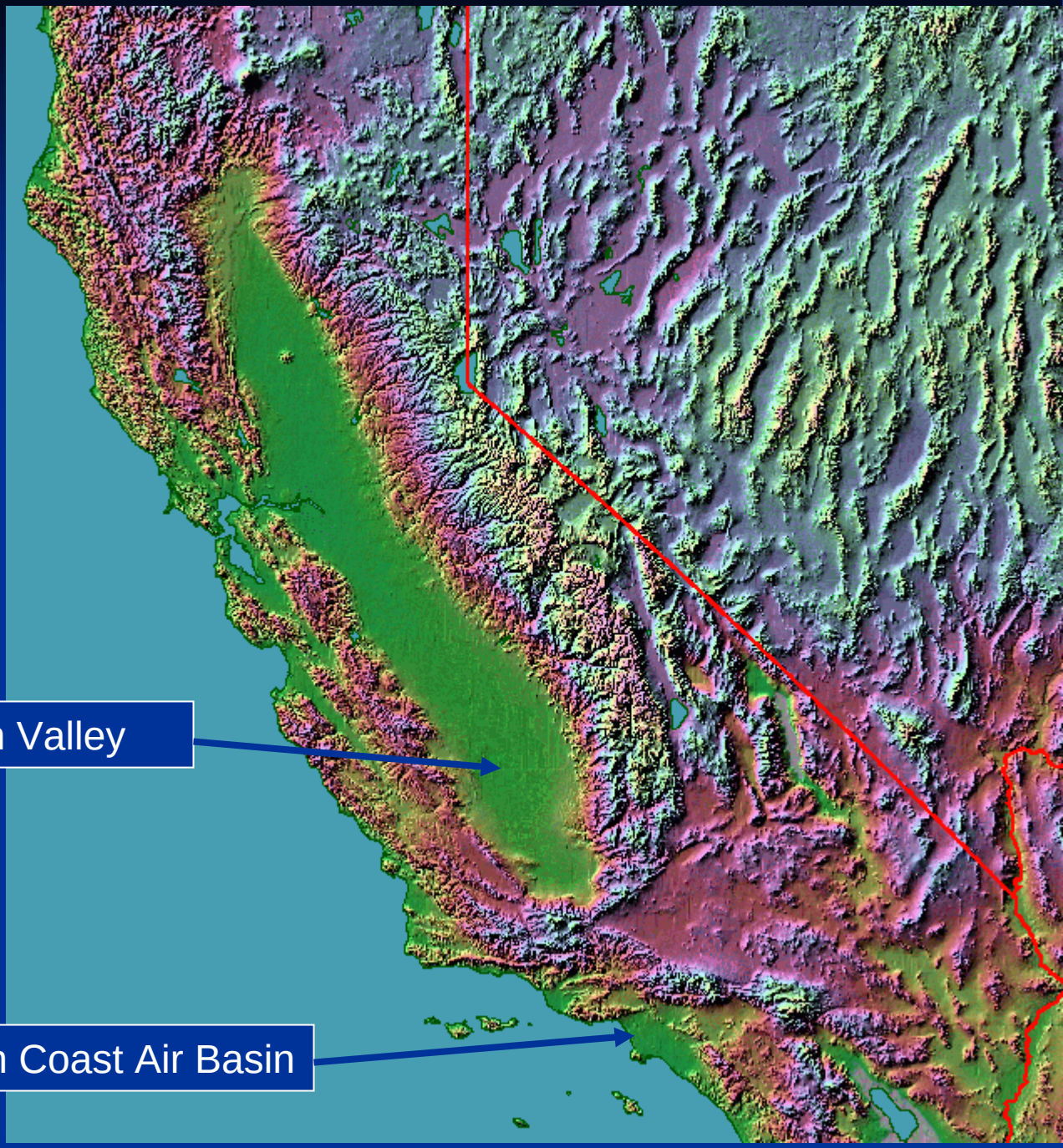
Impact of Global Change on Urban Air Quality via Changes in Mobile Source Emissions, Background Concentrations, and Regional Scale Meteorological Feedbacks.

Michael Kleeman*, Shuhua Chen+, Jamie Schauer++
*Civil and Environmental Engineering
+Atmospheric Science
UC Davis

++Civil and Environmental Engineering
University of Wisconsin, Madison

February, 2007

California's Major Air Basins



Counties Where Fourth Highest Daily Maximum 8-hour Ozone Concentration is Above the Level of the 8-hour Standard in 2004

Source: http://www.epa.gov/airtrends/ozone.html

PM2.5 Concentrations in the US

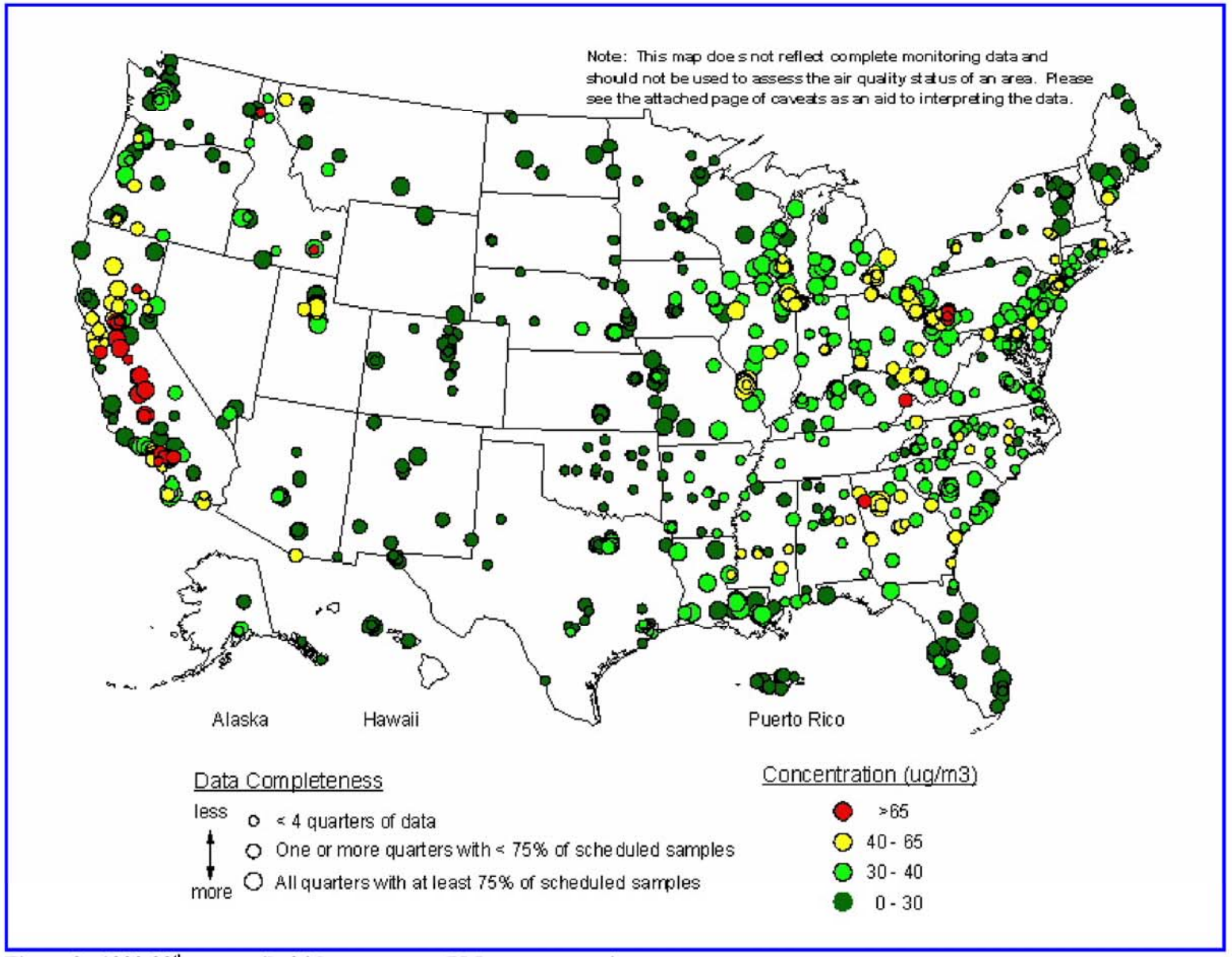
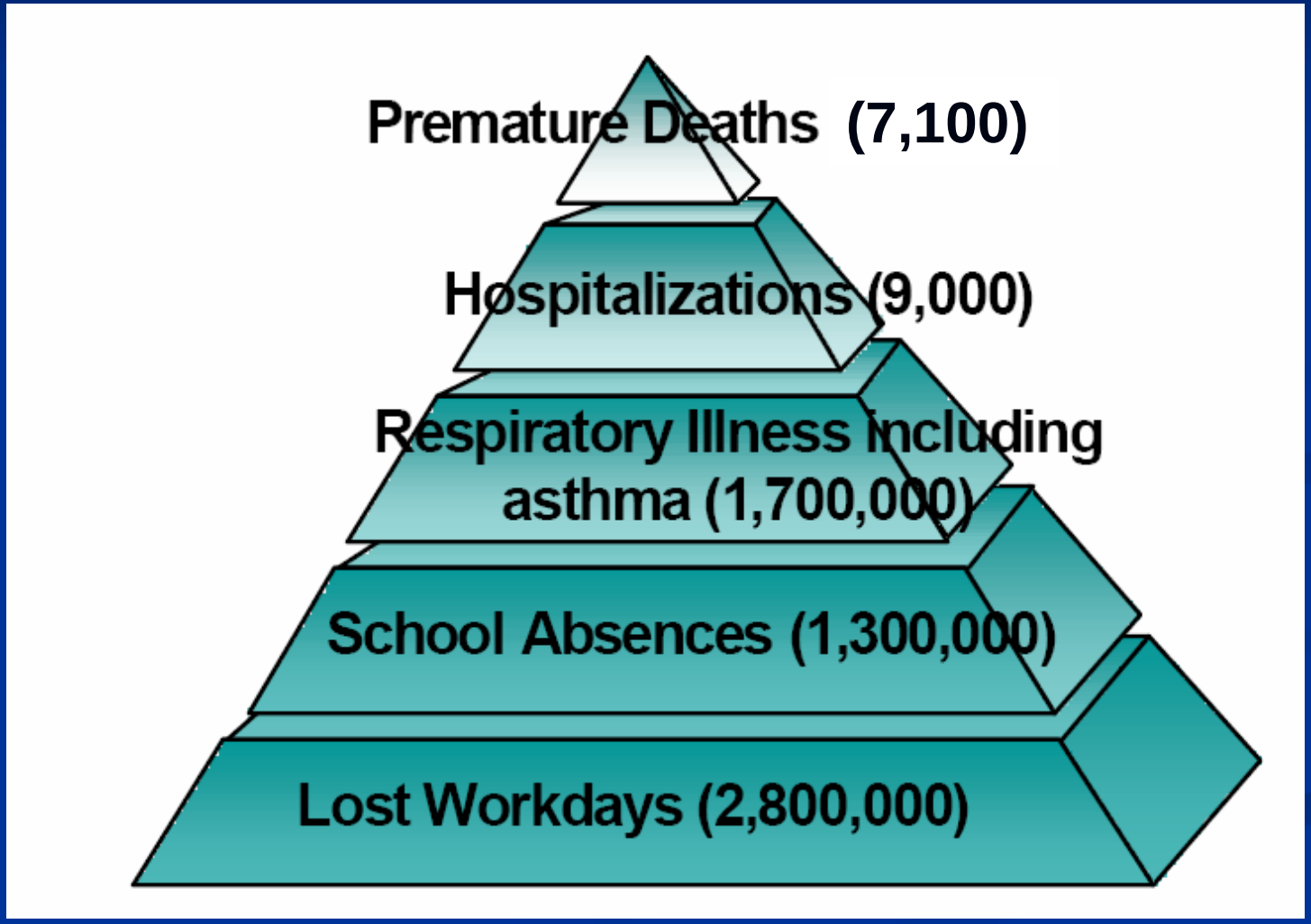


