BAAQMD Modeling Advisory Committee Meeting on Particulate Matter

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June 3, 2010

Meeting # 1

MAC Meetings

5 MAC Meetings

- June, October, December 2010
- March, May 2011

Purpose

- Promote collaboration
- Share technical information
- Receive feedback
- Provide information to planners and to the preparation of PM SIP
- Schedule: all technical work be completed by Oct. 2011
- Study PM formation in the region, identify its sources, study its health impact and make recommendation for effective emission controls

Contact info

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- Presentation materials and documents will be posted at our web site http://www.baaqmd.gov/Divisions/Planning-and-Research/Research-and-Modeling.aspx

MAC Meetings (cont.)

June 2010

- Attainment status
- Overall PM study plan (completed, on-going and future work)
- Conceptual formation of SFBA PM
  - Data analysis
  - Emissions inventory
  - Modeling

October 2010

- Emissions inventory in SFBA
- Model performance evaluation following EPA guidelines

December 2010

- Model sensitivity to changes in emissions
- PM transport

MAC Meetings (cont.)

March 2011

- PM health impact
- Summary of overall study findings
- Discussion

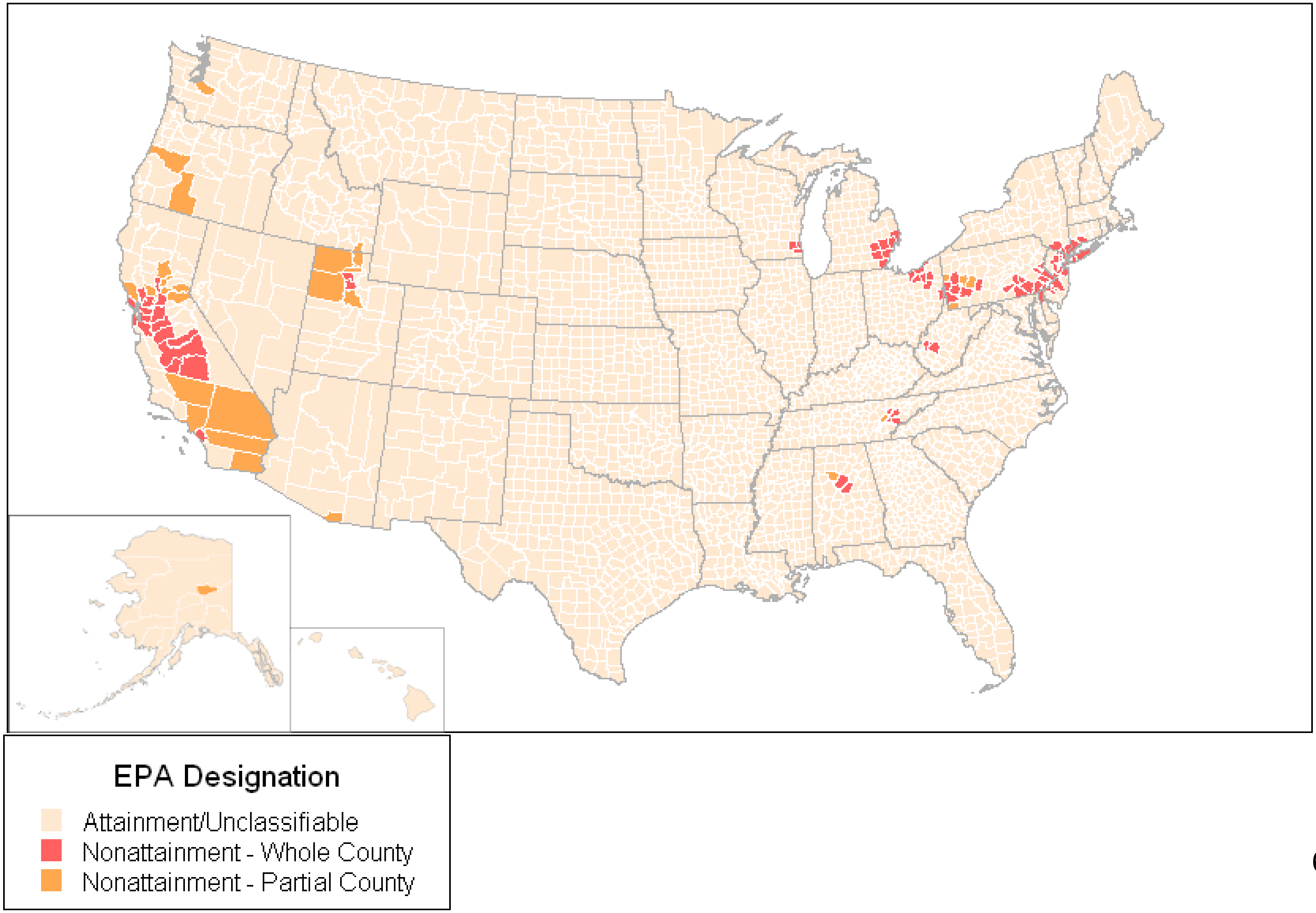
May 2011

- Prepare a draft document on study findings
- Receive feedback from MAC
- Finalize the document

Attainment Status

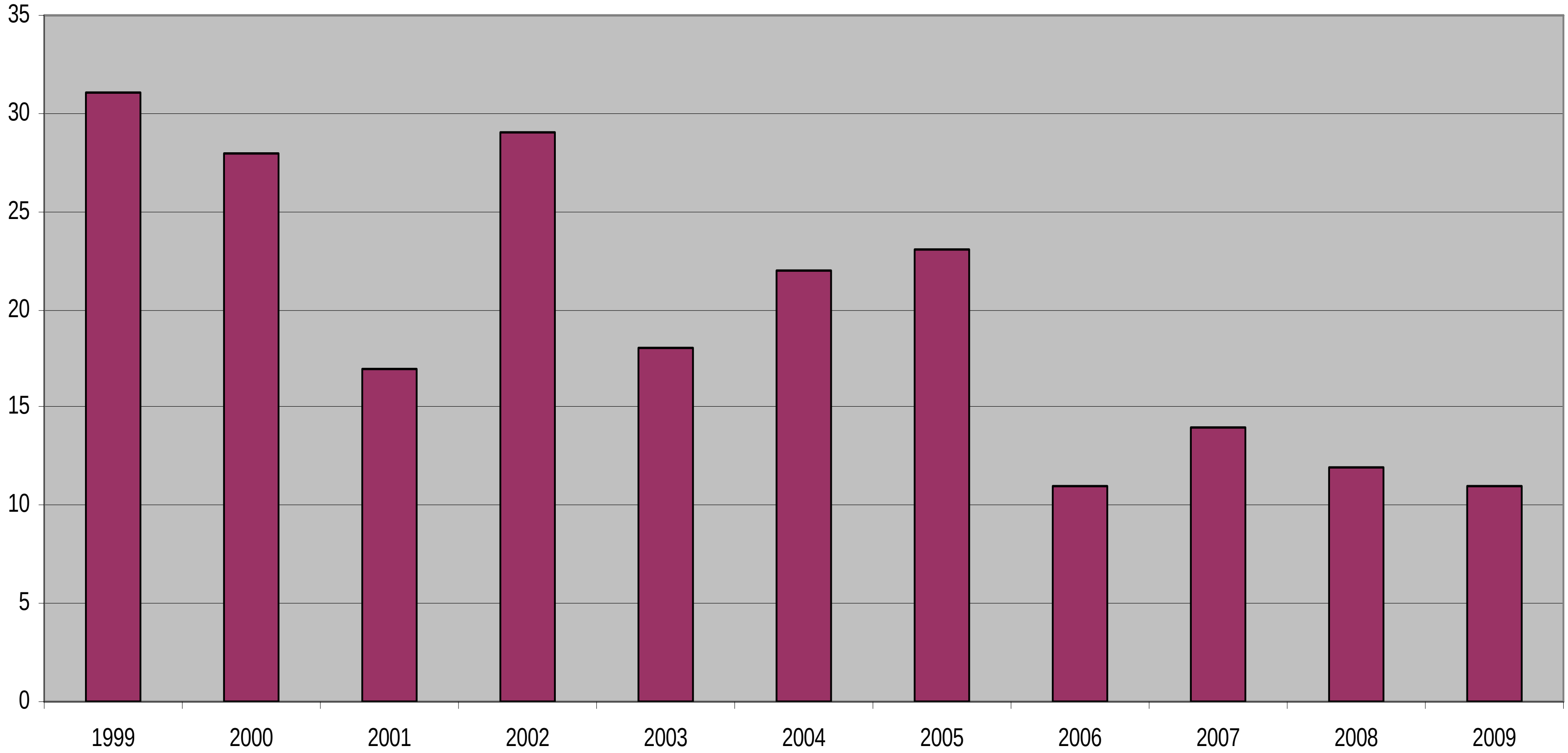
- Attainment designations
  - EPA October 2009
  - Based on data collected during 2006-2008
- 24-hr standard (35 µg/m^3)
  - SFBA not in attainment
    - Design value = 36 µg/m^3
    - Exceedances occur during winters: 1 November – 28 February
  - Design value (98th percentile, 3-year average)
    - Top 2 percent (about 7 days in a year) – not included
    - 8th highest PM level averaged over three years at each station
  - Other California regions' design values (from EPA July 2009 publication)
    - SJV 70 µg/m^3
    - Sacramento 56 µg/m^3
    - Yuba City-Marysville 47 µg/m^3
    - Chico 69 µg/m^3
    - Los Angeles 49 µg/m^3
- SFBA attains the annual average standard (12 µg/m^3)

