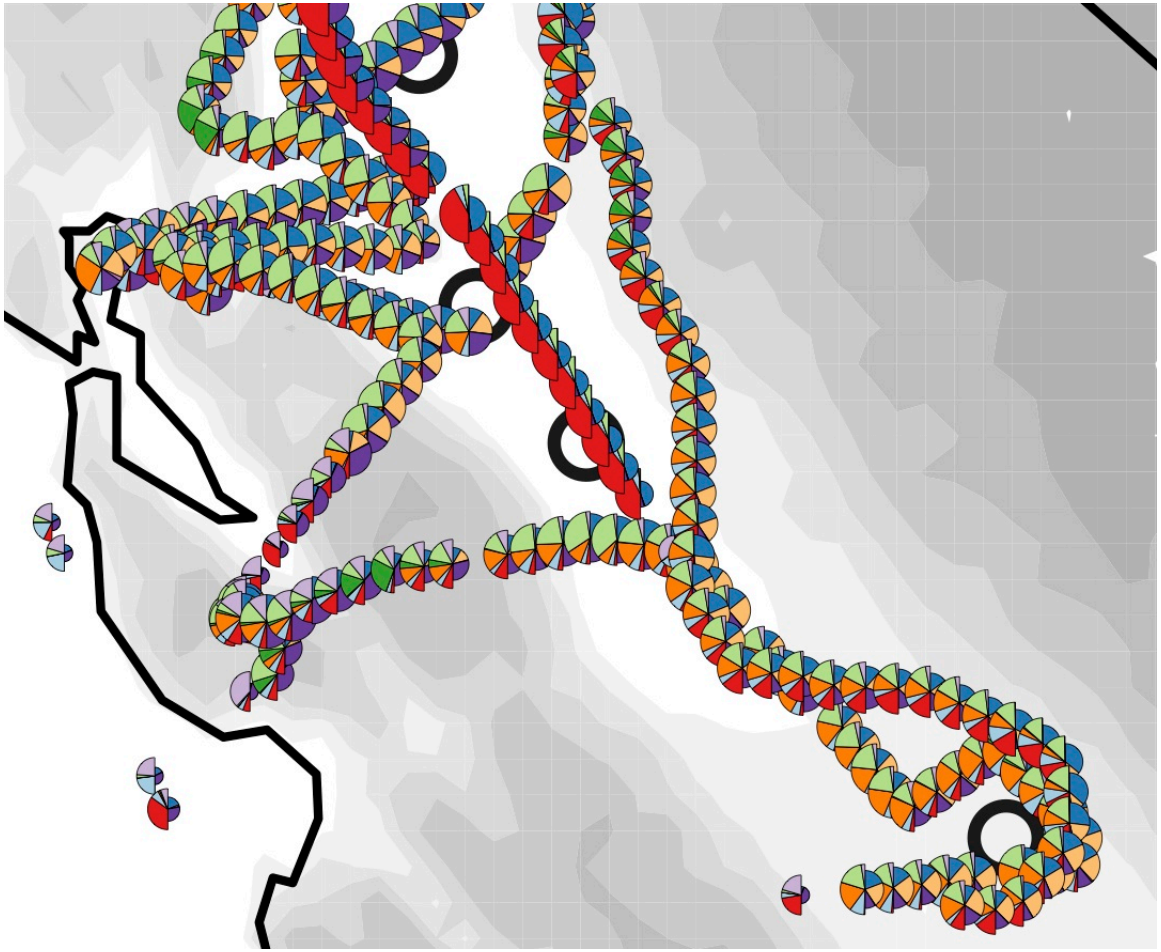
Key to symbol size, ppt





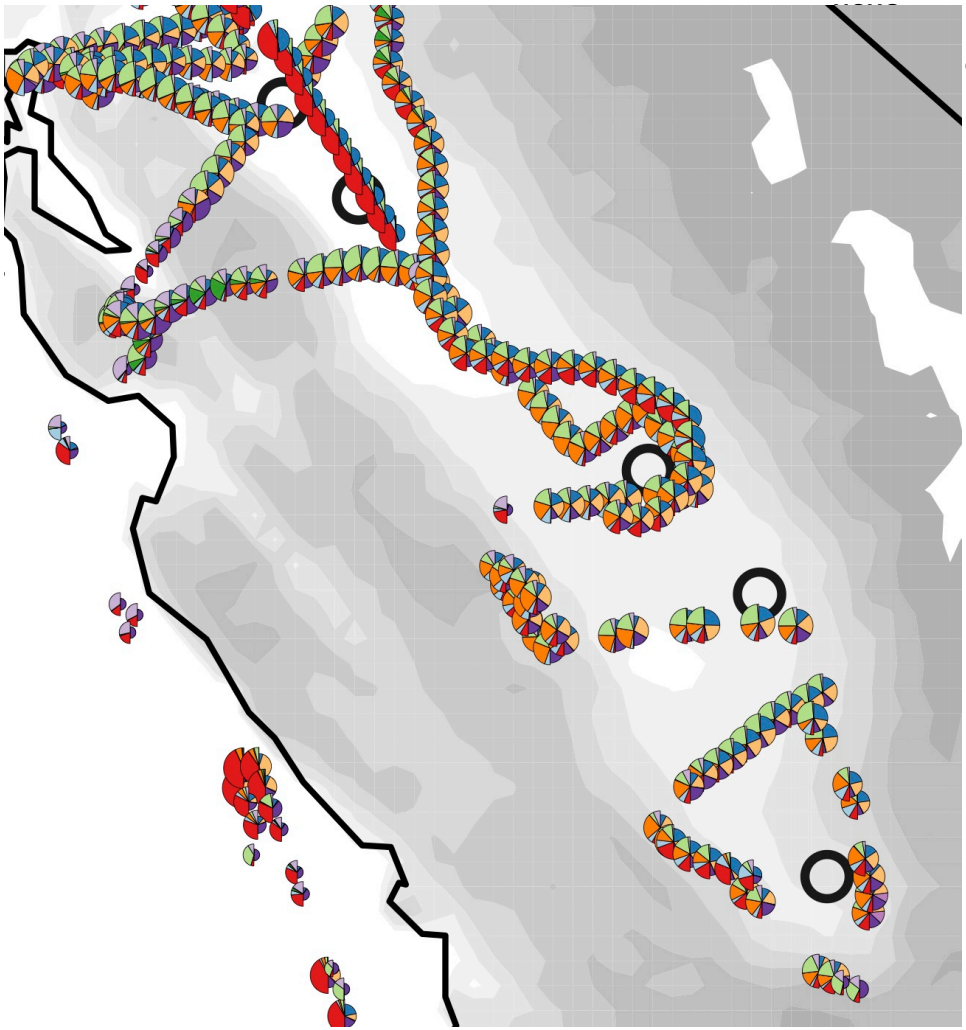
Actual Ozone production rate is very dependent on light, e.g., time of day but even surface brightness and aerosols

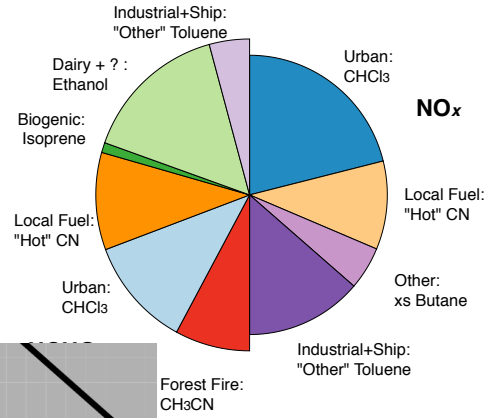




Bay and N San Joaquin Valley

Origin attributions for HCHO and NOx (reactivity-weighted VOC and NO) for the San Francisco Bay Area, California Delta, and the Northern San Joaquin Valley. Notable features regarding VOC's are the importance of fire emissions seen in the transect up the western San Joaquin (red), the significance of isoprene over the upland regions with tree emissions (dark green), and the ethanol-marked emissions over varied agricultural regions. Nitrogen oxides are seen to trace mainly to cities and localized combustion emissions, with localized significant contributions from toluene-related emissions, mostly in industrial areas.





