OTT
Office of Heavy Vehicle Technologies

The Environmental Science & Health Effects Program at the National Renewable Energy Laboratory

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San Diego, California

NREL
CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS

Environmental Science & Health Effects

PROGRAM MANAGER:
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Issues

- ozone
- particles
- air toxics
- visibility/regional haze
- health effects

Our Goal

To conduct policy-relevant research that will help us understand atmospheric impacts and potential health effects that may be caused by the use of petroleum-based fuels and alternative transportation fuels from mobile sources.

Environmental Science & Health Effects

Areas of Policy-Relevant Research

- Emissions Measurement Technologies
- Vehicle Emissions Measurements
  - Dynamometer testing of new and “in-use” vehicles
  - On-road measurements of “real-world” fleet
- Emission Inventory Development/ Improvements
  - Reconciliation of “Top-Down” vs. Bottom-Up Approaches
- Ambient Impacts
- Assessment of Health Impacts

New Regulatory Challenges

Air Toxics and Regional Haze

EPA's Hazardous Air Pollutants List
(188 "Air Toxics" – Candidate List of 21 Mobile Source HAPs)

List of Mobile Source Air Toxics (MSATs)

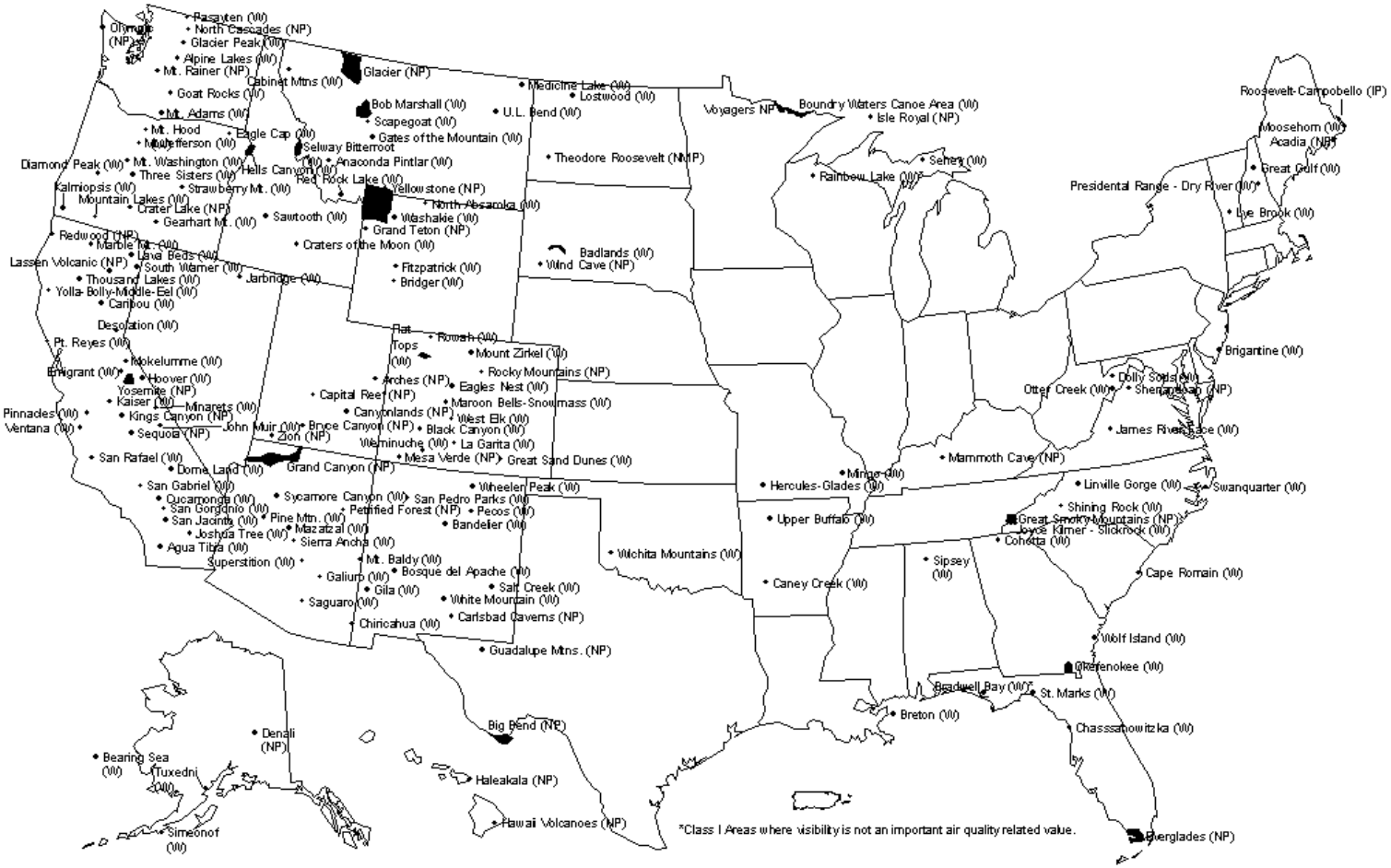
Acetaldehyde*	Diesel Exhaust	MTBE
Acrolein*	Ethylbenzene	Naphthalene
Arsenic compounds*	Formaldehyde*	Nickel compounds*
Benzene*	n–Hexane	POM (Sum of 7 PAHs)*
1,3-Butadiene*	Lead compounds*	Styrene
Chromium compounds*	Manganese compounds*	Toluene
Dioxin/Furans*	Mercury compounds*	Xylene

