Regional Air Quality Modeling

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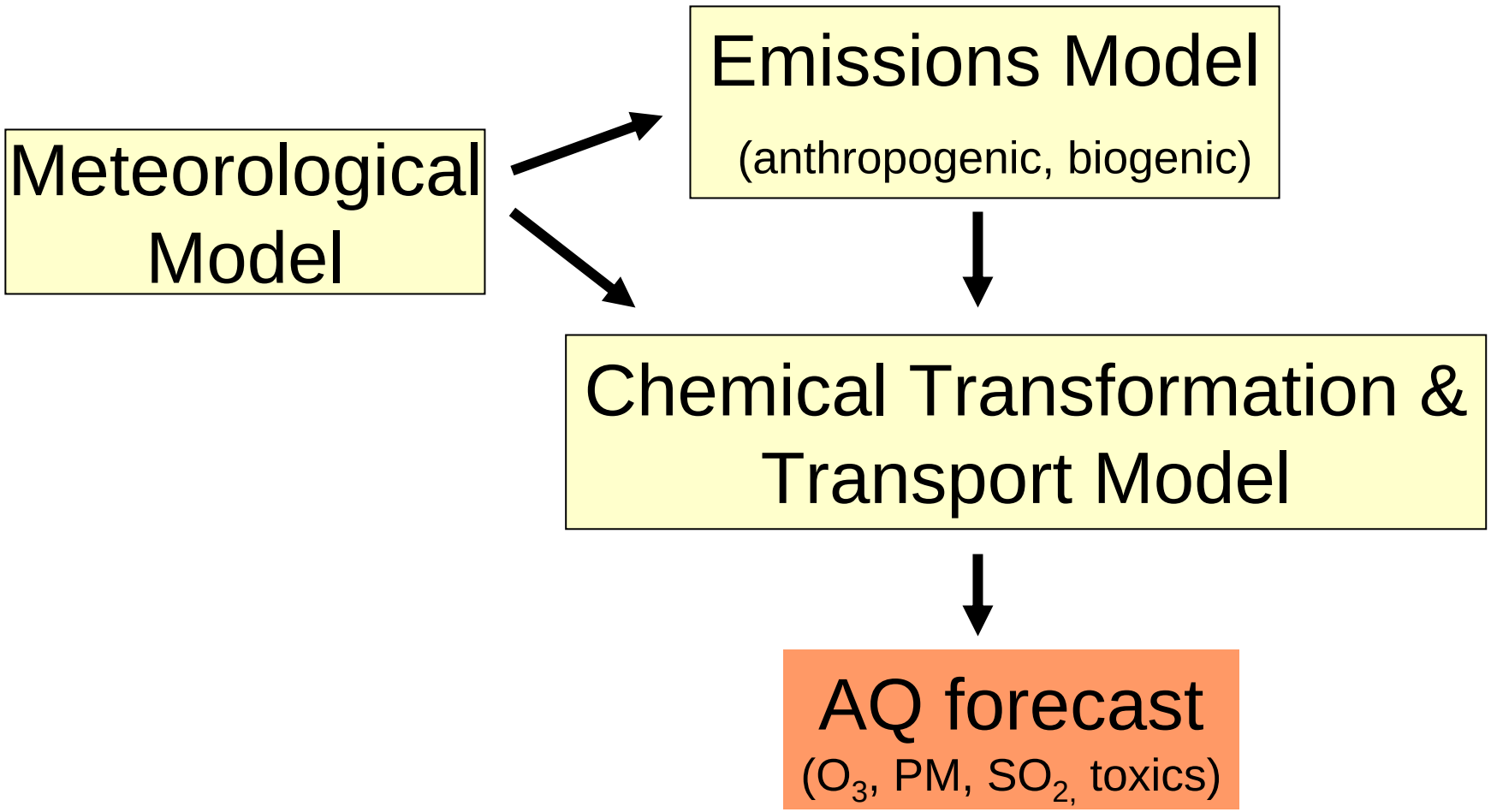
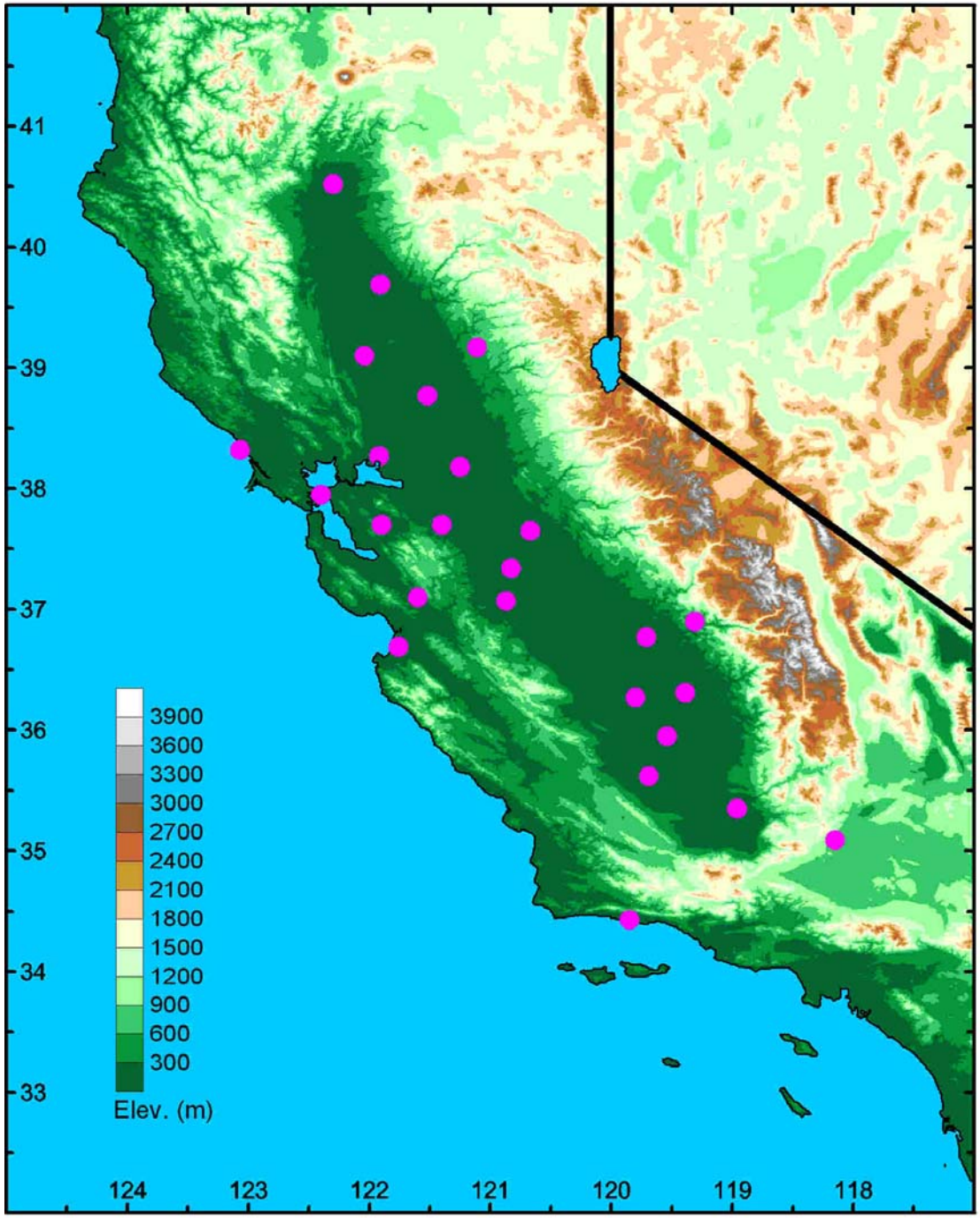
California

Texas

Eastern U.S.