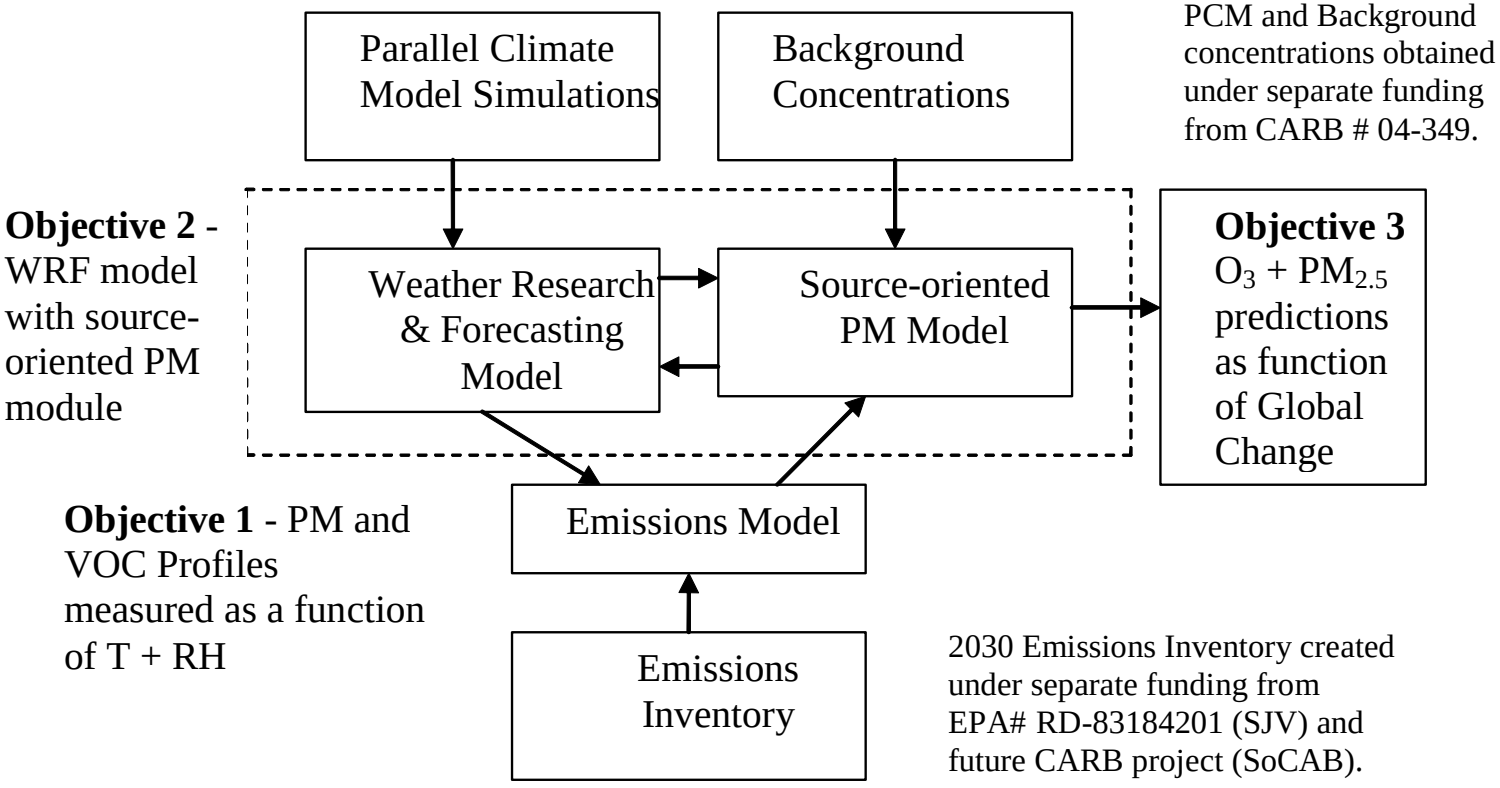
Figure 2. 1999 98th percentile 24-hour average $PM_{2.5}$ concentrations.
Source: U.S. EPA AIRS data base, July 12, 2000.