San Joaquin Valley

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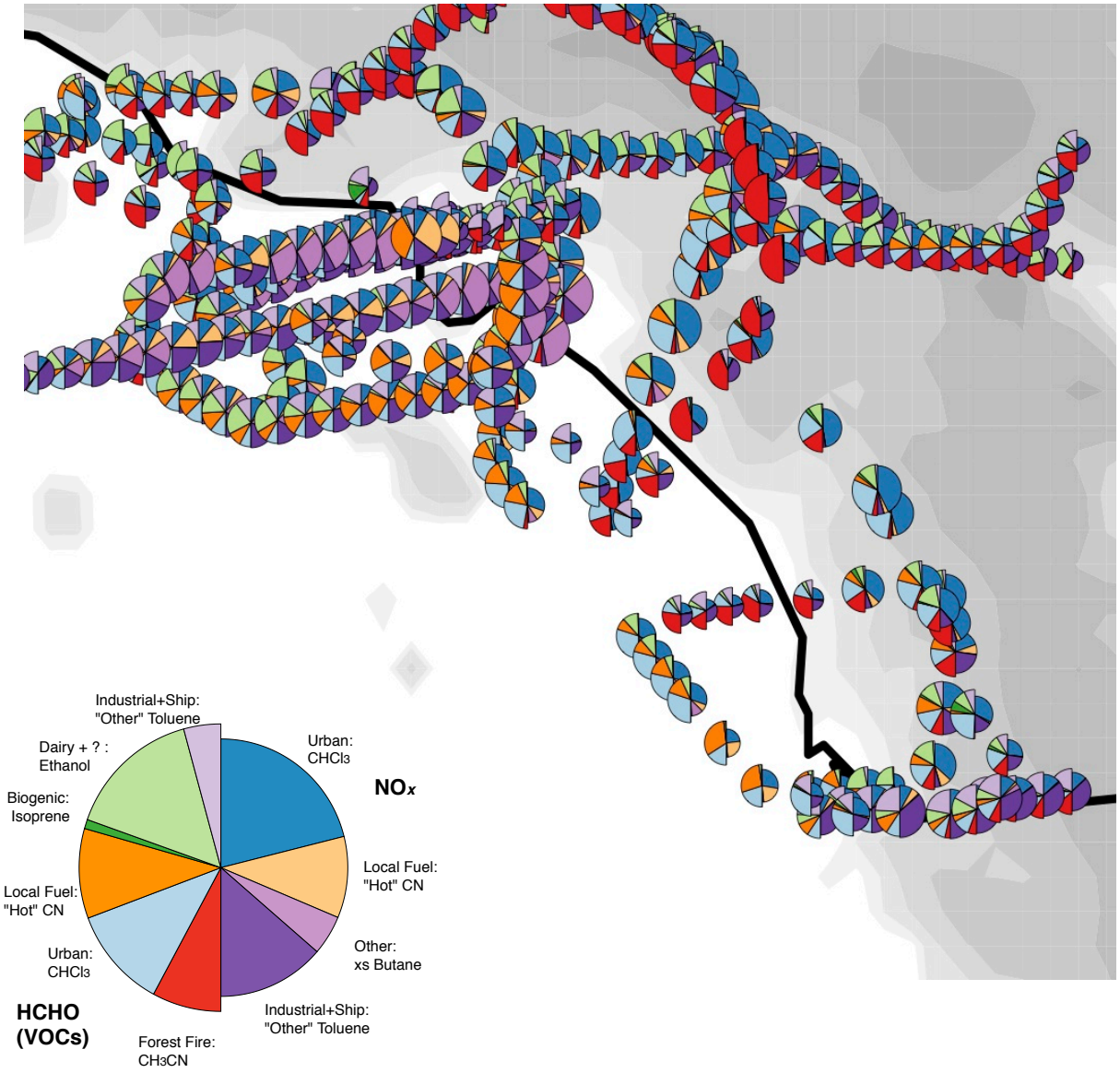
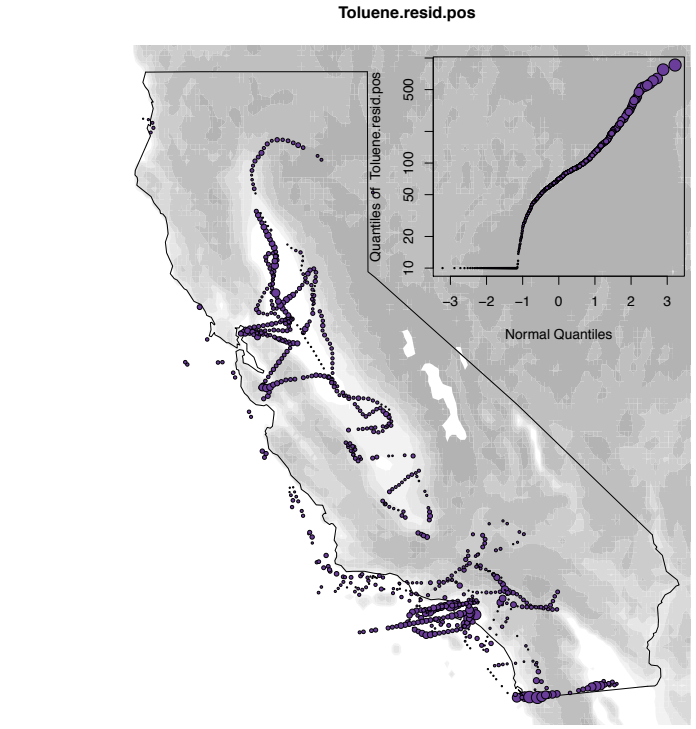