*Also on the list of urban HAPs for the Urban Air Toxics Strategy

EPA Final Regional Haze Rule

- Section 308 establishes baseline visibility conditions (2000-2004) and estimates “natural background” for each Class I area
- Specifies a “60-year glidepath” from baseline visibility conditions down to natural background
- All SIPS must address Long-Term Strategy (LTS); each 10-year LTS must meet reasonable progress

156 Class I Areas protected by Regional Haze Rule



Map of 156 National Park and Wilderness Areas
Protected by EPA's Regional Haze Rule

Legend:
NP= National Park
W= Wilderness
IP = International Park

Environmental Science & Health Effects

Three Major Programs – Status Report

- Weekday/Weekend Ozone Study
- Diesel Aerosol Sampling Methodology Study
- Comparative Toxicity Study

Environmental Science & Health Effects

Status Report

Weekday/Weekend Ozone Study

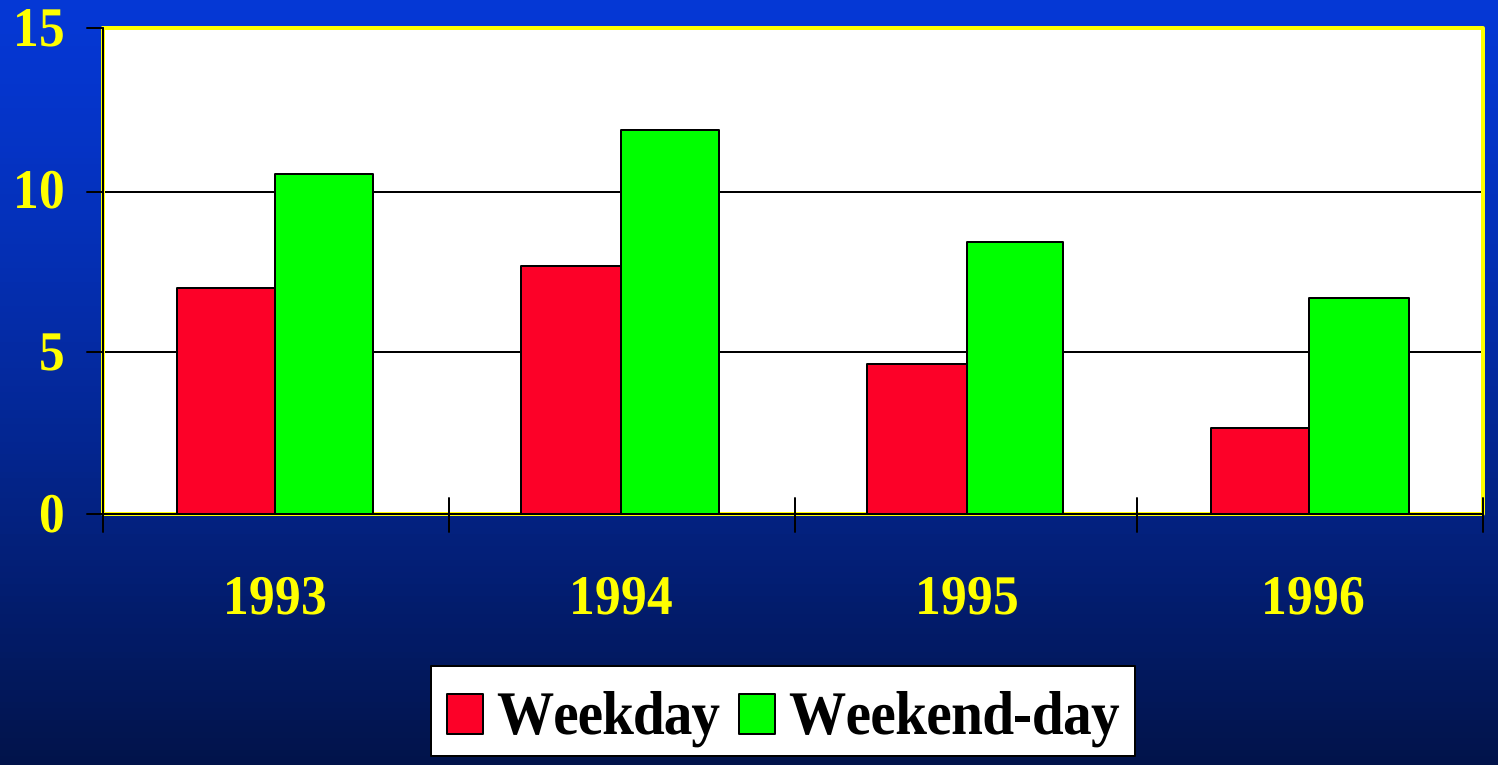
Center for Transportation Technologies and Systems

