

BAAQMD Modeling Advisory Committee Meeting on Particulate Matter

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February 10, 2011

Meeting #



Meeting Agenda

- Overall BAAQMD PM2.5 study program plan
- Model performance evaluation following EPA guidelines
- Model sensitivity to changes in emissions
- Uncertainty in model sensitivity stemming from meteorological model performance
- Discussion
- Next meeting

Contact info

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Overall BAAQMD PM2.5 Study Program Plan

- Major Components
 - Data analysis
 - Emissions inventory development
 - Modeling
 - MM5 (also evaluating WRF)
 - CMAQ
 - Health impacts study
- Goals
 - Provide technical information to SIP development effort
 - Prepare supporting documentation
 - Collaborate with regional partners to assess PM issues
 - Share information through reports*, papers, meetings

*Preliminary modeling report available online

MAC Meetings

June 3, 2010

- Attainment status
- Overall PM study plan
- Conceptual formation of SFBA PM
 - Data analysis
 - Emissions inventory
 - Modeling

October 14, 2010

- Emissions inventory in SFBA

February 10, 2011

- Model performance evaluation following EPA guidelines
- Model sensitivity to changes in emissions
- Uncertainty in model sensitivity stemming from meteorological model performance

MAC Meetings (cont.)

May-June 2011

- PM health impacts study
- 2015 emissions inventory, simulations, and trend analysis
- Preliminary WRF-CMAQ simulations
- Summary of overall study findings
- Discussion

September-October 2011

- Summary of key findings and discussion
- Review of draft document on study findings
- Receive feedback from MAC
- Finalize the document

Model setup

- Models applied
 - MM5
 - 3 nested domains with 36×36, 12×12, and 4×4 km horizontal resolutions
 - 30 vertical levels
 - Analysis nudging for 36 and 12 km domains
 - CMAQ
 - CRPAQS domain with 4×4 km horizontal resolution
 - 15 vertical layers
 - SAPRC-99 chemical mechanism with aerosol module
- Simulation periods
 - 1 December to 2 February, 2000-01 and 2006-07
 - Severe and moderate PM winters, respectively

Model Evaluation

Meteorological model

- Operational evaluation
 - Statistical metrics (METSTAT)
 - Graphical tools (ATMET, METSTAT)
 - No pass/fail benchmark
- Phenomenological evaluation
 - Identify and rank meteorological features that impact air quality
 - Compare simulated features against observations

Model Evaluation (Cont.)

Air quality model

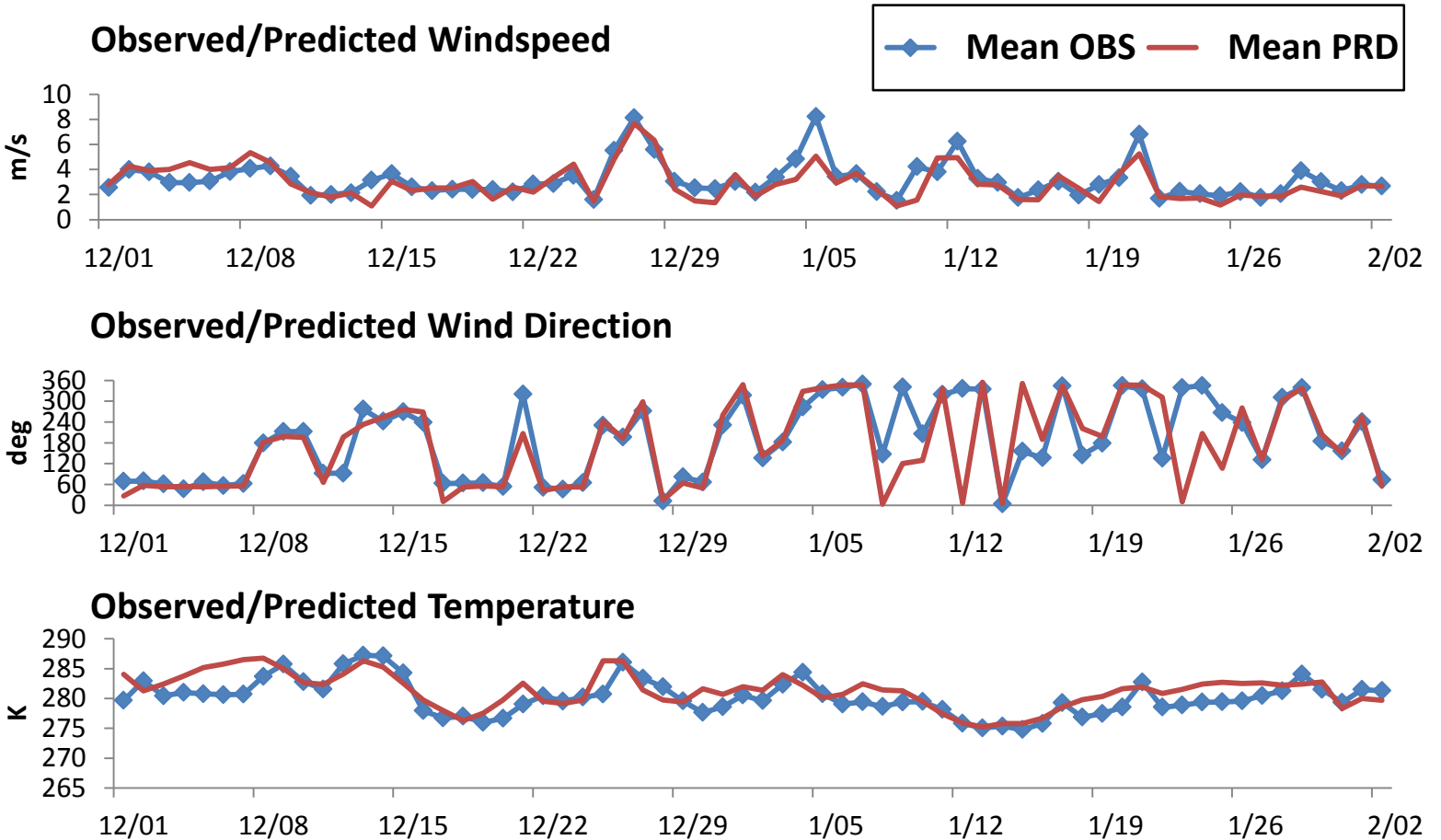
- Operational evaluation (how well observations are predicted)
 - Statistical metrics
 - Graphical tools (time series, tile, scatter, soccer, etc. plots)
 - No pass/fail benchmark
- Diagnostic evaluation
 - Compare predicted and observed ratios of indicator species
 - Compare predicted and observed trends
 - Source apportionment
 - Decoupled direct method
 - Process analysis

Meteorological Model Evaluation

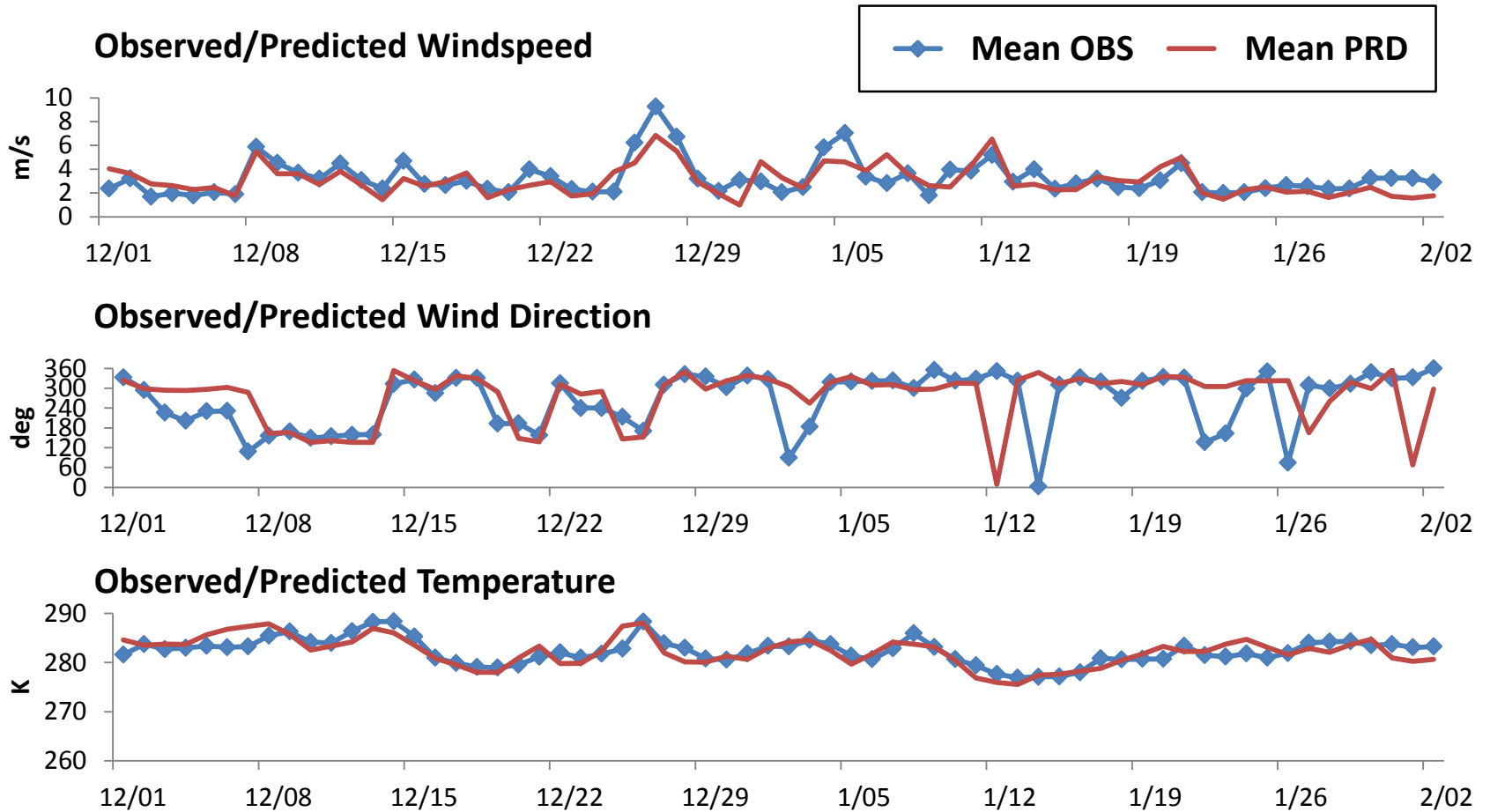
Statistics

2006-07	Wind Speed			Wind Direction		Temperature		
	Bias	Error	Correlation	Bias	Error	Bias	Error	Correlation
Bay Area								
All Days	-0.15	1.34	0.58	3.67	52.96	0.45	2.16	0.83
Exceedence Days	-0.16	1.27	0.55	3.12	55.41	1.50	2.46	0.83
Non-Exceedence Days	-0.17	1.41	0.60	3.41	50.15	-0.12	2.01	0.83
Sacramento								
All Days	0.25	1.45	0.56	4.51	50.82	1.08	2.33	0.83
Exceedence Days	0.55	1.33	0.50	3.38	63.03	2.49	2.81	0.86
Non-Exceedence Days	-0.03	1.56	0.61	5.58	39.36	-0.24	1.88	0.80
SJV								
All Days	-0.30	1.05	0.45	-2.82	60.04	1.19	2.19	0.85
Exceedence Days	-0.31	0.95	0.42	-4.01	68.38	1.71	2.43	0.87
Non-Exceedence Days	-0.30	1.21	0.49	-0.96	47.02	0.39	1.82	0.81
2000-01								
Bay Area								
All Days	-0.21	1.35	0.56	5.70	58.23	-0.49	2.22	0.79
Exceedence Days	0.04	1.23	0.54	8.78	65.81	0.77	2.30	0.84
Non-Exceedence Days	-0.41	1.46	0.58	3.17	51.99	-1.53	2.15	0.74
Sacramento								
All Days	0.00	1.28	0.52	2.82	55.20	-0.62	2.19	0.76
Exceedence Days	0.08	1.06	0.45	3.07	66.32	0.21	2.16	0.84
Non-Exceedence Days	-0.03	1.36	0.55	2.74	51.33	-0.90	2.20	0.73
SJV								
All Days	-0.60	1.07	0.46	-1.02	66.87	-0.44	2.38	0.66
Exceedence Days	-0.62	1.02	0.44	-4.37	70.62	-0.48	2.37	0.65
Non-Exceedence Days	-0.58	1.13	0.49	3.87	61.96	-0.38	2.41	0.68