South Coast

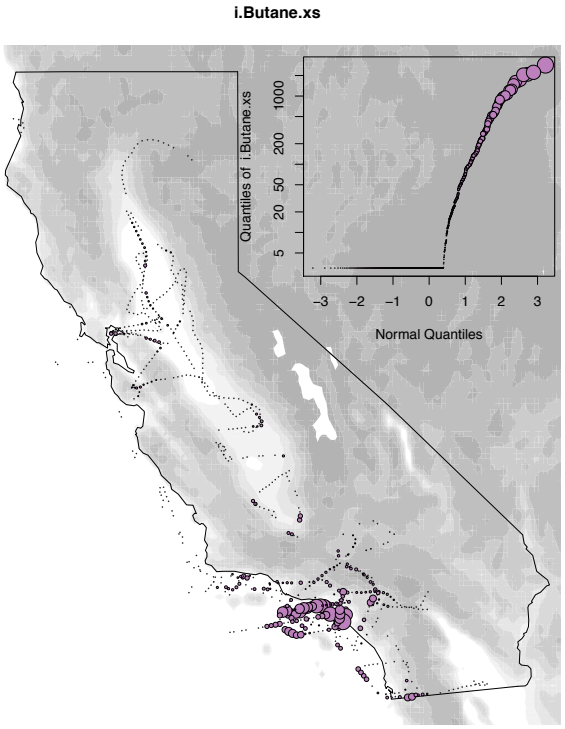
. Origin attributions for HCHO and NOx (reactivity-weighted VOC and NO) for urban Southern California and offshore. Urban emissions (light blue) dominate NOx emissions as expected; however many samples have very high NOx associated with i-butane but few other hydrocarbon compounds; this contribution is seen only in Western Los Angeles, offshore, and along the Mexican border and San Diego, not in other parts of California.

Two localized tracers: residuals from which burning and urban emissions have been removed, but … !