Weekday/Weekend O_3 Study

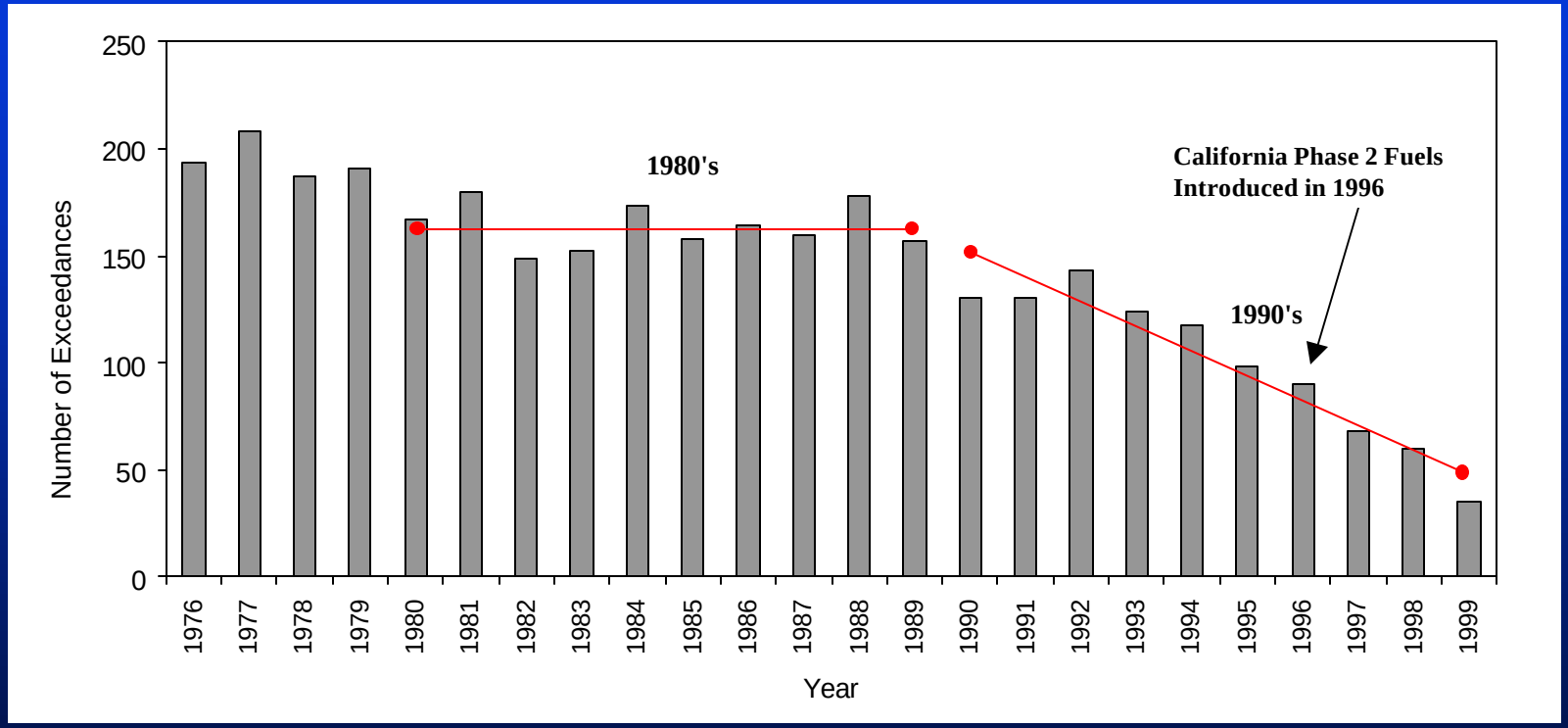
Why?

