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Real-World Studies of Ambient Ozone Formation as a Function of NOx Reductions – Summary and Implications for Air Quality Impacts

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Vehicle Technologies Program Merit Review
Health Impacts Program

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Project ID: ace_29_lawson

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Overview

Timeline

Start date: FY98

End date: FY12

Percent complete: 80%

Multiple projects co-funded over several years with other industry and government groups

Budget

FY09 – $80,000

Barriers

- NOx emission reduction systems have significant fuel consumption penalty, thus increasing our dependence on imported oil
- Inadequate data on influence of more stringent NOx regulations from LD and HD vehicles on ambient air quality
- Little real-world data on the impact of HD NOx regulations on real-world NOx emissions

Partners

- California Air Resources Board
- South Coast Air Quality Management District
- Coordinating Research Council
- Lake Michigan Air Directors Consortium

DOE OVT Program Manager: Dr. James Eberhardt, Chief Scientist

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PM Emissions from "Mobile Sources"

PM from light-duty vehicle "normal" emitter's tailpipe = <1-2 mg/mile
PM from new 2007-compliant heavy-duty diesel trucks = 1-4 mg/mile
PM from Amy Winehouse's open window at 60 mph = 5 mg/mile

Objectives

Health Impacts Program

Overall Objectives:

- To provide a sound scientific basis underlying any unanticipated potential health hazards associated with the use of new power train technologies, fuels and lubricants in transportation vehicles; and
- To ensure that vehicle technologies being developed by VT for commercialization by industry will not have adverse impacts on human health through exposure to toxic particles, gases, and other compounds generated by these new technologies.

Objectives of Projects Presented Today:

- To evaluate the impact of tighter mobile source NOx emission regulations on ambient ozone levels
- To assess the impact of current/future NOx controls on HD vehicles on real-world emissions

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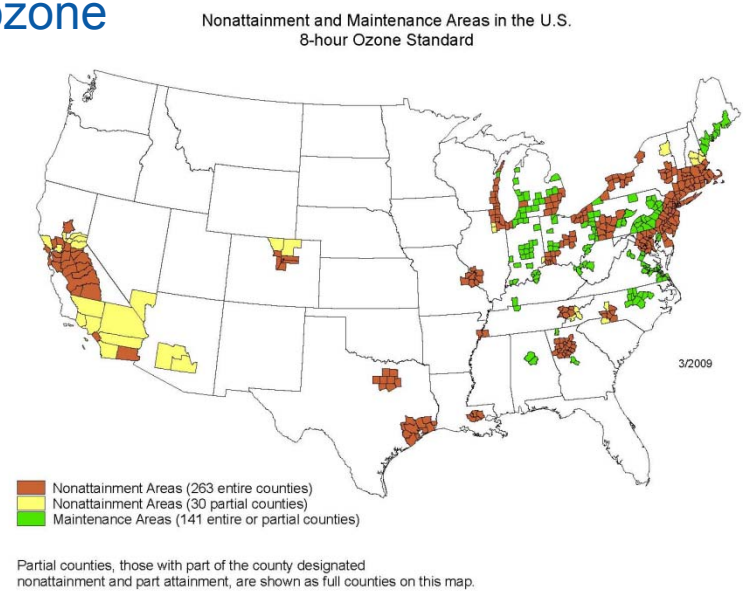
Background

I. Evaluate the impact of tighter mobile source NOx emission regulations on ambient ozone levels

- In 2008 EPA tightened the National Ambient Air Quality Standard for ozone, resulting in more parts of the country being in nonattainment for ambient ozone