Health Impacts of Air Pollution in California (per year)



Source: Recent Research Findings: Health Effects of Particulate Matter and Ozone Air Pollution, January 2004. California Air Resources Board (http://www.arb.ca.gov/research/health/fs/PM-03fs.pdf)

Overall Project Design



Ongoing Research #1

- *Impact of climate change on meteorology and regional air quality in California (California Air Resources Board Project # 04-349)*
  - *Dynamically downscale GCM predictions to 4km meteorology around the year 2030 using WRF*
  - *Examine how meteorology during typical air pollution events is different in the future using statistical analysis of meteorological variables*
  - *Predict how air pollution system in California will respond to changes in meteorology*
  - NO COUPLING BETWEEN AIR QUALITY and METEOROLOGY

Ongoing Research #2

- *Regional Development, Population Trend, and Technology Change Impacts on Future Air Pollution Emissions in the San Joaquin Valley (EPA Contract # RD-83184201)*
  - *Develop emissions inventories for the SJV for the year 2030 under various policy scenarios (no control, smart growth, …)*
  - *Predict how the air pollution system will respond to changes in emissions inventories*
  - NO PREDICTION OF HOW CLIMATE CHANGE WILL MODIFY EMISSIONS PROFILES

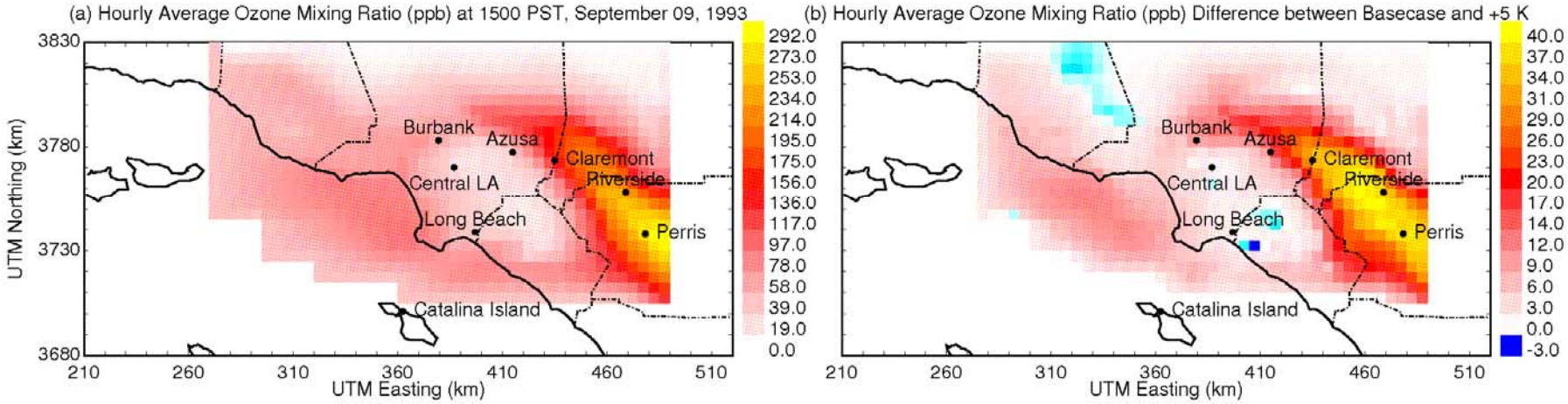
Objectives of the Current Project

- Measure emissions from mobile sources powered by alternative fuels as a function of temperature and humidity
- Create a source-oriented PM module for the Weather Research & Forecasting model (WRF-PMSO) to quantify feedback between air quality and regional meteorology
- Calculate California air quality in the year 2030 during a range of O3 and PM2.5 pollution events

Results from Ongoing Research

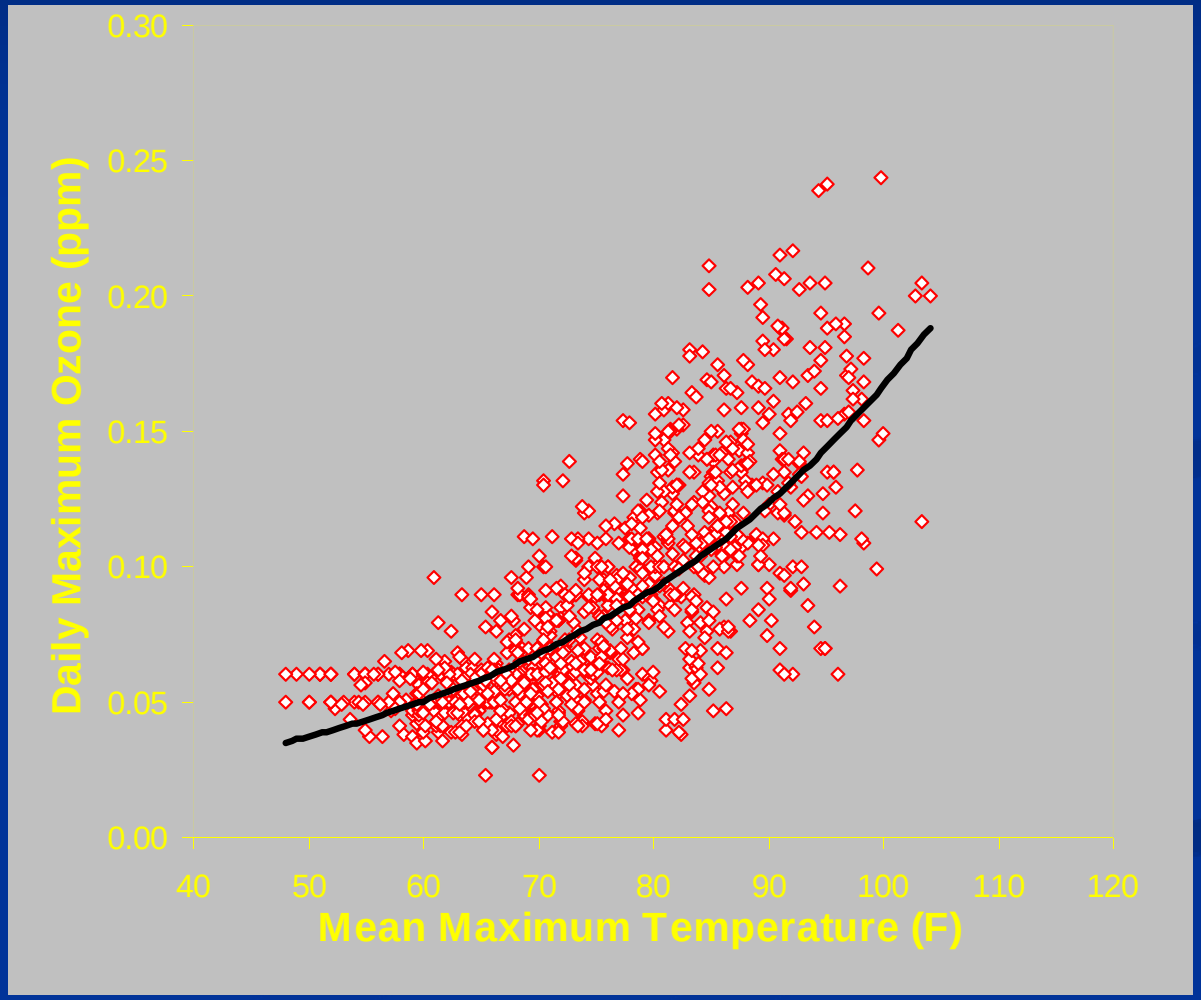
- Sensitivity Analysis for Air Quality in California has been completed
- Preliminary Estimates for Future Emissions in the SJV have been created

Sensitivity Analysis: 1hr-Average O3 Concentration Difference (ppb) Caused by +5K