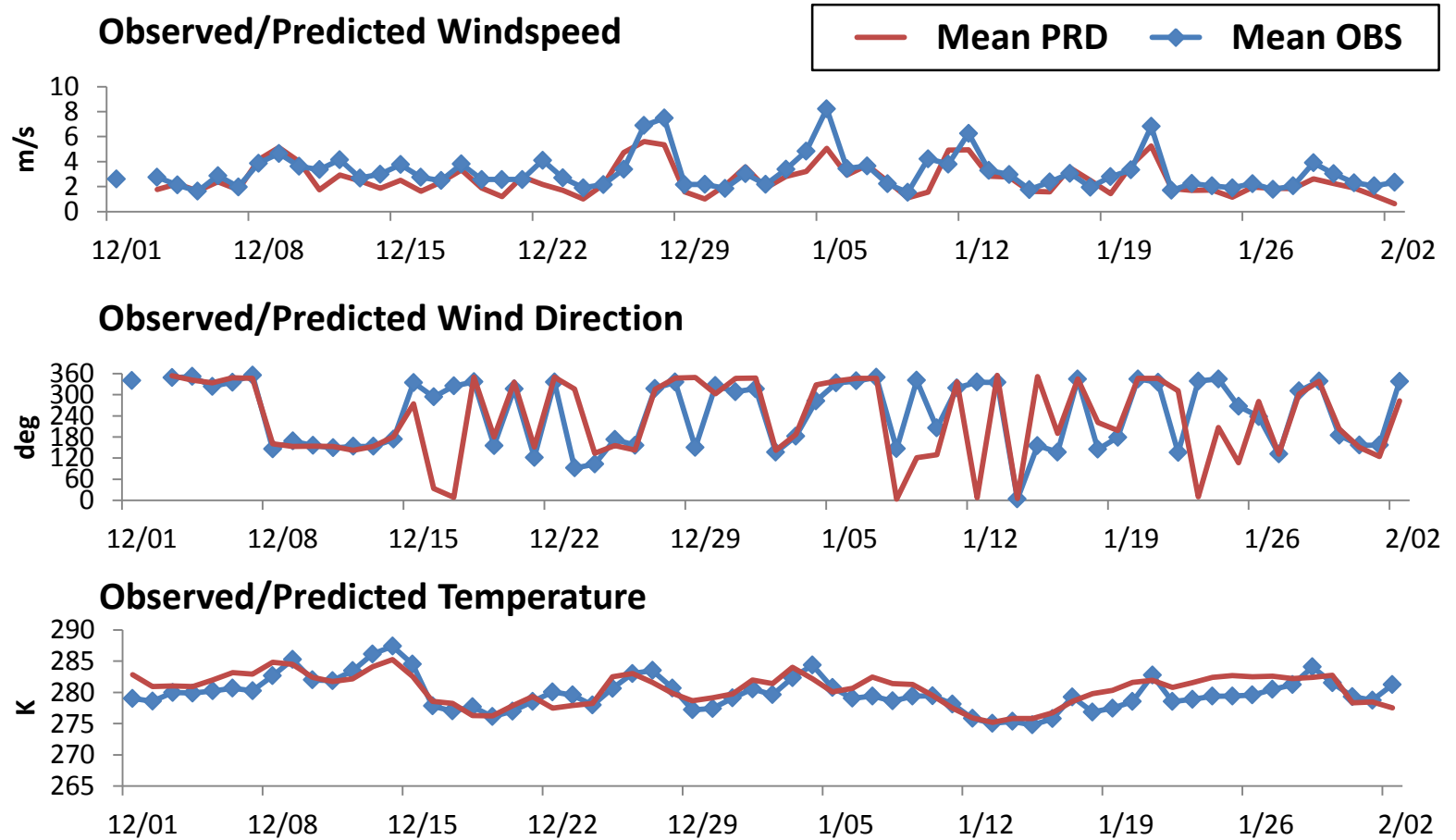
Livermore, 2006-07



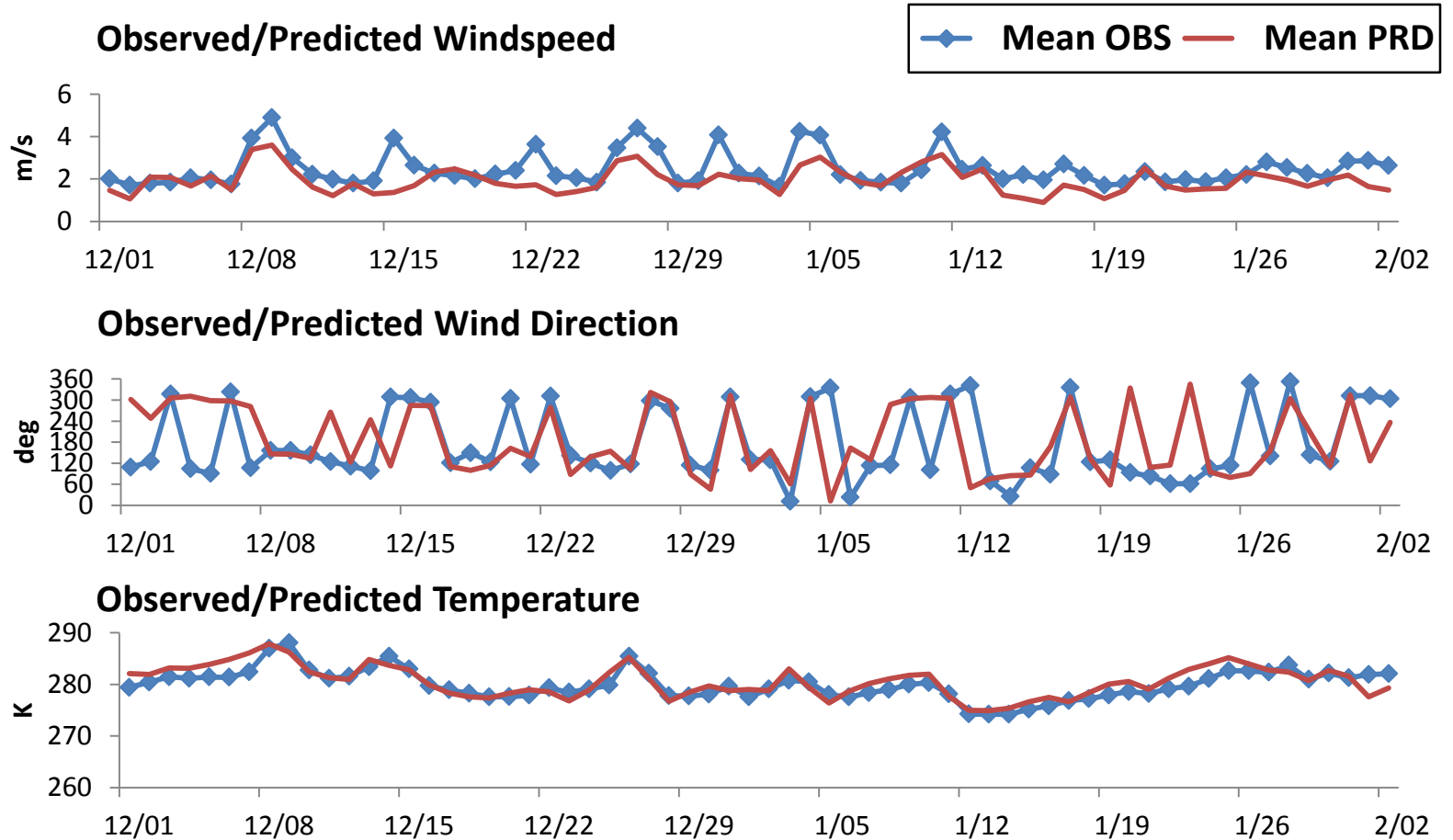
San Jose, 2006-07



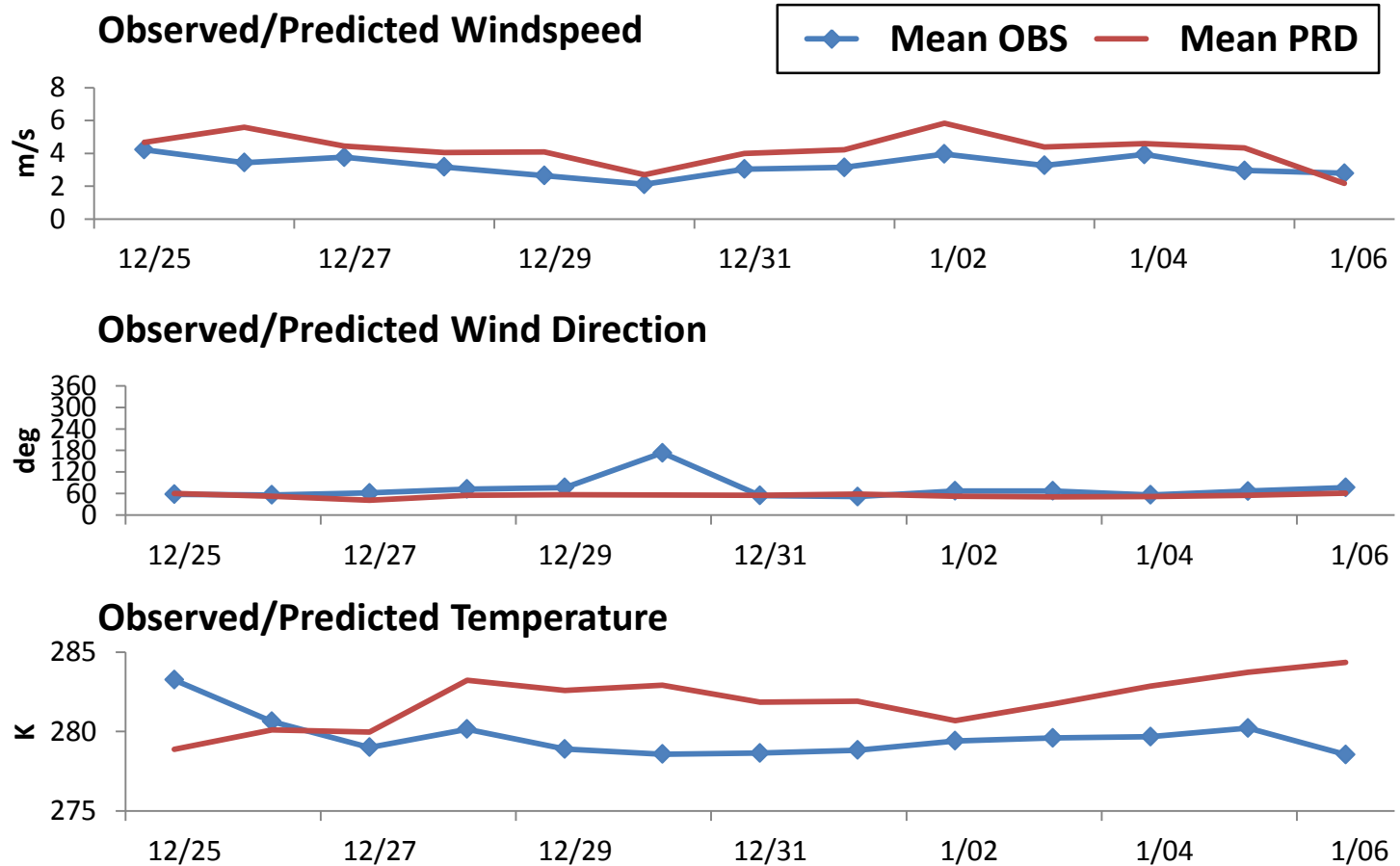
Sacramento, 2006-07



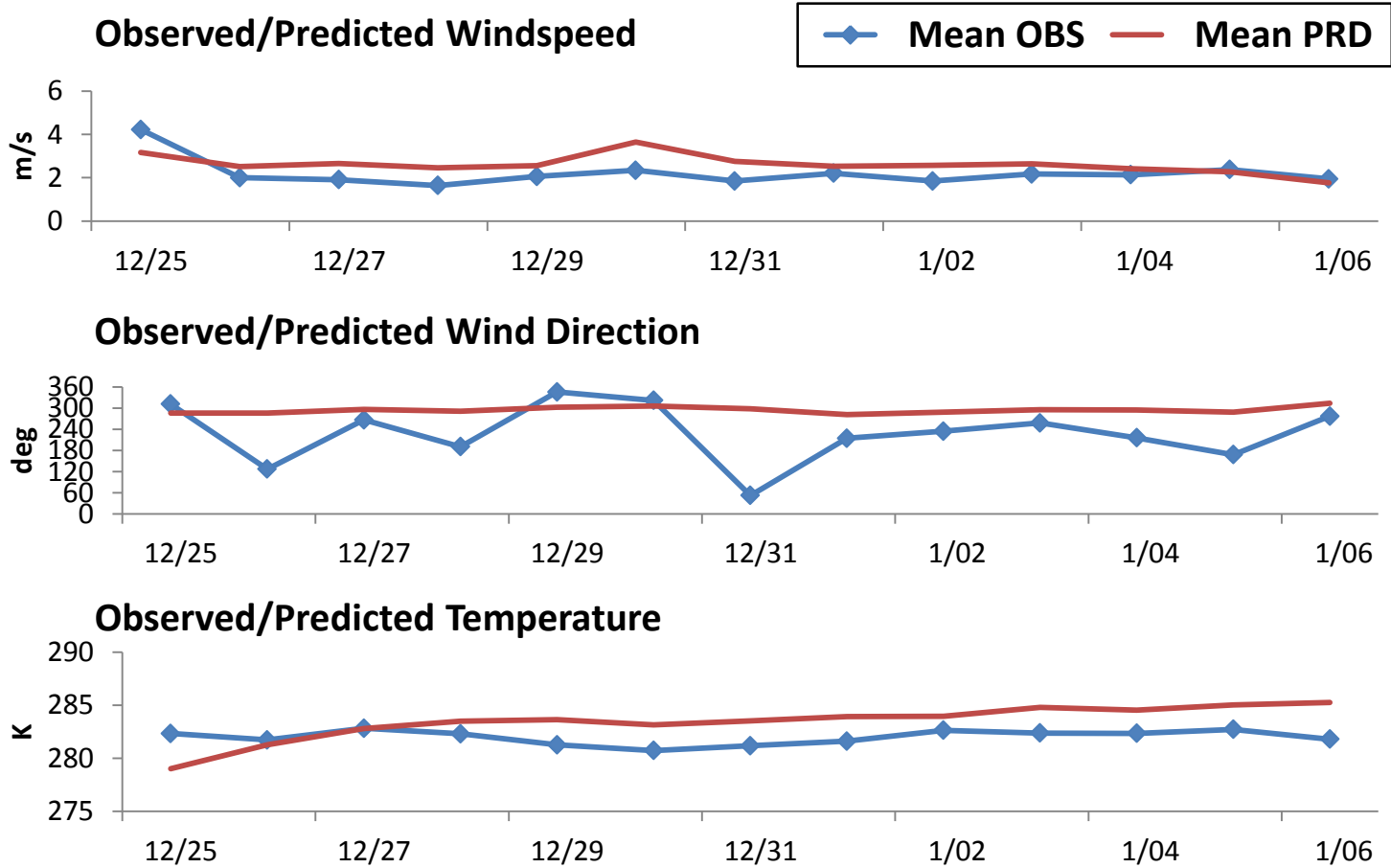
Fresno, 2006-07



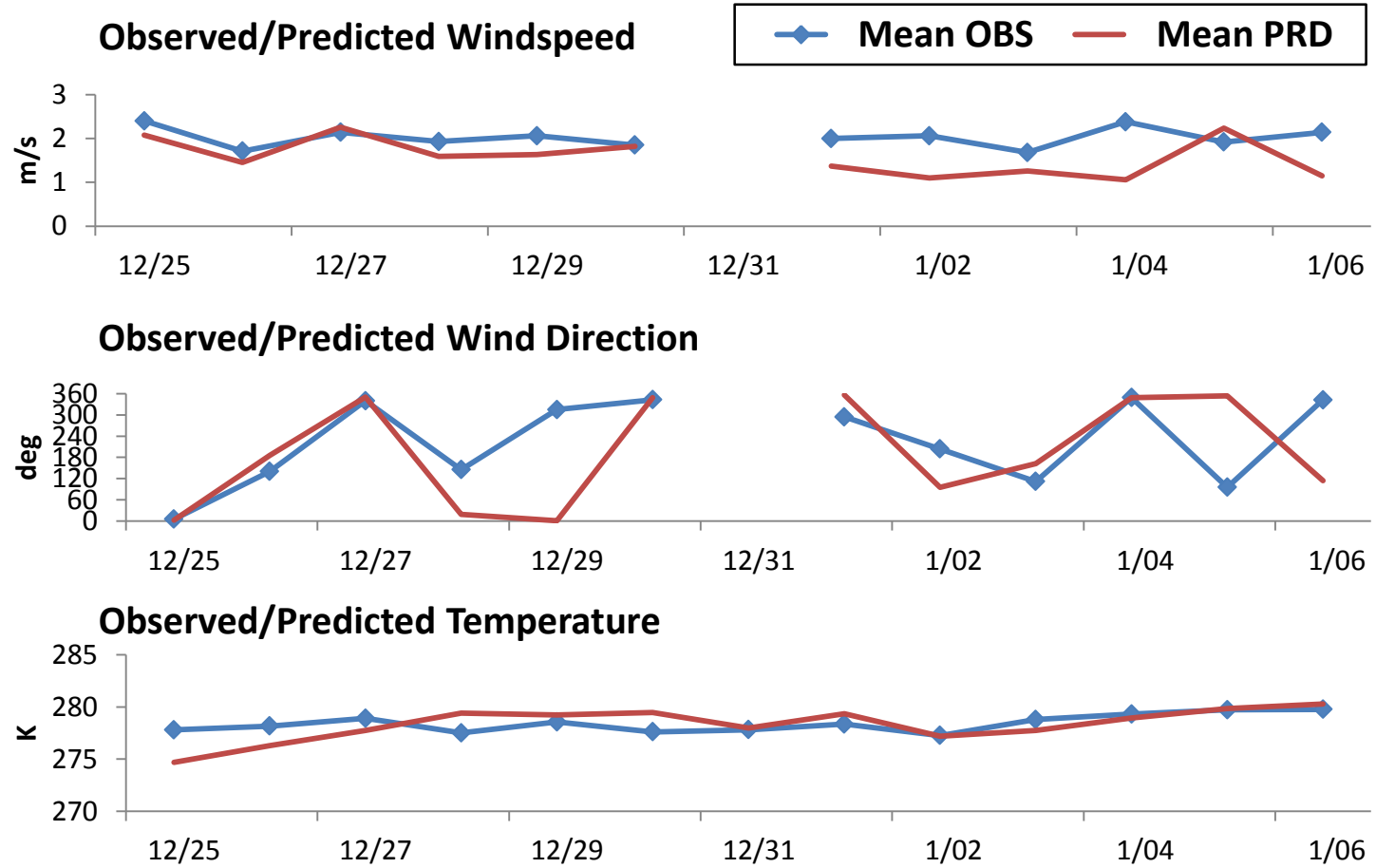
Livermore, 2000-01



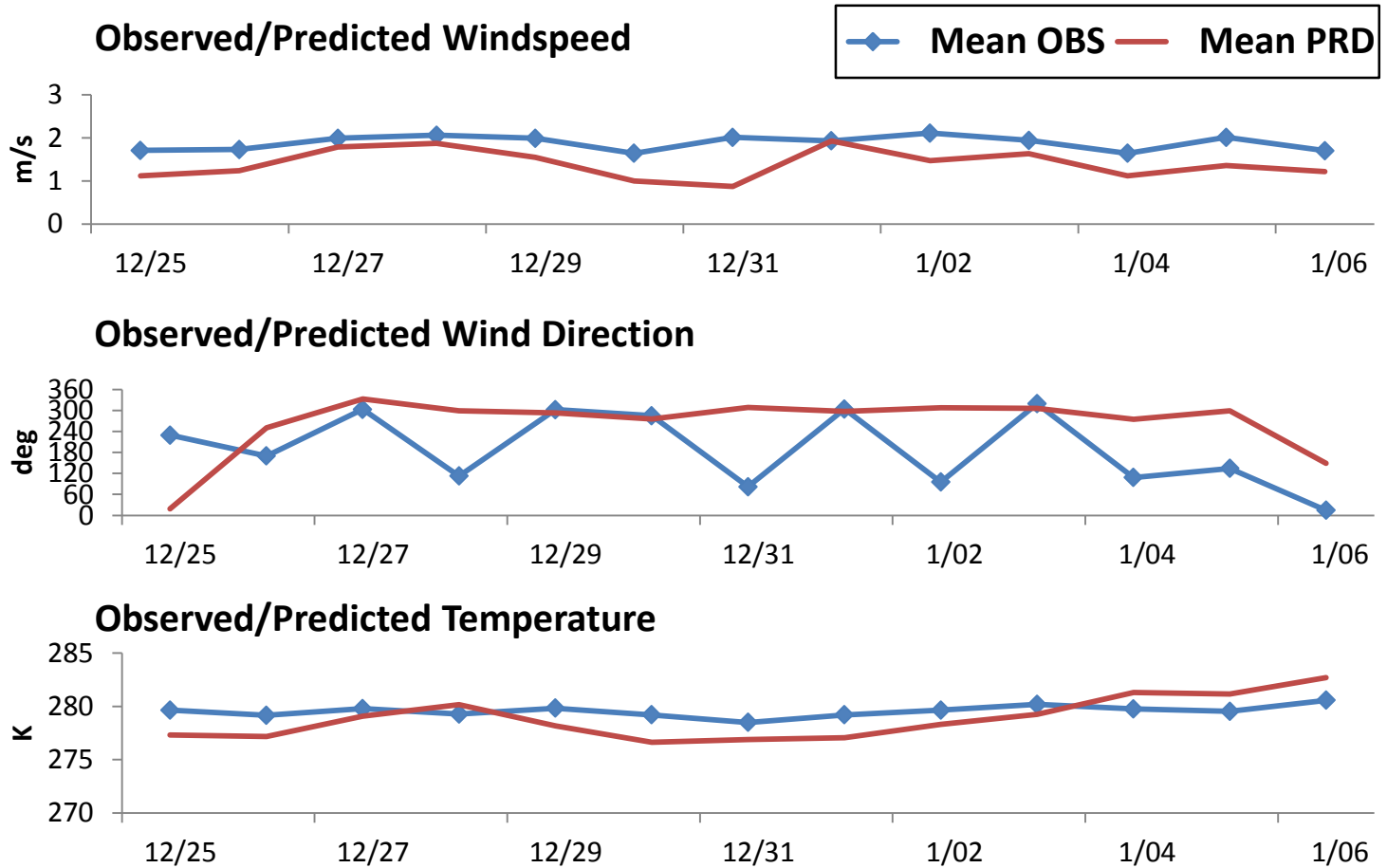
San Jose, 2000-01



Sacramento, 2000-01



Fresno, 2000-01