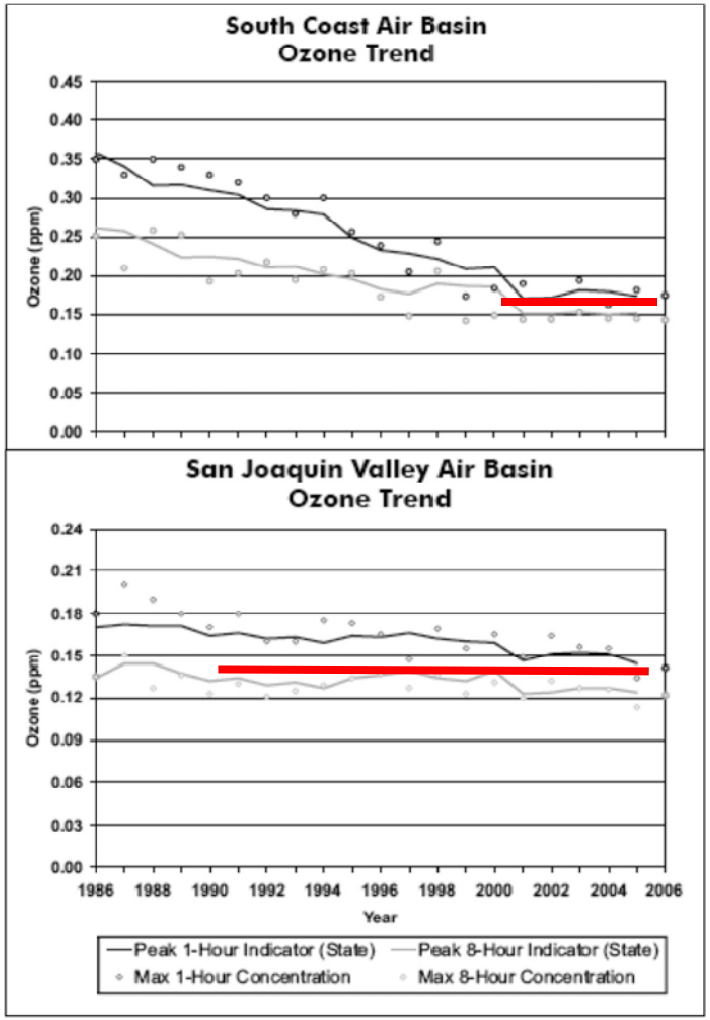


- Question to be addressed: Multi-year debate as to the most effective and least costly approach for reducing ambient ozone levels – should it be hydrocarbon controls or nitrogen oxides controls, or both?

Background

Additional Challenge: In California and other parts of the country, ambient ozone levels have not dropped or are increasing

California Ozone Trends, 1986-2006



South Coast Air Basin – Unchanged Since 2001

San Joaquin Valley – Unchanged Since 1990

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Milestone

Changes in emissions on weekends relative to weekdays can be used as a "Natural Emission Control Experiment" to evaluate how these changes influence ambient ozone levels

- Continue publication of peer-reviewed papers on "Weekend Ozone Effect"
- Paper published in December 2008 issue of the *Journal of the Air & Waste Management Association* titled "Differences between Weekday and Weekend Air Pollutant Levels in Atlanta, Baltimore, Chicago, Dallas-Fort Worth, Denver, Houston, New York, Phoenix, Washington DC, and Surrounding Areas," the ninth paper in a series of peer-reviewed papers coordinated and sponsored or co-sponsored by the OVT Health Impacts Program

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Approach

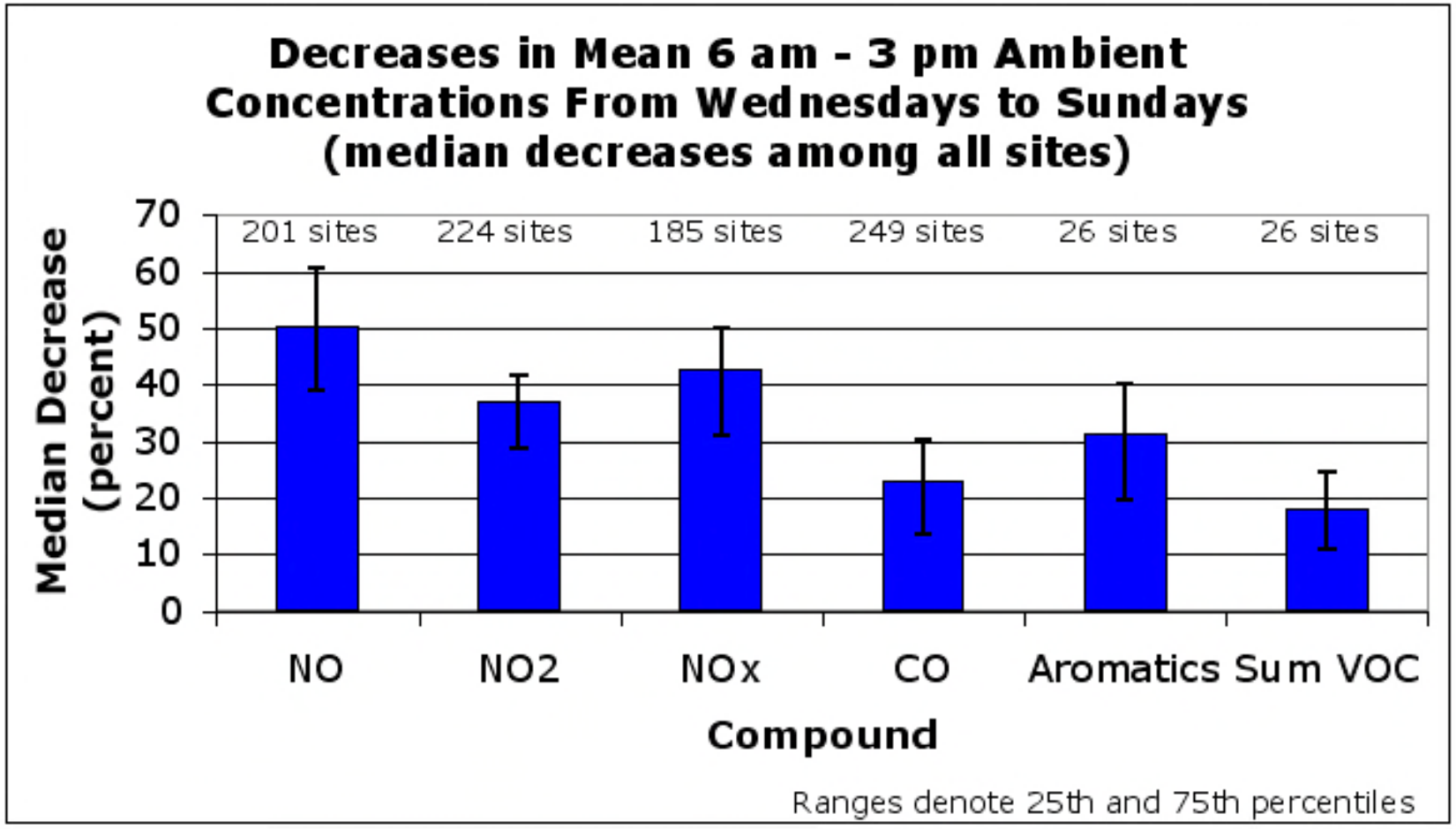
Analyze weekday and weekend ambient air quality monitoring data to evaluate how these changes influence ambient ozone levels