24-hr PM2.5 Nonattainment Areas



Annual Number of Days Exceeding the National PM2.5 Standard

San Francisco Bay Area PM2.5 Sites, 1999-2009

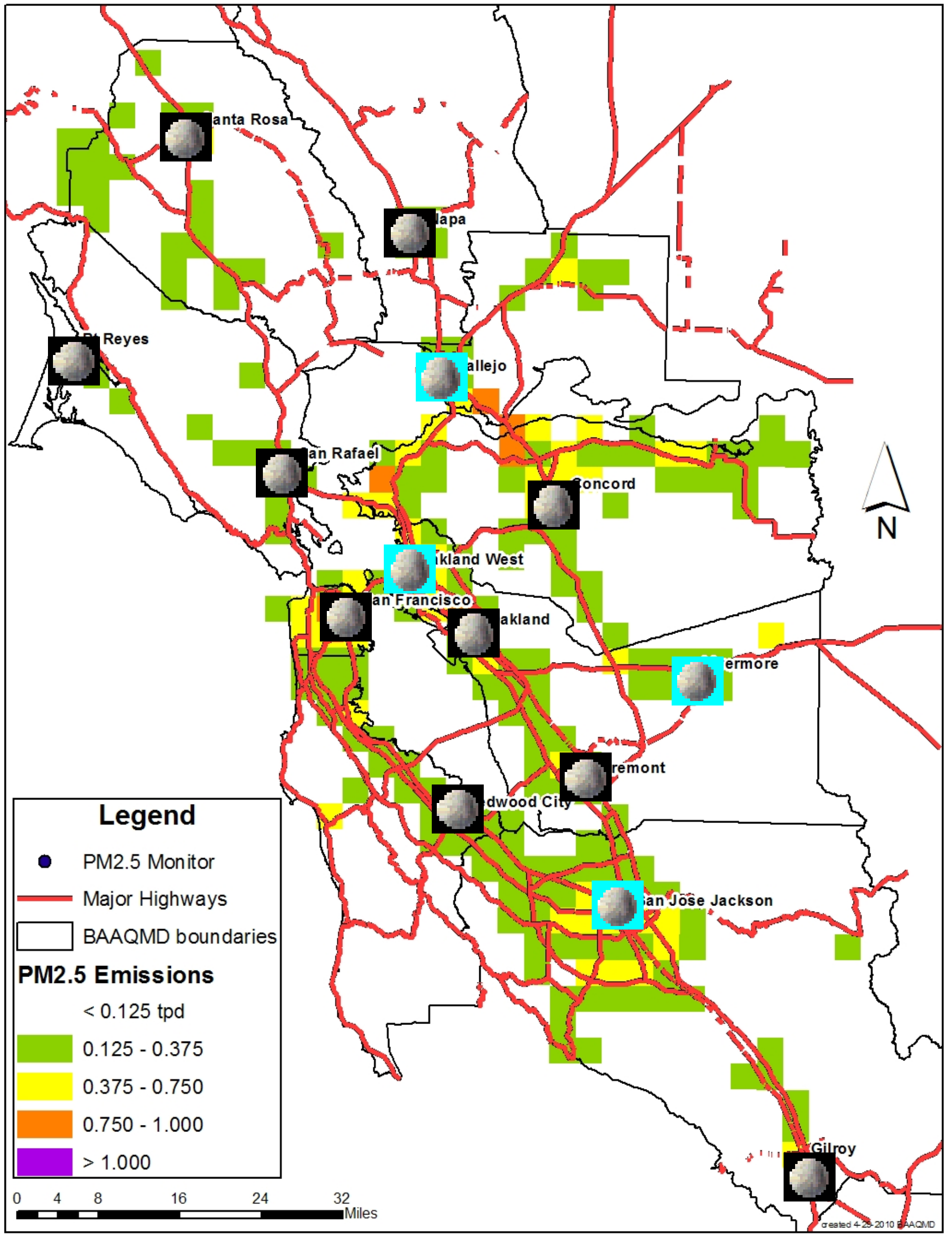


*Number of days per year where at least one BAAQMD site measured PM2.5 at least 35 ug/m3, the national standard. The data are limited to Federal Equivalent Method (FEM) and Federal Reference Method (FRM) measurements, the latter of which are filter-based. Filter measurements are not made every day at every site. Thus, the true # of exceedances is likely to be greater.

SFBA PM2.5 monitoring locations

Speciated

Directly emitted PM2.5 tpd



SFBA Study Plan (Completed Work)

Data analysis

- Chemical Mass Balance (CMB) analysis to identify major SFBA PM sources and composition
- Cluster analysis to identify weather patterns impacting SFBA PM levels
- Data analysis to establish relationships among PM, emissions and meteorology

Emissions inventory

- Obtained preliminary modeling inventory from ARB for 2000 for CRPAQS domain
- Updated SFBA portion of the inventory using the CARE program inventory for 2005
- Developed ammonia emissions inventory for SFBA
- Updated wood smoke emissions estimate for SFBA
- Created modeling inventories for (1 December – 31 January, 2000-01 and 2006-07)
    - 2000-01 severe and 2006-07 moderate winter PM seasons

SFBA Study Plan (Completed Work Cont.)

Modeling

- Simulated winters 2000-01 and 2006-07 using MM5 and CMAQ with 4 km horizontal grid resolution over CRPAQS domain
- Analyzed observed and simulated fields
- Evaluated model performance
- Studied preliminary model response to changes in emissions
- Documented findings
  - Published 2 journal articles (cluster analysis and meteorological model performance)
  - Prepared data analysis and modeling report
  - Prepared several conference presentations and papers

SFBA Study Plan (On-going Work)

Data analysis

- Updating CMB analysis with recent data
- Updating cluster analysis with recent data
- Further investigating meteorological conditions impacting PM levels

Emissions inventory

- Developing modeling inventories from the CARE program inventory for 2010, 2015 and 2020
- Comparing the base year inventory (2005 for now) against future year inventories
- Participating in CRPAQS effort

SFBA Study Plan (On-going Work Cont.)

Modeling

- Evaluating CMAQ following EPA guidelines
- Testing CMAQ performance with WRF
- Conducting sensitivity simulations with 10, 20, 30, 40 and 50 percent emission reductions
  - NOx +VOC
  - Ammonia
  - Primary PM
  - Sulfur
- Sensitivity simulations for major sources: on-road, off-road, area, point, etc.
- Sensitivity with future year inventories: From 2005 to 2020
- Preparing EKMA diagrams
- Documenting results

SFBA Study Plan (Future Work)

Emissions inventory

- Develop inventories for winters 2006-08
  - January – February 2006
  - November 2006 – February 2007
  - November 2007 – February 2008
  - November – December 2008
- Develop inventory for winter 2012 or 2013
- Evaluate inventories
- Coordinate inventory development with ARB

SFBA Study Plan (Future Work Cont.)

Modeling

- Conduct simulations with new inventories
- Evaluate model performance for 2006-2008
- Evaluate model sensitivity
- Study PM transport
- Study PM exposure and health impact
- Assess health and monetary benefits of changes in emissions
- Prepare final report

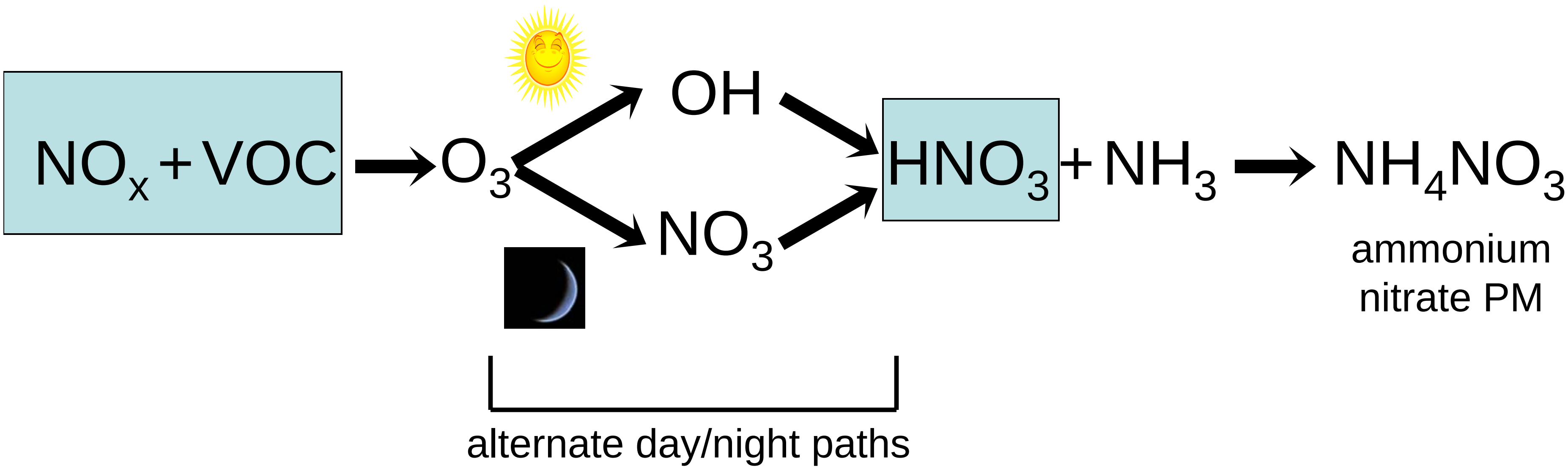
Selected Areas of Investigation

- What is the contribution of primary and secondary PM in SFBA?
- Is SFBA ammonia- or NOx-limited?
- How do ammonia and NOx emissions mix in the atmosphere?
- Is secondary PM formation chemically more efficient inland?
- How is meteorology impacting PM in SFBA?
- What is the contribution of transported PM to SFBA, where are the most impacted SFBA sub-regions?
- Is transported PM primary, secondary, or both?
- What is the benefit of the SFBA wood burning rule?
- Others