Air Quality Forecast System



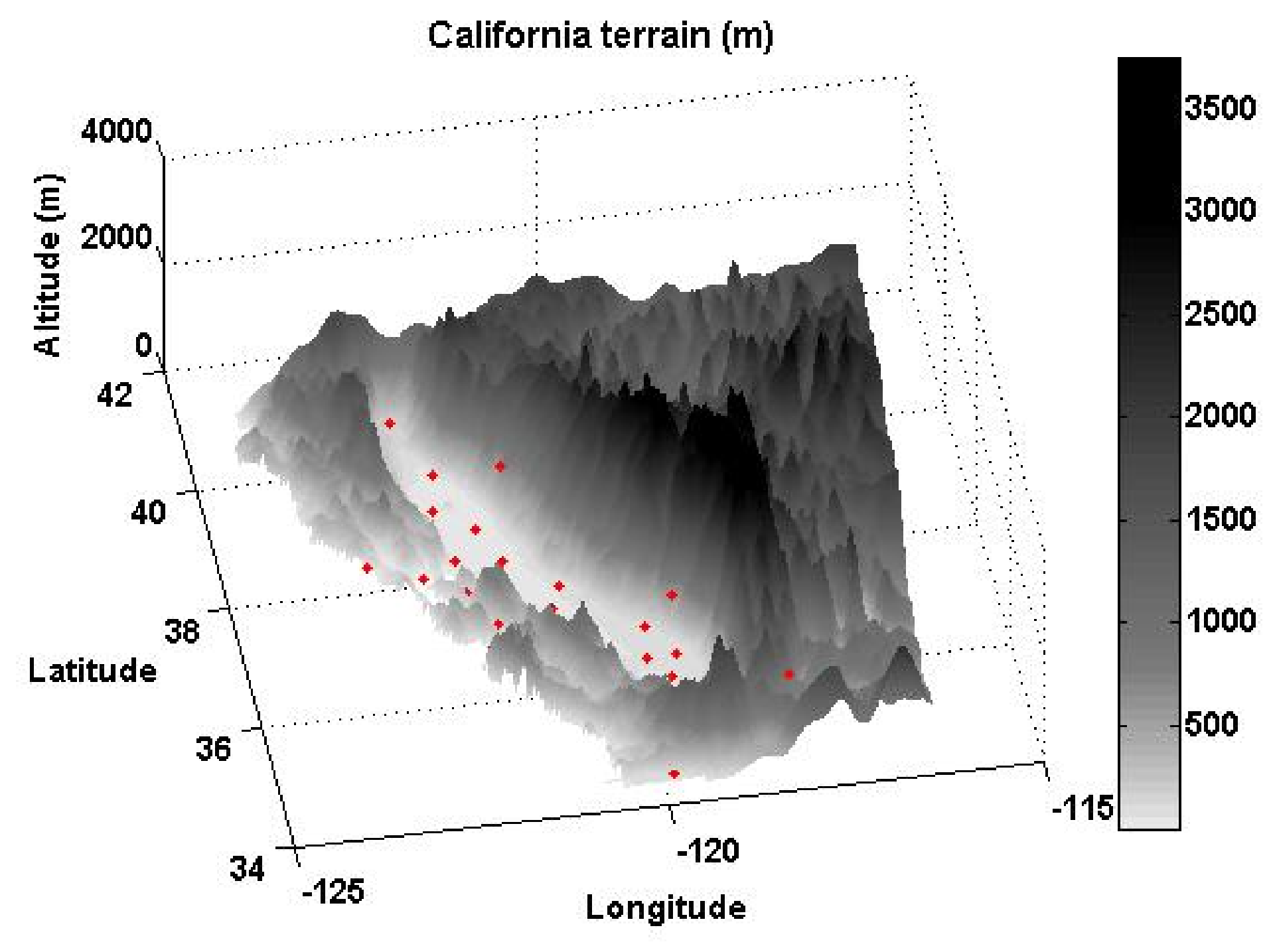


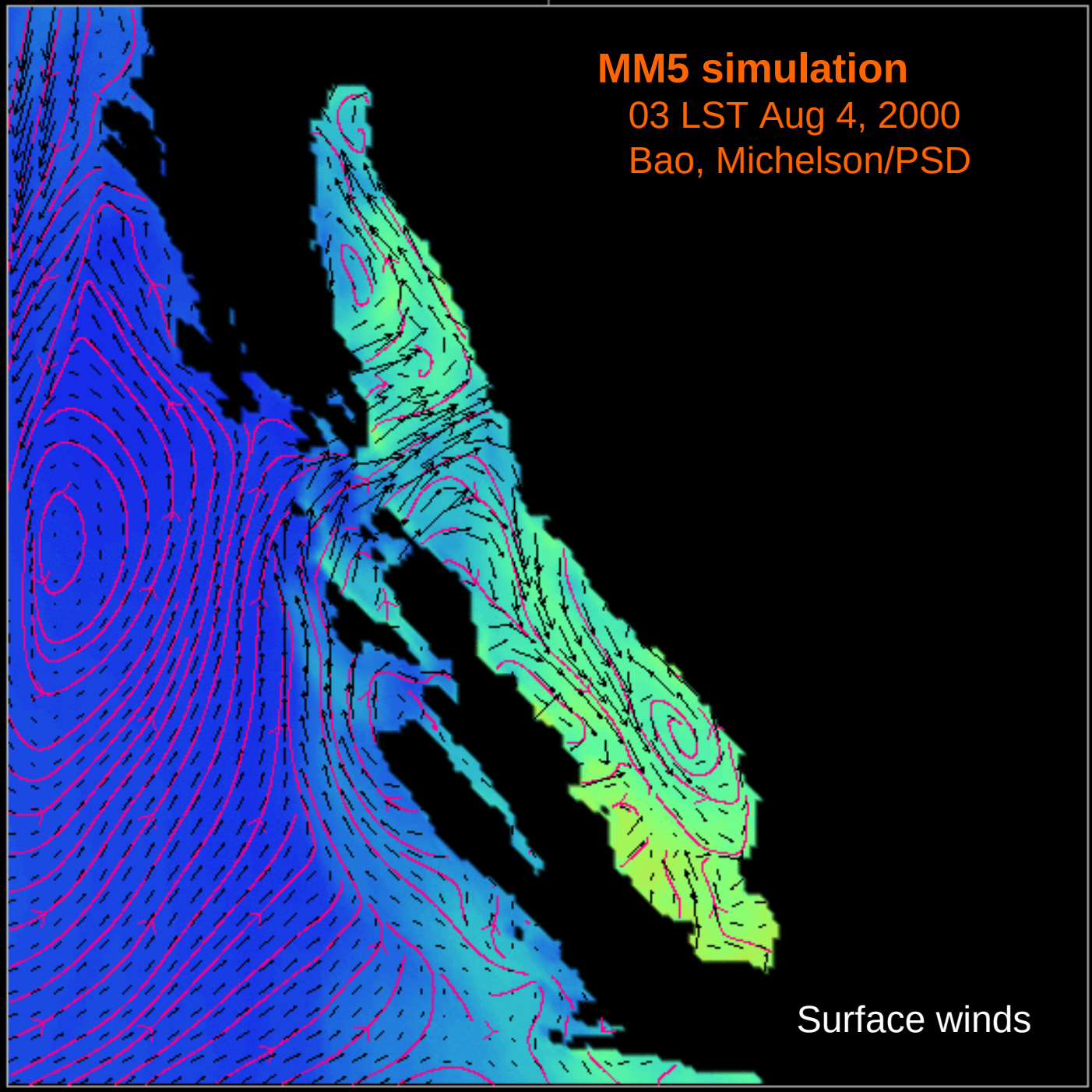
Central Valley:
600 km long
100 km wide

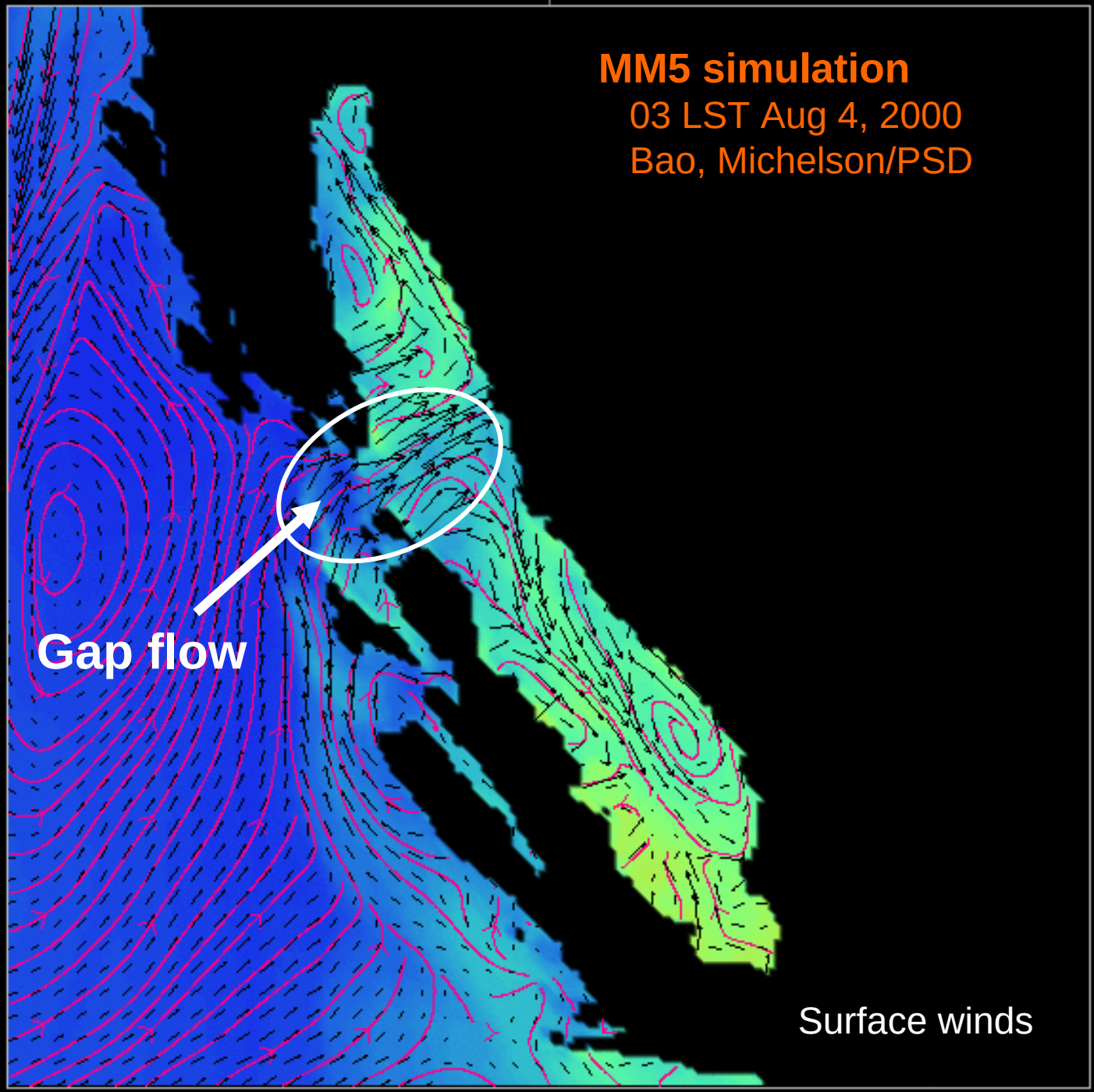
5 of top 10 most polluted cities in U.S. are in California's Central Valley