- Evaluated weekday/weekend changes in ozone precursor concentrations (hydrocarbons and nitrogen oxides) in 23 states outside of California having ozone air quality problems
- Data between 1998 and 2003 were analyzed from up to 540 air quality monitoring sites, depending upon pollutant

What are the results?

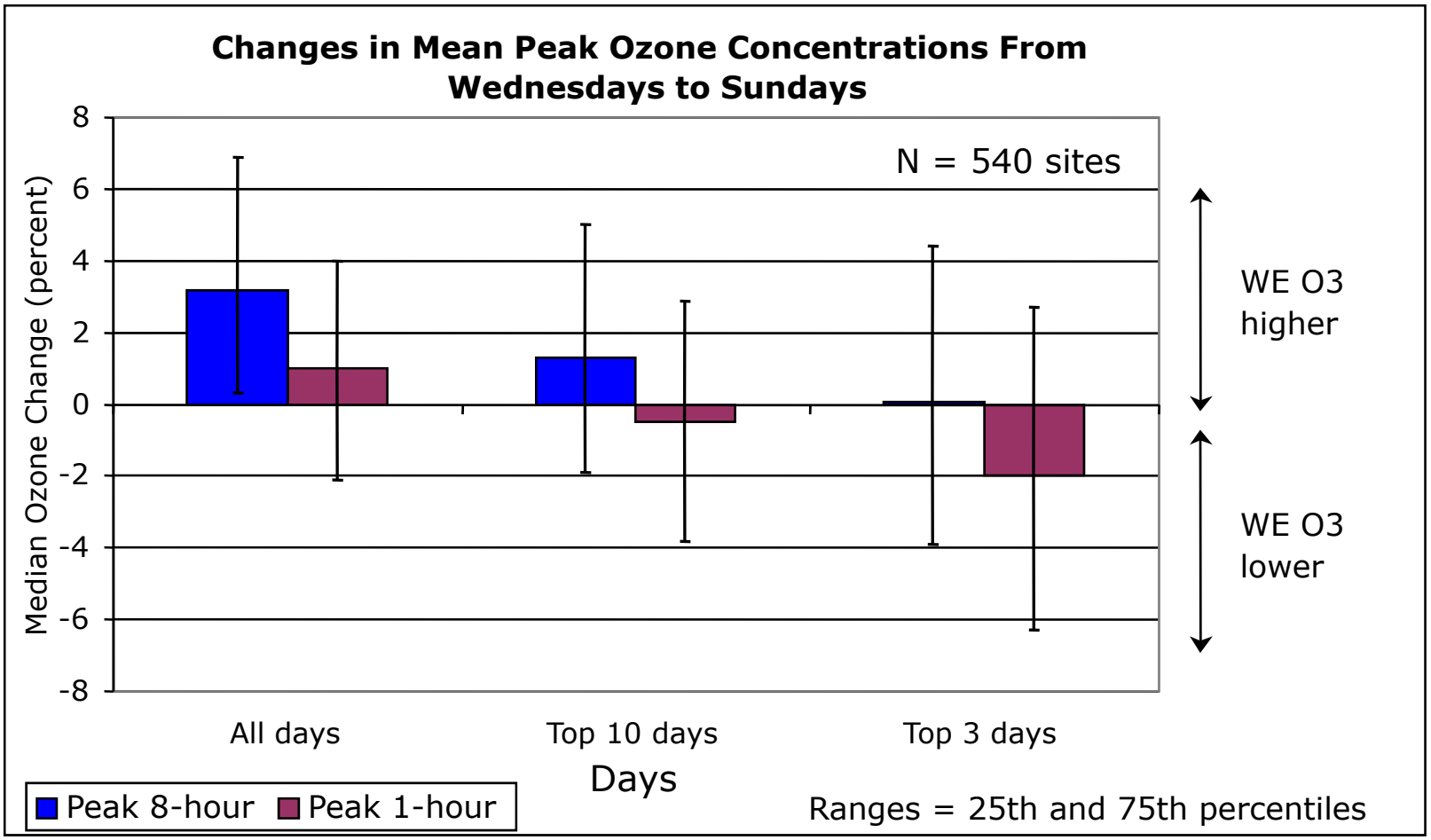