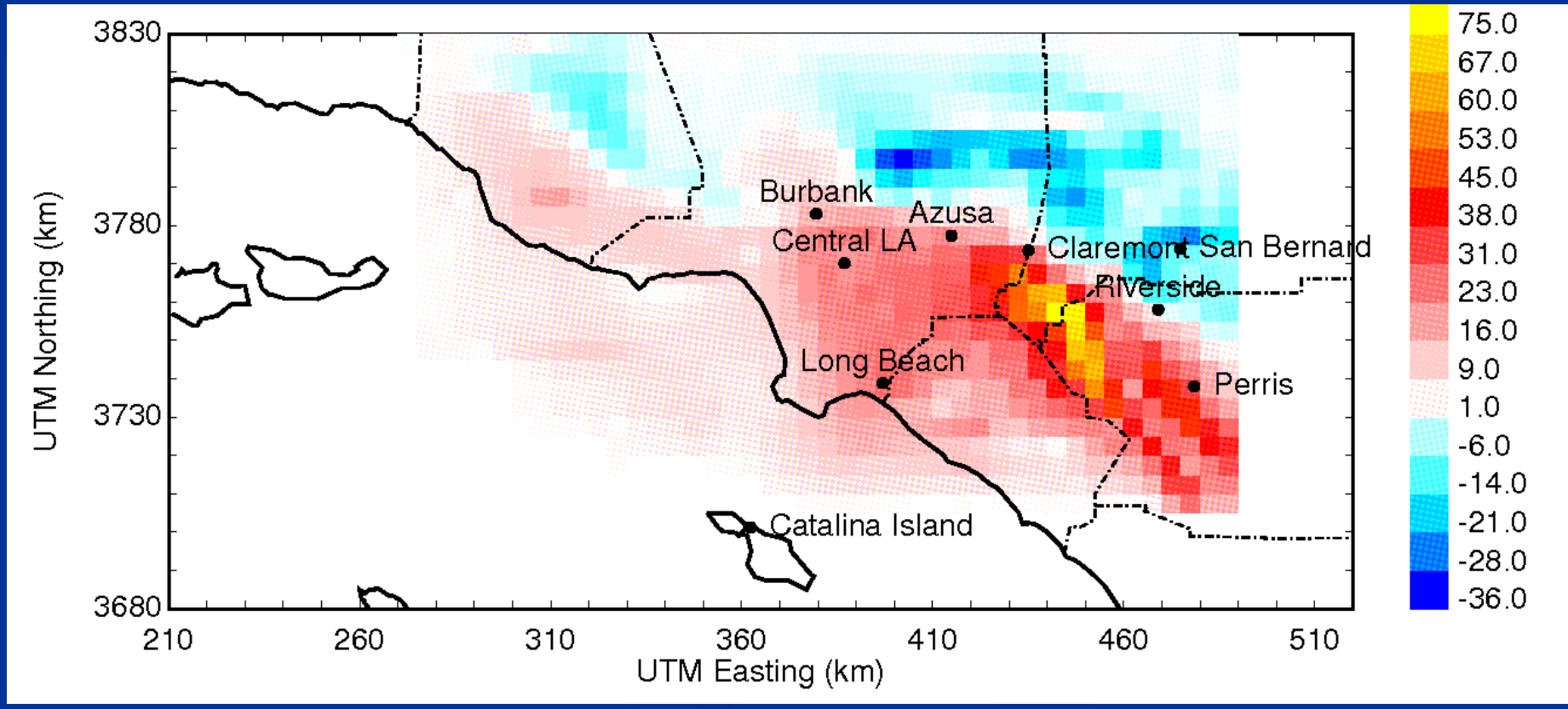


Source: M.J. Kleeman, “A Preliminary Assessment of the Sensitivity of Air Quality in California to Global Change”, Climatic Change, in review, 2007.

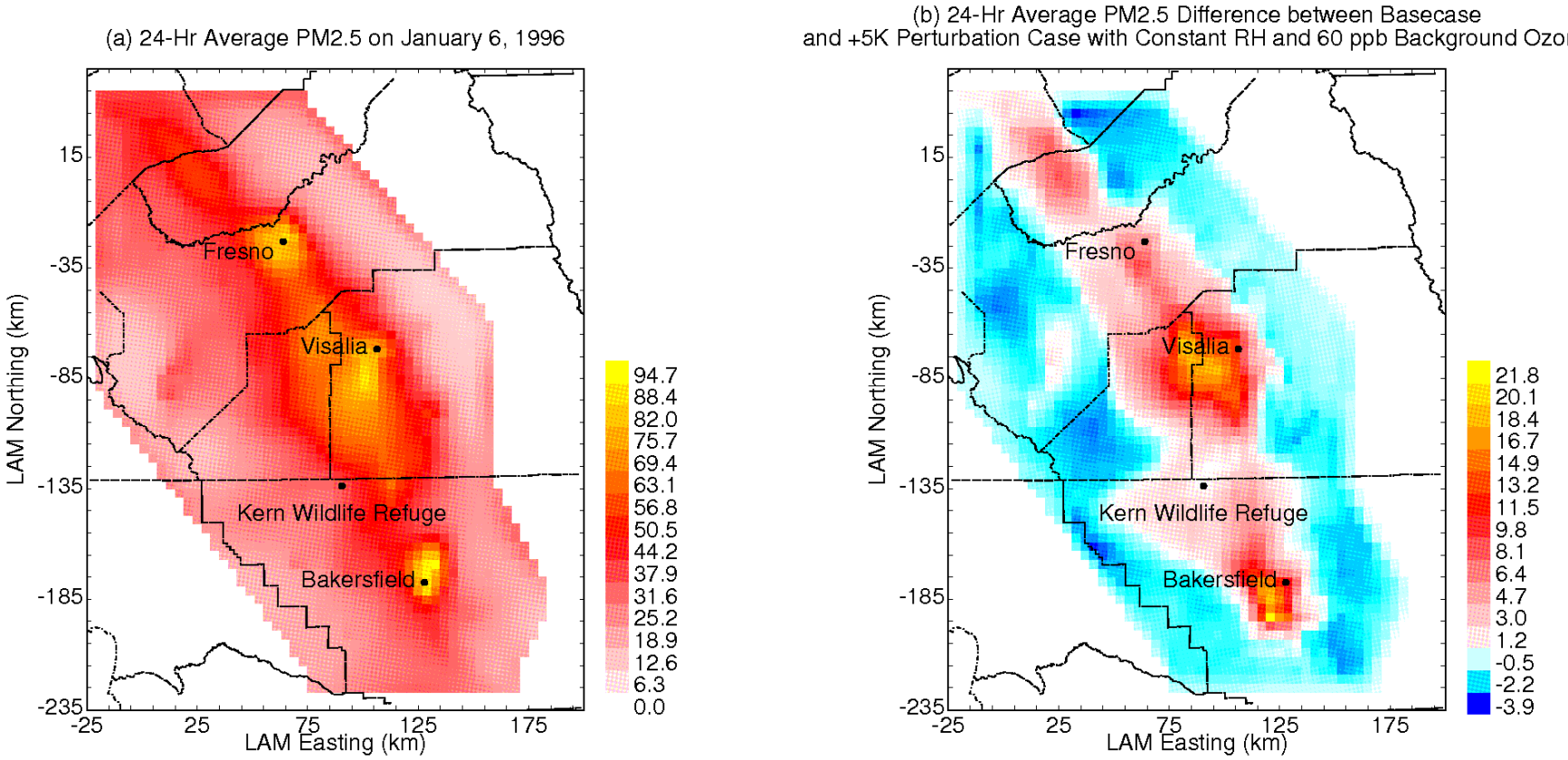
Observed Relationship Between Ozone and Temperature



1hr-Average O3 Concentration Difference (ppb) Caused by +50% Increase in Mixing Depth