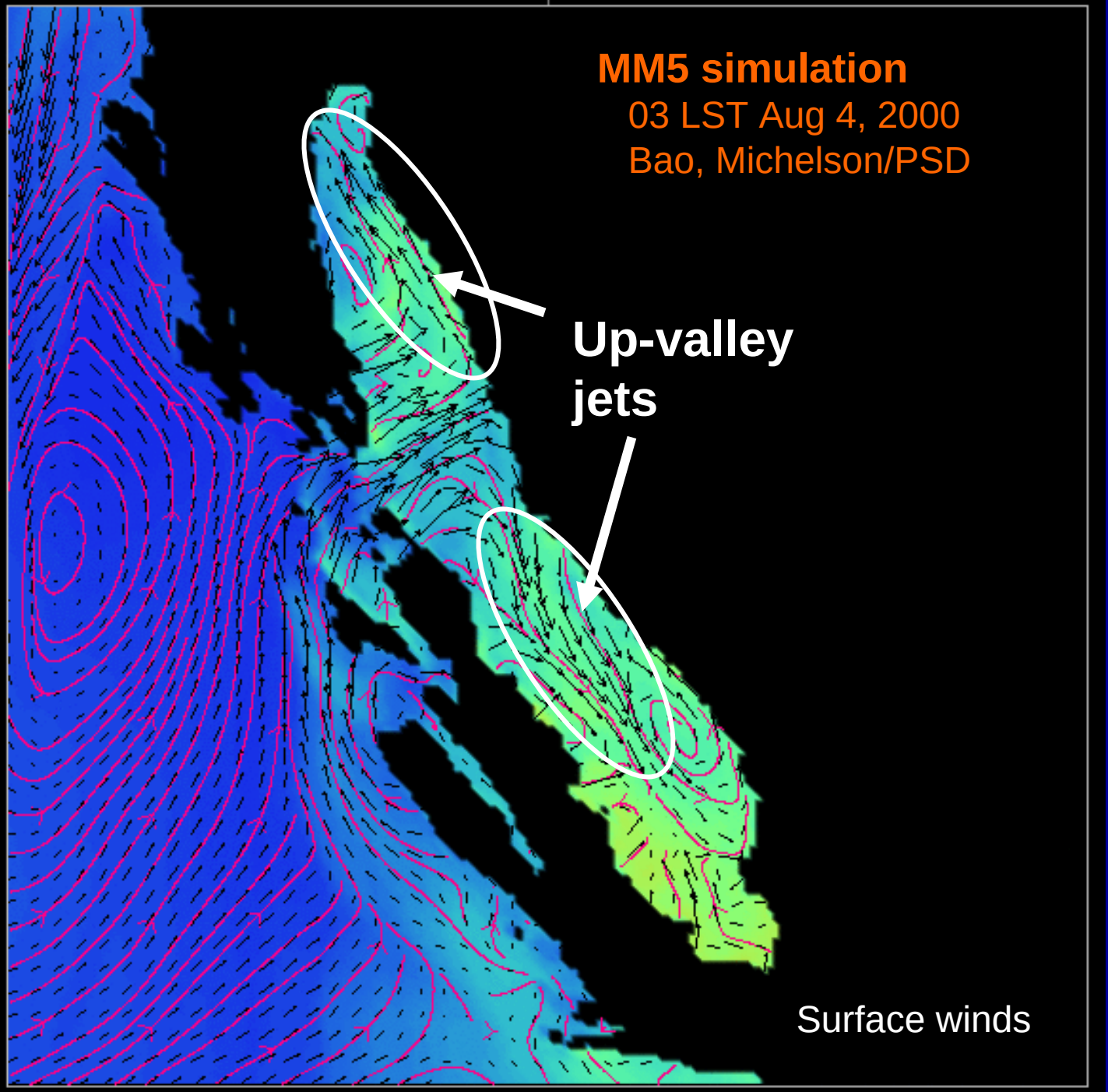
Central California Ozone Study 2000

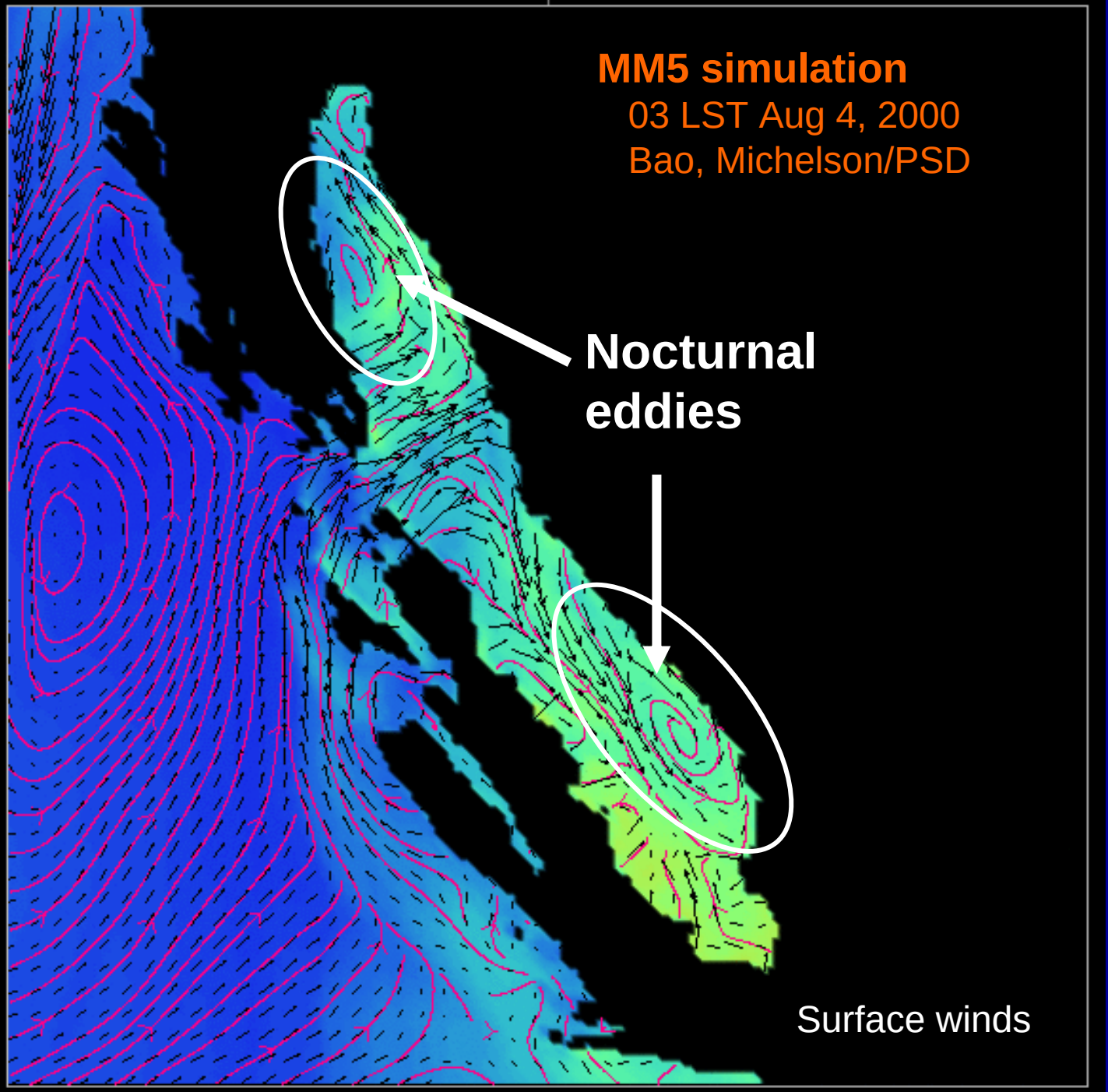
Wind Profiler Network ●

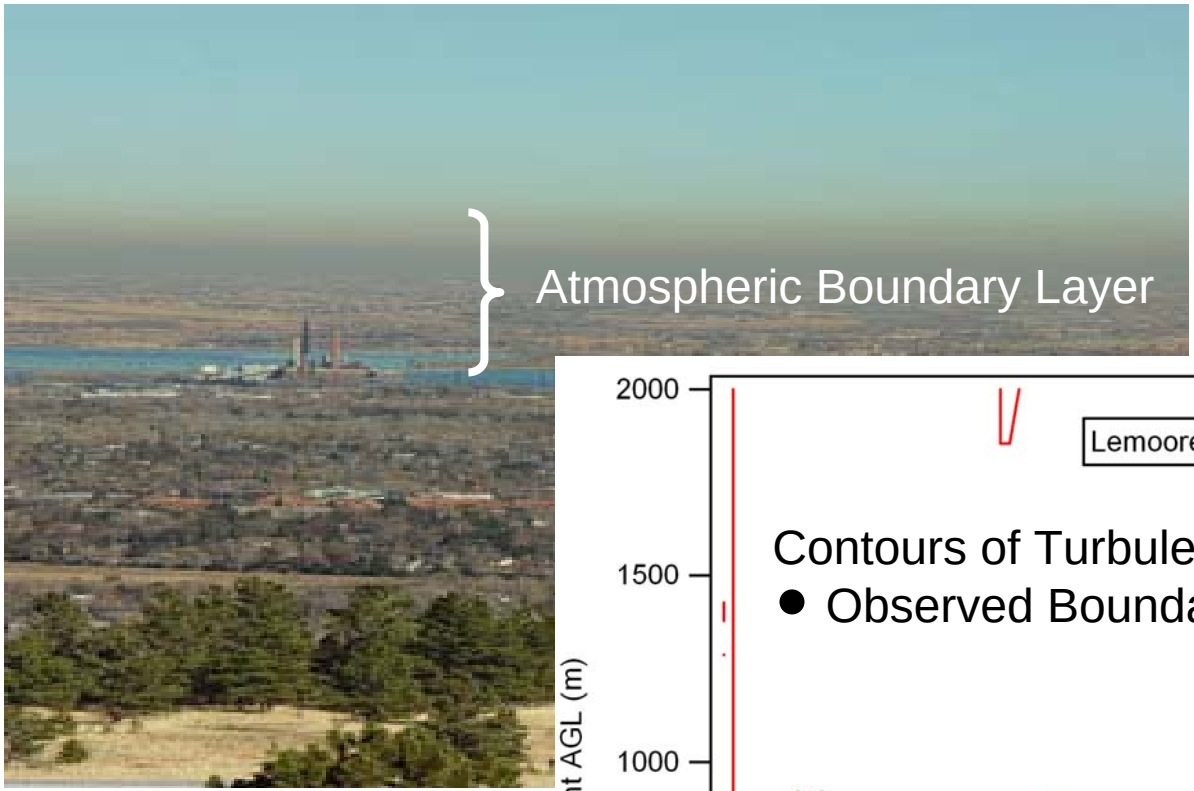

California terrain (m)
Altitude (m)
4000
2000
0
42
40
38
36
34
Latitude
-125
-120
-115
Longitude
3500
3000