Air Quality Model Evaluation

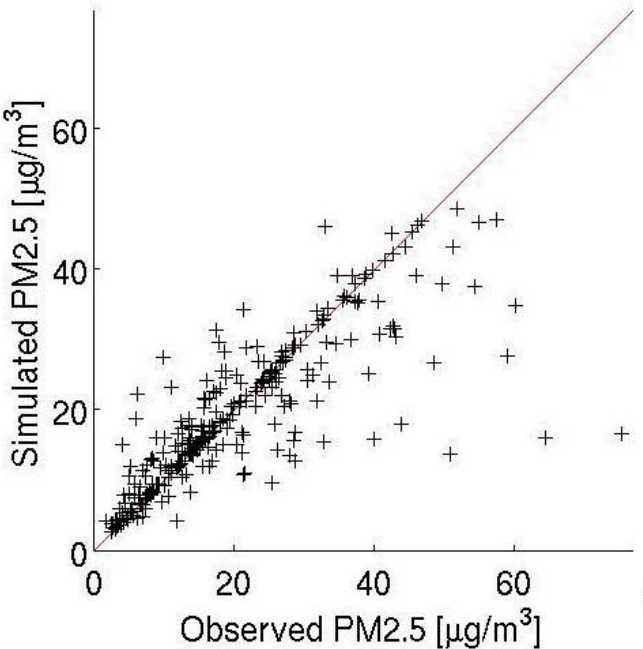
Statistics: total PM2.5 levels

	Bias ($\mu\text{g}/\text{m}^3$)	Error ($\mu\text{g}/\text{m}^3$)	Correlation	Sample size
Bay Area				
All simulation days	-1.1	4.0	0.81	288
Exceedance days (17)	-5.6	6.6	0.45	83
Non-exceedance days (46)	0.6	2.9	0.8	205
SJV				
All simulation days	-7.5	9.0	0.81	158
Exceedance days (39)	-10.9	11.7	0.62	109
