Collaborative Research at ESRL on Regional Air Quality: Meteorology, Model Evaluation and Forecasting

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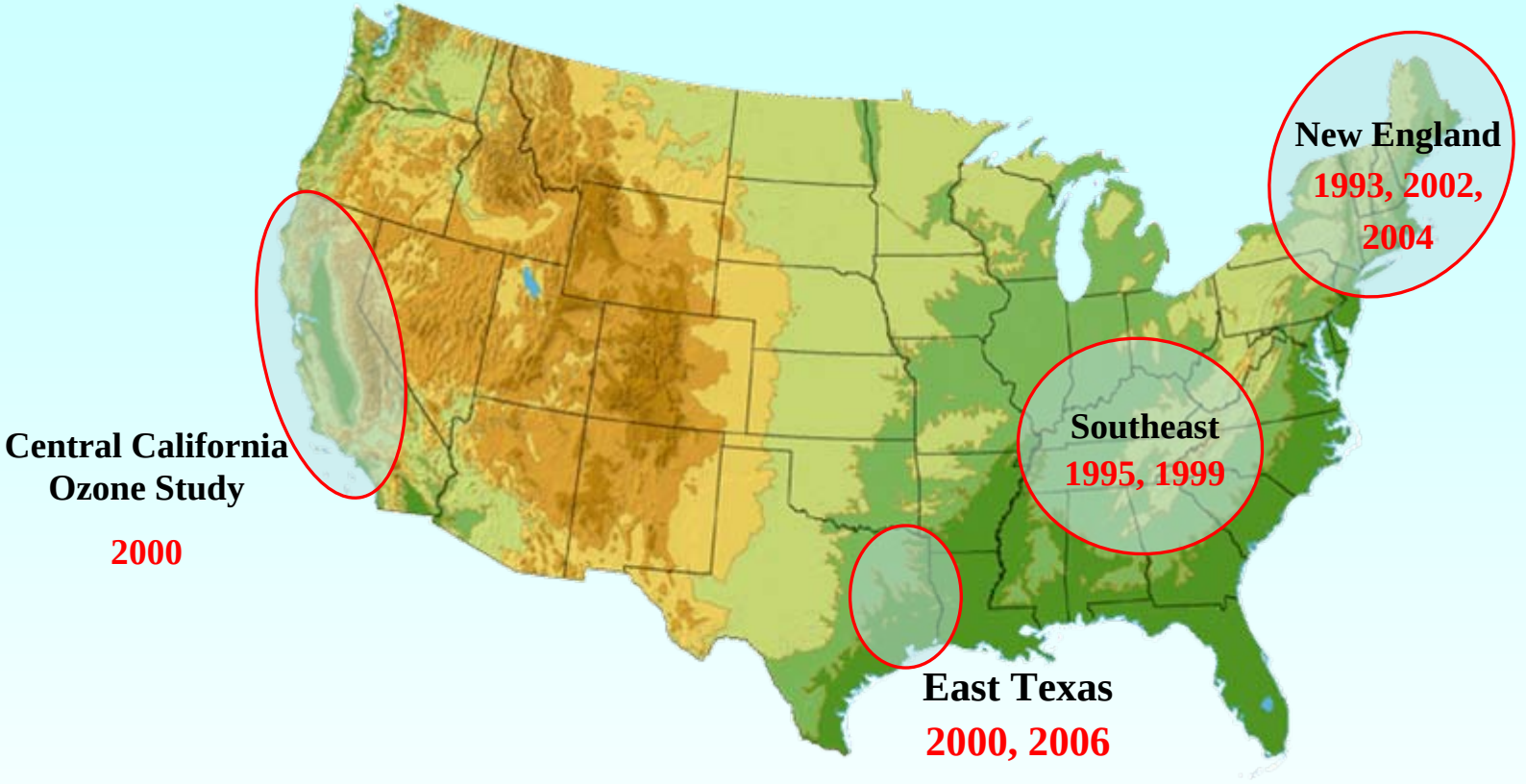
ESRL Regional Air Quality Research