2500
2000
1500
1000
500

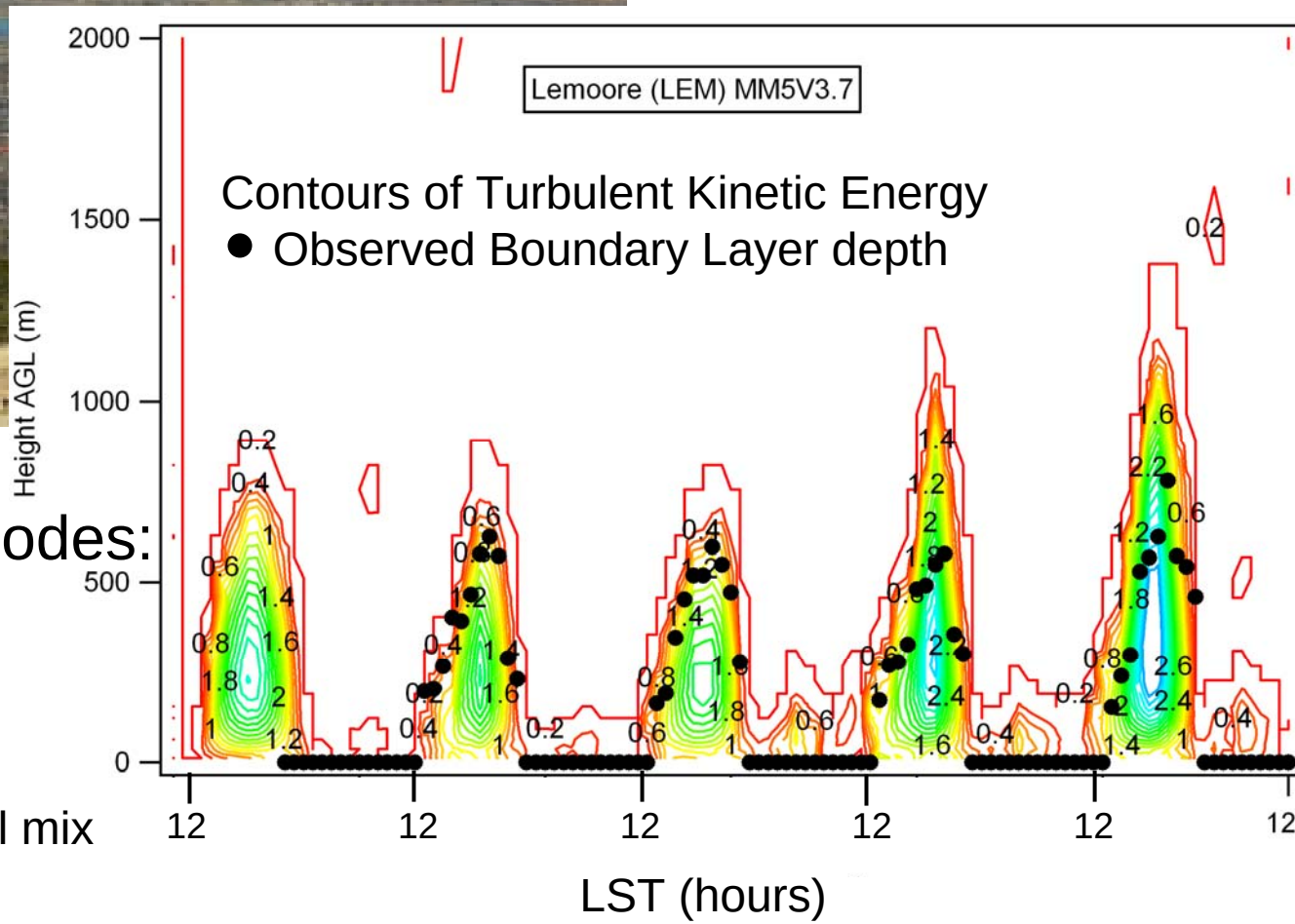

MM5 simulation
03 LST Aug 4, 2000
Bao, Michelson/PSD
Surface winds


MM5 simulation
03 LST Aug 4, 2000
Bao, Michelson/PSD
Gap flow
Surface winds


MM5 simulation
03 LST Aug 4, 2000
Bao, Michelson/PSD
Up-valley
jets
Surface winds