- EPA's new ozone standard means more parts of the country will be in nonattainment; current status of NAAQS for ozone uncertain
- Heavy-duty vehicles are a significant source of NO_x, a precursor of ozone
- The NO_x/HC/O_3 system is nonlinear
- Recent studies shown that LD and HD contributions to emission inventory are uncertain
- Ozone has higher concentrations on weekends than weekdays in California

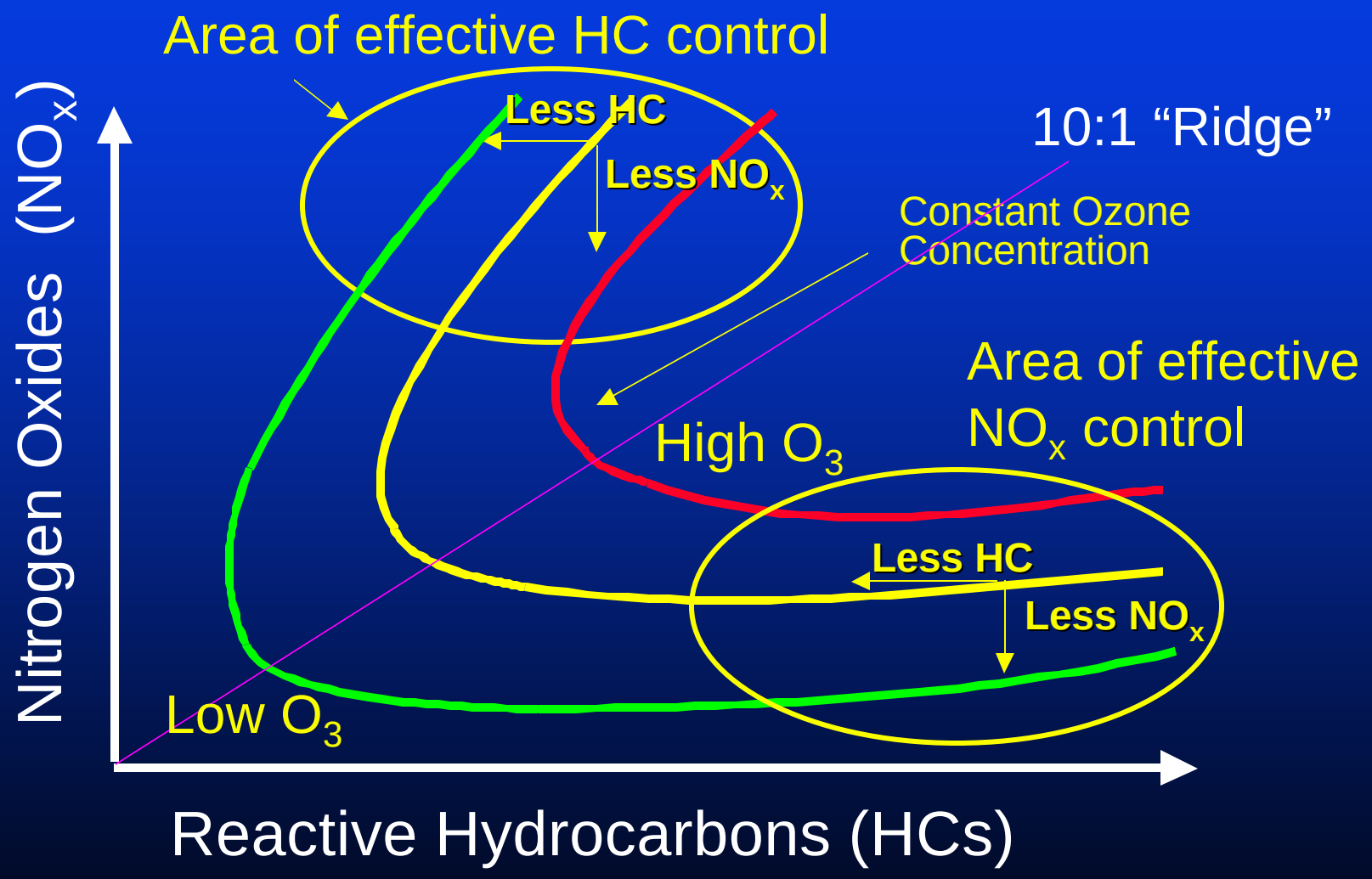
South Coast Air Basin Station-Hours per Day Above 1-Hr Ozone Standard