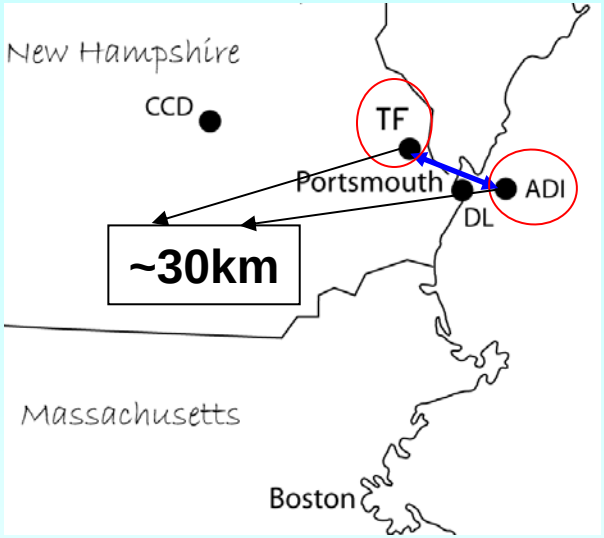


- East Tennessee Ozone Study
- Texas Air Quality Studies
- New England Air Quality Study
- Central California Ozone Study

OUTLINE

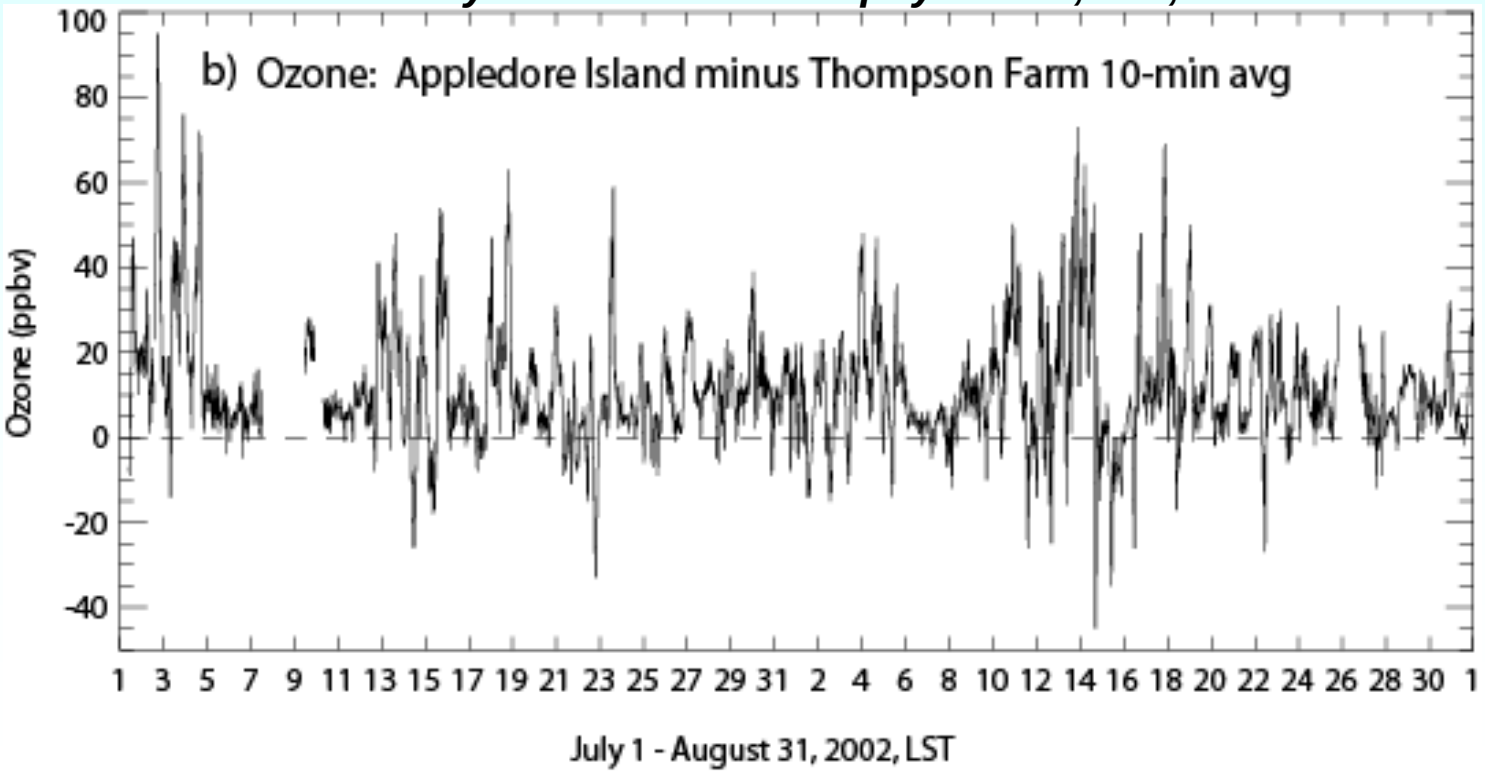
- **An illustration of why meteorological research is important to air quality research**
- **A paradigm for collaborative research**
- **Highlights of ensemble air quality forecast research**