Primary vs Secondary PM

Emissions	Ambient or Model	Pollution
Directly-emitted PM →	**Without chemistry**	→ Primary PM
Precursor gases: **NO_x**, **VOC**, **NH_3**, **SO_2** →	**Ozone photochemistry & gas-to-particle conversion**	→ Secondary PM

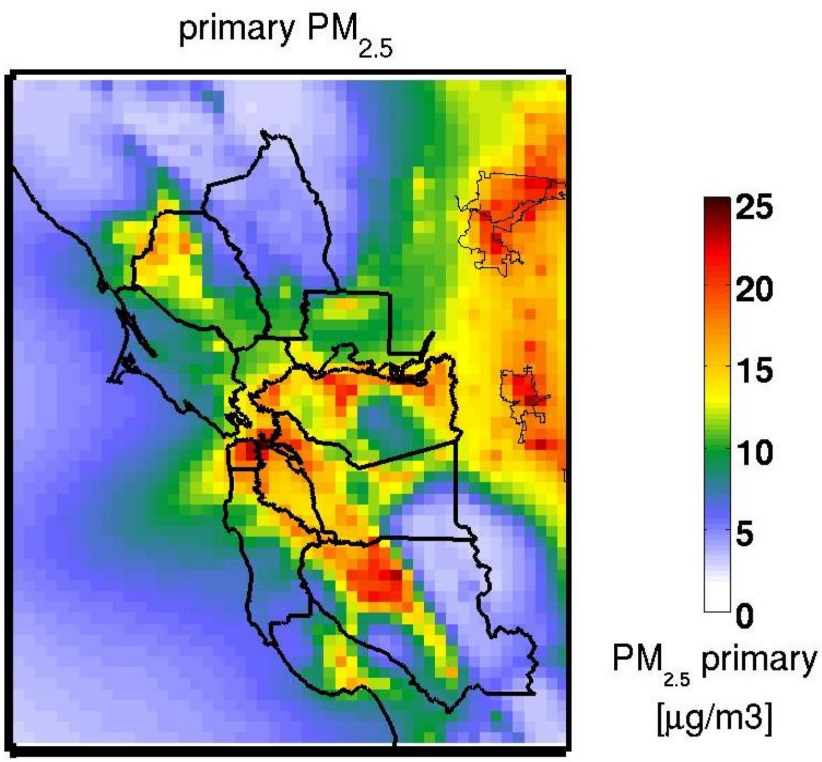
Secondary PM Chemistry & Physics

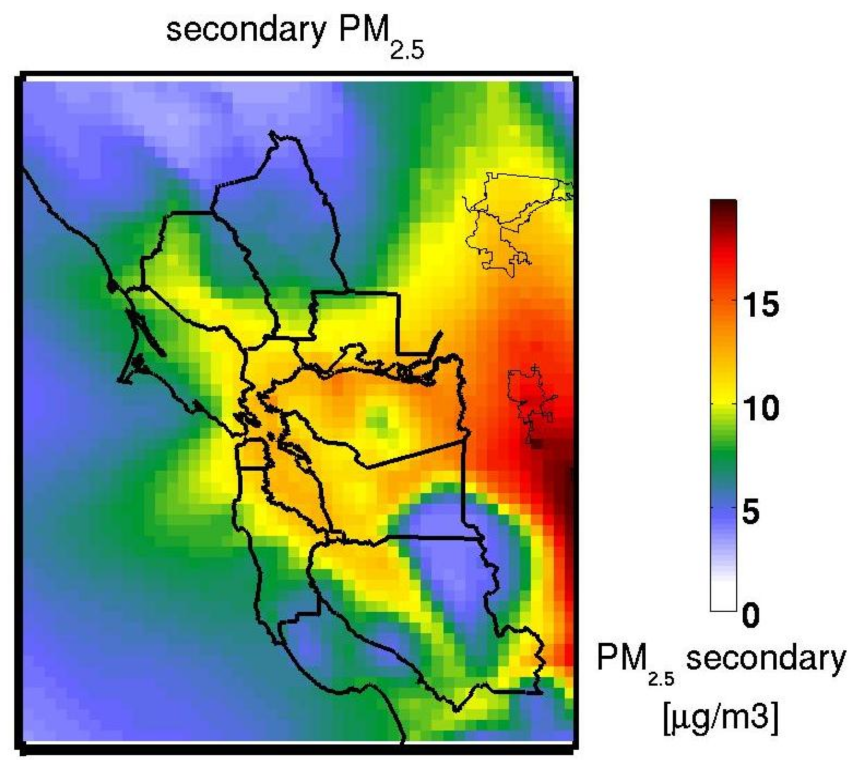


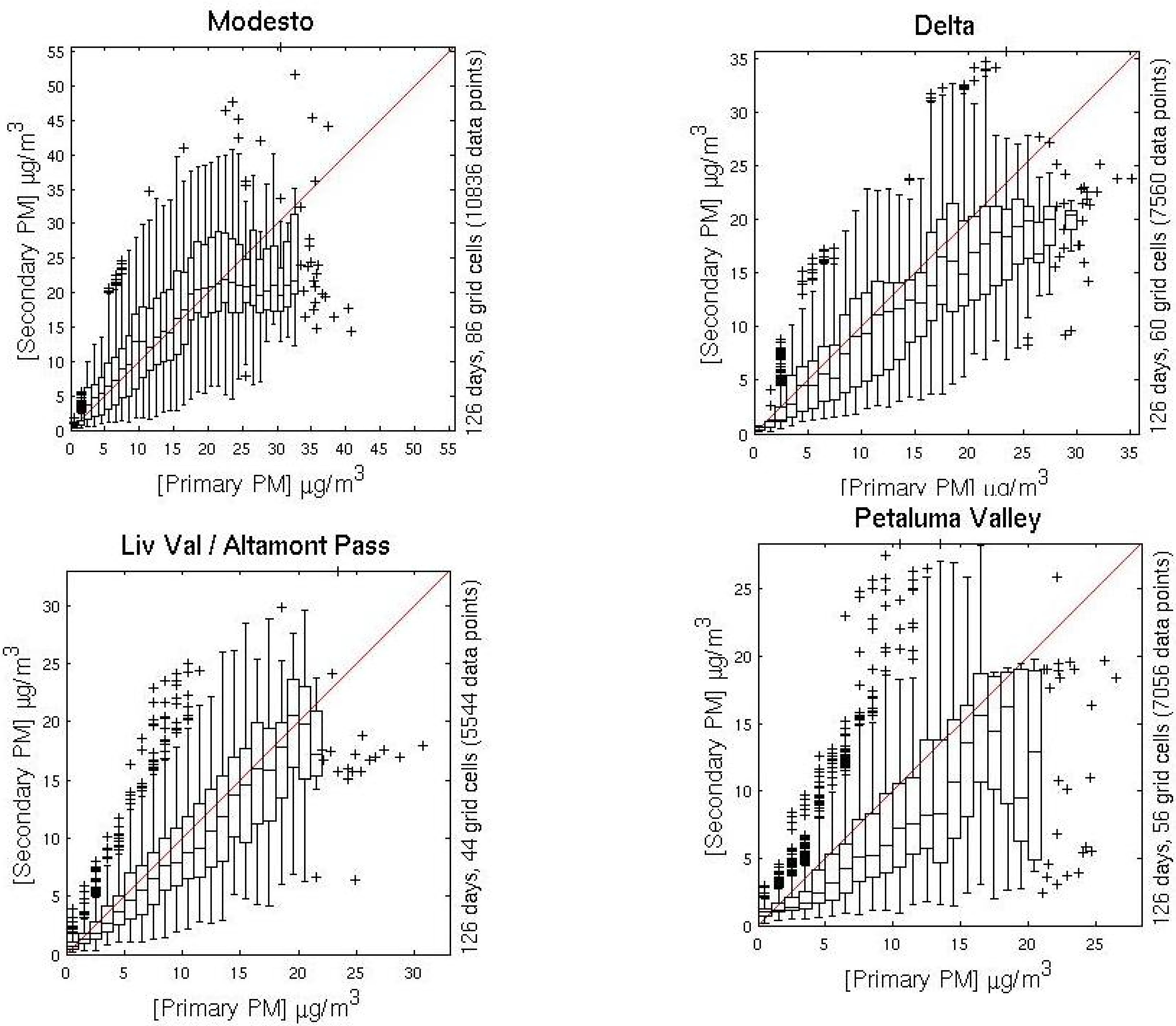
- Only ~4% of O3 involved in radical formation
- Particulate form of ammonium nitrate temperature-dependent

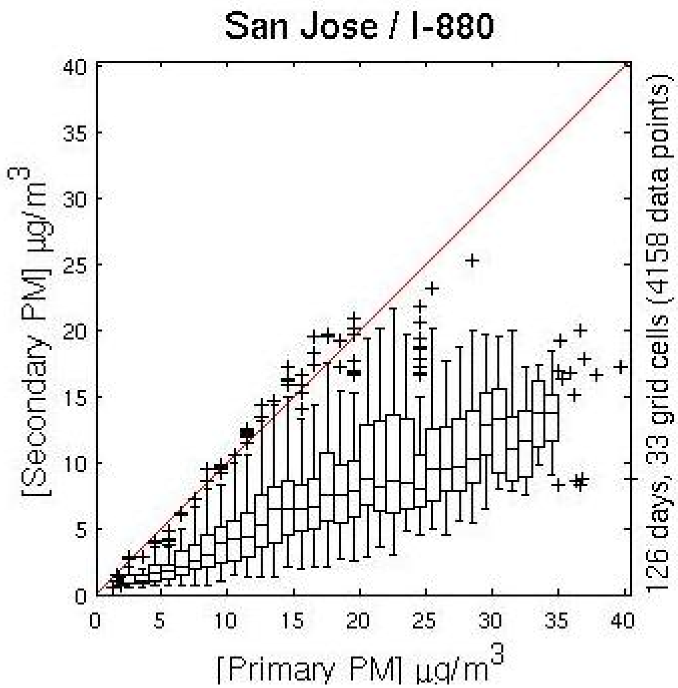
Similar pathway for ammonium sulfate PM.