Accomplishments

Weekend Concentrations of Ozone Precursors –
Large & Significant Declines, All Areas



Accomplishments

Weekend Ozone Compared to Weekday Ozone –
Small Changes with Some Increases, All Days & High Ozone Days



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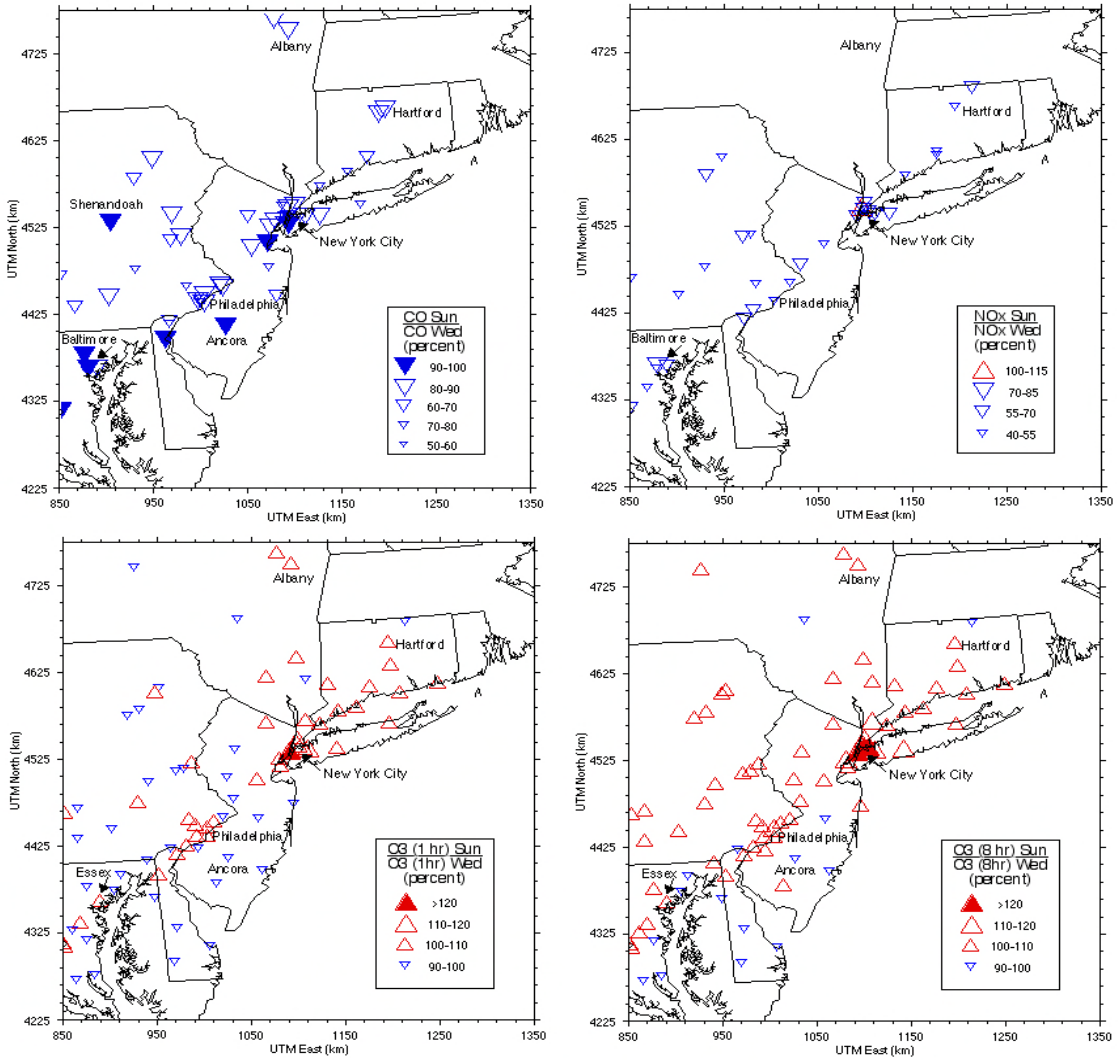
Accomplishments