A Case Study of Meteorology Affecting Air Quality

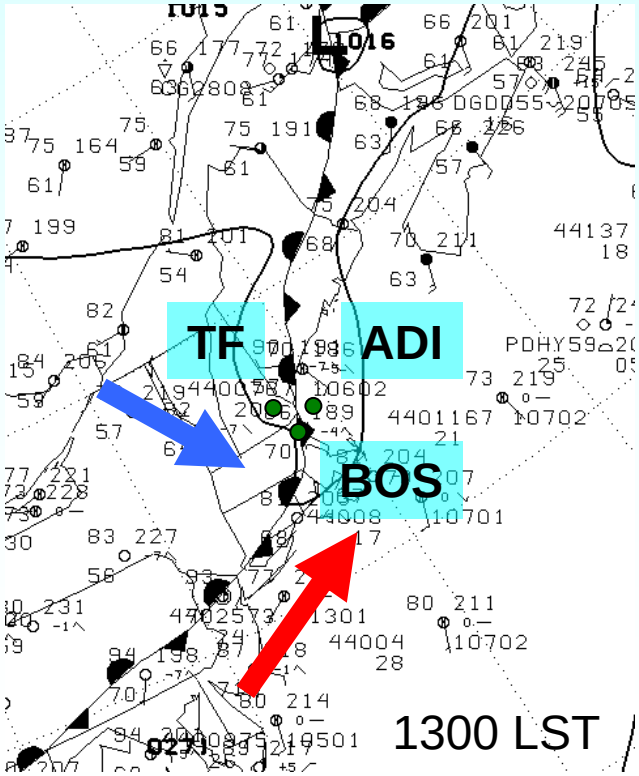


- **Appledore Island (ADI) had much higher O_3 than Thompson Farm (TF) on many days during the summer of 2002, with differences exceeding 50 ppbv at times. The stations are only ~30 km apart, with little or no local production of pollution.**

Darby et al. 2007: J. Geophys. Res., 112, D16S91.



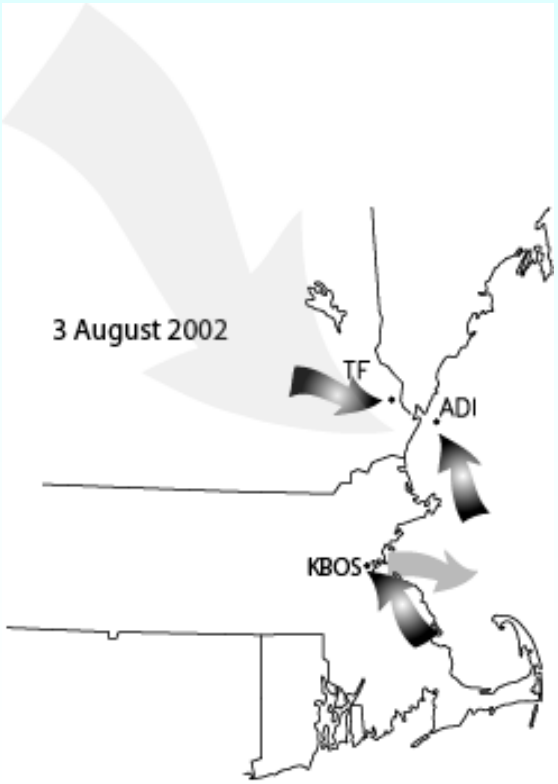
- **It was hypothesized based on model simulations that the differences in O_3 maxima between the two sites were due, in part, to meteorology**
  - **features that affect regional transport, e.g., stationary fronts, cold fronts, and the Appalachian lee-side trough**
- **Differences in deposition and titration between the two sites at night may have played a role too, with TF losing more O_3 after sunset than ADI**