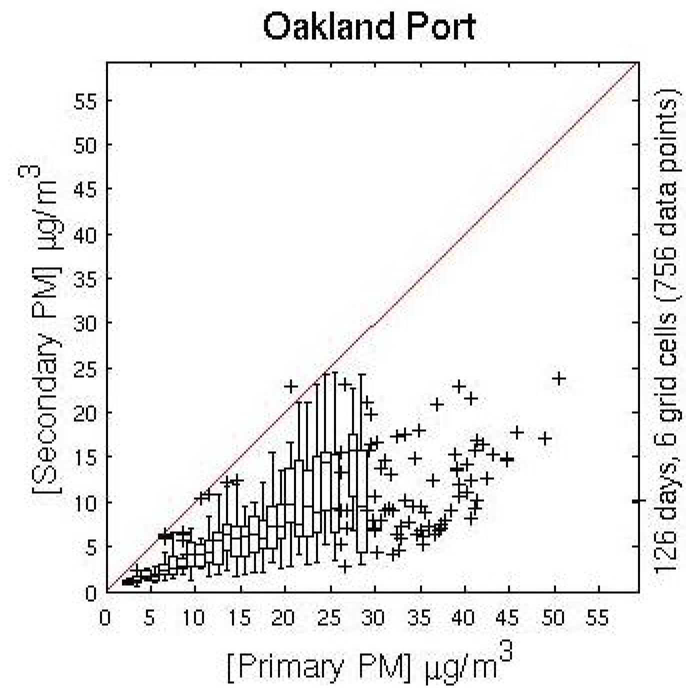
Simulated SFBA primary vs secondary PM distribution (example)

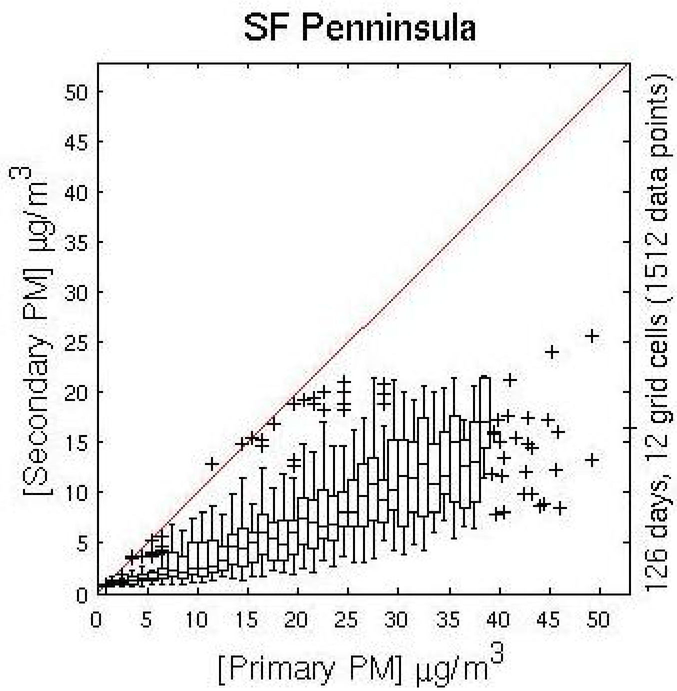


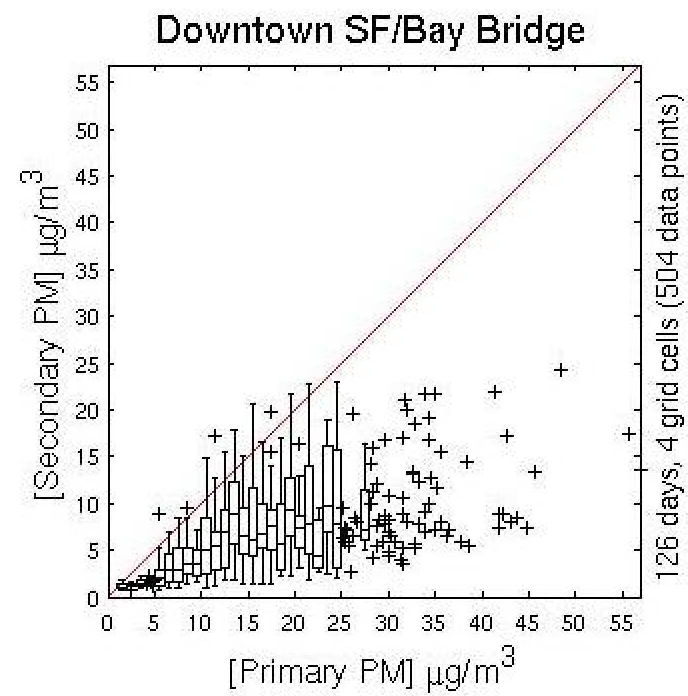



Modesto
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 86 grid cells (10836 data points)
Delta
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 60 grid cells (7560 data points)
Liv Val / Altamont Pass
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 44 grid cells (5544 data points)
Petaluma Valley
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 56 grid cells (7056 data points)


San Jose / I-880
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 33 grid cells (4158 data points)

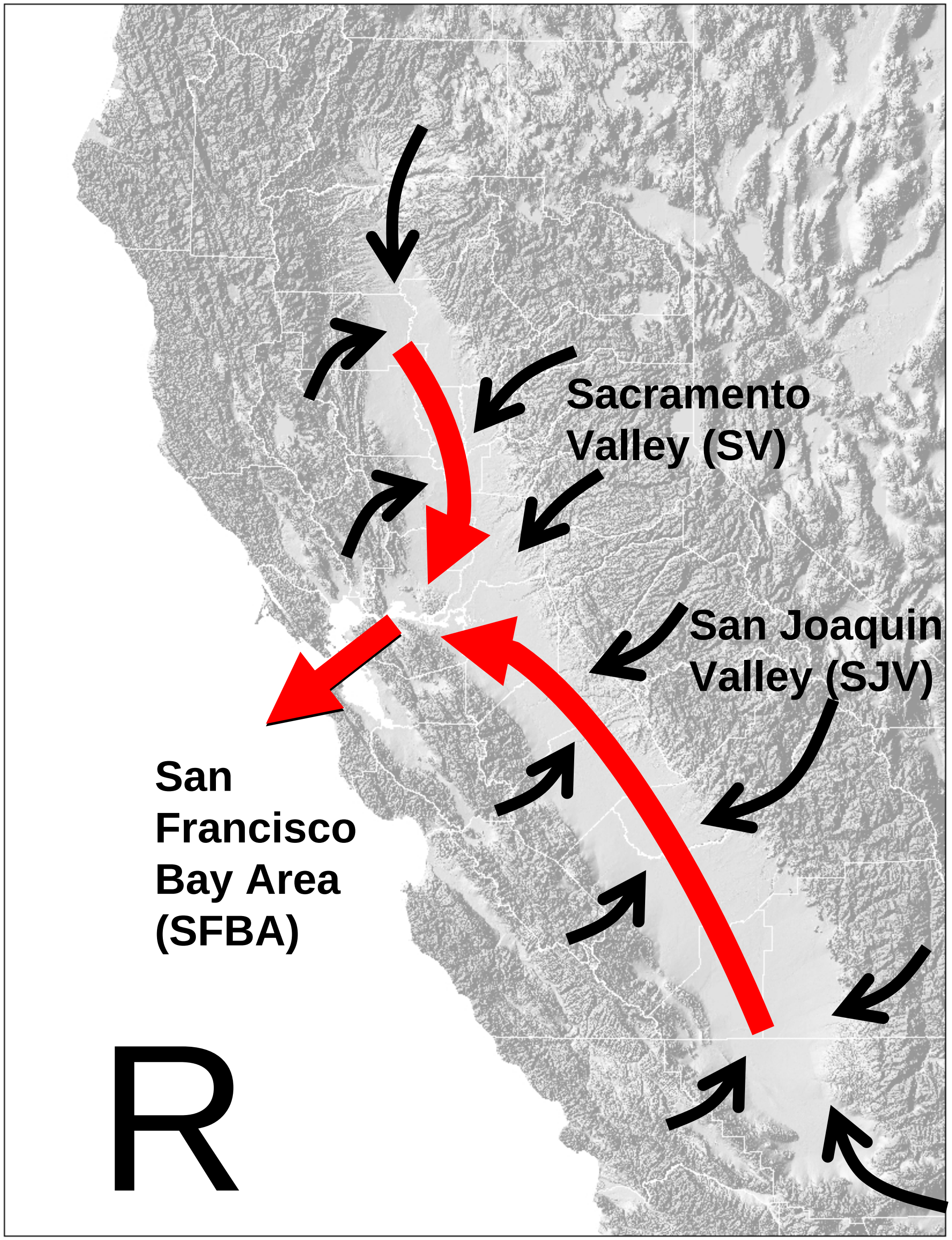

Oakland Port
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 6 grid cells (756 data points)