MM5 simulation
03 LST Aug 4, 2000
Bao, Michelson/PSD
Nocturnal eddies
Surface winds



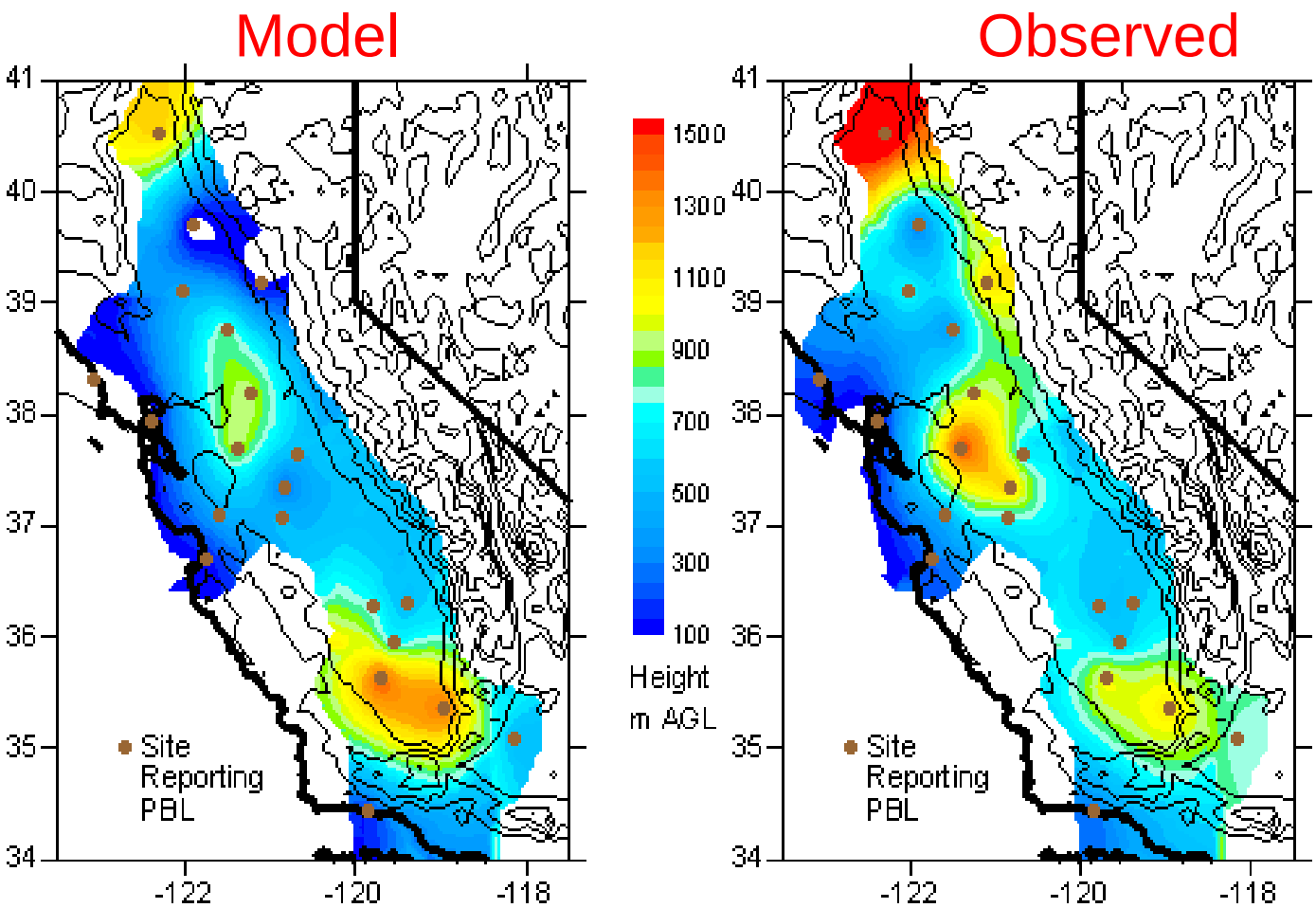


High pollution episodes:

- Light winds
- Clear skies
- High pressure
  - ⇒ subsidence
  - ⇒ reduced vertical mix