Small solid arrow – Boston export; 0800 LST

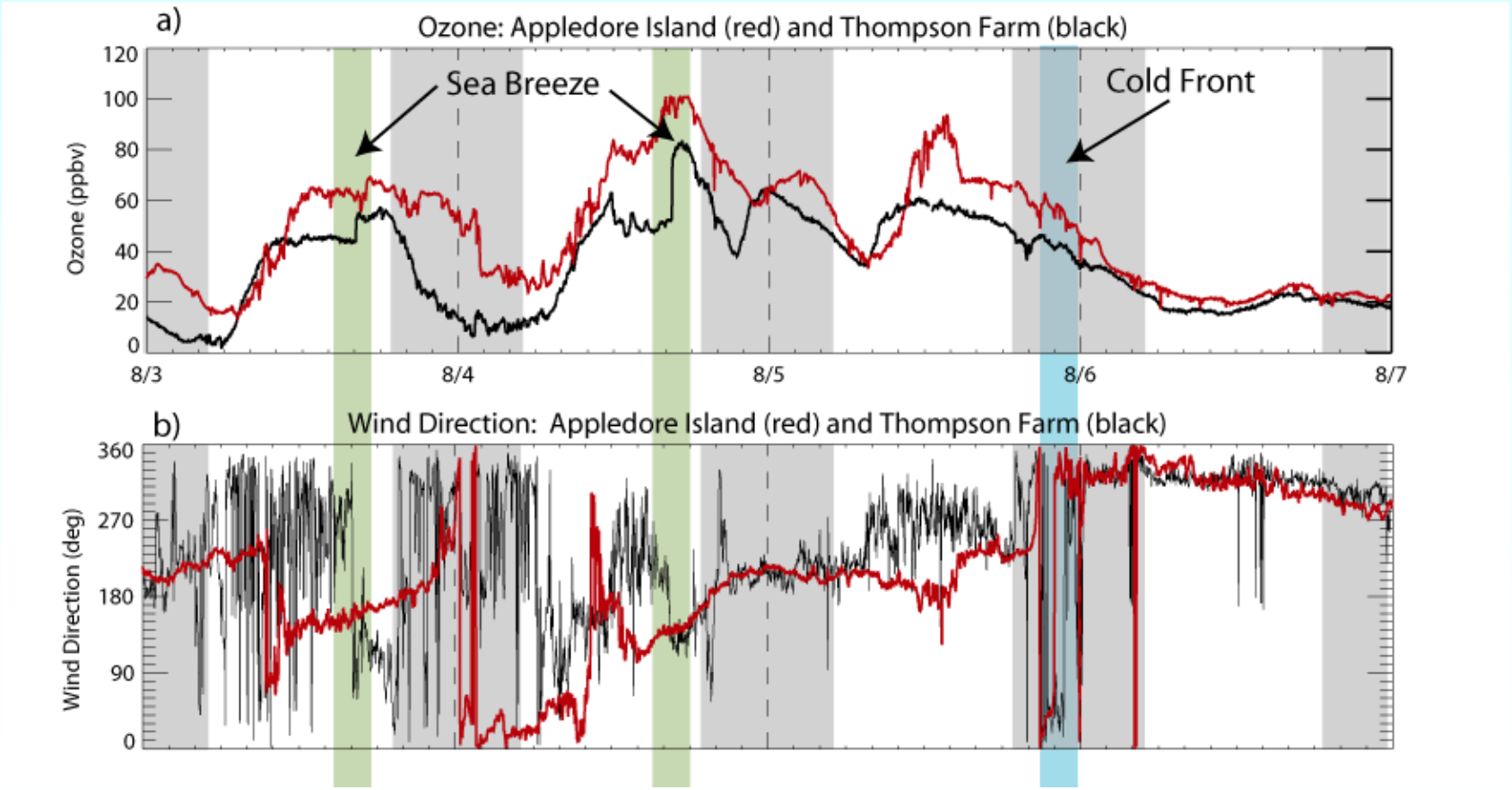
Small dark arrow – transport to Boston, ADI, and TF; 1300 LST

Large arrow – Transport at 925 mb (~766 m st. atm.)