Non-exceedance days (24)	0.2	3.1	0.84	49
Sacramento				
All simulation days	-6.7	8.6	0.74	219
Exceedance days (32)	-13.2	13.9	0.41	112
Non-exceedance days (31)	0.1	3.1	0.79	107

Scatter Plots

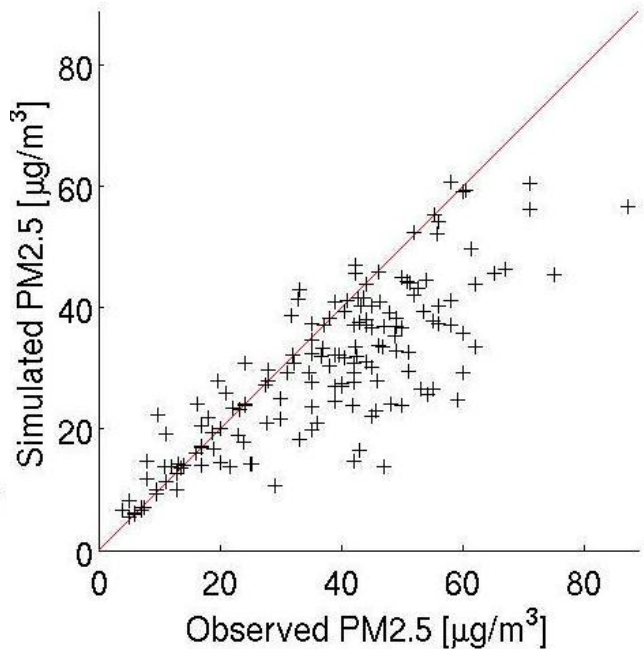
SFBA (8 sites)

Correlation coef = 0.81



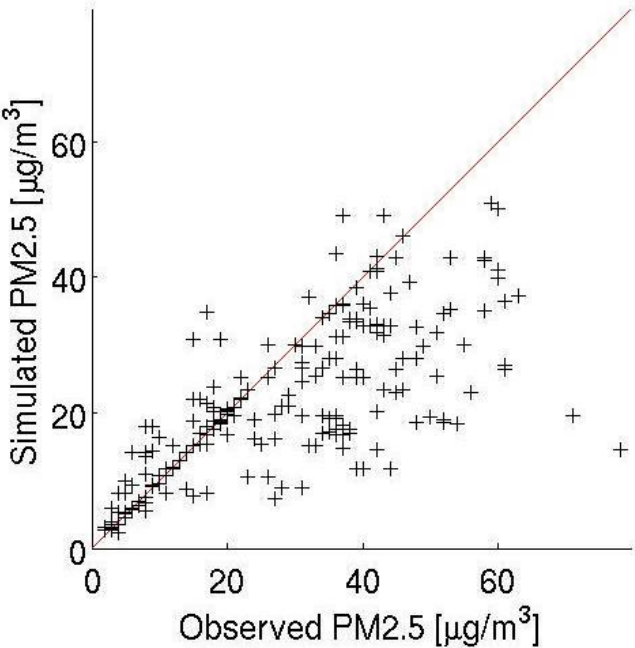
SJV (6 sites)

Correlation coef = 0.81

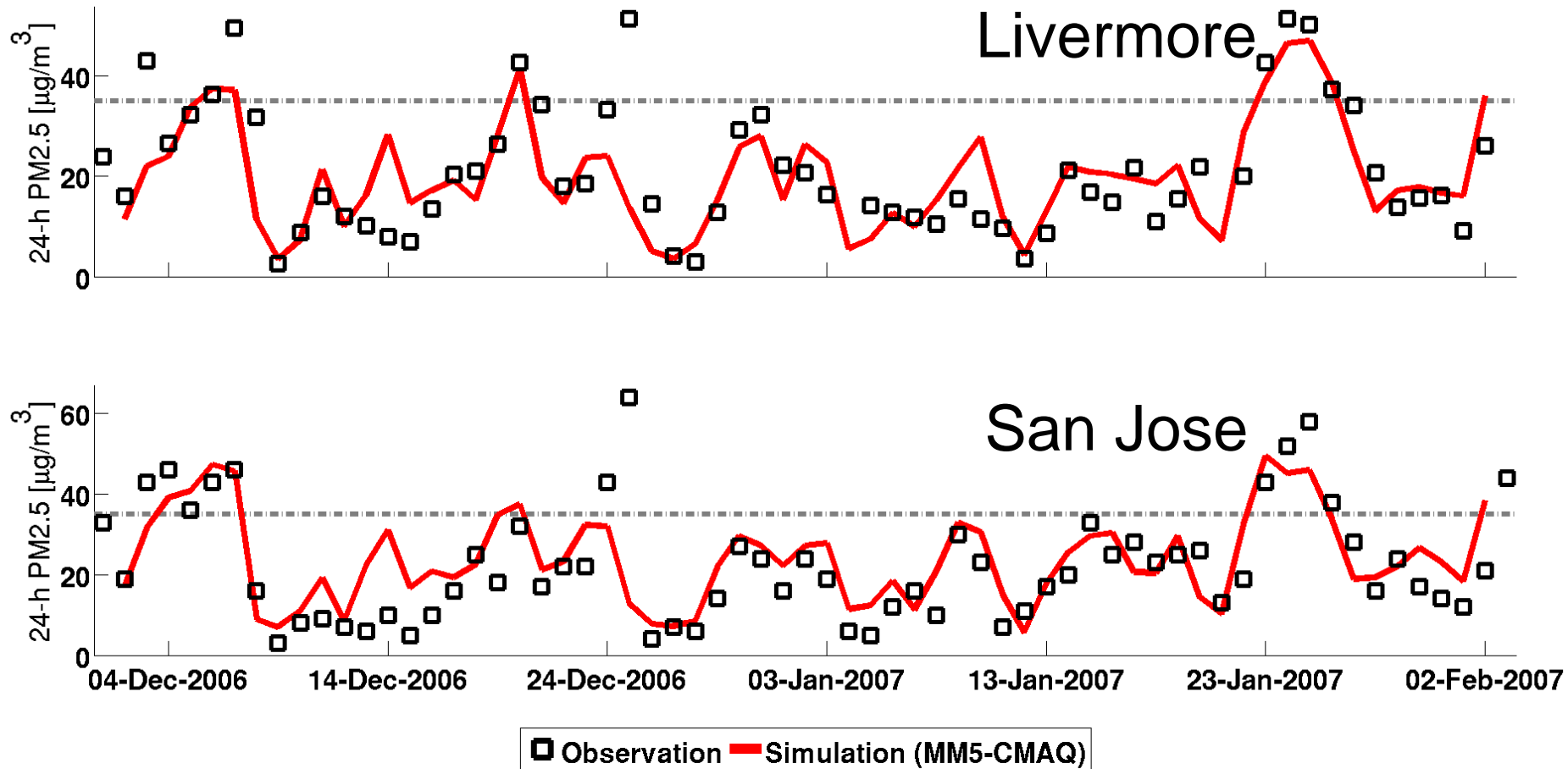


Sac (5 sites)