SF Penninsula
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 12 grid cells (1512 data points)


Downtown SF/Bay Bridge
[Secondary PM] µg/m3
[Primary PM] µg/m3
126 days, 4 grid cells (504 data points)

SFBA Episodic Meteorological Conditions

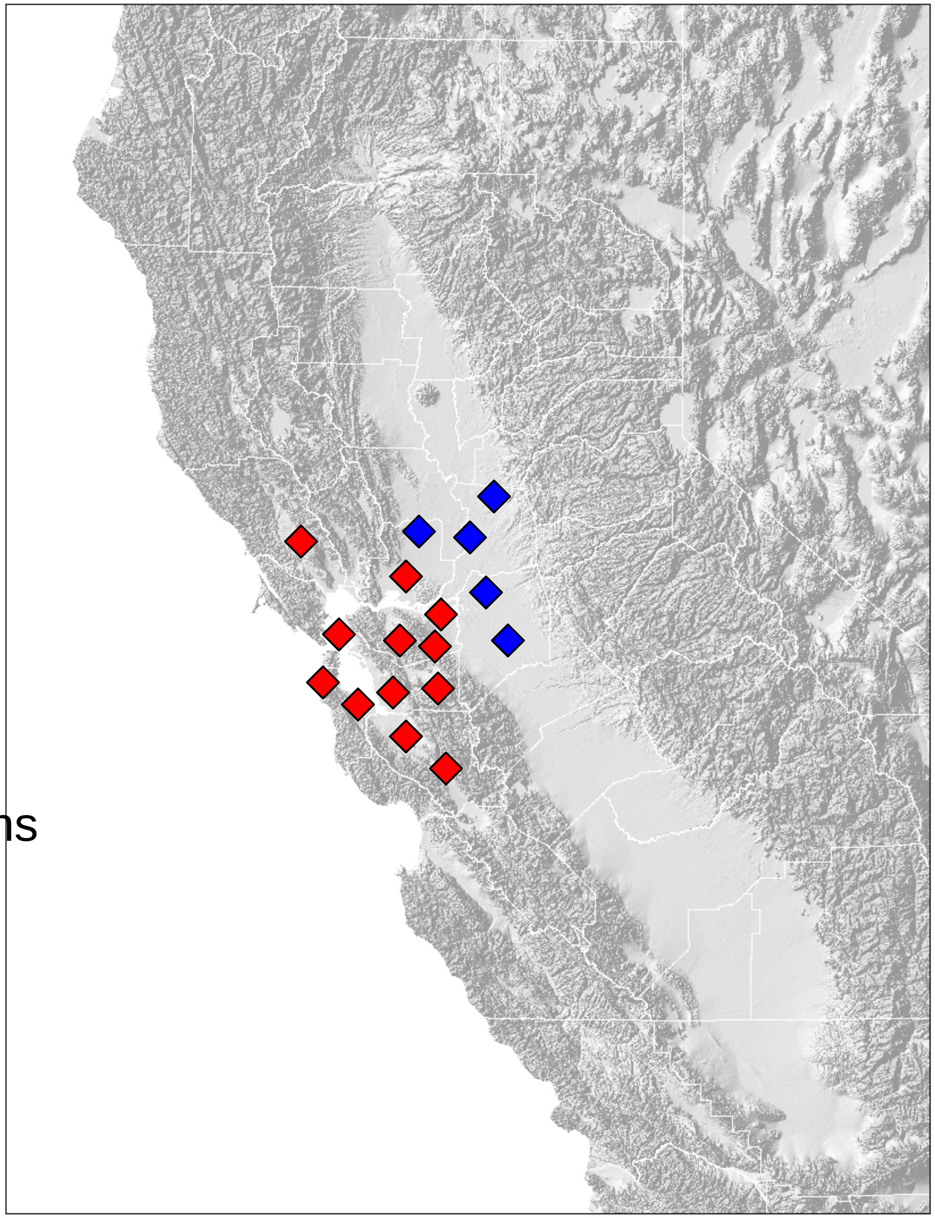
- Stable conditions under aloft high pressure ridge
- Weak large-scale pressure gradient
- Persistent drainage airflow off Central Valley rims
- SFBA surface flows from inland Central Valley



Clustered Weather Stations

SFBA weather stations (12)

Delta weather stations (5)



<u>Nov-Apr</u>

1999-2007, 1001 days

Identified: 3 PM-conducive weather patterns

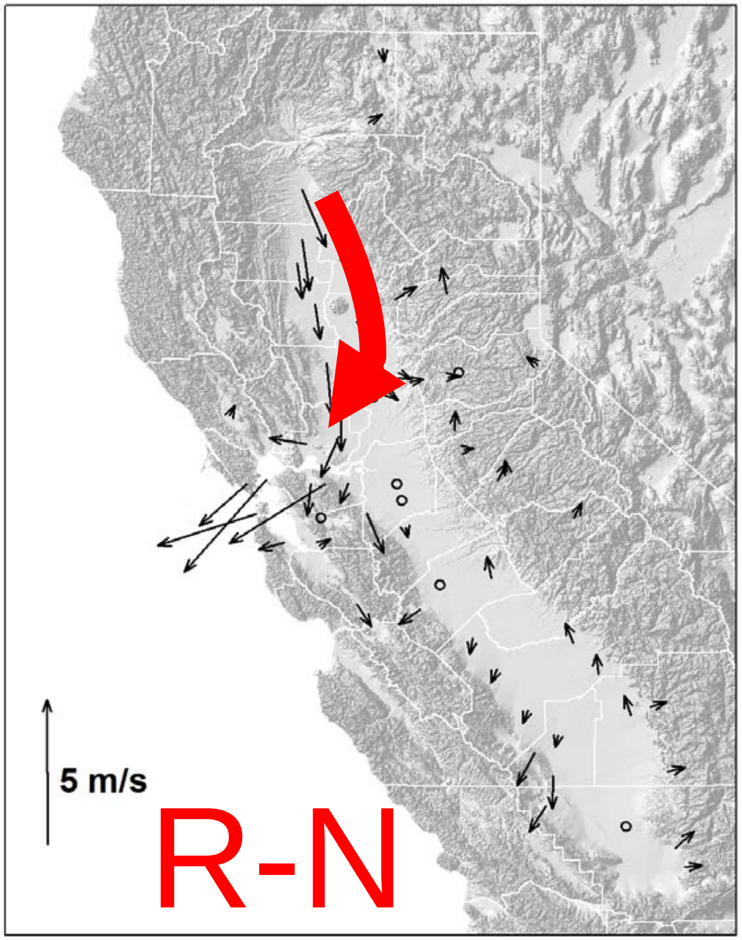
R-N (Ridge-Northerly winds entering Delta)

R-S (Ridge-Southerly winds entering Delta)

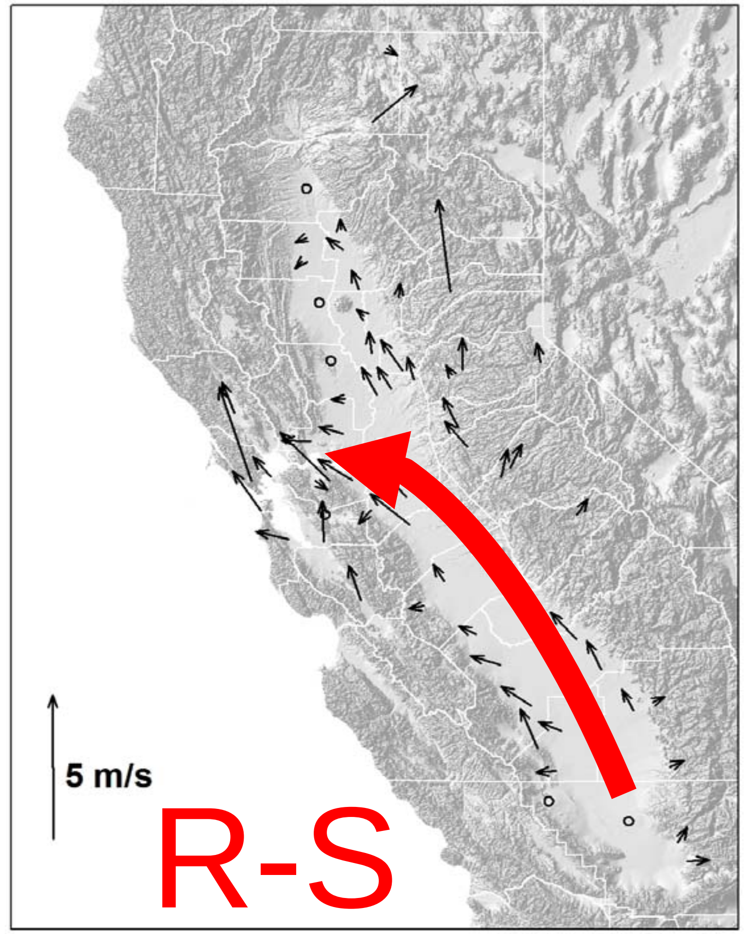
R-C (Ridge-Convergence in Delta)

Clustering Results

60% of SFBA exceedances
(south SFBA)
Aloft ridge over Central CA



20% of SFBA exceedances
(east SFBA)
Aloft ridge inland; pre-storm



Clustering Results (Cont.)