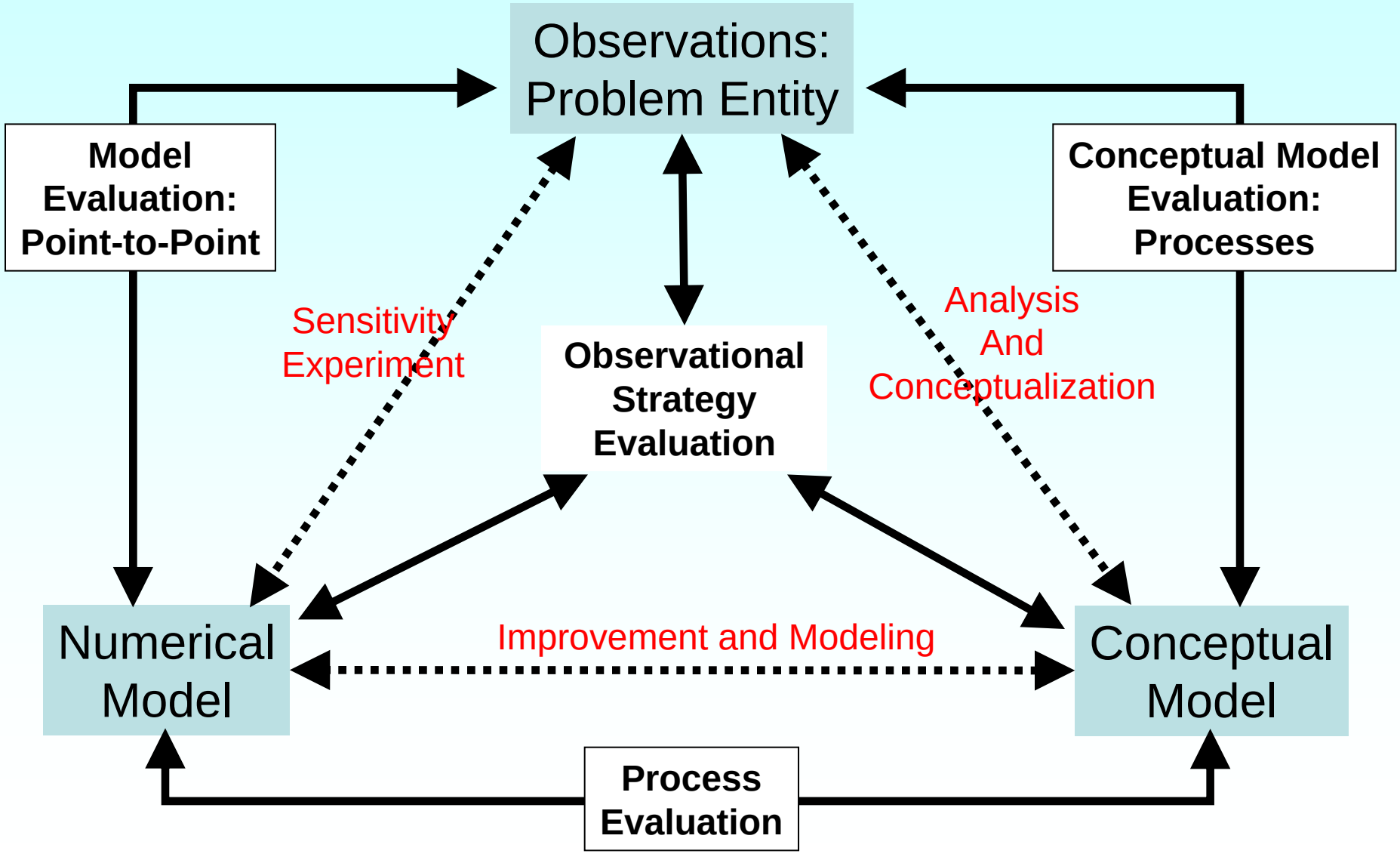


Key Points of This Case study

Differences in regional transport associated with cold fronts, stationary fronts, mesoscale lows, Appalachian lee-side troughs contributed to differences in ozone concentrations at ADI & TF



A Paradigm for Numerical Model Evaluation



An “Inverse Problem”