Correlation coef = 0.74

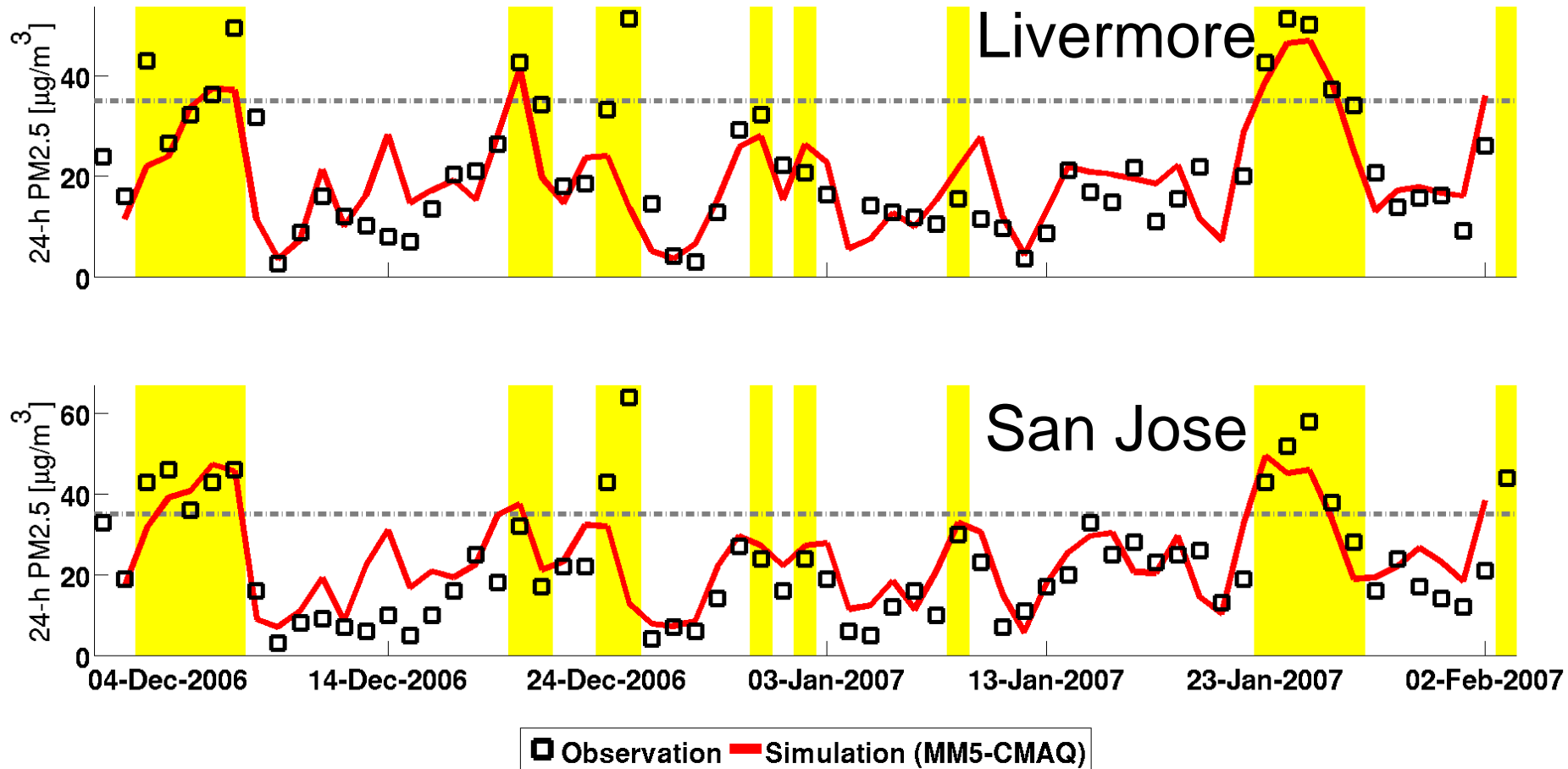


Time series plots: total PM2.5

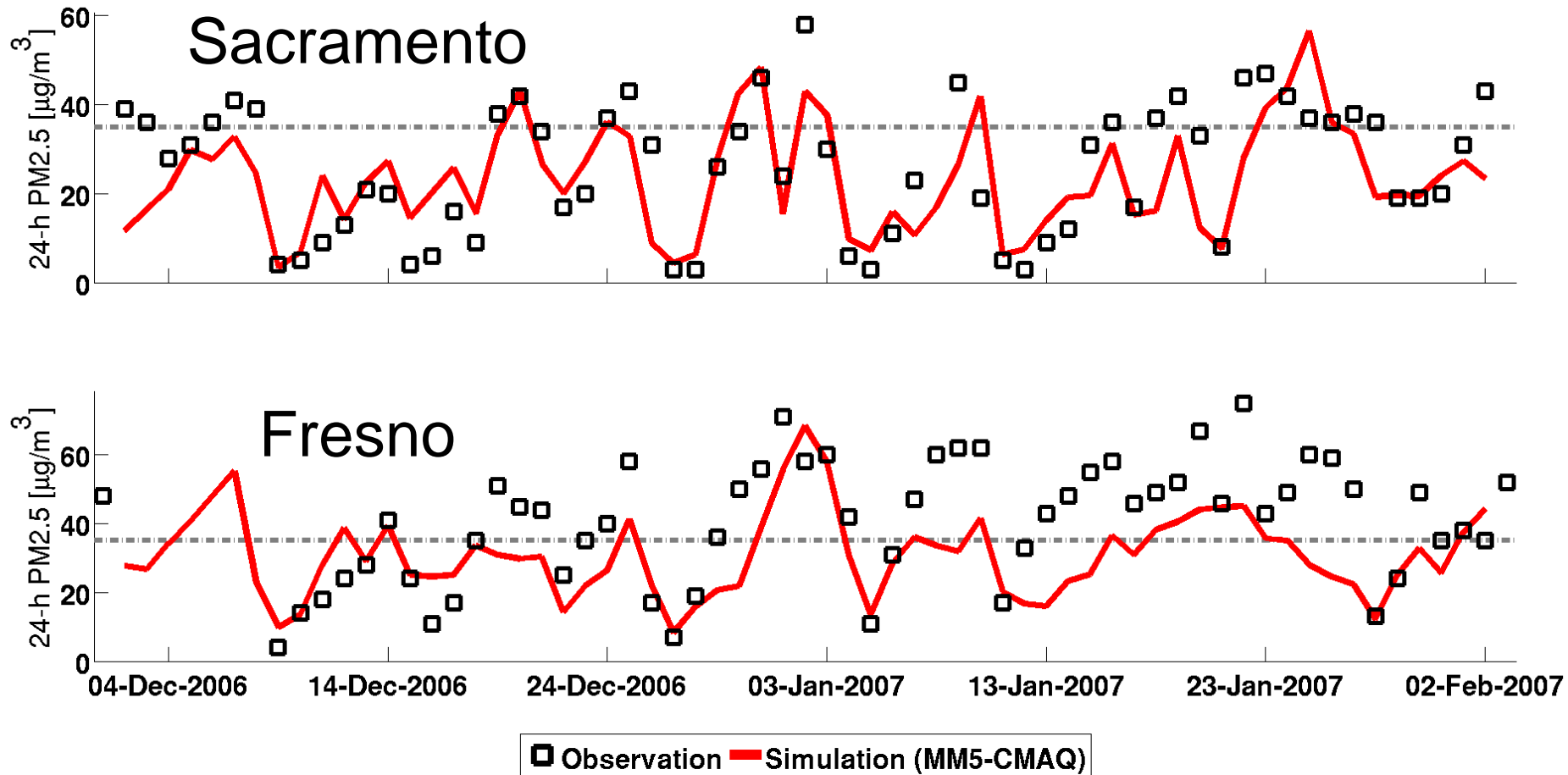


Time series plots: total PM_{2.5}

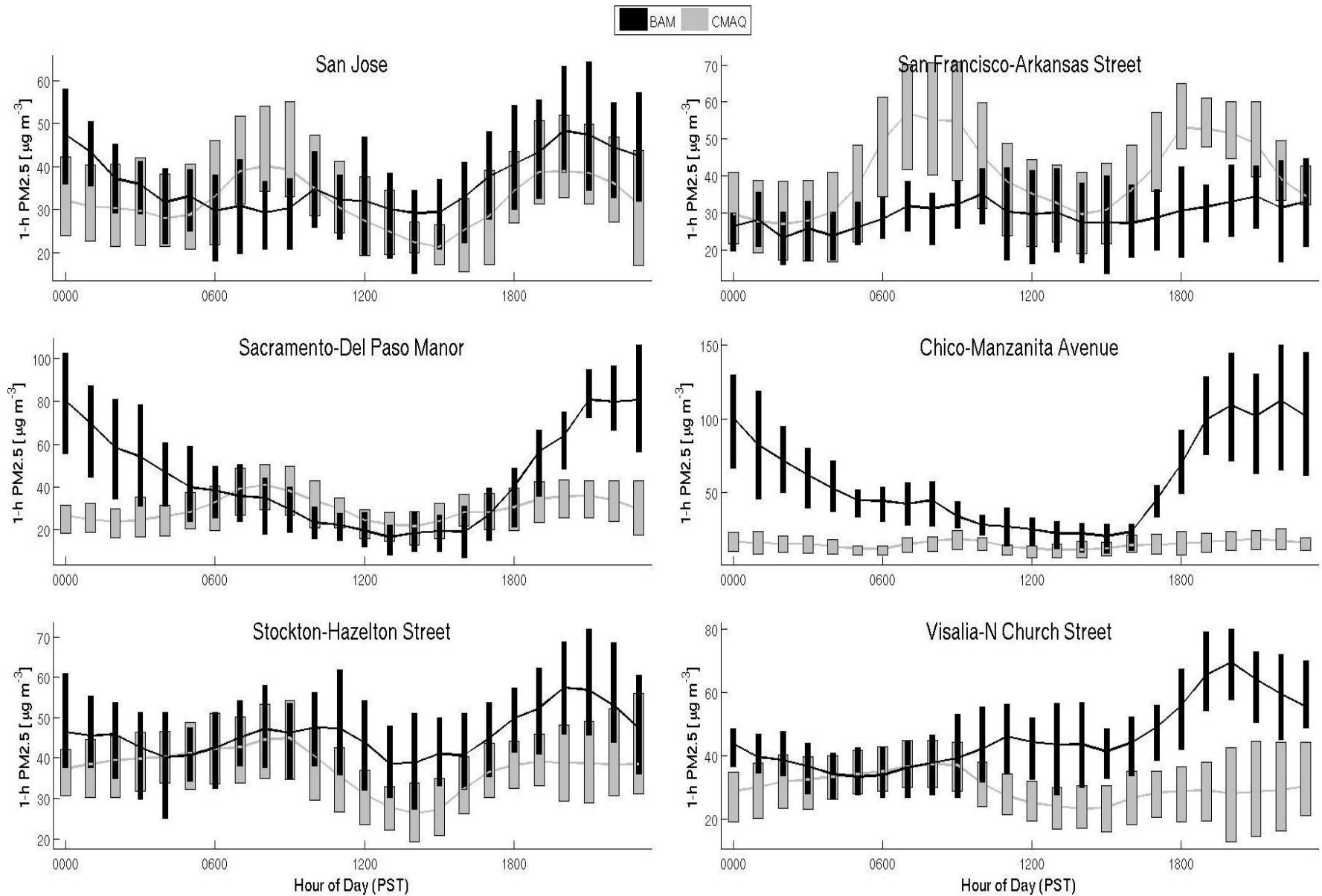
17 SFBA 24-h PM_{2.5} exceedance days (> 35 $\mu\text{g}/\text{m}^3$)



Time series plots: total PM2.5



Diurnal Distribution Plot



Statistics: PM2.5 component levels

San Jose

(exceedance days only)

Every-day measurements:

P = PM_{2.5}

3 = ozone (O₃)

x = NO_x

3rd or 6th day measurements:

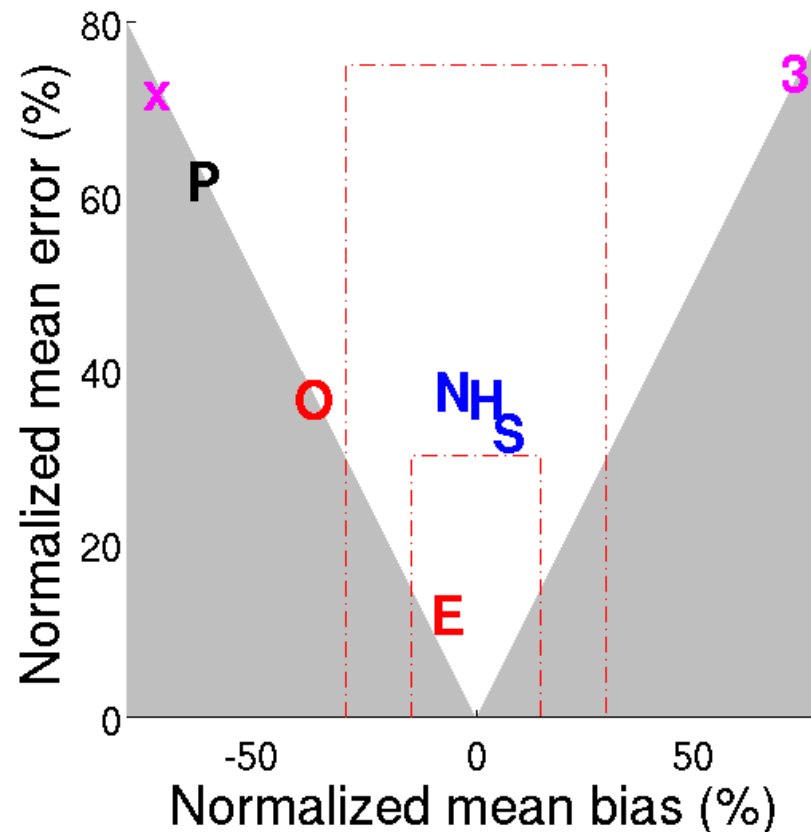
E = elemental carbon (EC)