Unexplained toluene, explains variance in HCHO and VOC

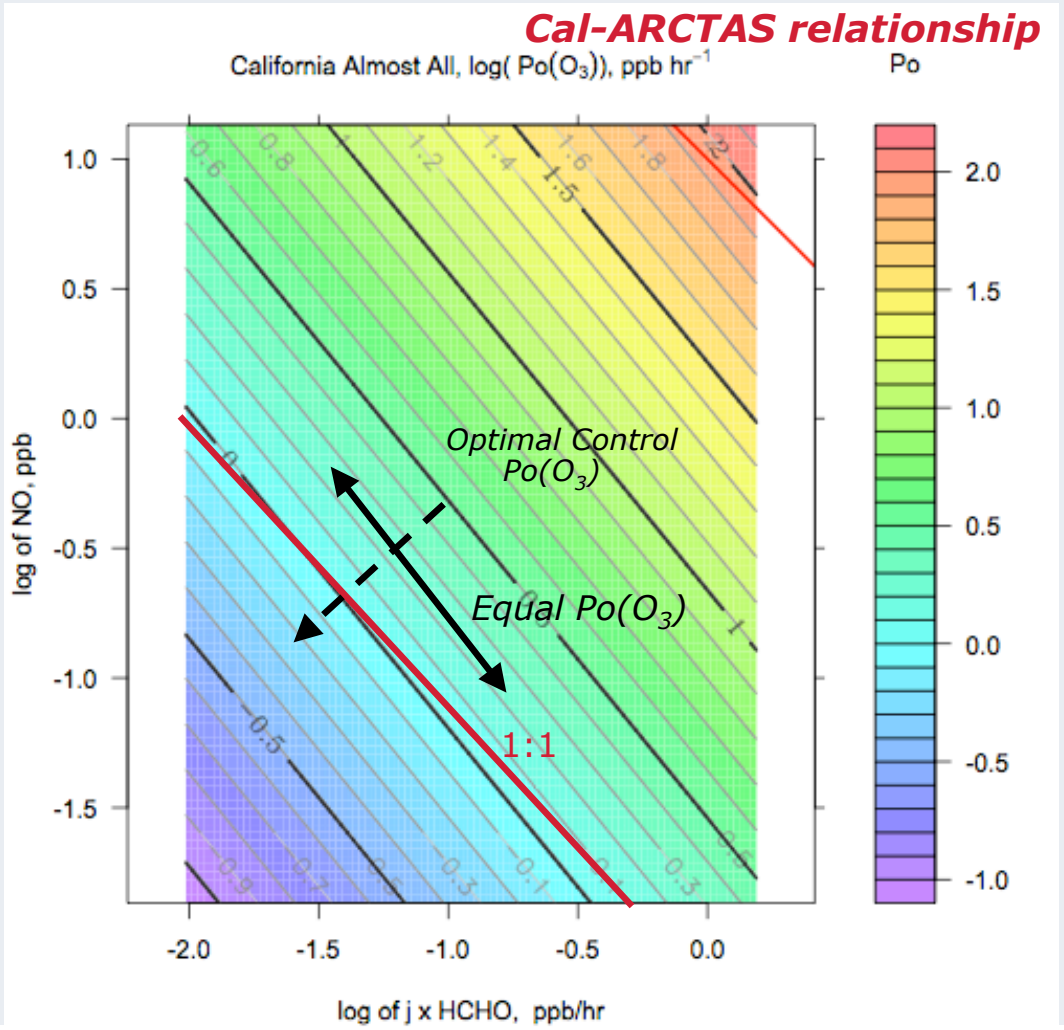


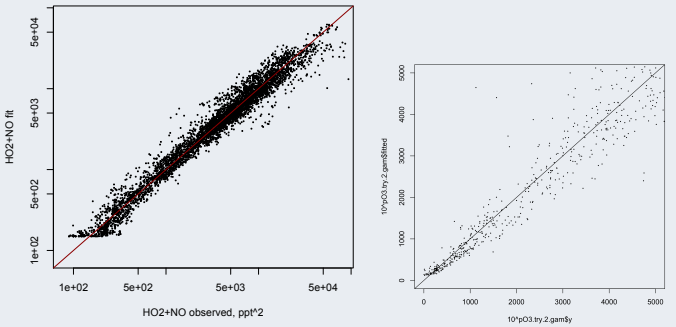
Very puzzling unexplained i-butane, related to very high NOX



If the goal is a very high R^2, then one must include these

Formaldehyde and NO (NOx) have a strong quantitative relationship to smog chemical ozone production



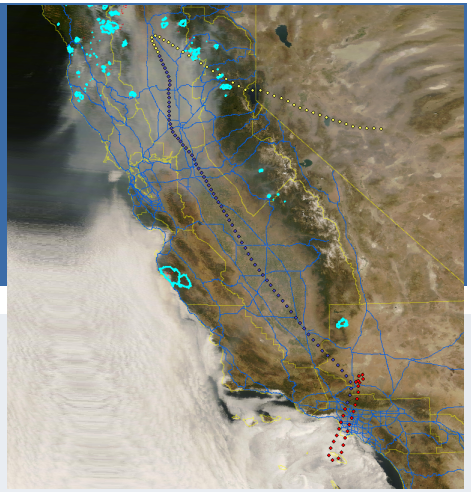