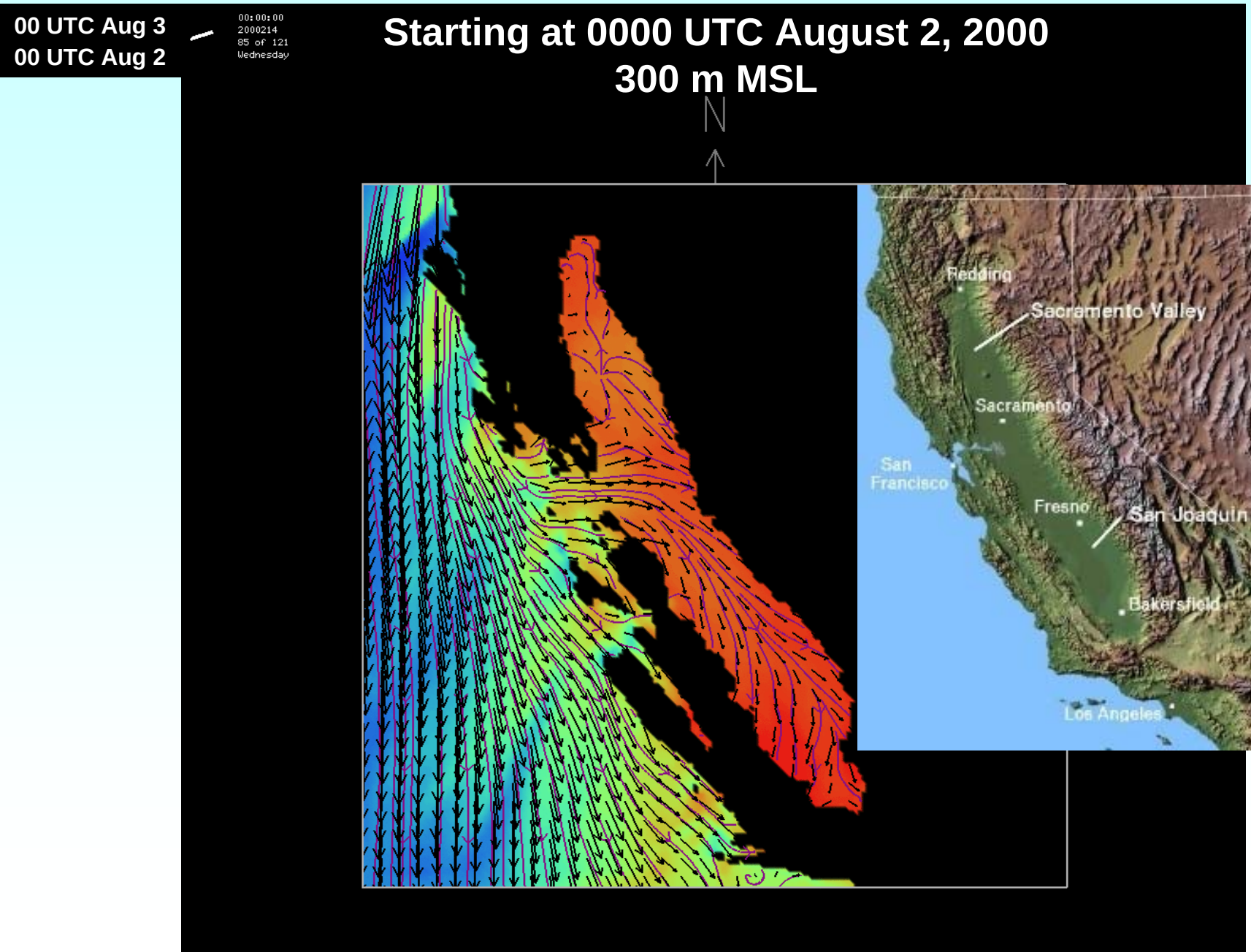
Model evaluation can be regarded as an inverse problem because it infers the errors in the input and physics of the model from the forecast errors.

A priori knowledge derived from process studies can be very useful as additional constraints to meaningfully solve the “ill-posed” inverse problem.

Bao J.-W., S. A. Michelson, S. A. McKeen, G. A. Grell, 2005: Meteorological evaluation of a weather-chemistry forecasting model using observations from the TEXAS AQS 2000 field experiment, J. Geophys. Res., 110, D21105, doi:10.1029/2004JD005024.