O = organic carbon (OC)

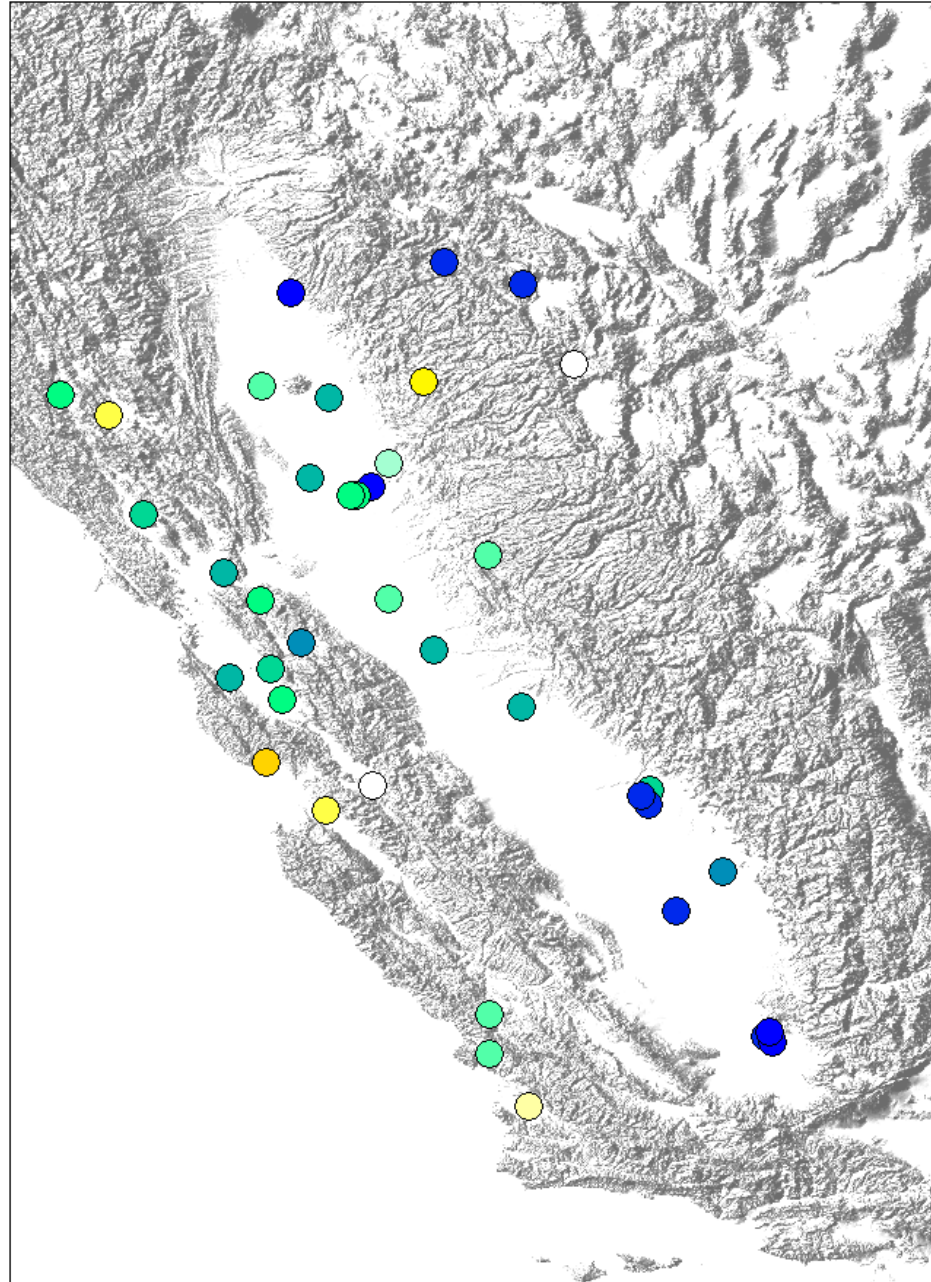
H = ammonium ion (NH₃⁺)

N = nitrate ion (NO₃⁻)

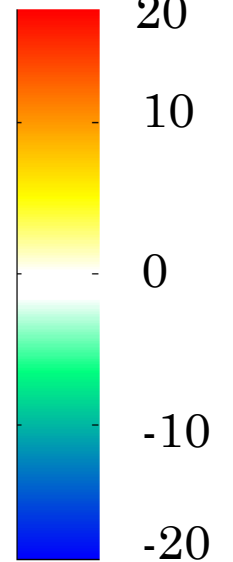
S = sulfate ion (SO₄²⁻)



Bias



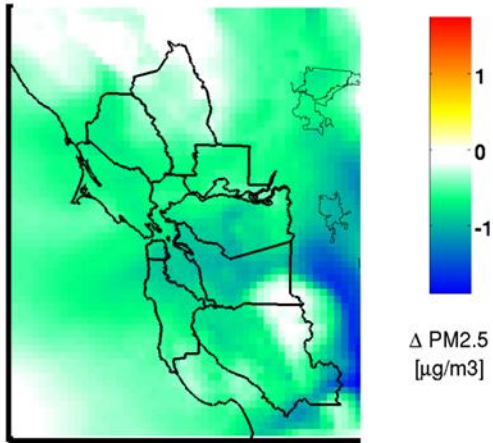
$\mu\text{g}/\text{m}^3$



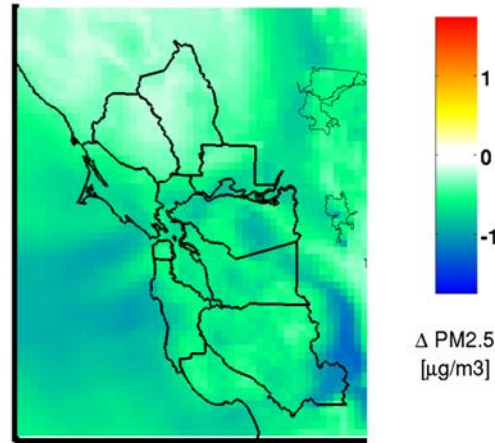
Sensitivity results

Domain-wide and across-the-board 20% anthropogenic emissions reductions

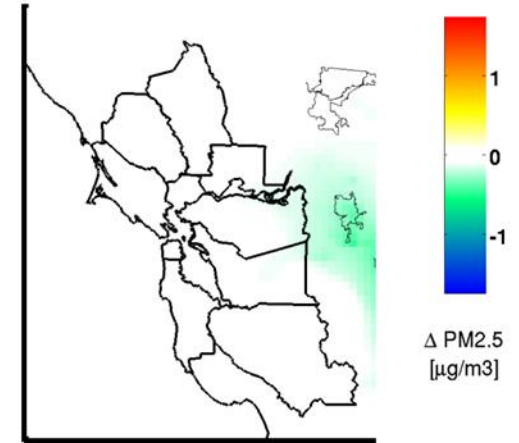
NO_x + VOC combined



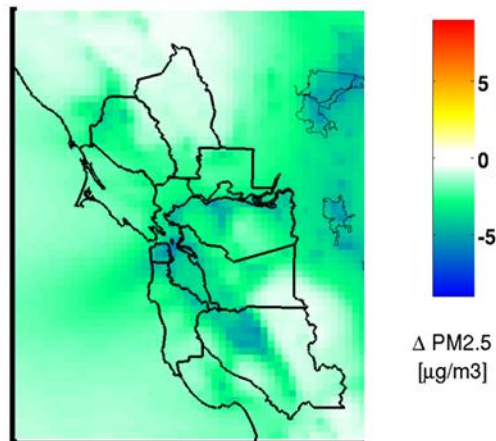
Ammonia



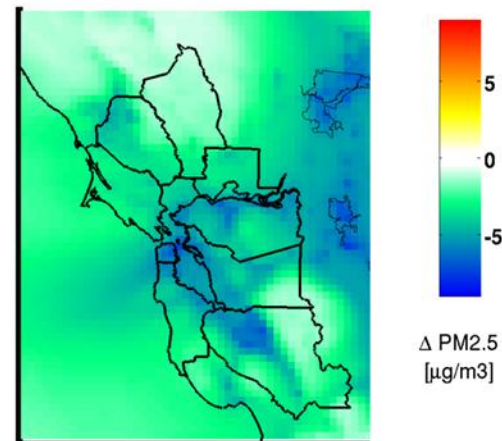
SO₂



Direct PM_{2.5}



All emissions

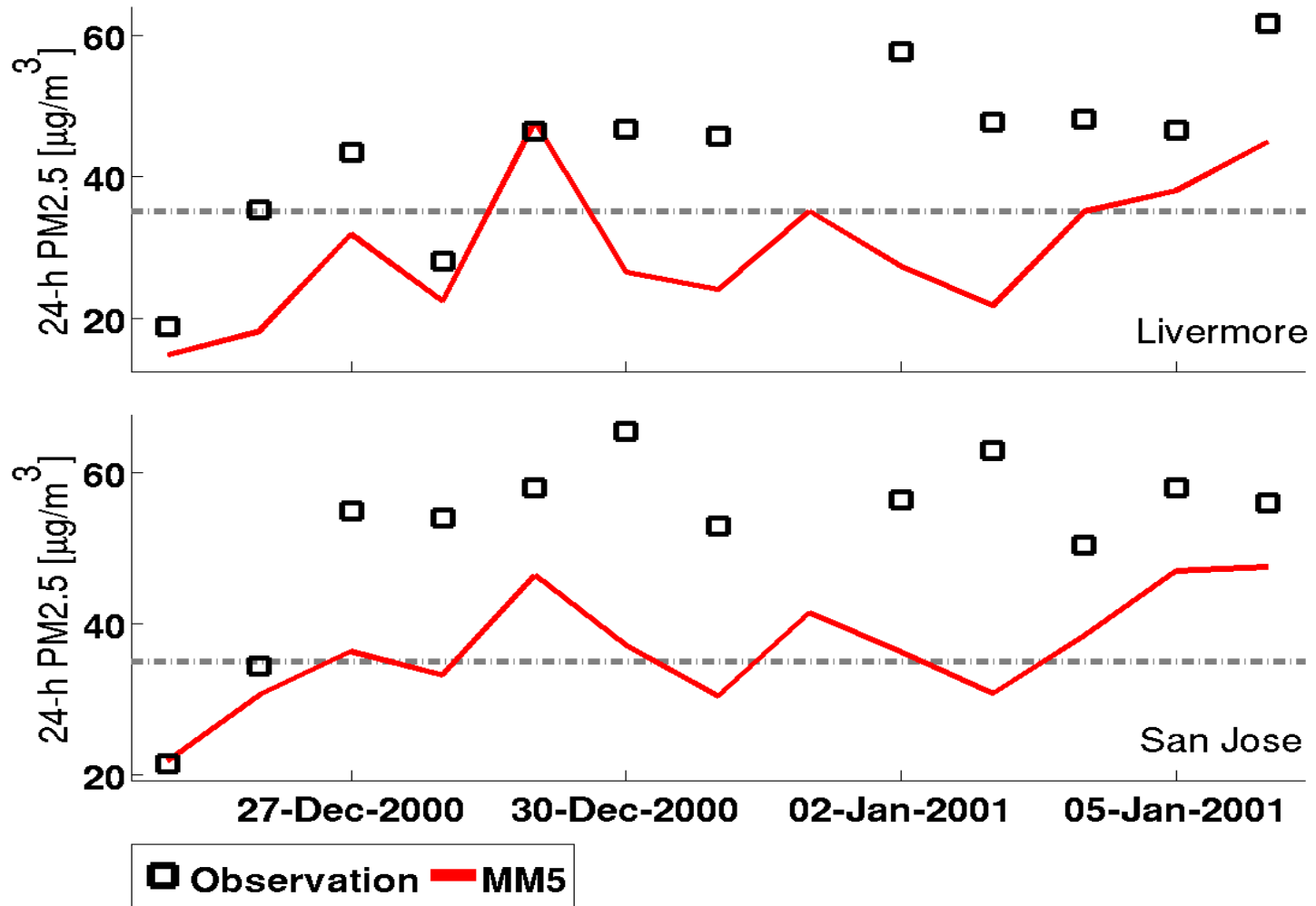


Uncertainty in Air Quality Model Sensitivity Stemming from Meteorological Model Performance

Motivation

- Air quality models consistently underestimate ozone and PM in Central California (CC)
 - MM5 as a meteorological model
 - CAMx, SAQM and CALGRID as ozone models
 - CMAQ as a PM model
- The most severe underestimation is during peak episode days when attainment is demonstrated
- Underestimation appears to coincide with meteorological model performance issues
- Today's topic: how does this problem introduce uncertainty to model sensitivity analyses?