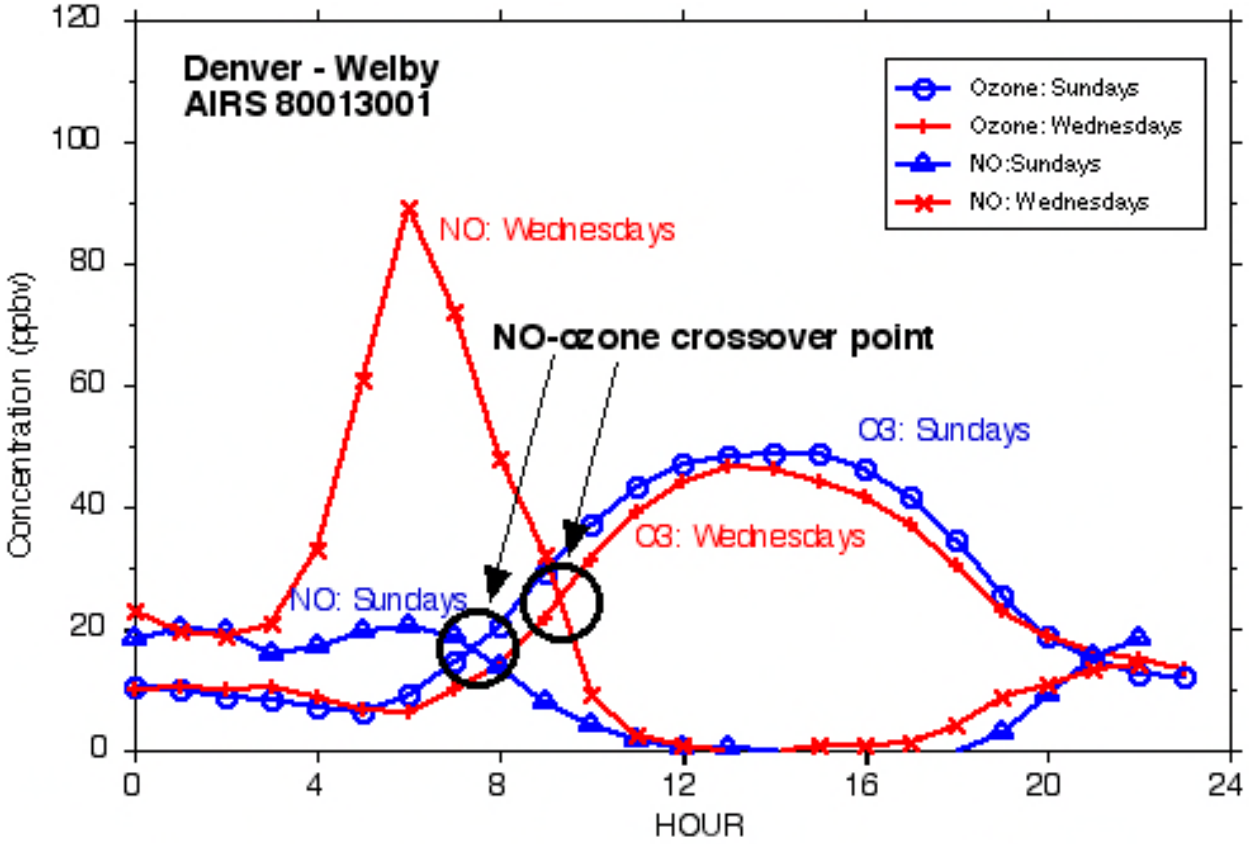
Mean Sunday to mean Wednesday daytime (6 am through 3 pm) CO and NOx and peak one-hour and eight-hour ozone in the mid-Atlantic region, all days, March-October 1998-2003.

So why don't ozone levels decline on weekends?

Accomplishments

Main Reason for Weekend Effect -

Local Ozone Formation Starts Sooner – Less Fresh NO from HD Trucks and Buses on Weekends than on Weekdays