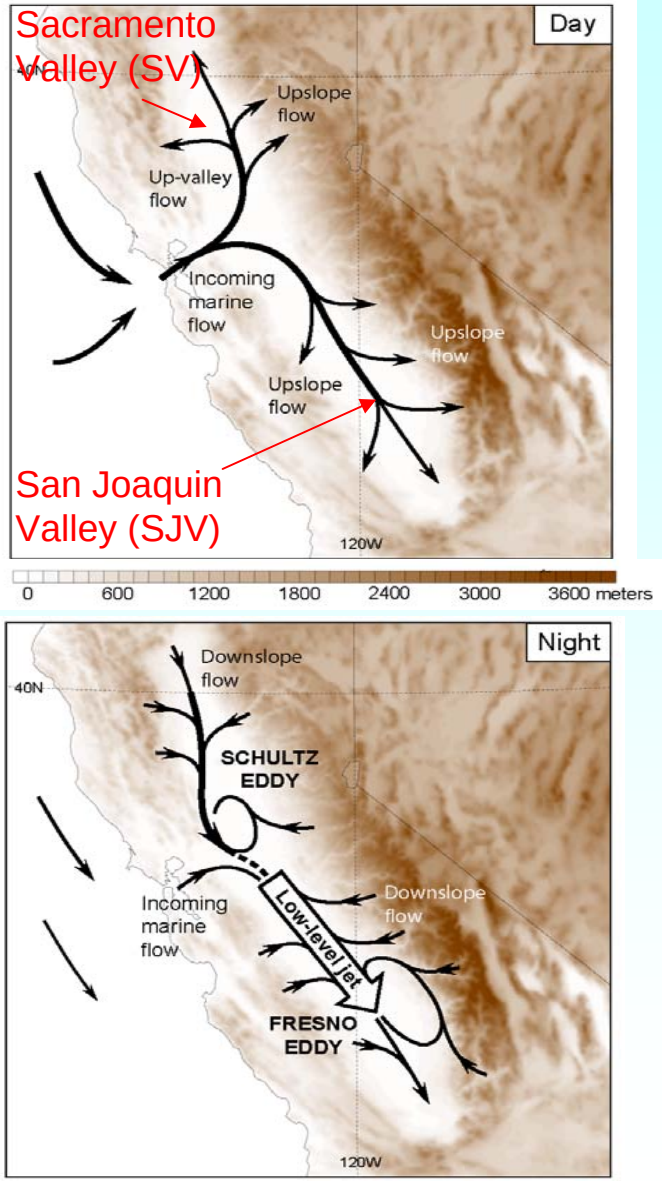
Darby, L.S., S.A. McKeen, C.J. Senff, A.B. White, R.M. Banta, M.J. Post, W.A. Brewer, R.D. Marchbanks, R.J. Alvarez II, S.E. Peckham, H. Mao, and R. Talbot, 2007: Ozone differences between near-coastal and offshore sites in New England: Role of Meteorology. J. Geophys. Res., 112, D16S91, doi:10.1029/2007JD008446.

Central California Ozone Study (CCOS) 2000



Impact of CCOS-2000

The State of California turned to NOAA for our expertise in meteorological modeling and observations, and their current plans on how to reduce ozone in the future are based on the model simulations carried out at PSD.

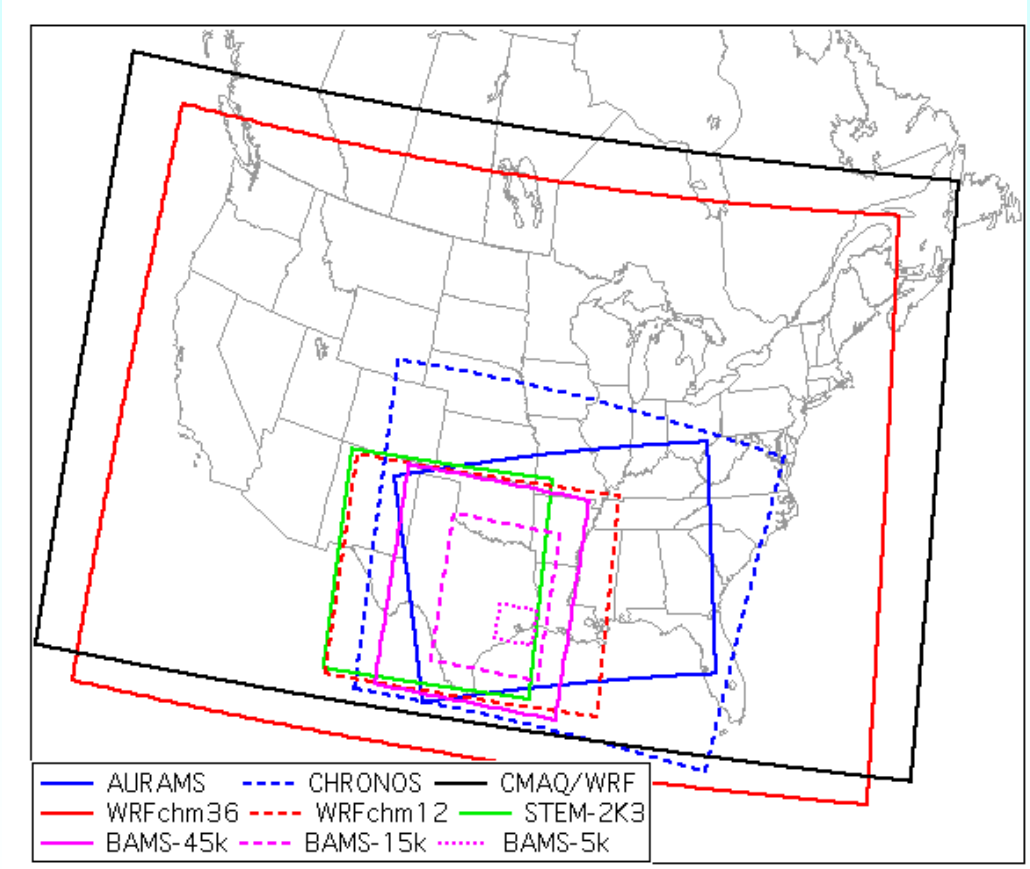


Bao, J.-W., S. Michelson, O. Persson, I. Djalalova, and J. Wilczak, 2008: Observed and WRF-simulated low-level winds in a high-ozone episode during the Central California Ozone Study. To appear in *J. Appl. Meteor. Clim*.