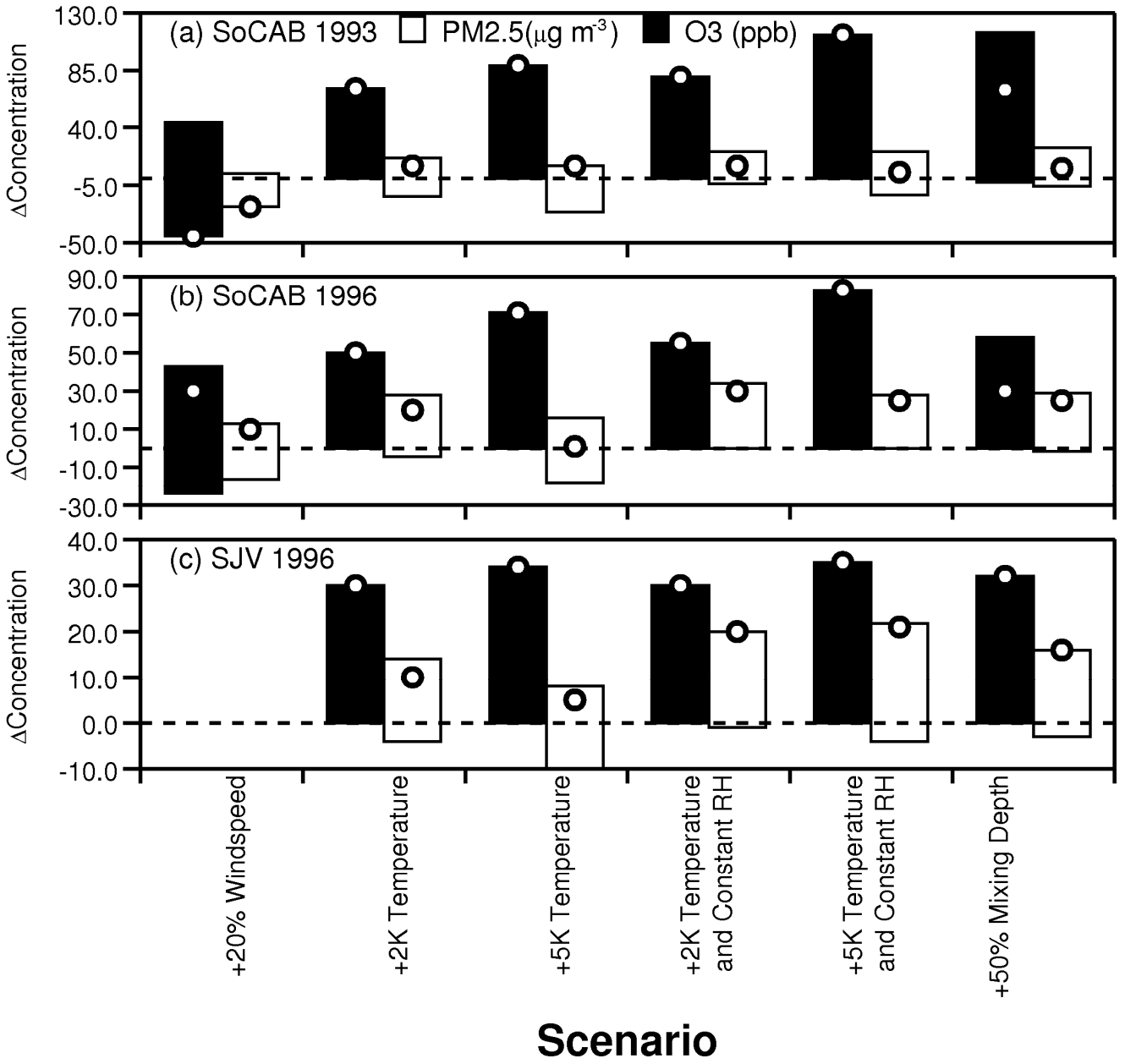


24hr-Average PM2.5 Concentration Difference (μg m^{-3}) Caused By +5K With 60ppb Background O3

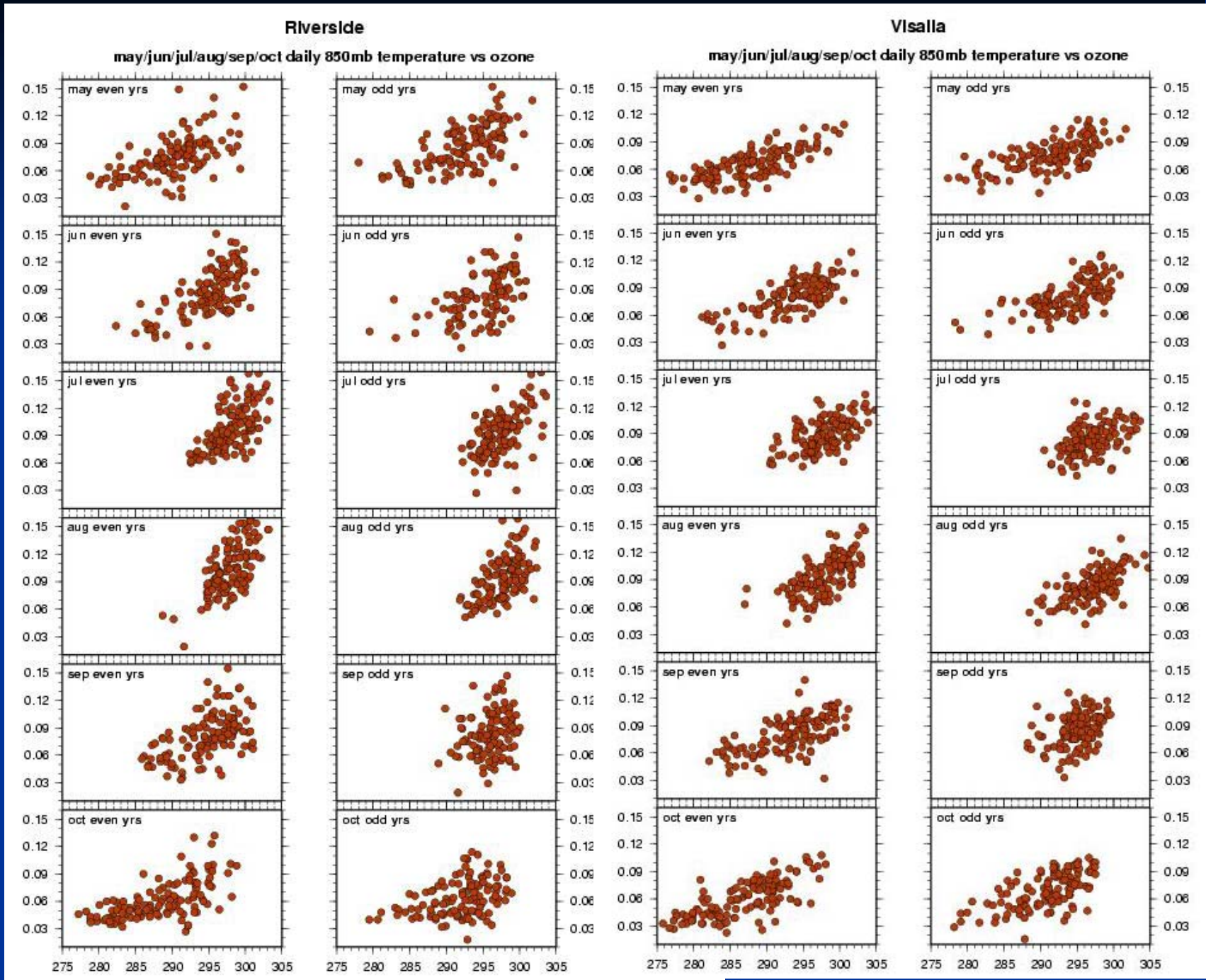


Source: M.J. Kleeman, “A Preliminary Assessment of the Sensitivity of Air Quality in California to Global Change”, Climatic Change, in review, 2007.

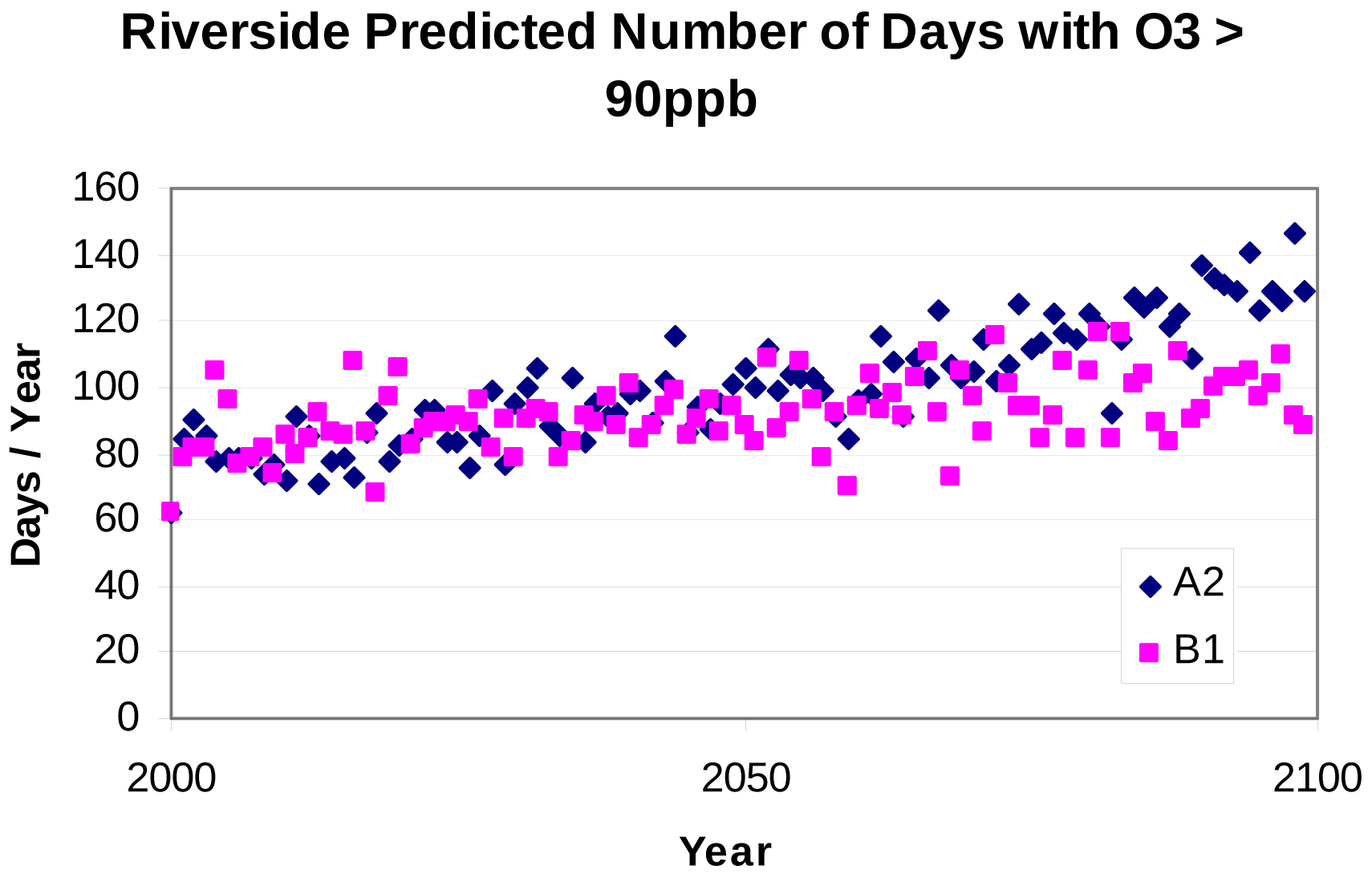
Summary of Pollutant Response Across All Episodes:



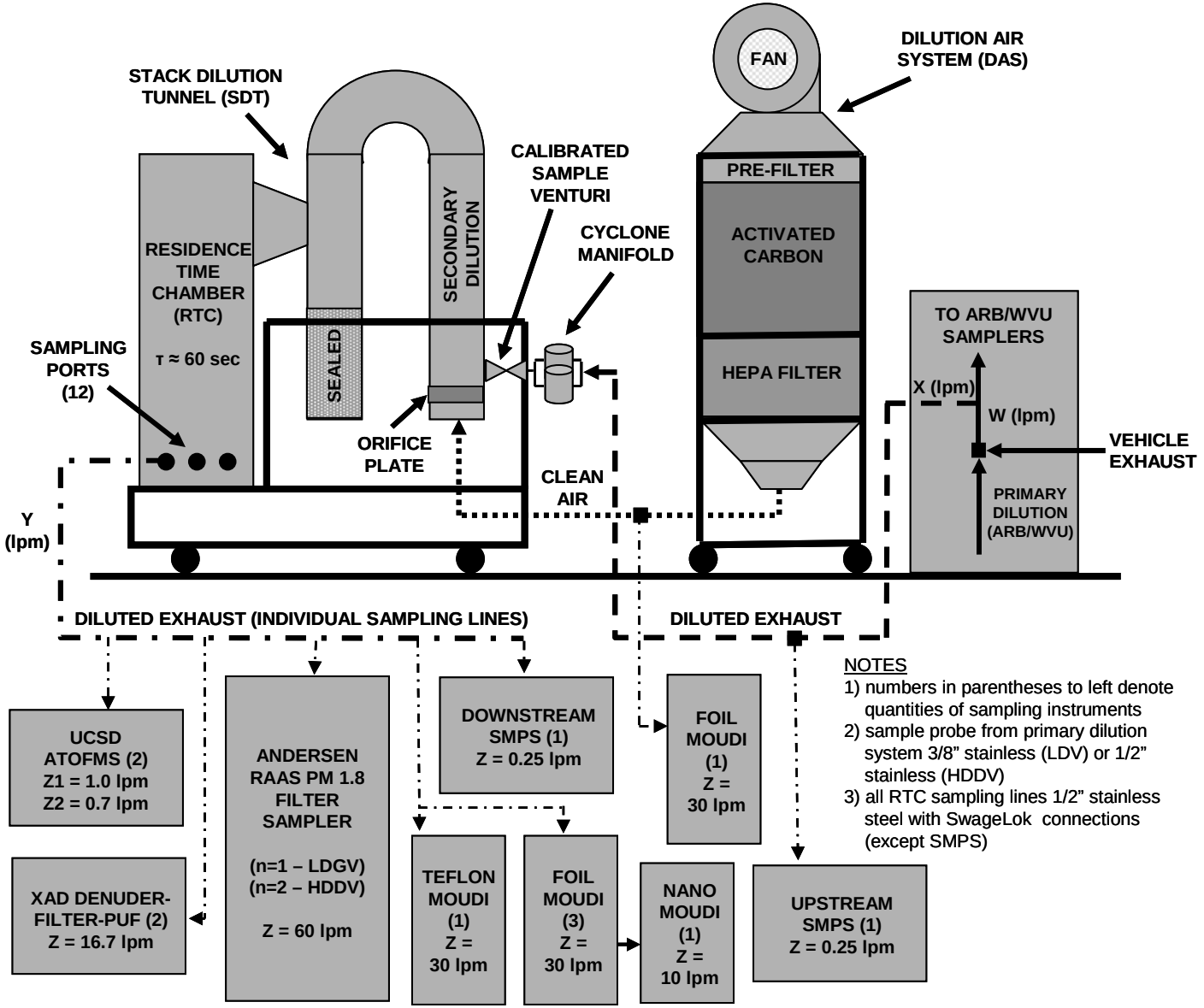
T850 vs. Maximum 1hr-average O3



GFDL Model Predictions

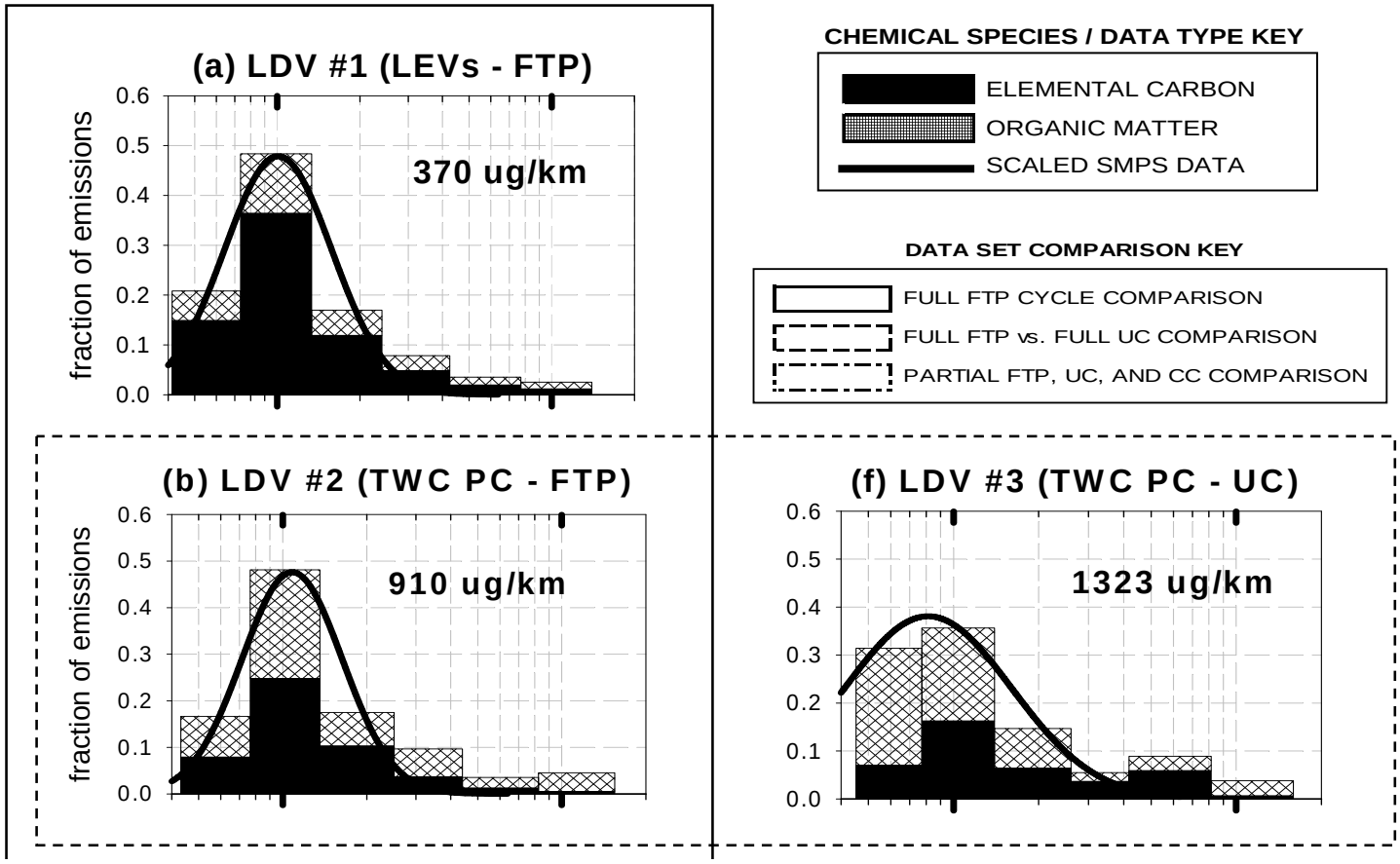


Approach For Future Work: Emissions Testing



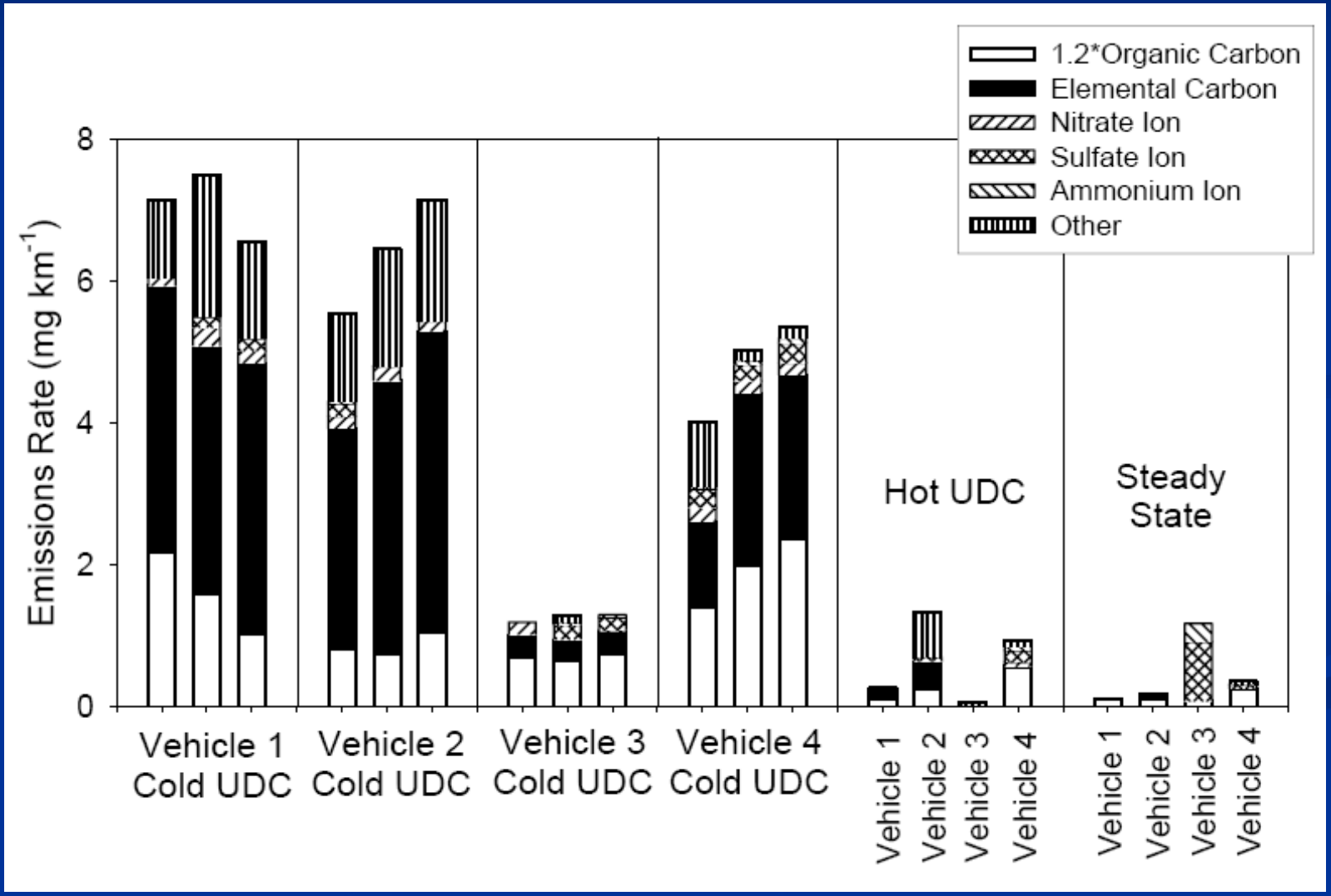
Source: M.A. Robert et al., “Size and Composition Distributions of Particulate Matter Emissions 1. Light Duty Gasoline Vehicles”, Journal of the Air and Waste Management Association, in review, 2007.

Examples of Emissions Source Profiles For Gasoline Vehicles