10-20% of SFBA exceedances (east SFBA)

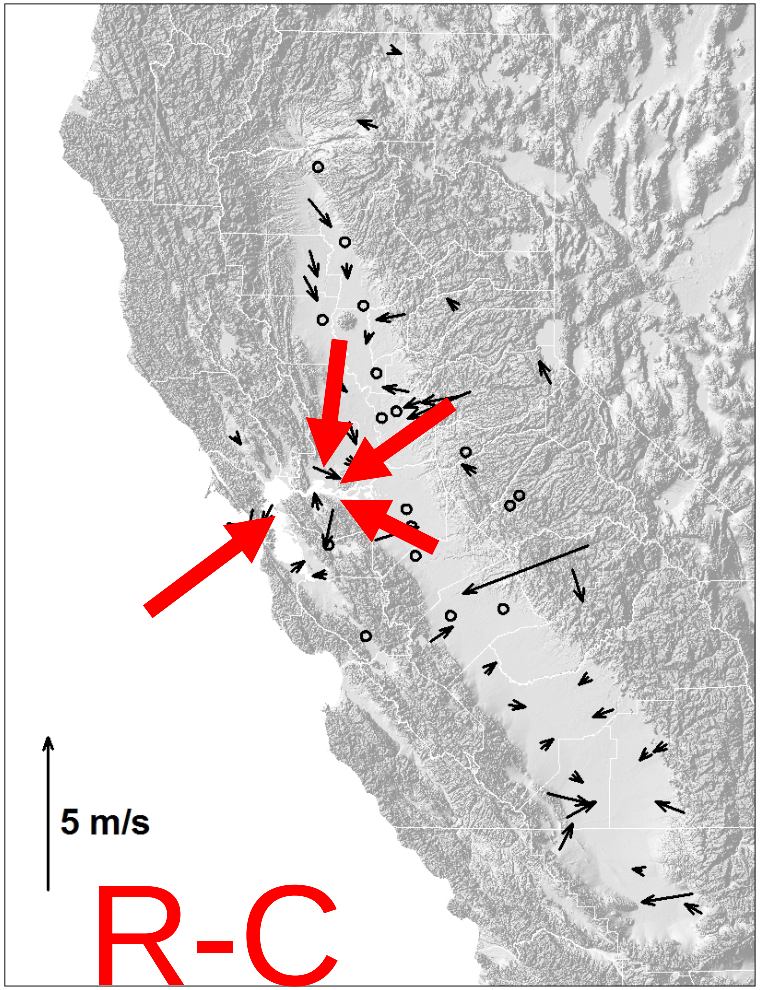
Aloft ridge transient

Easterly in the Delta

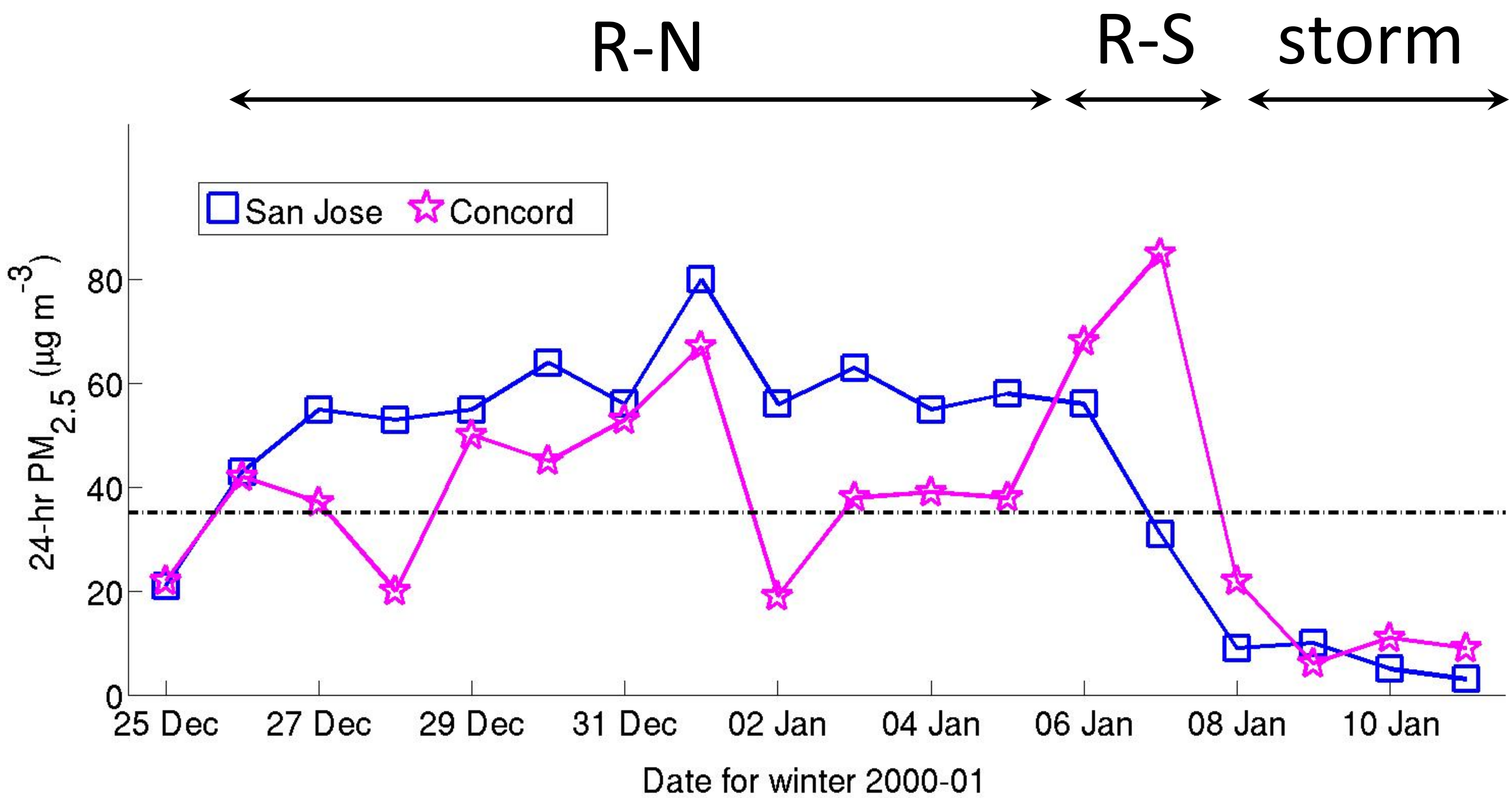
- Previous day and/or
- Morning hours

Westerly in the Delta

- Afternoon hours

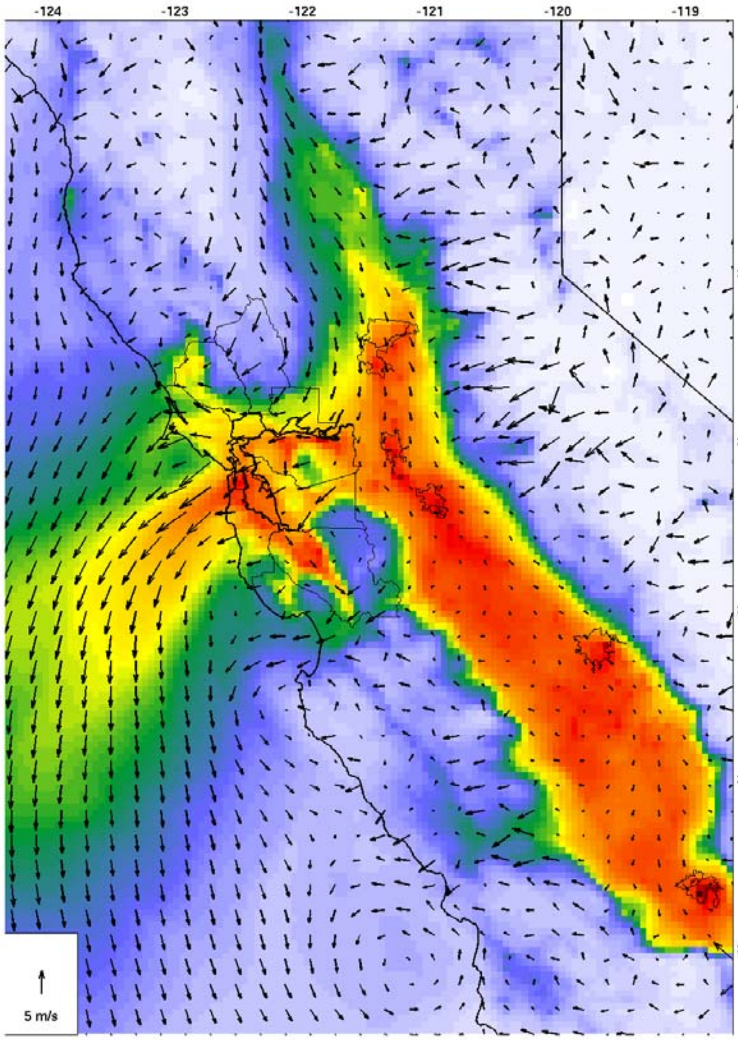


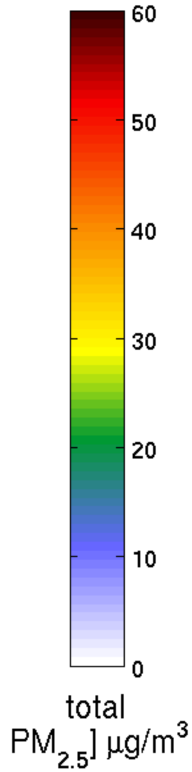
Observed PM (example)