Boundary Layer Depths

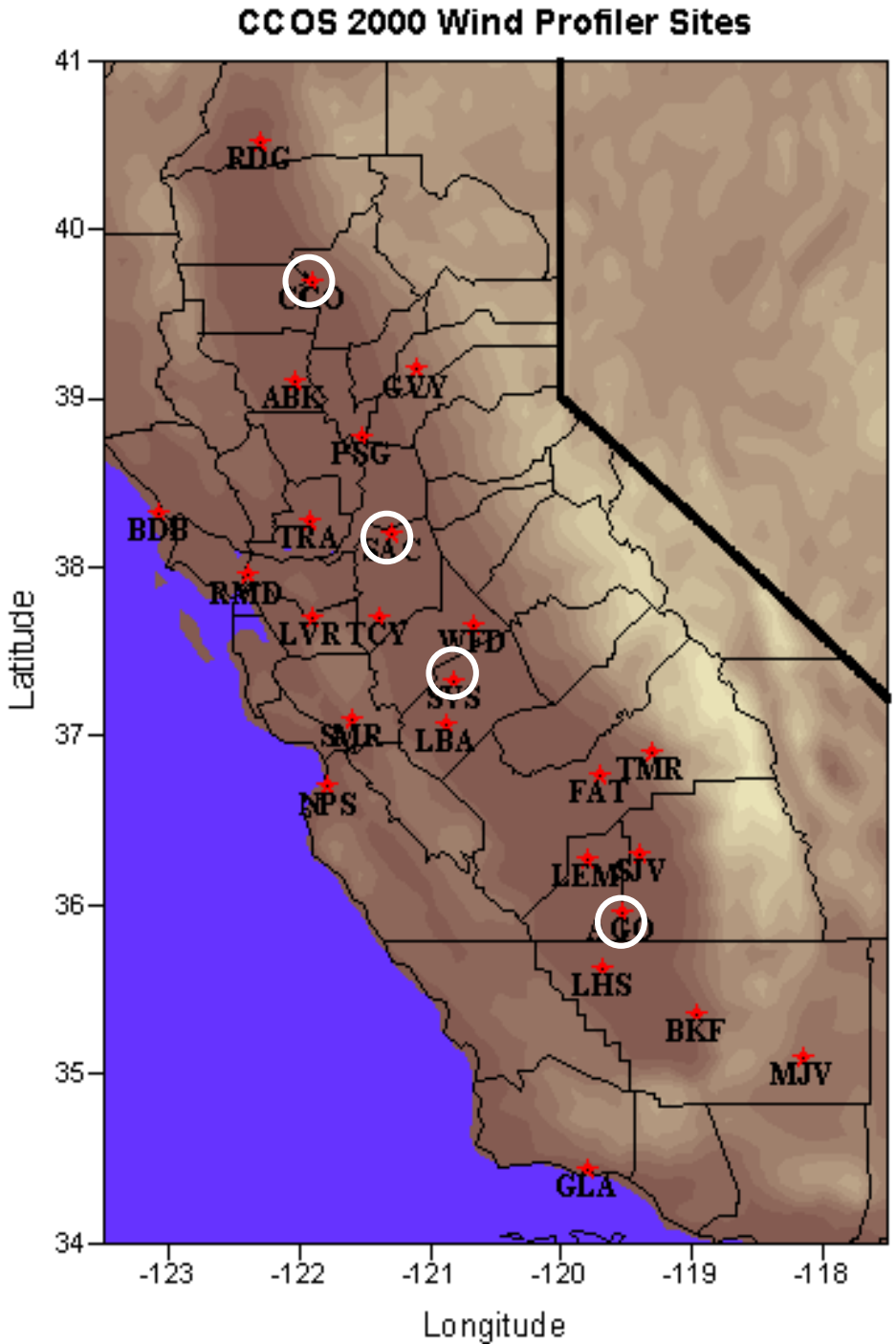
15 LST 31 July 2000



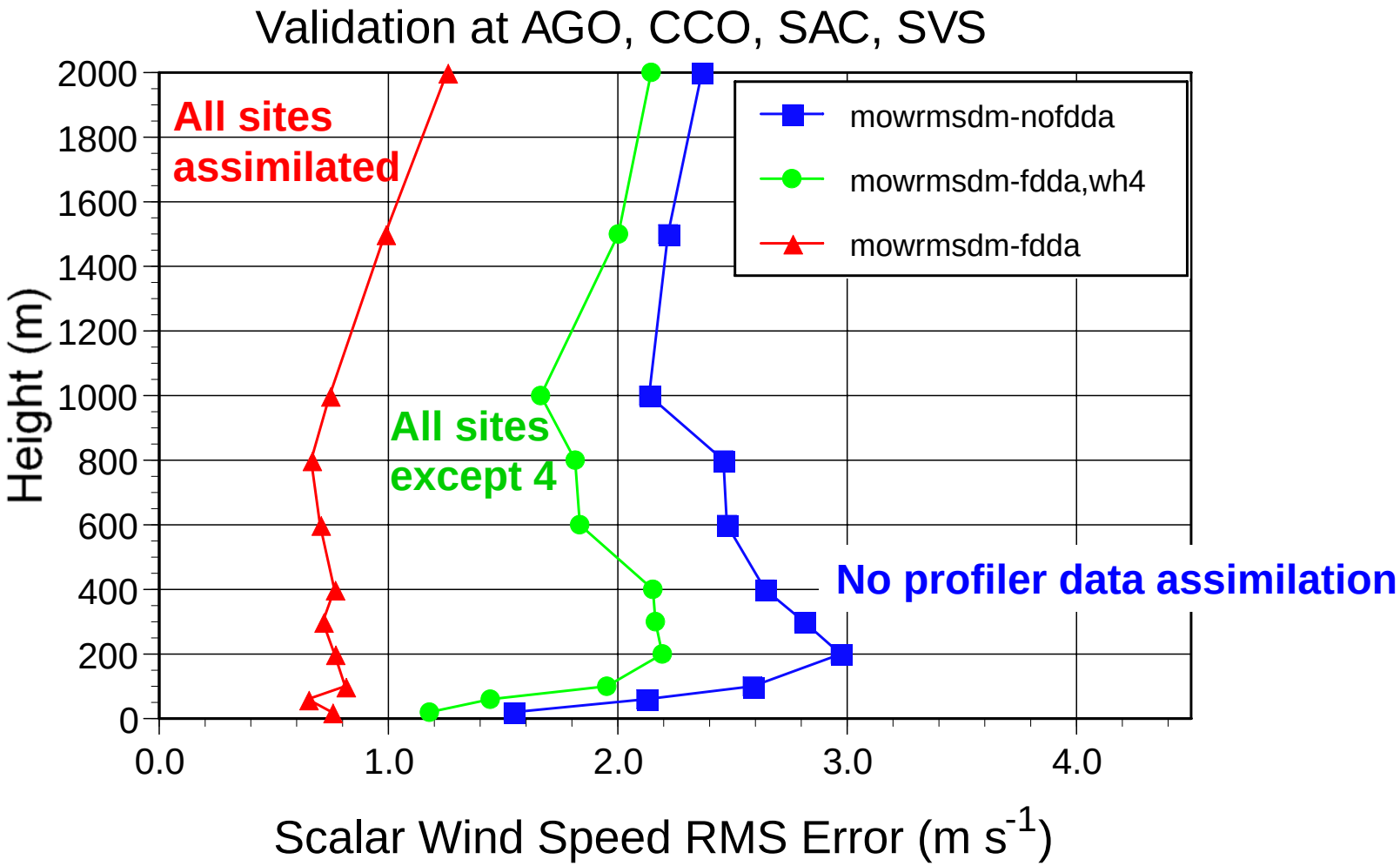
Developing Pollution Control Strategies:

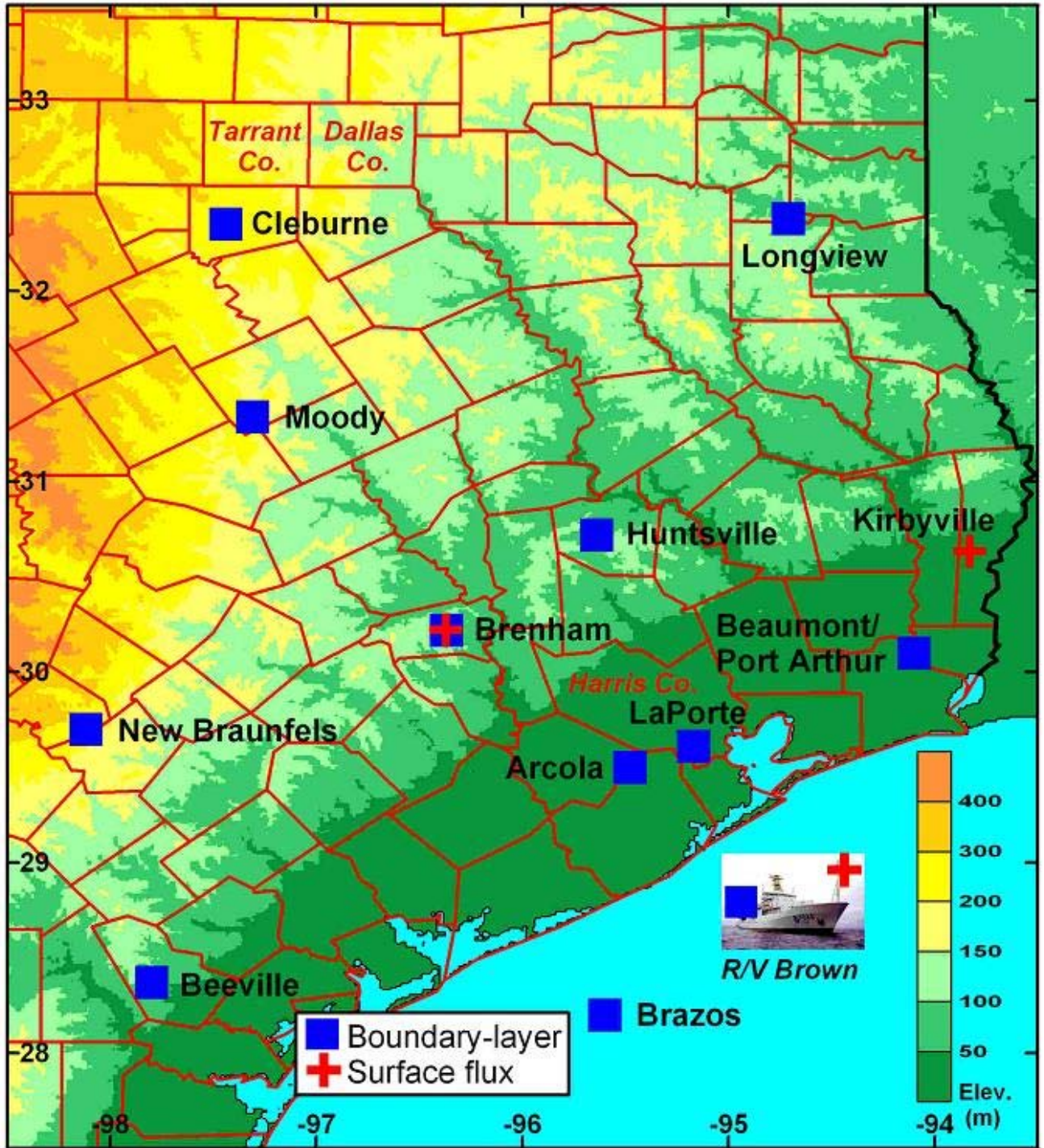
1) Use Data Assimilation to get best possible meteorological fields