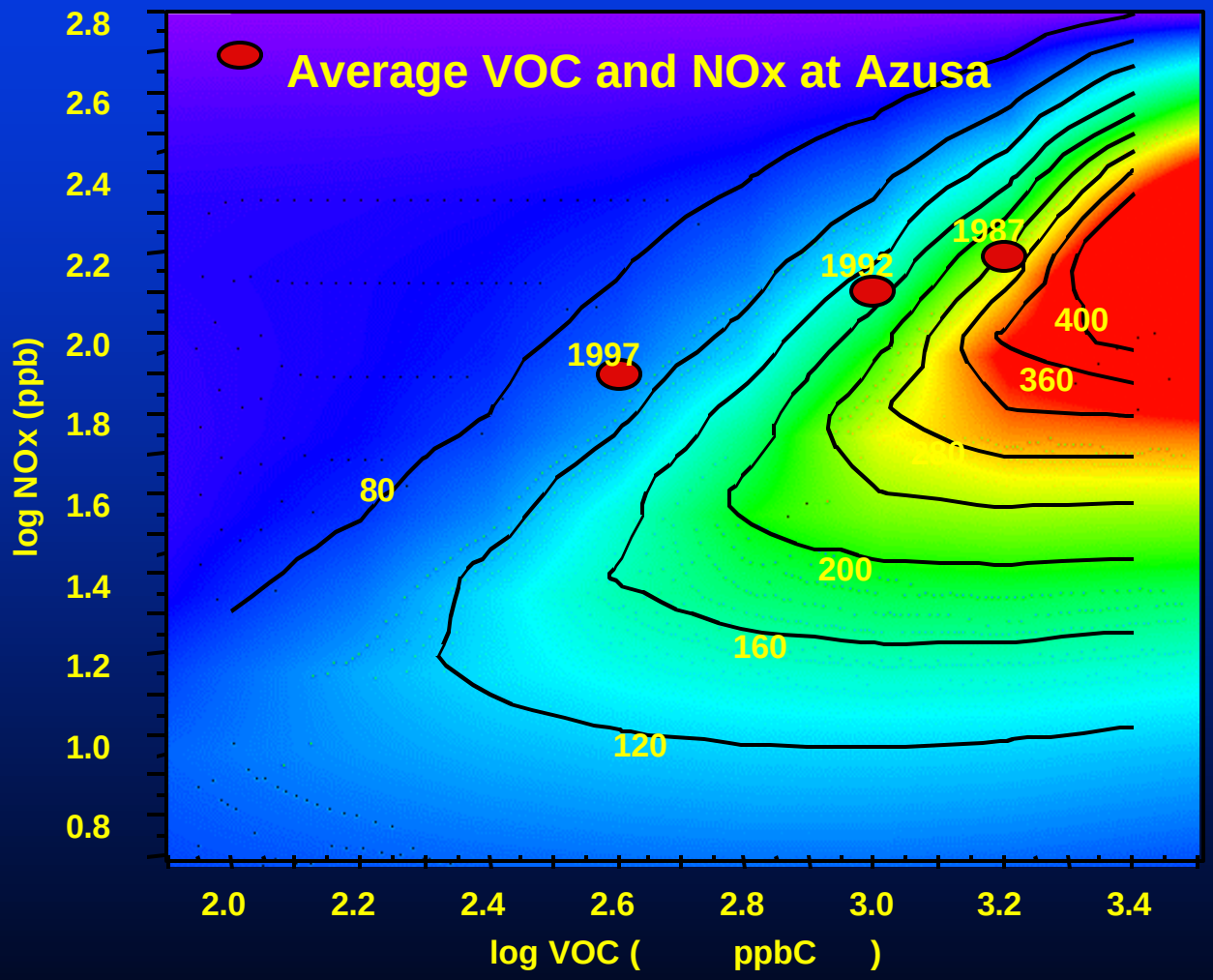
Annual 1-hr Ozone Exceedances in South Coast Air Basin, 1976-1999