Source: M.A. Robert et al., “Size and Composition Distributions of Particulate Matter Emissions 1. Light Duty Gasoline Vehicles”, Journal of the Air and Waste Management Association, in review, 2007.

Impact of Cold Start and Ambient Temperature on Gasoline Vehicle PM Emissions



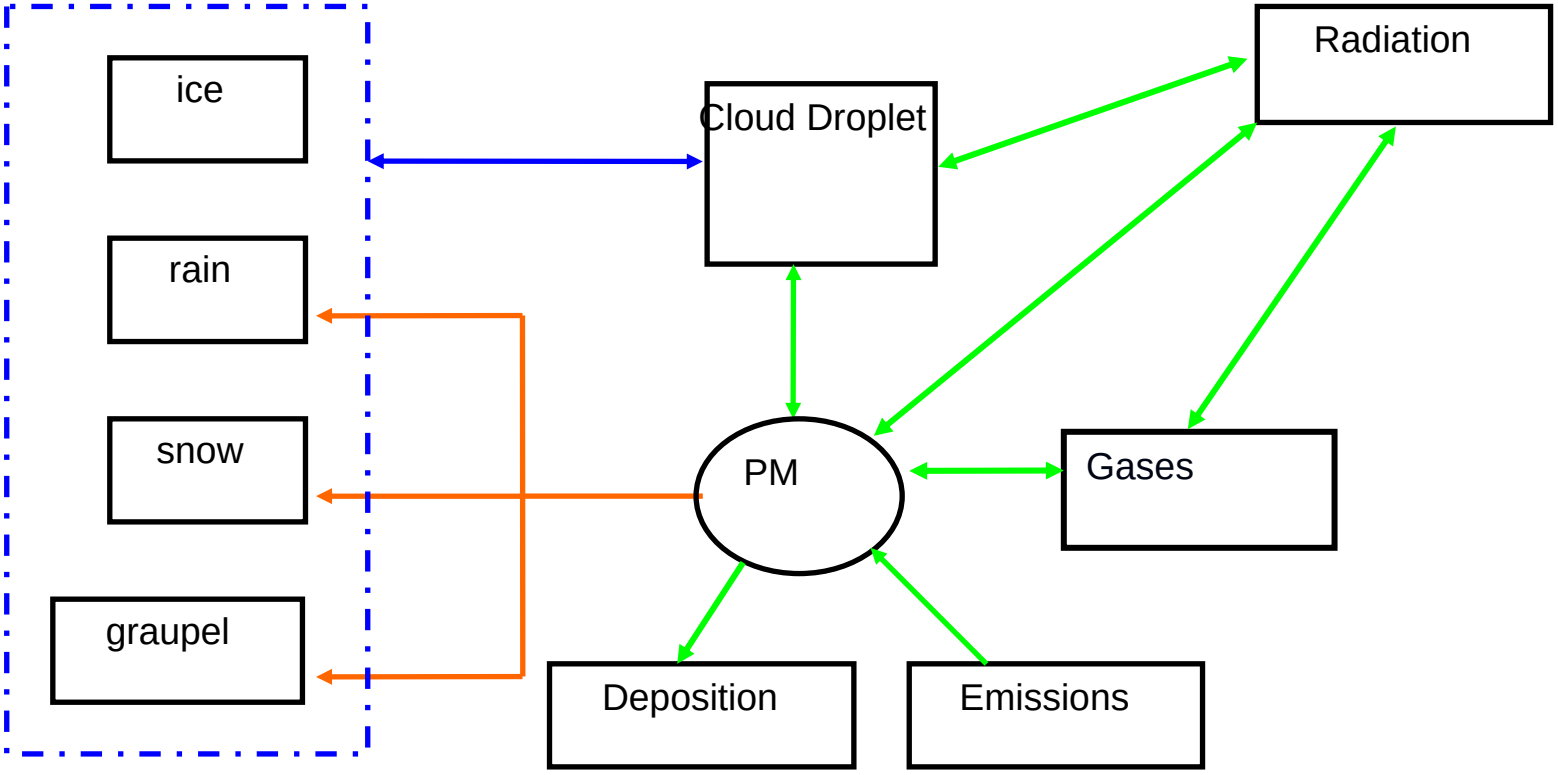
Emissions Testing Plan

- Light duty vehicles measured as a function of temperature and humidity
  - Gasoline
  - Gasoline-electric hybrid
  - Ethanol blends
- Heavy duty diesel engines as a function of temperature and humidity
  - Diesel
  - Biodiesel