Can change in second—minutes:
j_{photol}HCHO and NO

But …
Change over hours:
HCHO and NO

***Chatfield et al*,**
Atmos. Environ., 2010, 2012

Reprise: Current Status and Costing



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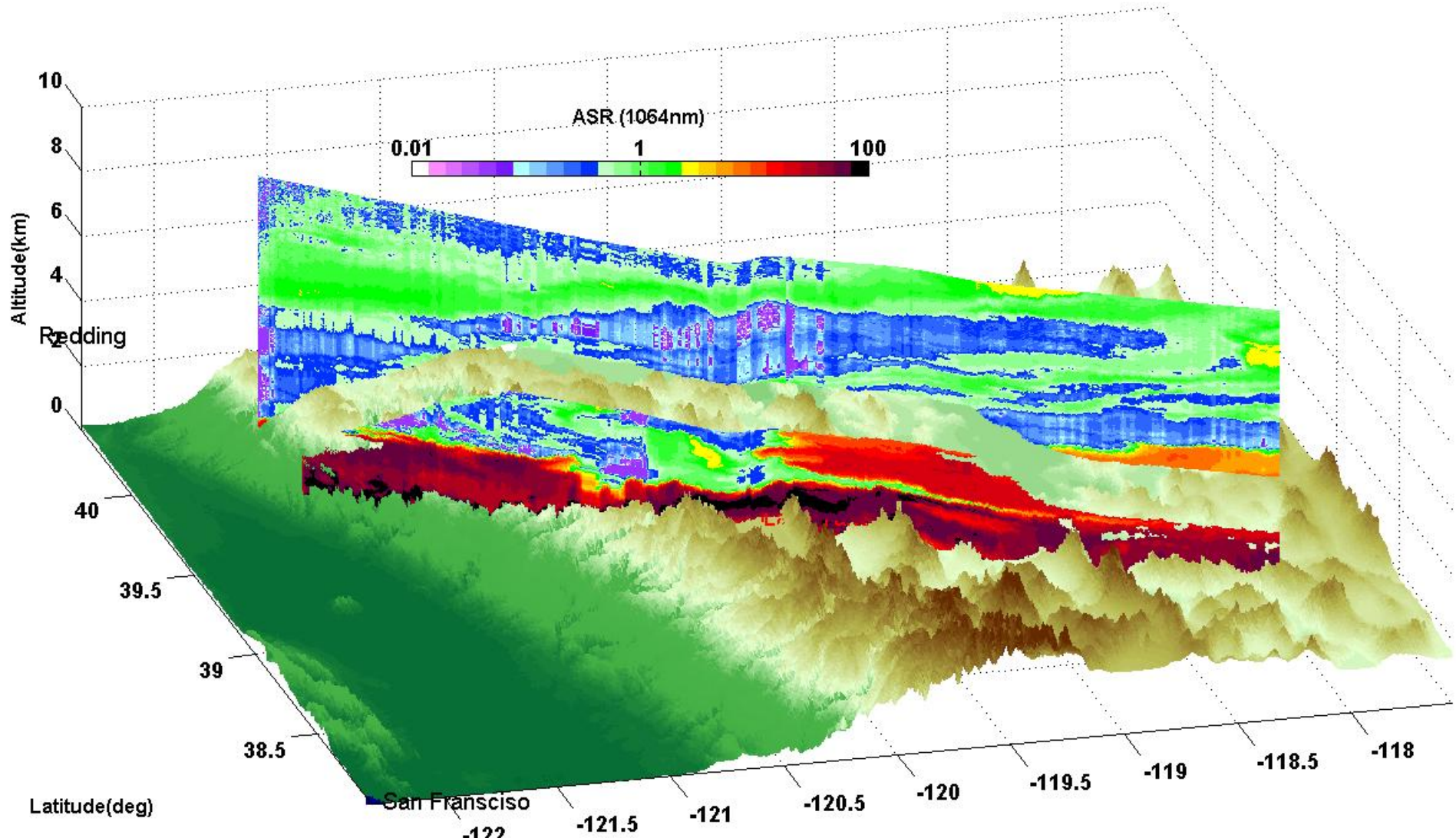
Aerosol seen by DIAL lidar
from DC-8 flying high above the Sacramento Valley; Note the complexity of California atmosphere