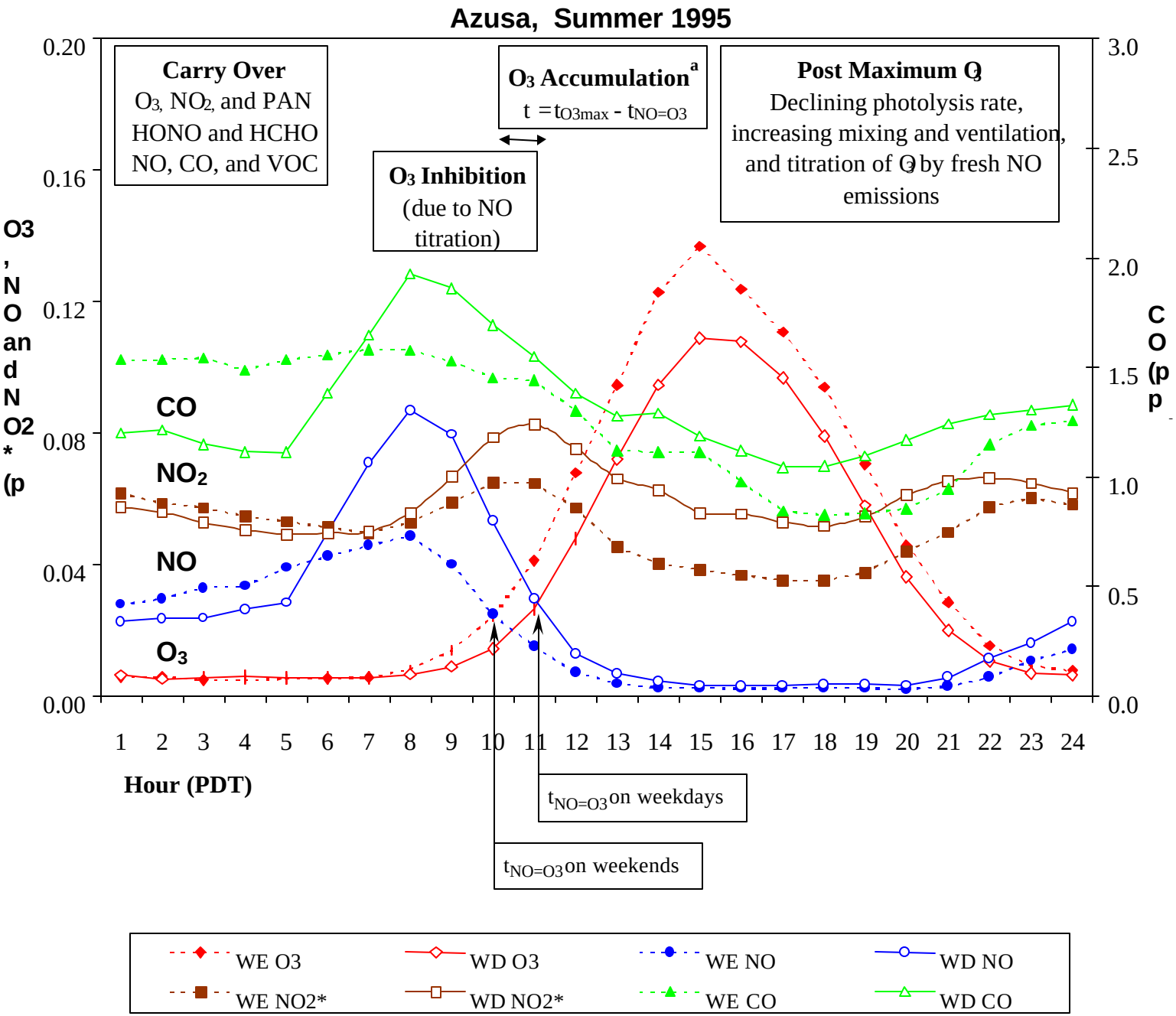


Ozone Isopleth Plot (EKMA Diagram)