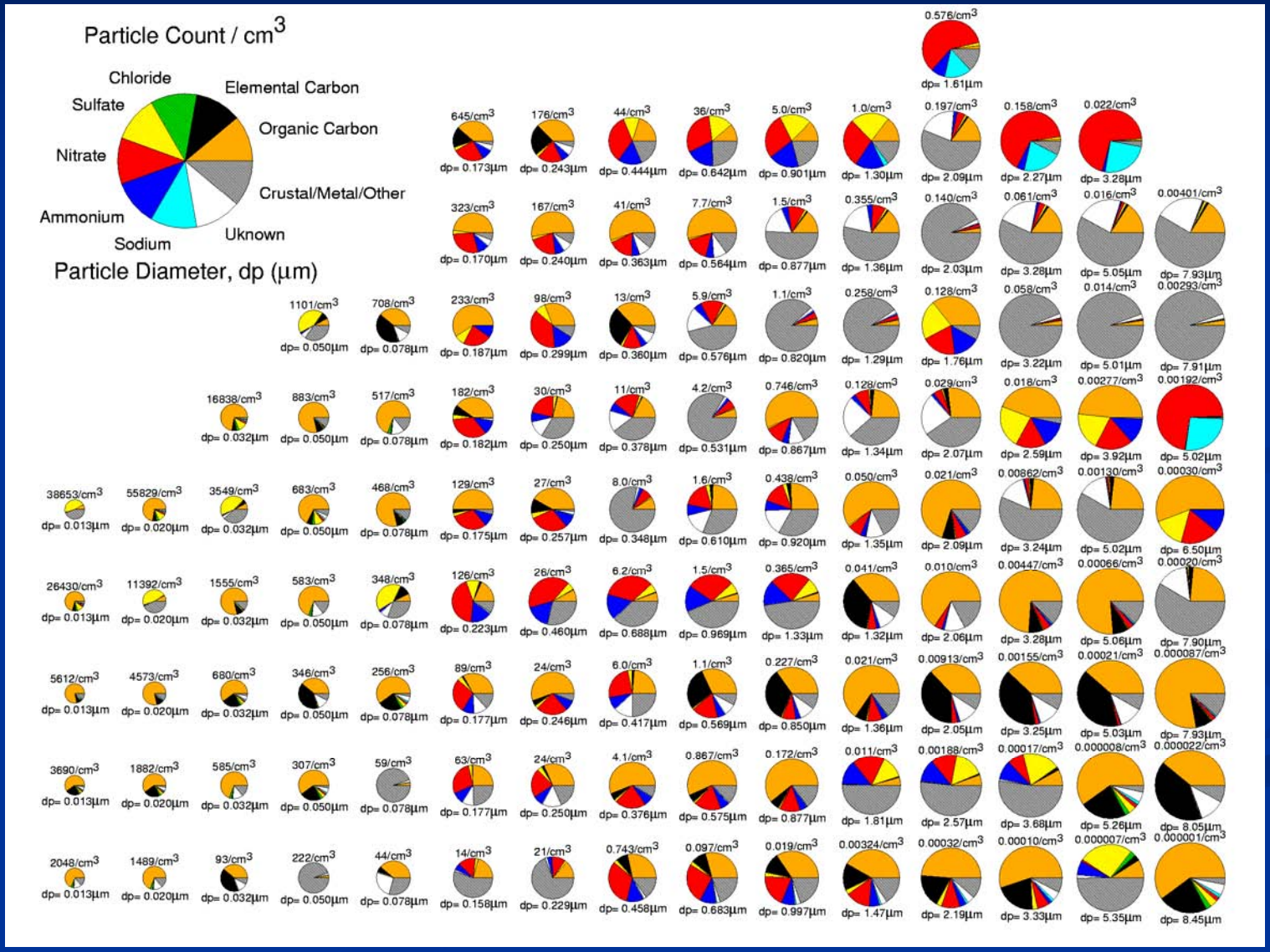
Target Analytes for Mobile Source Emissions Testing

Substrate Code	Substrate Description	Flowrate (lpm)	Sample Location	Summary of Analytes
QF1	47 mm Quartz Fiber Filter	30	Residence Chamber	ECOC
QF2	47 mm Quartz Fiber Filter	*	Residence Chamber	Back-Up ECOC
TF1	47 mm Teflon Filter (Teflo)	30	Residence Chamber	Mass, Metals
TF2	47 mm Teflon Filter (Teflo)	30	Residence Chamber	Mass, Ions
FPX1	Filter/PUF/XAD/PUF	200	Residence Chamber	Organics
SUMMA	6 Liter SUMMA Canister	0.2	Primary CVS	PAMS, Others
DNPH	DNPH Impregnated Cartridge	2.0	Primary CVS	Carbonyls
AMT	Acid Mist Sample Tube	0.5	Primary CVS	Nitric Acid
NH3	Ammonia Sample Tube	0.5	Primary CVS	Ammonia
CIMP	Aluminum Foil Substrates	9.0	Residence Chamber	Size resolved PM

Future Work: WRF Source-Oriented PM Module: WRF-PMSO



Particle Representation



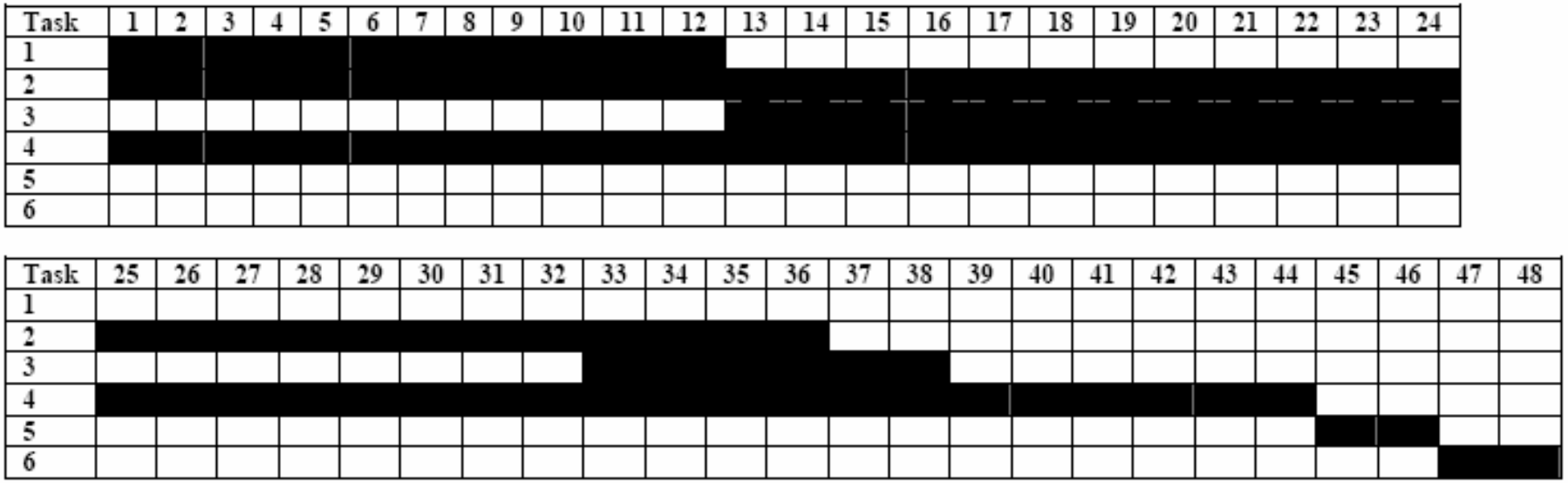
Dynamic Downscaling of GCM Results

- PCM Climate Predictions
  - A2
  - B1
- WRF-PMSO downscaling between years 2027 – 2033 during air pollution events
- Does coupling between air quality and meteorology make a significant difference?
- What are the dominant factors that influence future air quality?
  - Climate
  - Local emissions
  - Background concentrations

Deliverables

- Source profiles for vehicles powered by gasoline, ethanol blends, diesel, and biodiesel as a function of temperature and humidity.
- WRF-PMSO model
- Air quality model simulation results for the year 2030

Timeline



Task 1: Measure preliminary source profiles from gasoline, gasoline-electric hybrid, and ethanol blends as a function of T and RH.
Task 2: Measure source profiles from larger fleet of vehicles as a function of T and RH..
Task 3: Measure Diesel Evaporative Emissions
Task 4: Build source-oriented PM modules for WRF model.
Task 5: Combined measured source profiles with WRF-PMSO model to predict impact of Global Change on California Air Quality.
Task 5: Draft Final Report
Task 6: Final Report