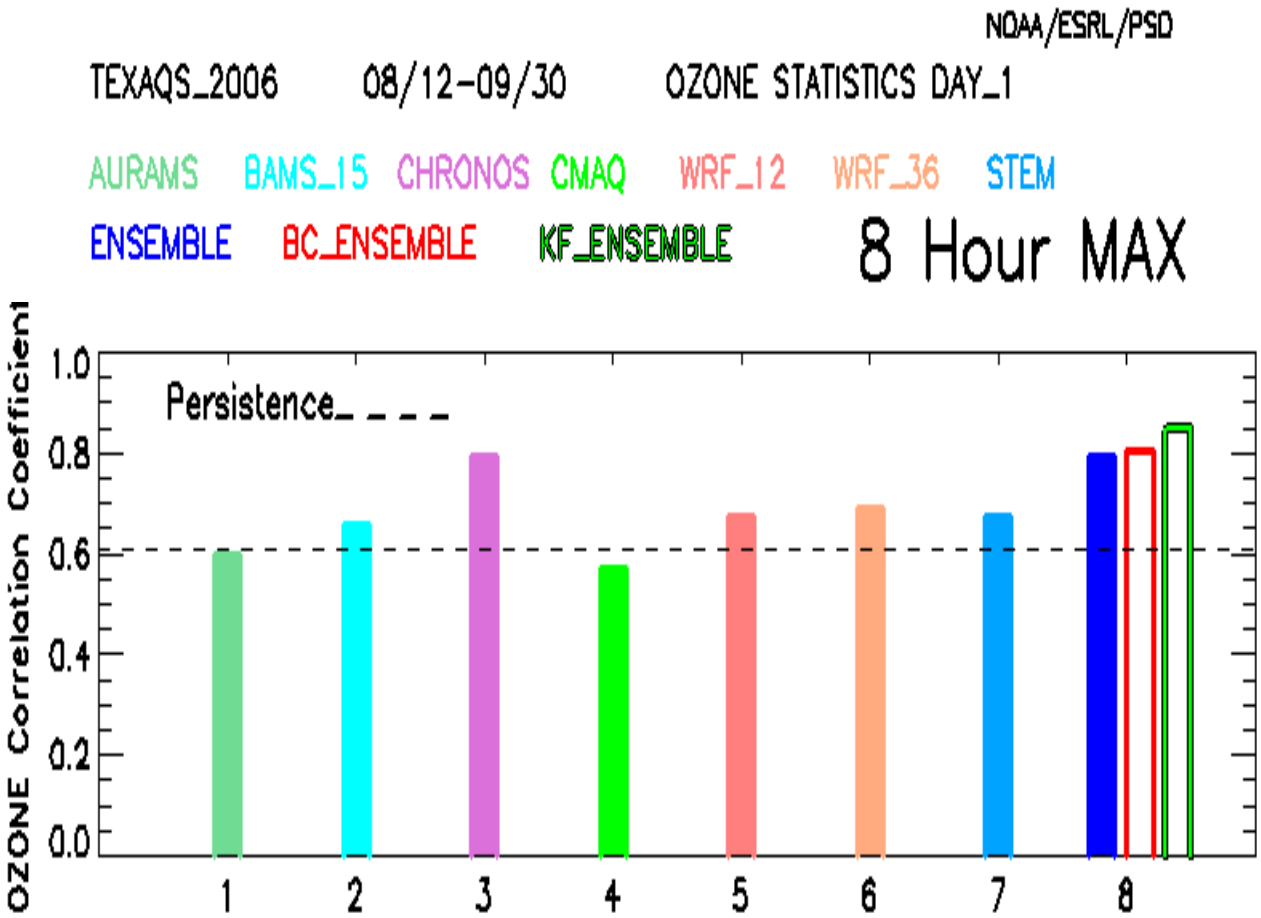
2) Re-run AQ model with varying emissions controls



Data assimilation significantly improves meteorological fields

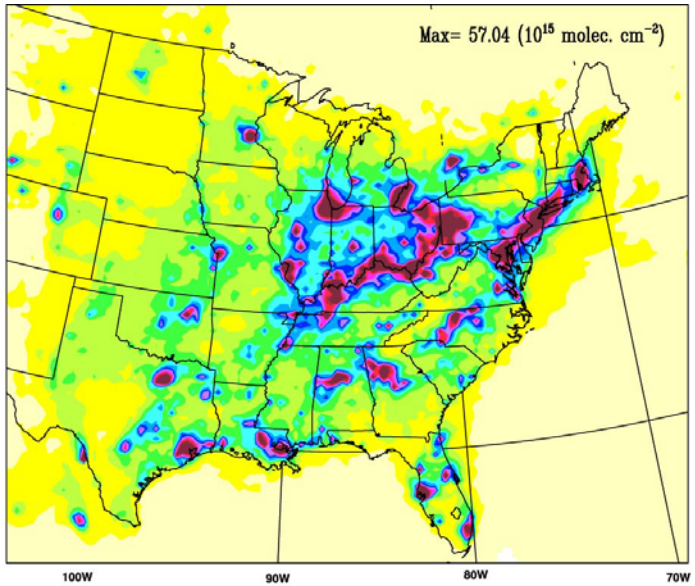



Tarrant Co.
Dallas Co.
Cleburne
Longview
Moody
Huntsville
Kirbyville
Brenham
Beaumont/
Port Arthur
Harris Co.
LaPorte
New Braunfels
Arcola
R/V Brown
Beeville
Brazos
Boundary-layer
Surface flux
400
300
200
150
100
50
Elev. (m)
33
32
31
30
29
28
-98
-97
-96
-95
-94

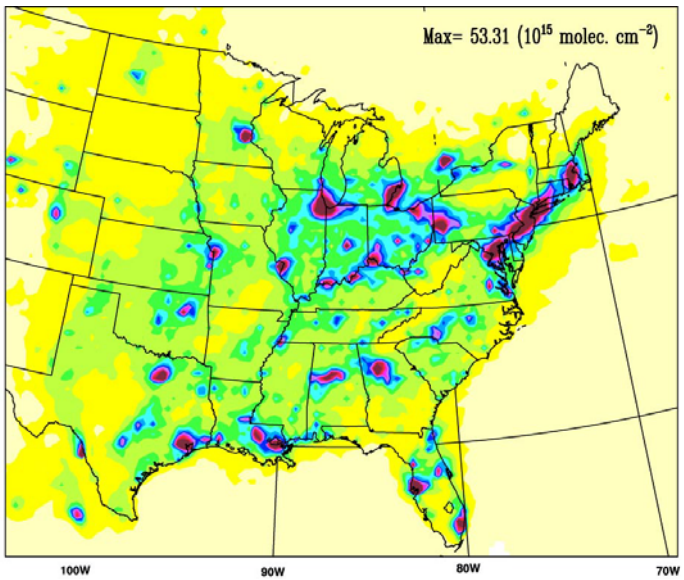


- Ensemble is more skillfull than individual models
- Post-processing (bias removal) improves skill
- Ensemble provides probablistic information

Satellite Verification and Regional Model Analysis of U.S. NOx emission reductions