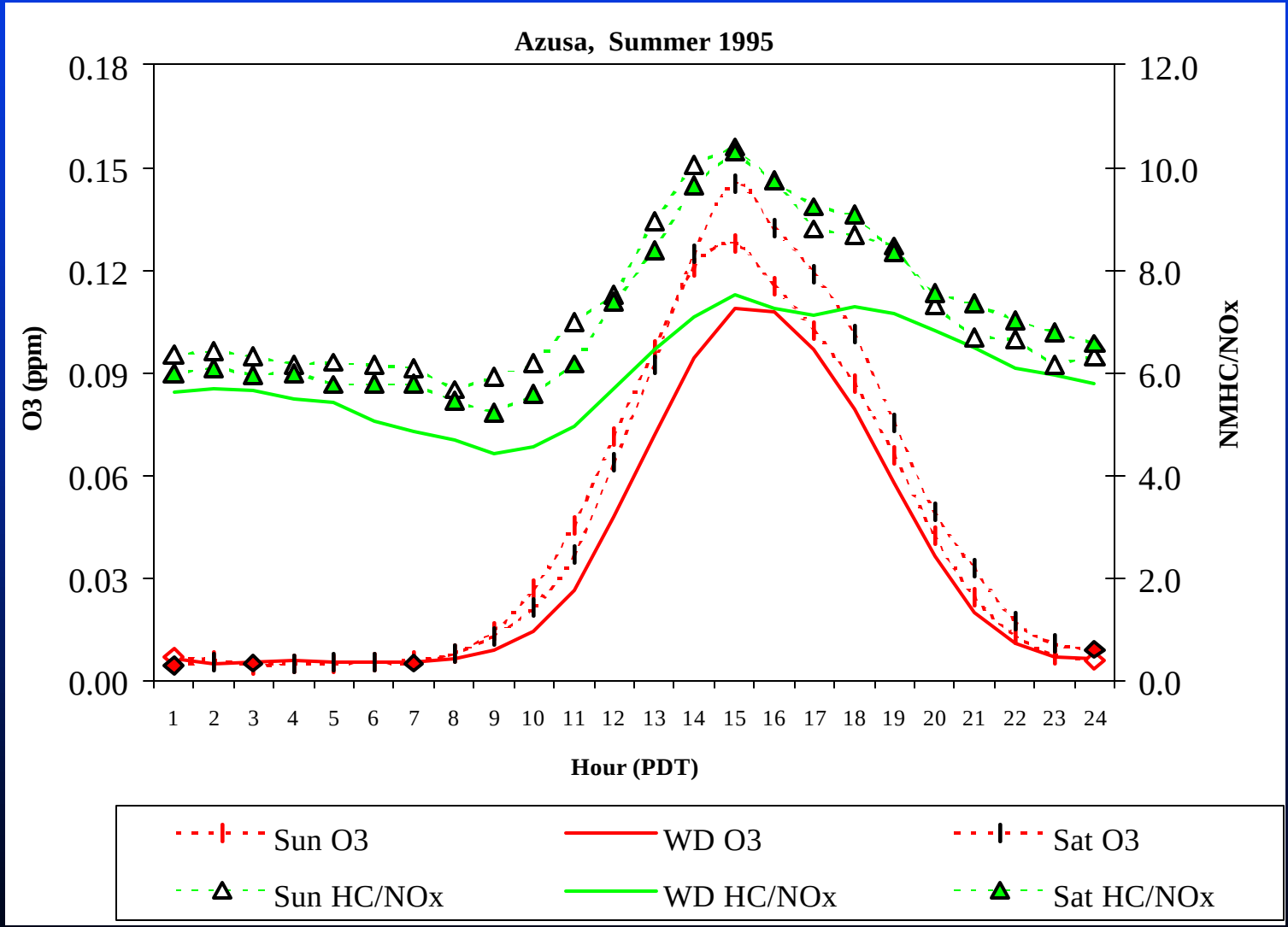


Ozone Isopleth EKMA Plot




Azusa, Summer 1995
Carry Over
O3, NO2, and PAN
HONO and HCHO
NO, CO, and VOC
O3 Inhibition
(due to NO titration)
O3 Accumulation[a]
t = tO3max - tNO=O3
Post Maximum O3
Declining photolysis rate, increasing mixing and ventilation, and titration of O3 by fresh NO emissions
O3, NO and NO2* (p
CO (pp
CO
NO2
NO
O3
0.20
0.16
0.12
0.08
0.04
0.00
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour (PDT)
tNO=O3 on weekdays
tNO=O3 on weekends
WE O3
WD O3
WE NO
WD NO
WE NO2*
WD NO2*
WE CO
WD CO

Average Summer 1995 Diurnal O_3 and HC/NOx at Azusa on Weekdays and Weekends



Weekday/Weekend O_3 Study

Progress to Date

- Analyses suggest South Coast Air Basin is hydrocarbon-limited with respect to ozone formation, i.e., major NOx reduction programs will likely increase ozone formation and make it more difficult to attain the ozone standard
- Field study to be conducted later this summer to test hypotheses regarding ozone formation