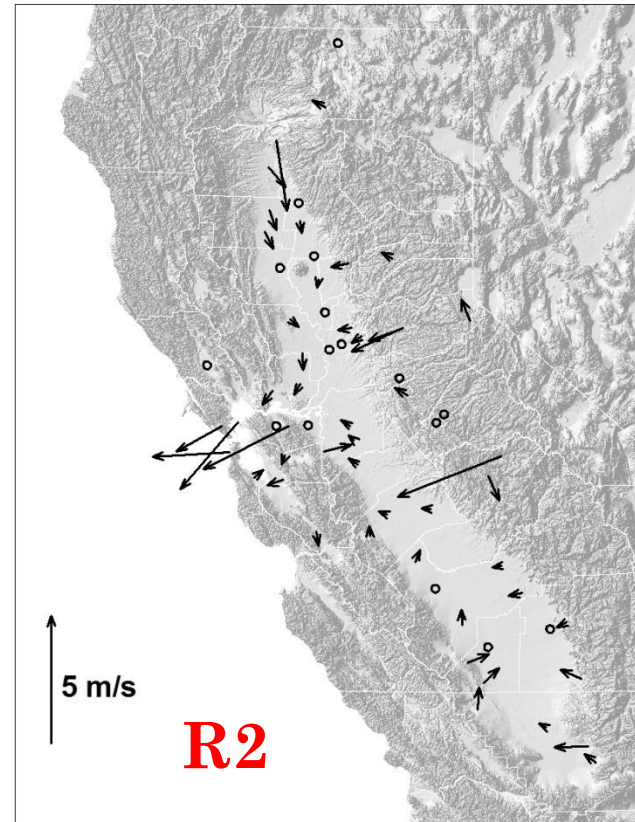
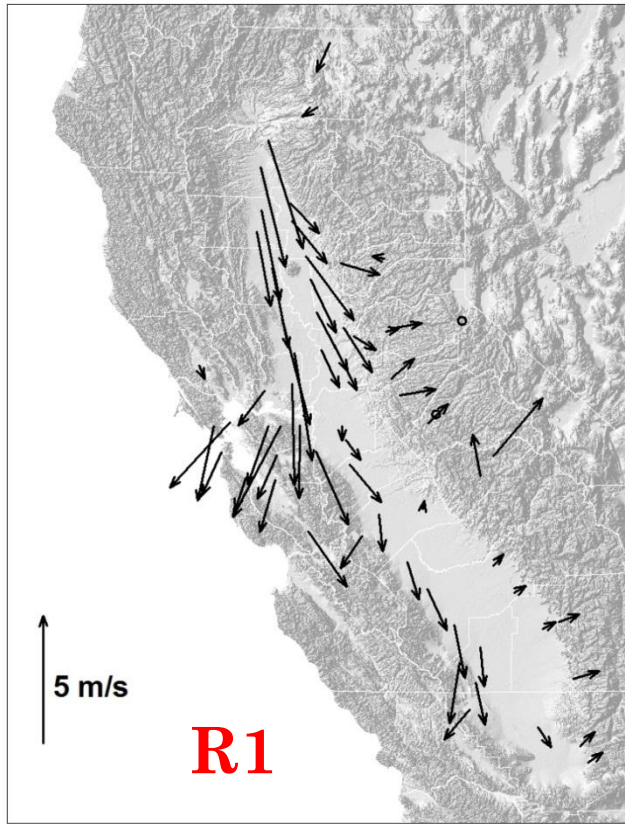
Example: CMAQ Performance for PM2.5



Background Study

- Conducted cluster analysis
 - Classified *observed* meteorology to identify regimes conducive to poor air quality
- Applied EOF analysis
 - Classified *simulated* meteorology into same regimes identified from observations
- EOF analysis
 - A powerful tool, provides more information than simple statistical model performance evaluation
 - Details: [Beaver et al., 2010](#): Pattern-Based Evaluation of Coupled Meteorological and Air Quality Models. JAMC, V49, pp 2077-2091.

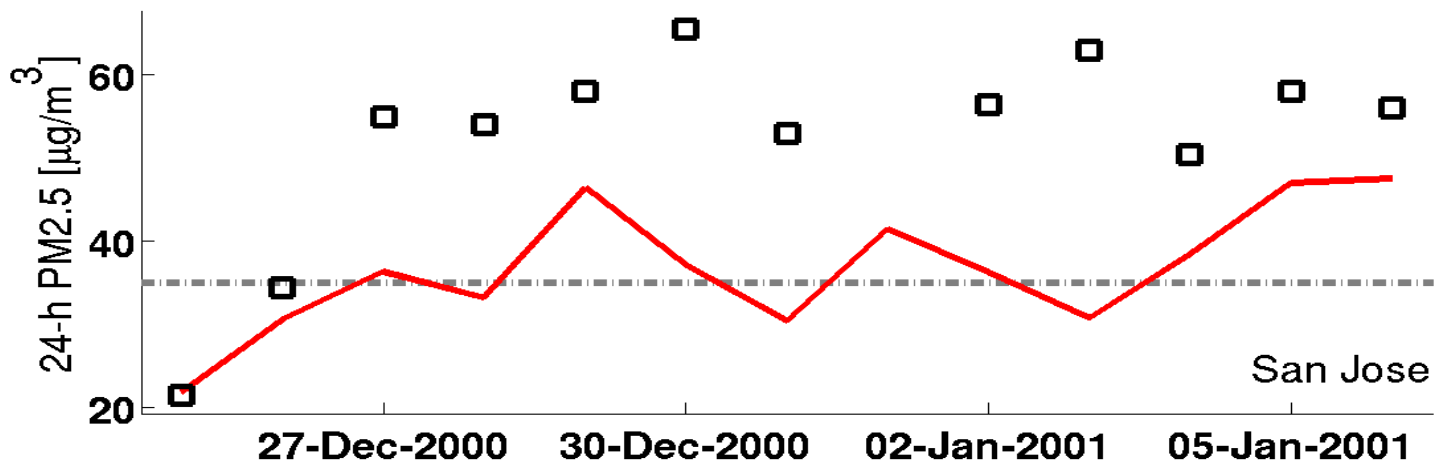
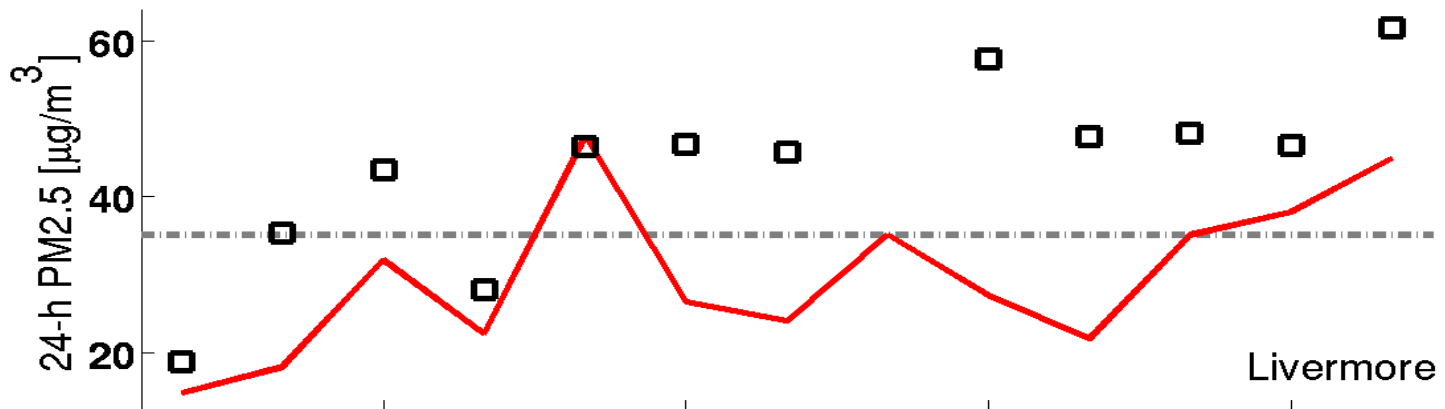
Clustered Observed Winds



R1 → Elevated PM days, but rare Bay Area exceedances

R2 → 80% of 24-h PM Bay Area exceedances

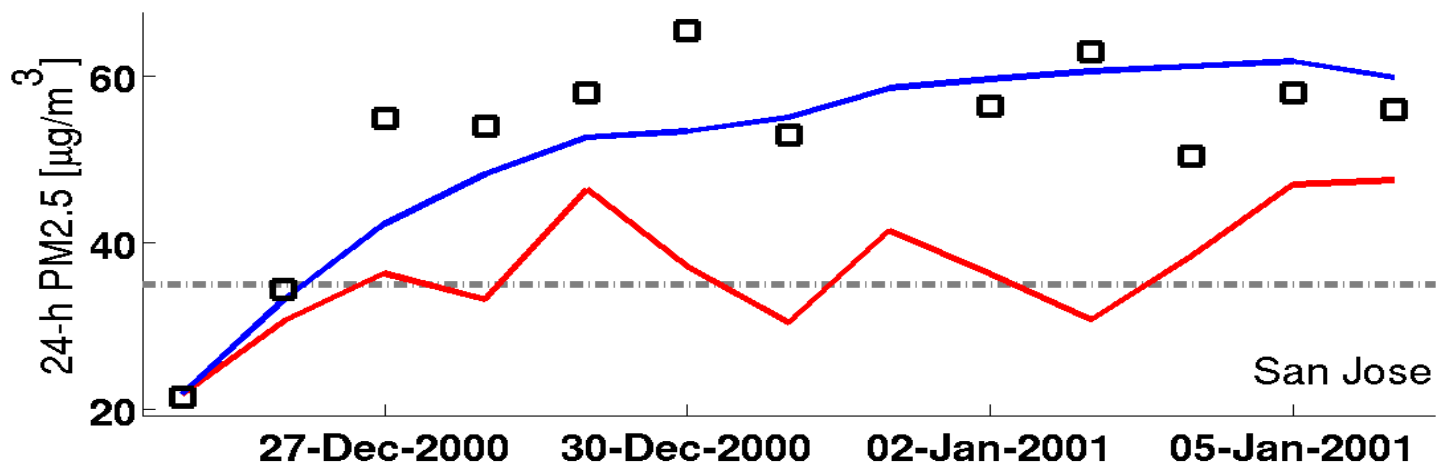
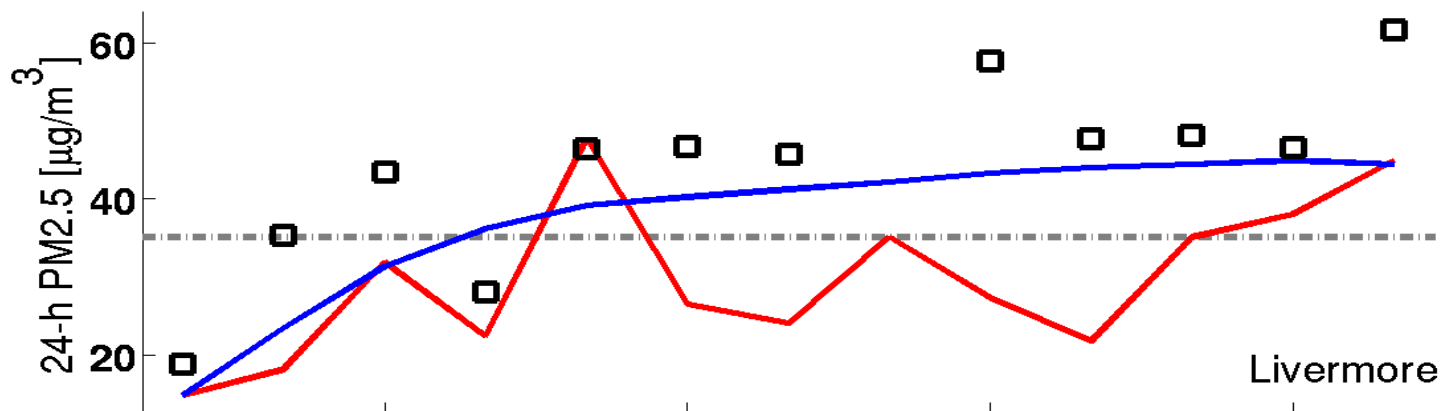
R1	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2
R1	R1	R1	R1	R*	R*	R1	R1	R1	R1	R*	R2	R+