Explaining VOC via HCHO linear regression

Tracer	
Fire	CH3CN
Urban	CHCl3
Local Comb	Refract.CN (Res)
Biogenic tree	Isoprene
Biogenic—stock?	Ethanol
Indust./Port?	Toluene (Res)

Organic Reactivity as Described by Markers that Explain HCHO via Linear Regression

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	390.76391	84.45389	4.627	4.36e-06	***
CH3CN	9.20908	0.18437	49.948	< 2e-16	***
CHCl3	84.05451	8.52739	9.857	< 2e-16	***
Refract.CN (Res)	0.23695	0.02393	9.900	< 2e-16	***
Isoprene	0.54565	0.06533	8.352	3.12e-16	***
Ethanol	0.80795	0.05979	13.513	< 2e-16	***
Toluene (Res)	2.93300	0.54554	5.376	1.01e-07	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Multiple R-squared: 0.8331 Adjusted R-squared: 0.8318

F-statistic: 638 on 6 and 767 DF, p-value: < 2.2e-16

Residual standard error: 1251 (ppt) on 767 degrees of freedom

Explaining NOx via linear regression

Tracer

Urban Local Comb ? Indust/Port?

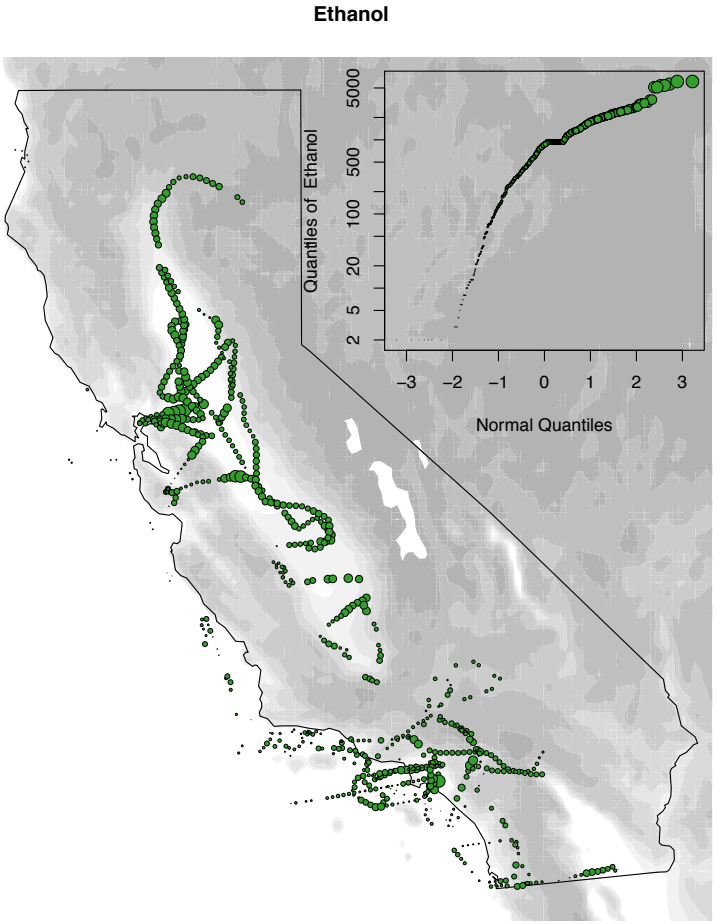
```
Coefficients:
                      Estimate Std. Error t value Pr(>|t|)
(Intercept)         -1.155e+03  1.705e+02  -6.776 2.46e-11 ***
CHCl3                1.534e+02  1.788e+01   8.581  < 2e-16 ***
Refract.CN (Res)     6.540e-01  4.548e-02  14.379  < 2e-16 ***
Excess i.Butane(Res) 6.276e+00  4.743e-01  13.233  < 2e-16 ***
Toluene.resid.pos    9.375e+00  1.174e+00   7.986 5.10e-15 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2510 on 769 degrees of freedom
Multiple R-squared: 0.6522  Adjusted R-squared: 0.6504
F-statistic: 360.4 on 4 and 769 DF,  p-value: < 2.2e-16
```