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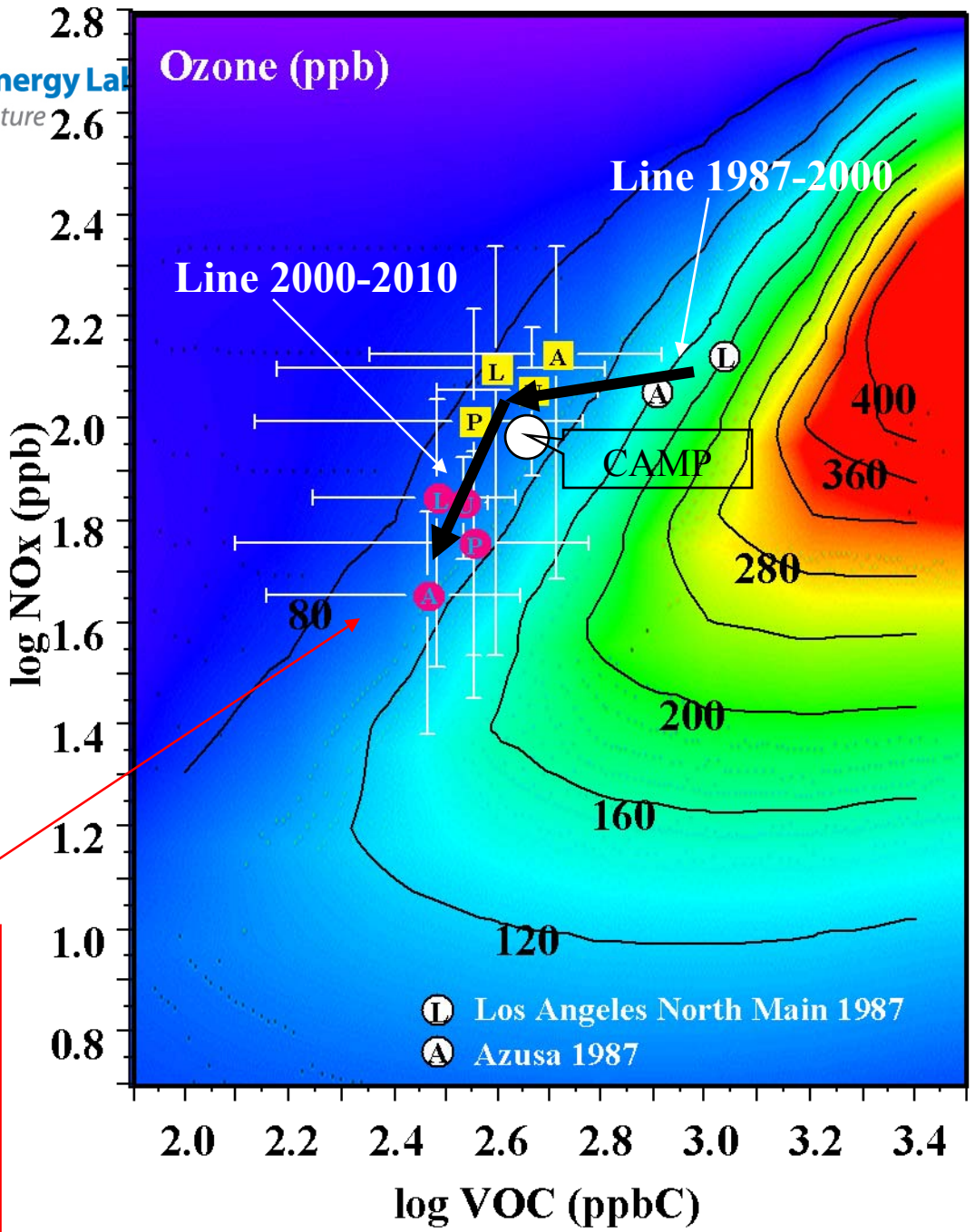
1987-2010 VOC, NOx and Ozone in Los Angeles

Mean Wednesday
± 1 sigma

Mean Sunday
± 1 sigma

Monitoring Stations

A – Azusa
L – Los Angeles, N. Main
P – Pico Rivera
U – Upland



Weekday VOC and NOx emissions in 2010 are projected to be similar to weekend emissions in 2000 – therefore, little change in ambient ozone levels.

Weekend Ozone Studies

- Extremely large NOx emission reductions in urban areas on weekends throughout the U.S. (from fewer trucks and buses on the roads) do not result in decreases in ambient ozone levels, and even produce ozone increases
- Emission inventory projections suggest that ambient ozone levels may not decrease over the next few years
- Because ambient ozone levels will not drop significantly, and because EPA has tightened the National Ambient Air Quality Standard for ozone, it is likely that EPA will tighten HD NOx emissions standards after 2010.

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Background

II. Evaluate the impact of tighter mobile source NOx emission regulations on real-world HD NOx emissions

- EPA and California Emission Standards
  - PM – 0.01 g/bhp-hr MY 2007
  - NOx – 0.2 g/bhp-hr MY 2010
- San Pedro Bay Ports Clean Air Action Plan (CAAP)
  - Beginning 10/1/08 Pre-1989 trucks banned
  - By 2012 all trucks not meeting 2007 standards banned
  - CAAP goal – 50% alternative fuel trucks
- CARB Drayage Truck Regulation
  - Dec. 31, 2009 – Pre-1994 engines retired or replaced
  - 1994-2003 engines to meet 85% PM reduction
  - Dec. 31, 2013 – All trucks to meet 2007 MY emissions
- CARB Statewide Truck and Bus Rule
  - 2011-2014 – Phase-in most PM requirements
  - 2013-2023 – Phase-in NOx requirements

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Objectives

"On-Road Heavy-Duty Diesel Truck Emission Measurements in the South Coast (Los Angeles) Air Basin"

- To obtain on-road heavy-duty diesel truck (HDDT) emissions baseline using remote sensing devices
- To examine how HDDT emissions are impacted by changing fleet regulations and new emission standards over the next few years