Ensemble Air Quality Forecast Research

Real-time Forecast Model Results, Collected and Stored at NOAA/ESRL/CSD, During NEAQS-2004 and TexAQS-2006

McKeen et al., JGR, 110, D21307, 2005



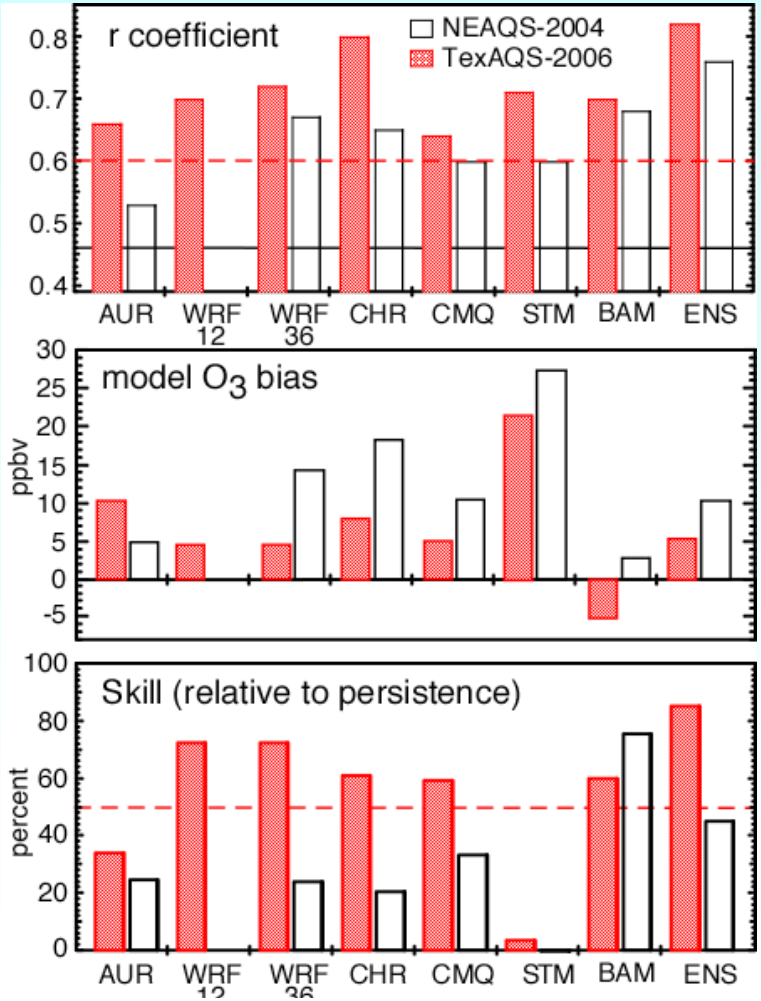
Model:	Emission Inventory:
→ AURAMS - 28km	Canadian National Inv.
→ CHRONOS - 21km	
→ CMAQ/WRF(5x) - 12km	National 2001 inv., grown to 2006
BAMS - 45km	
→ BAMS - 15km	
BAMS - 5km	
→ WRF/CHEM - 36km(*)	NEI-99, NOAA/ESRL/CSD 2004 CEMS
→ WRF/CHEM - 12km(*)	
WRF/CHEM/NMM 40km	
→ STEM(2K3) - 12 km	Vukovich (2005 base)

(*) Indicates a retrospective run

→ Indicates models used in analysis

Also: Real-time forecasts from University of Houston not used in this study

2006 versus 2004 surface O_3 statistics (no bias corrections)



Improved Correlation

Reduced Bias

Improved Skill
(fraction with
RMSE < persistence)

Ensemble shows the highest skill and correlation during TexAQS-2006

McKeen et al., JGR, 110, D21307, 2005

SUMMARY AND CONCLUSIONS

- **Meteorological process studies are important to air quality forecasts.**
- **Close collaboration between modelers and observationalists is crucial in model evaluation.**
- **Ensemble technique is very promising for the improvement of air quality forecast.**