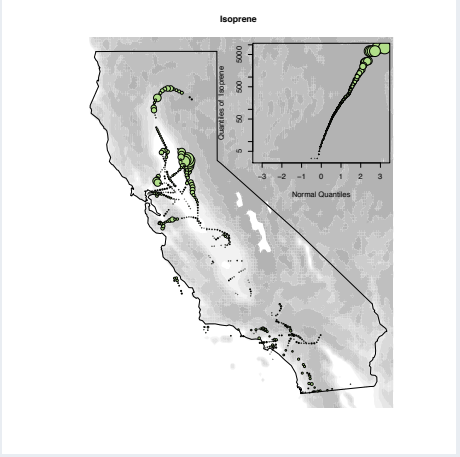
NOx can be very transient and hard to trace: note also “irrelevant” sources

Interactions

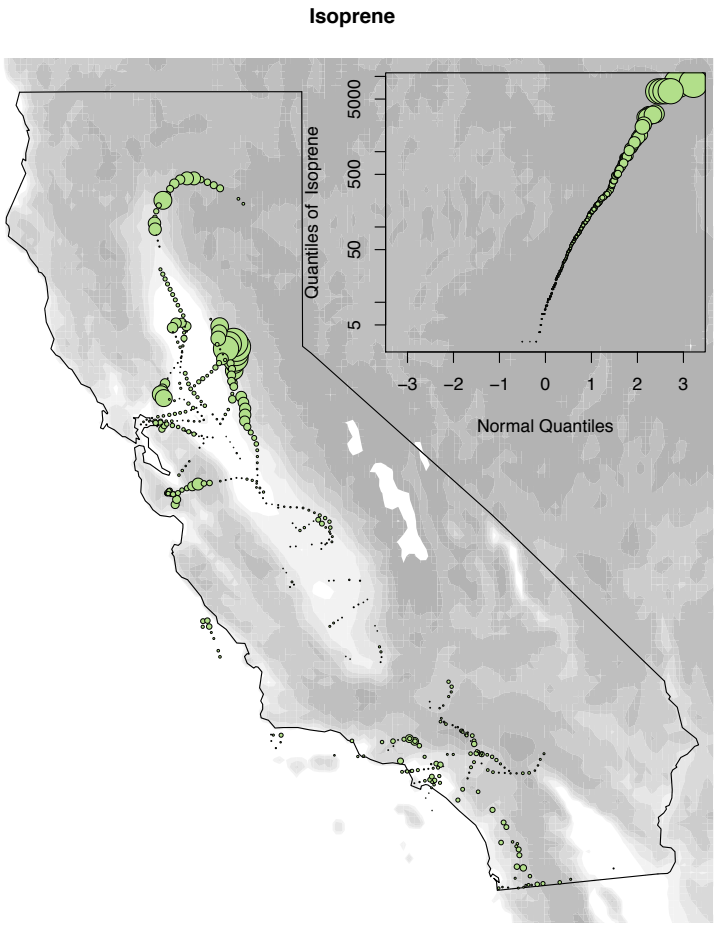
Ethanol:
a *tracer* of various livestock-connected activities