- Project co-sponsored with South Coast Air Quality Management District

Approach

Equipment and Measurements

DU multi-spectrometer remote sensing device

NDIR – CO, CO_2, HC, %Opacity

UV – NO, NO_2, NH_3, SO_2

Speed and Acceleration
License Plate Photo

ESP 4600

NDIR – CO, CO_2, HC, %Opacity

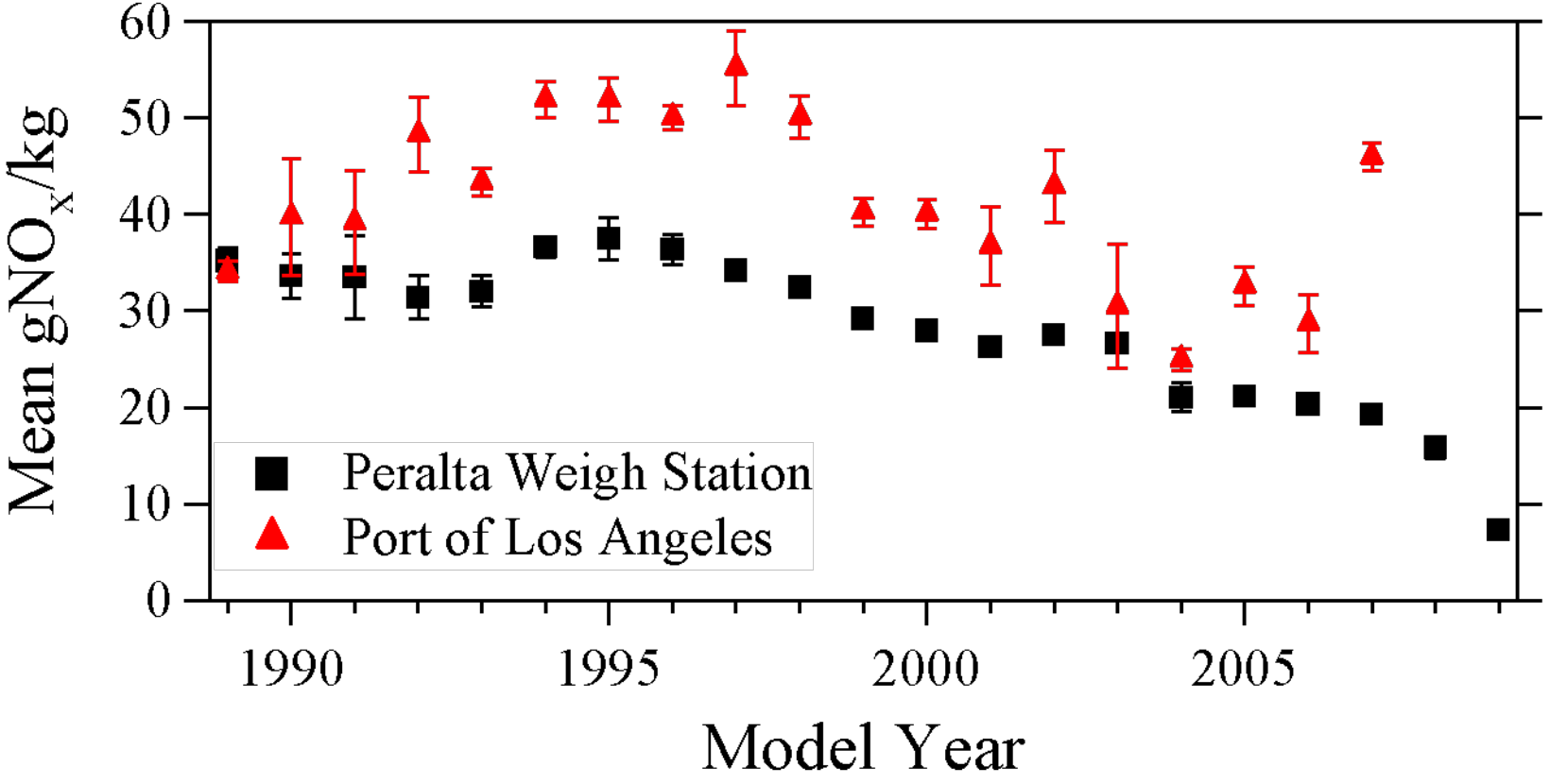
UV – NO, Smoke Factor

Peralta Weigh Station
EB CA-91/Weir Canyon Rd.
April 4, 7 - 10 2008
34 hrs / 2,629 Measurements
Mean MY 2000.4
5 – 15mph (Accel)

Port of Los Angeles
Water Street Exit
April 12, 14 - 17 2008
38 hrs / 1,436 Measurements
Mean MY 1995.6
0 – 5mph (Creep)