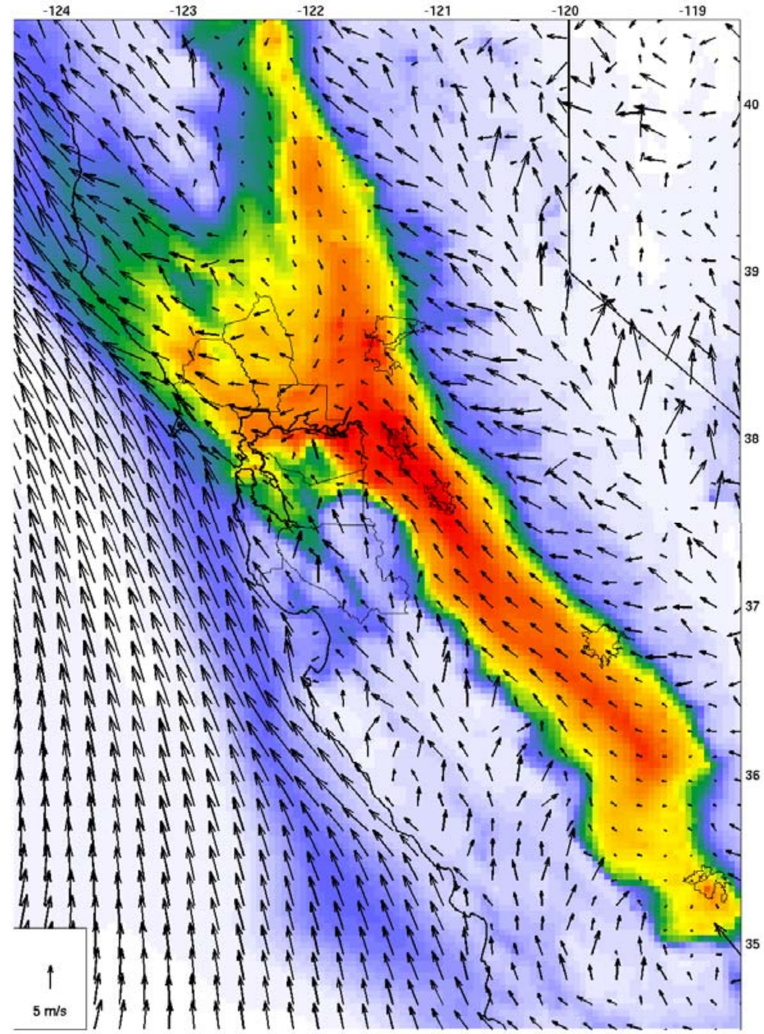
Simulated PM (example)

5 January 2001: R-N





7 January 2001: R-S



PM Sensitivity to Emission Reductions

Calculation

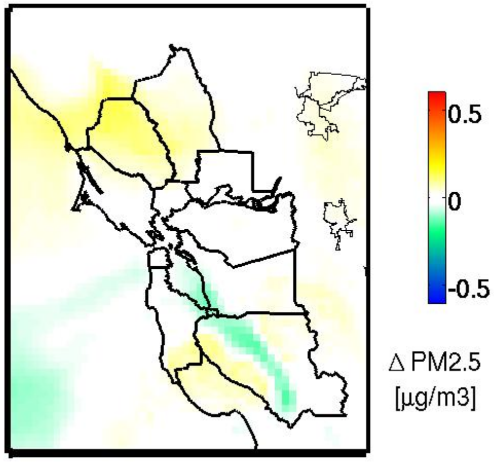
- Perform 2 simulations
  - Base case
  - With reduced emissions
- Compute difference for each grid cell and day
  - Positive ΔPM2.5 shows <u>benefits</u>

Interpretation

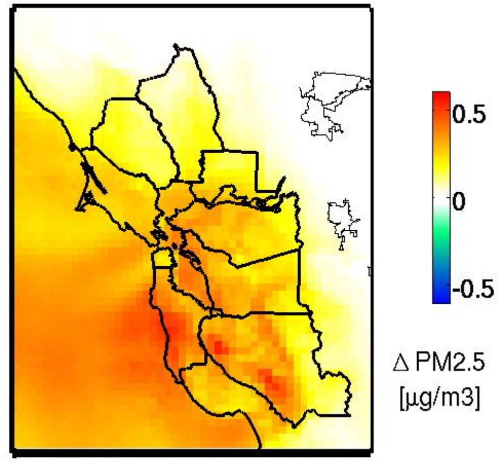
- Qualitative: <u>Which</u> emissions reductions are effective?
- Quantitative: <u>How much</u> do those reductions impact PM?