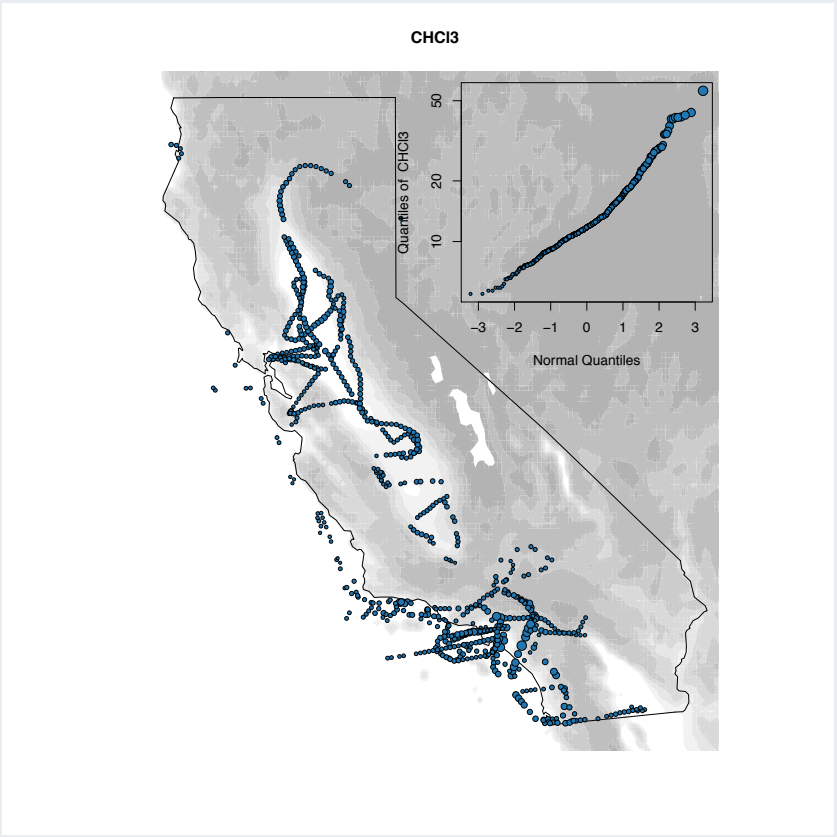
Ethanol may have other sources than livestock: see NE California & isoprene



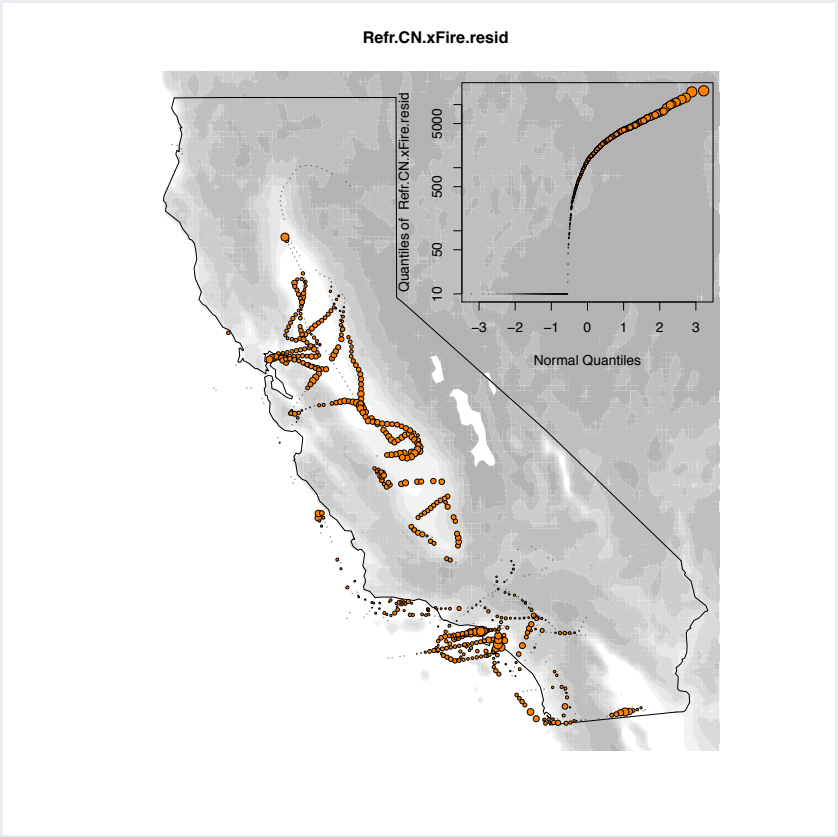
Of course, isoprene – only seen at elevation (woodlands, not, e.g., tree crops …check!)



Other tracers we found added explanation
CH_3Cl and extremely fine but heat-refractory particles



A tracer of urban emissions including automotive



A tracer of combustion; omitting fire, probably local automotive