□ Observation — MM5

27-Dec-2000 30-Dec-2000 02-Jan-2001 05-Jan-2001

R1	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2
R1	R1	R1	R1	R*	R*	R1	R1	R1	R1	R*	R2	R+
R1	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2



Observation
 MM5
 MM5 (substituted)

Uncertainty Evaluation

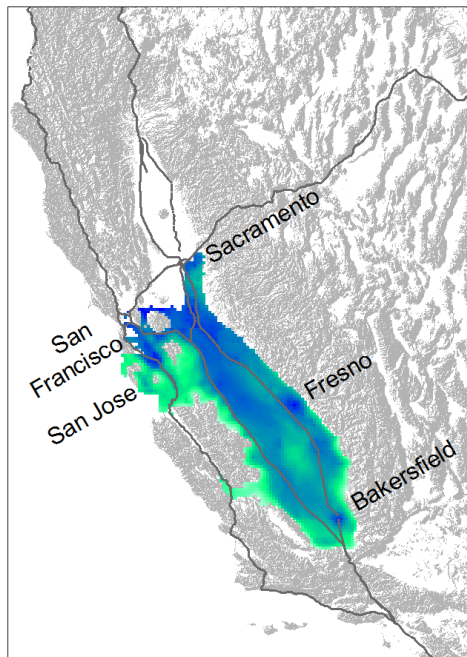
Four CMAQ simulations

- Original meteorology
 - Base case
 - anthropogenic emissions reduced 20%
- Substituted meteorology
 - Base case
 - anthropogenic emissions reduced 20%

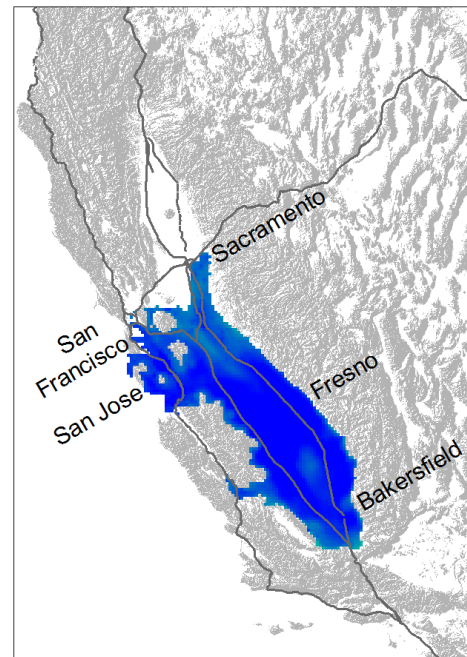
Model response analyses

- Absolute concentration difference
- Difference in Relative Response Factors (RRFs)
 - $RRF = \text{Reduced-emissions simulation} / \text{Base simulation}$
 - $\text{Attainment demonstration} = RRF \times \text{design value}$

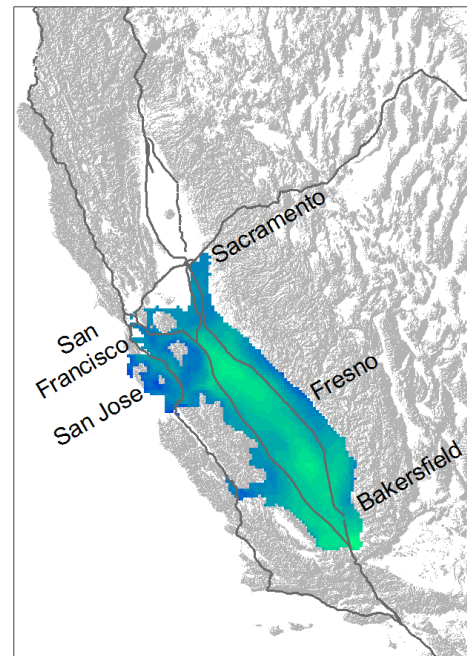
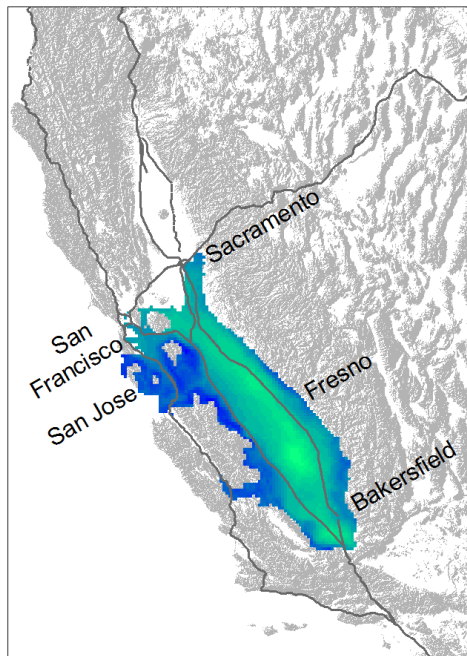
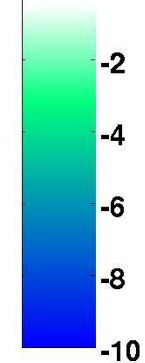
Original MM5



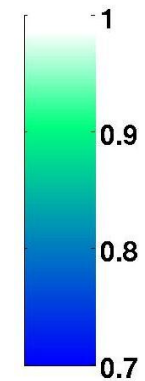
Substituted MM5

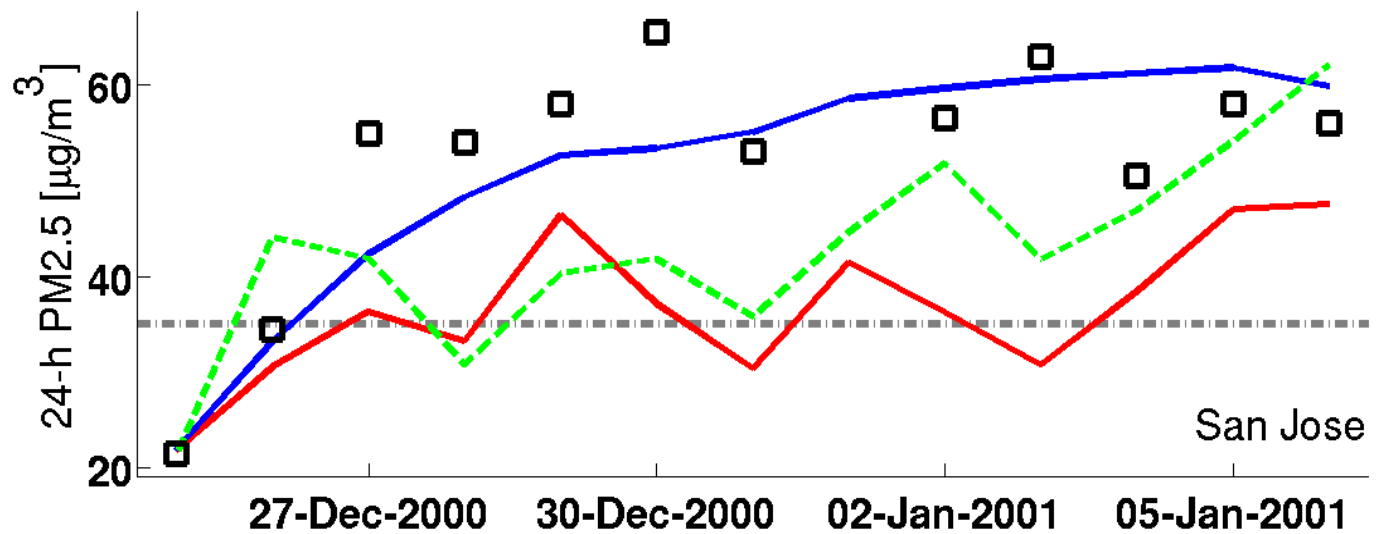
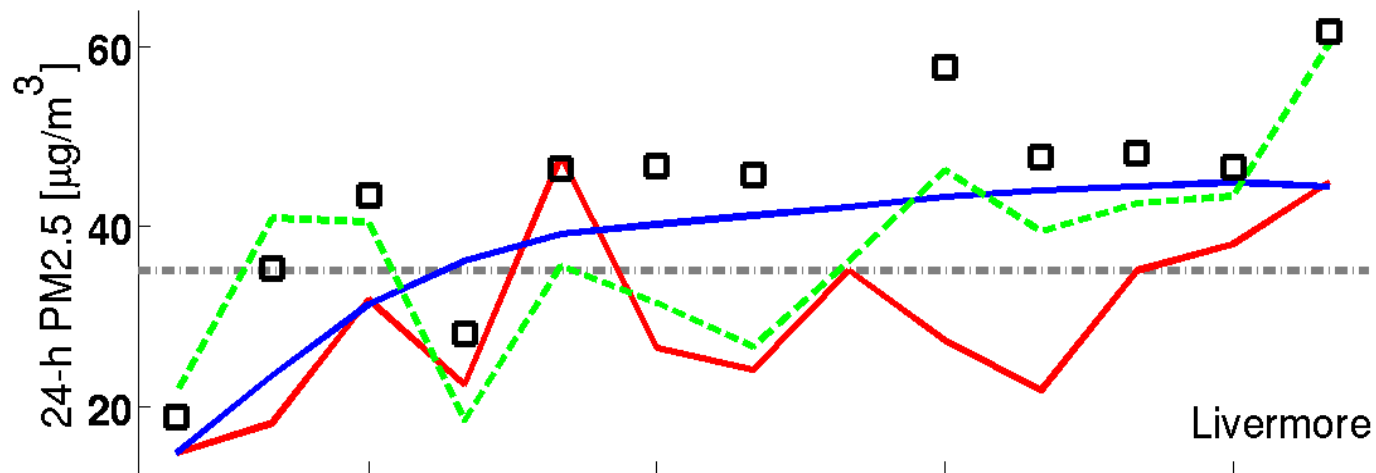


Concentration
Difference,
 $\mu\text{g}/\text{m}^3$



RRF





Thank you

Meeting is open for questions and comments