Sensitivity Simulation Results*

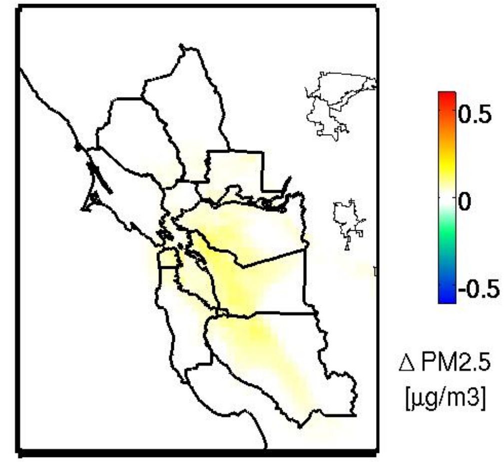
NOx+VOC emissions reduced 20%



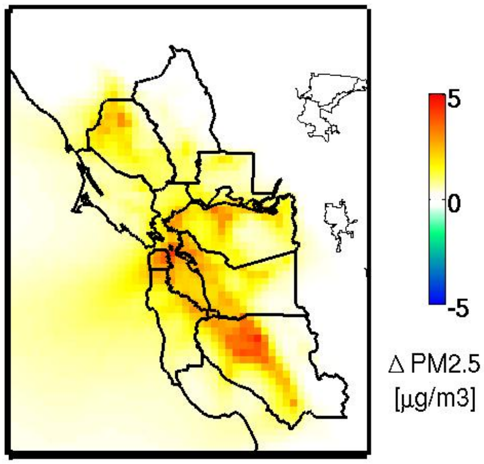
NH3 emissions reduced 20%



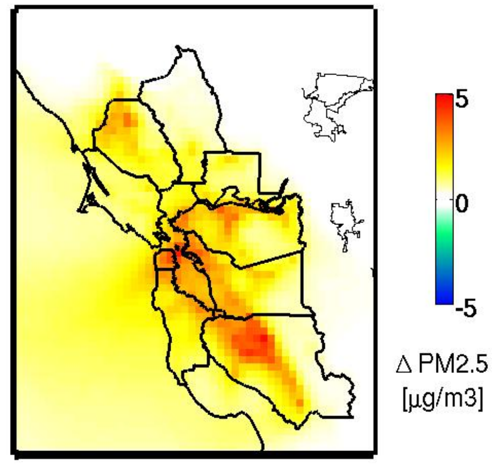
SO2 emissions reduced 20%



PM emissions reduced 20%

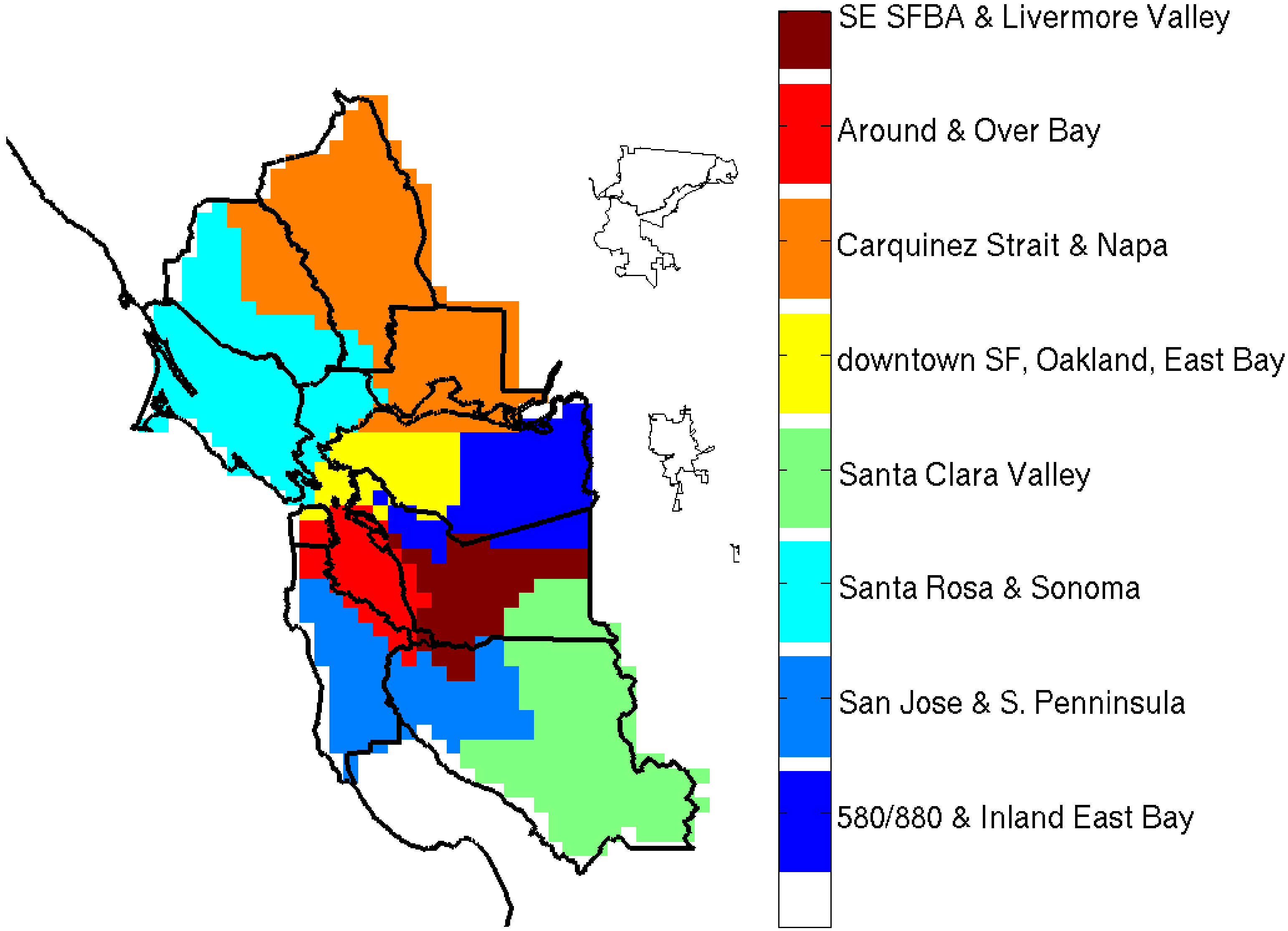


All emissions reduced 20%



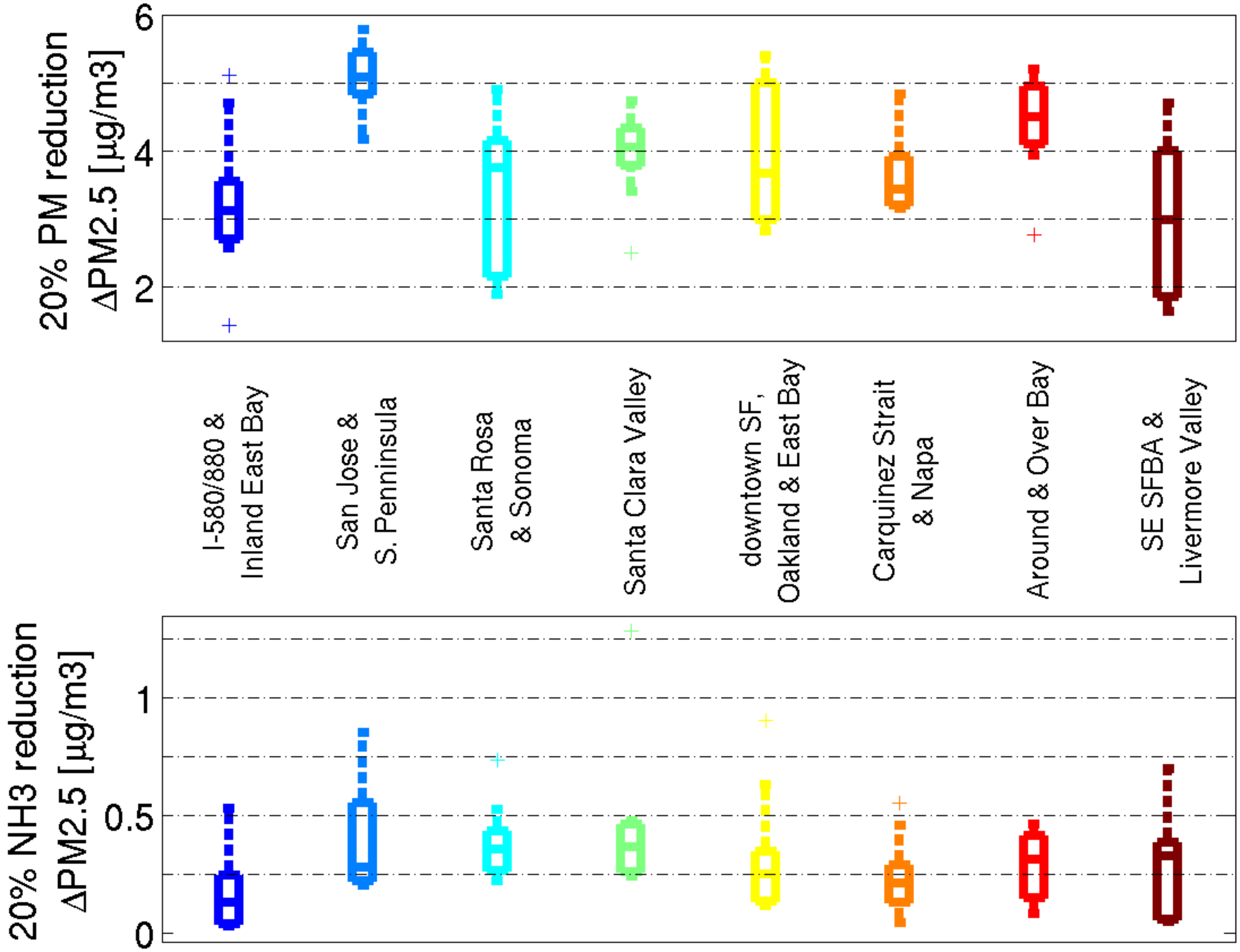
*Means for 20 exceedance days

Sensitivities by Subdomain*



*Cluster grid cells to identify temporal patterns: areas with strongly correlated PM levels (rise/fall together)

Quantified Sensitivities* for PM & NH_3



*Distribution over top 10 days and single grid cell with highest PM level

Summary and Conclusion

- Significant progress made
- Preliminary results promising
- PM exceeds the 24-hr standard when winds are low (under 3 m/sec) and the 24-hr average wind direction is from the east along the Delta
- The highest primary and secondary PM do not necessarily develop on the same day
- Wood burning may be contributing about 33% to PM
- PM is almost always elevated in the CV when elevated in SFBA
- PM levels are 1.5-2.5 times higher in the CV compared to SFBA

Summary and Conclusion (Cont.)

- Primary PM is dominant around the Bay
- Primary PM emission reductions may bring concentrations down faster around the Bay
- On average, 43% of PM in SFBA is secondary PM when PM levels elevated
- Secondary PM contribution increases inland
- Both primary PM and secondary precursor emission reductions may be effective inland

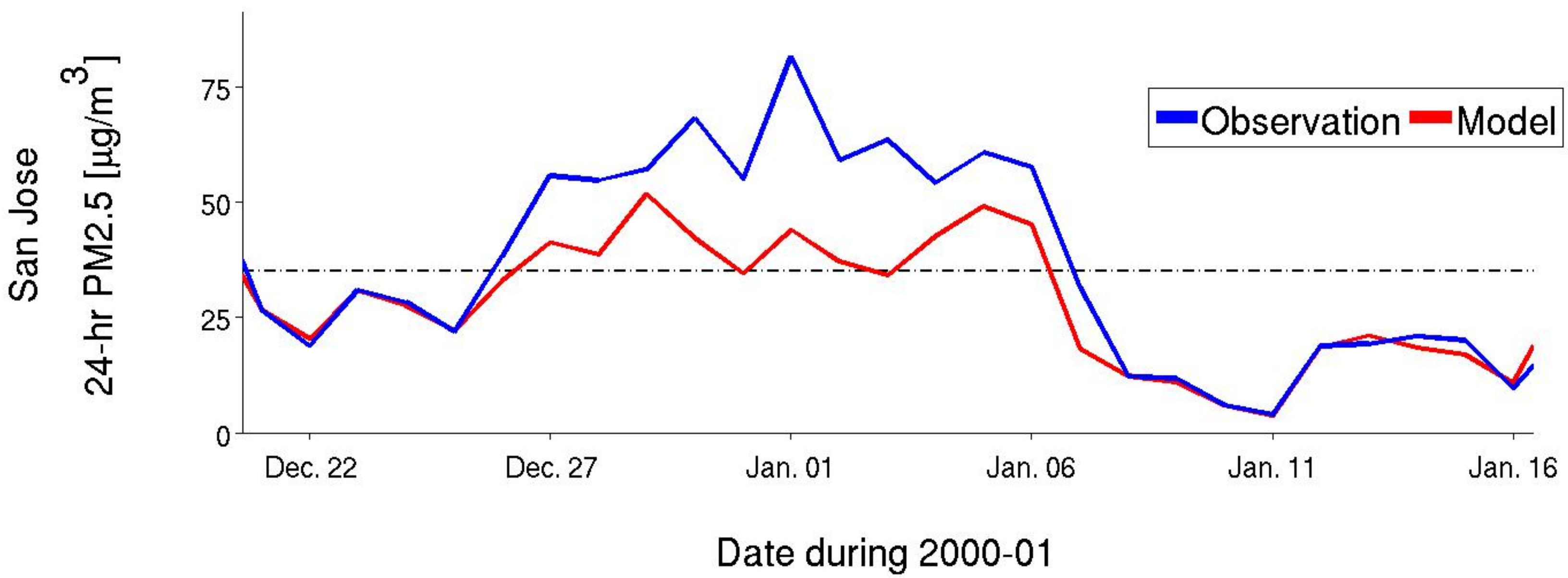
Summary and Conclusion (cont.)

Areas For Further Investigation – Reported to CCOS/CRPAQS group

- CMAQ underestimates PM when concentrations are high
  - Due to deficiency in the meteorological model (MM5)
  - High PM days used to show attainment and yet model underestimates PM on high days the most
  - The same problem may exist in the WRF model (under investigation)
- CMAQ response to secondary PM precursor emissions reductions seems about half that supported by observations (based on limited comparison in San Jose)
  - This could be true elsewhere – especially over the west coast
  - Areas dominated by secondary PM may face difficulties in demonstrating attainment

Simulated vs Observed PM

Example of CMAQ's underestimation



Thank you

Questions and Comments