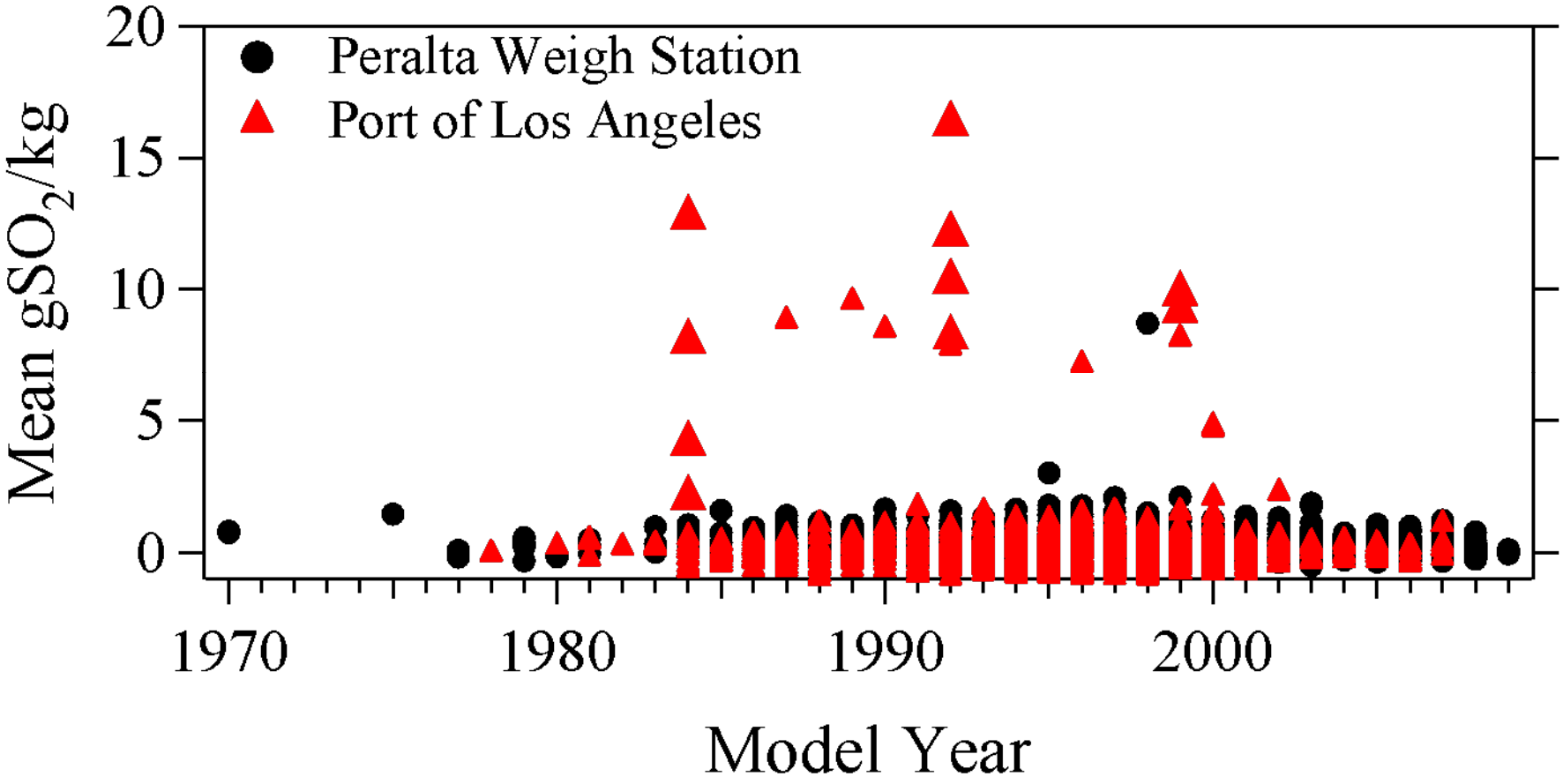
Accomplishments

2008 Measurements



Accomplishments

2008 Measurements



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Accomplishments

Observations from First Year of Five-Year Project

- Successful measurements at two locations with different fleets and operating modes
- Mean gNO/kg emissions at Peralta have decreased 15% since 1997
- Trucks operating at the Port are older and have higher NO_x emissions likely due to age and driving mode; emissions distributions are similar
- Likely high sulfur-misfueled trucks identified
- IR and UV smoke systems report similar trends

Summary

Health Impacts Program

- No responses from last year's Merit Review Program for the projects described today; not presented in last year's evaluation
- Have met Program milestones for the projects presented today
  - Published 23-state weekend ozone paper
  - Carried out first year of five-year on-road HD emissions measurement project
- The Health Impacts Program is successfully evaluating potential health hazards and exposures associated with the use of new power train technologies, fuels and lubricants in transportation vehicles
- 100 peer-reviewed articles in scientific journals over the past ten years
- Numerous invited public presentations, workshops, and specialty conferences result from the Health Impacts Program