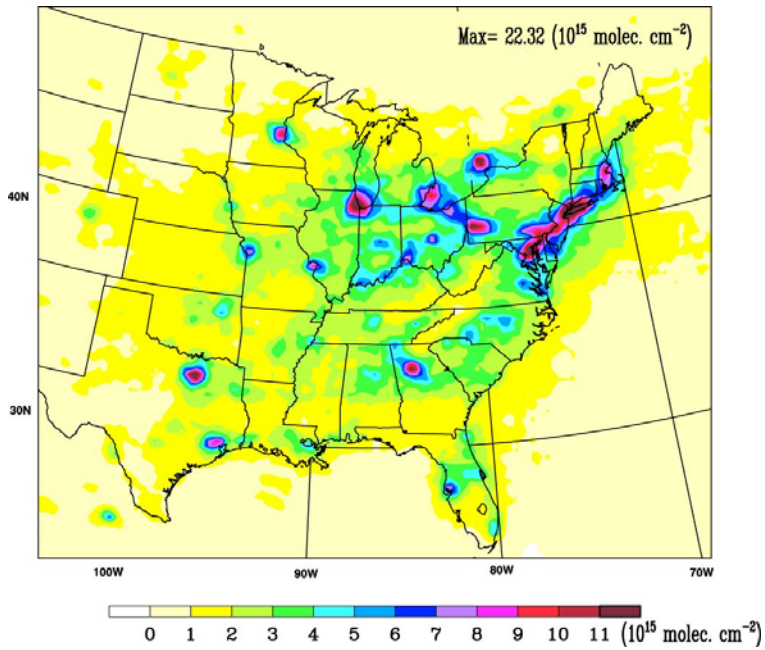
WRF/Chem - EPA NEI-99 v3 emissions



WRF/Chem NEI emissions plus observed emissions from ~1000 CEMS monitors

NO_2 columns

Summer 2004 (June-August) Averages



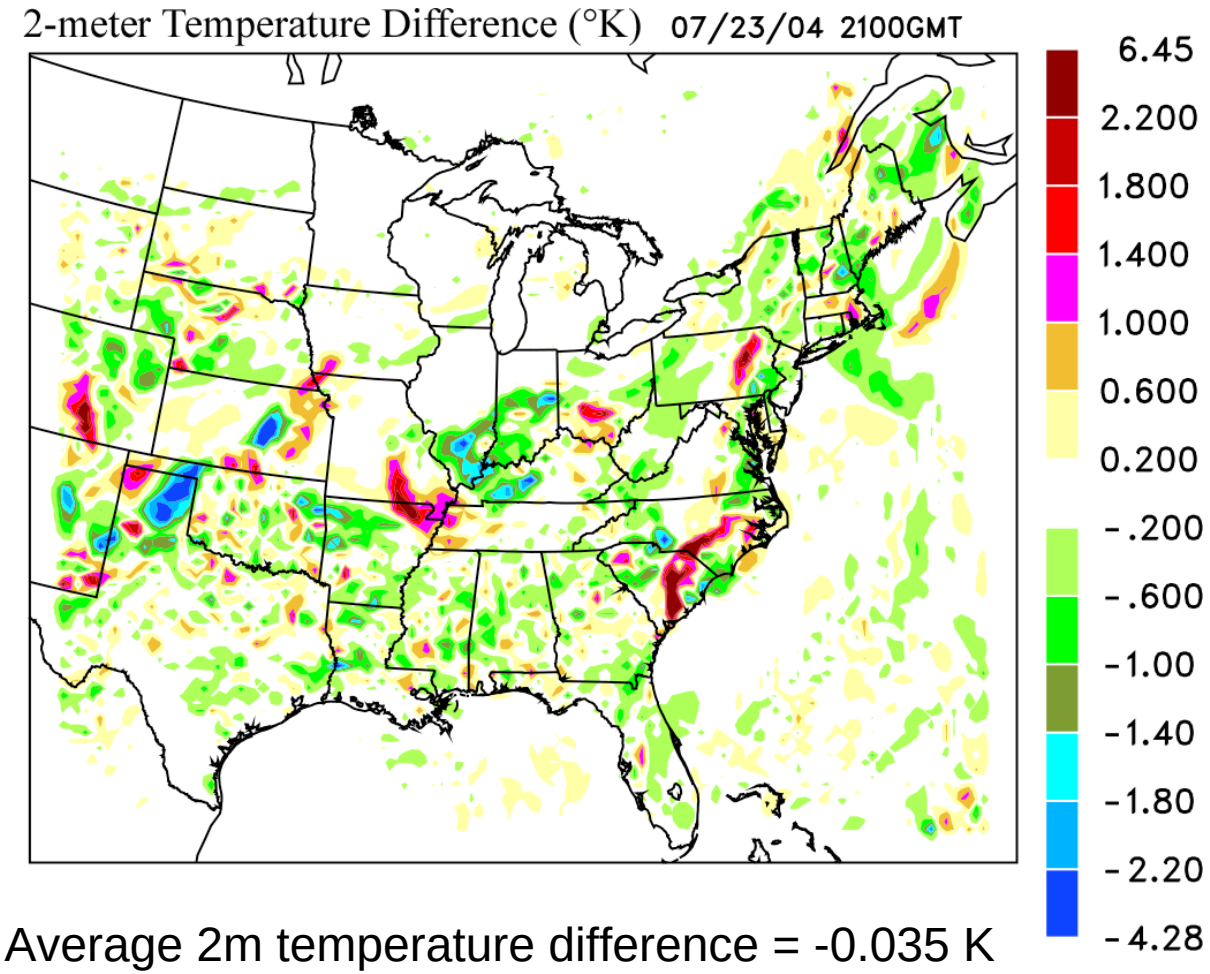
SCIAMACHY satellite observations

- Regulations have reduced emissions, improved AQ
- Regional models can be used to validate satellite emission estimates

Kim et al., ESRL/CSD 2006

Direct and Semi-direct Effects of PM2.5 Aerosols on Meteorology - Sensitivity Studies with WRF-Chem

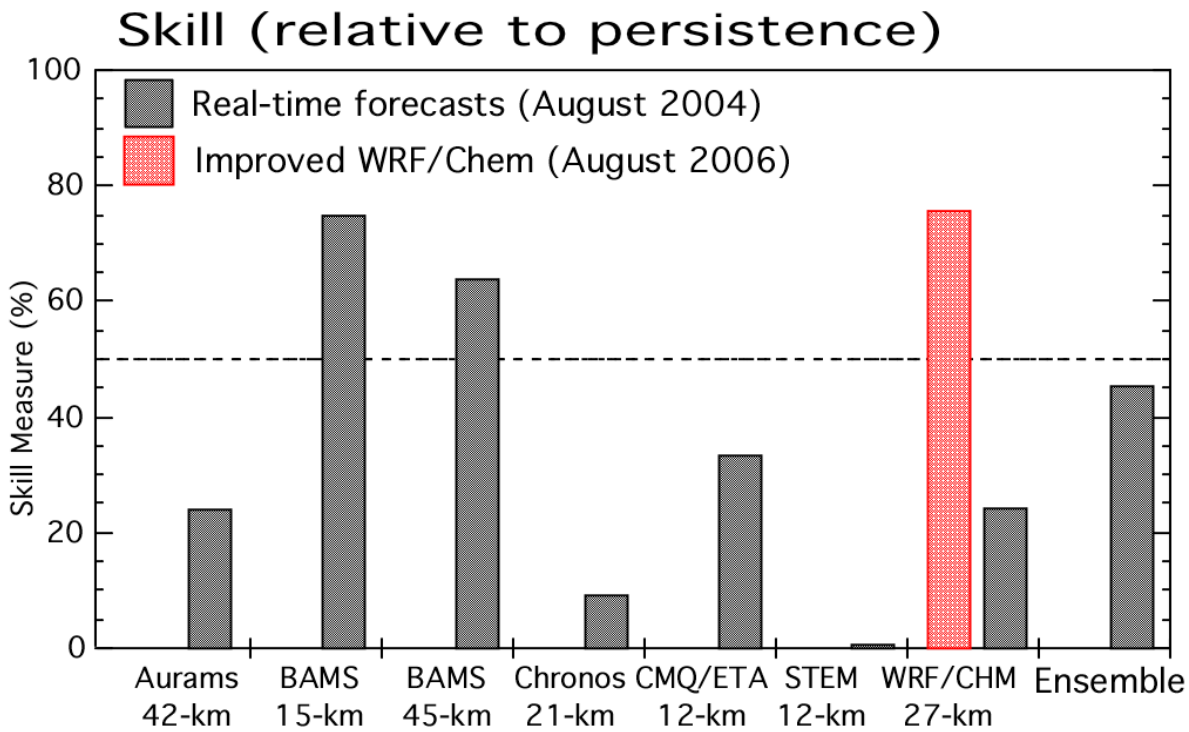
Case with aerosol scattering + absorption included minus control (no aerosol-radiation interactions); 68 hours after initialization



Average 2m temperature difference = -0.035 K

Chung, CSD/ Grell GSD

Improvements in WRF and WRF/Chem from 2004 to 2006: comparisons with AIRNow surface O_3 data



Maximum 8 hour average ozone
352 O_3 monitors - eastern U.S. and Canada
53 days (July and August 2004)

McKeen/CSD
Grell/GSD

Summary

- Air Quality models combine meteorology, chemistry, and emissions estimates
- Regional AQ models are necessary because of the fine grid resolution required
- Meteorological parameters important for AQ forecasts are the opposite of severe weather forecasts
- Ensembles and post-processing improves AQ forecasts
- Regional intensive field campaigns have helped improve models