Environmental Science & Health Effects

Status Report

Diesel Aerosol Sampling Methodology Study

Center for Transportation Technologies and Systems

Diesel Aerosol Sampling Methodology Study

- Program started 9/98; ends 9/01
- $2MM project funded by DOE through NREL ($1.2MM), CRC, AAM, API, EMA, SCAQMD
- In-kind contributions ($435K estimate) from Caterpillar and Cummins
- Investigators are University of Minnesota, West Virginia University, Carnegie Mellon University, Paul Scherrer Institute (Switzerland), Tampere University (Finland), Desert Research Institute, UC Davis, and NIOSH

Diesel Aerosol Sampling Methodology Study

Program Objectives

- Compare on-road data with data generated in dynamometer testing facilities
- Determine actual particle size distributions and particle number concentrations in exhaust plume from on-road heavy-duty vehicles
- Determine the zone of influence of ultrafine particle emissions from a roadway
- Characterize chemical composition and surface properties of bulk PM emissions

Environmental Science & Health Effects

Status Report

Comparative Toxicity Study

Center for Transportation Technologies and Systems

Comparative Toxicity Study

Program Objectives

- Collect on-road and dynamometer gasoline and diesel vehicle PM and semi-volatile (SVOC) exhaust samples from new and in-use vehicles
- Perform detailed chemical analyses on collected samples
- Conduct comparative toxicity studies of gasoline and diesel exhaust samples

Comparative Toxicity Study

- Subcontractors are Desert Research Institute, Southwest Research Institute, University of Dayton Research Institute, Lovelace Respiratory Research Institute, NIOSH, ORNL; pilot studies completed in April 1999
- 2 Phases for collection of gas and diesel exhaust
  - Dynamometer testing to acquire 4 gr PM and associated semi-volatile compounds (SVOC); completed in June 2000
  - Ft. McHenry (Baltimore) Tunnel study testing to acquire 4 gr PM and associated semi-volatile compounds (SVOC); completed Sept. 1999
- 14 samples selected by NREL and sent to Lovelace for comparative toxicity testing between gas and diesel emissions
- Selected samples will go to NIOSH for genotoxicity testing
- Gasoline and diesel PM and SVOC dynamometer samples have been collected at SwRI and sent to ORNL for morphological analyses

Comparative Toxicity Study

Samples for Testing

- **Dynamometer Samples at 72 °F (PM and SVOC):**

  1) Ave. gasoline emitters
  2) Black Smoker gasoline emitter
  3) White Smoker gasoline emitter
  4) Current technology diesel emitters
  5) High emitter diesel
  6) New technology gasoline vehicles
  7) New technology diesel vehicle

- **Dynamometer Samples at 72 °F (SVOC only):**

  8) Ave. gasoline emitters (same as 1)
  9) Current technology diesel emitters (same as 4)

- **Dynamometer Samples at 30 °F (PM and SVOC):**

  10) Ave. gasoline emitters (same as 1)
  11) Current technology diesel emitters (same as 4)

- **Samples from Fort McHenry Tunnel (PM and SVOC):**

  12) “Diesel” fleet sample plus “background” sample
  13) “Gasoline” fleet sample plus “background” sample

Project Status and Results

Dynamometer Testing Results Run on the Unified Driving Cycle

Description	# of UDCs per 4-g sample	Average PM Rate (mg/mi)	Approx. PM Sample Mass (g)
Gasoline average PM emitter	36	13.6	5.4
Black gasoline smoker	5	85.9	4.8
White gasoline smoker	1	1,004	11.1
Diesel high PM emitter	6	419	4.5
Gasoline average PM emitter at 30 F	24	42.9	12.4
Gasoline ULEV (99 Honda Accord)	NA	2.8	0.04
Gasoline NLEV (99 Ford Windstar)	NA	4.3	0.04

Project Status and Results

1. All tunnel and dynamometer exhaust PM and SVOC samples collected
2. Fuel and lube oil samples were analyzed at SwRI
3. Extractions and chemistry being conducted at DRI; samples are being sent to U. Dayton Res. Inst.
4. Some samples have been sent to LRRI; samples are being sent to NIOSH for testing
5. Toxicity assays underway at LRRI
6. Preliminary finding: SVOC fraction, as well as filter fraction, have significant toxicity

Summary

- ES&HE programs are focus of much national interest
- The these programs are to address policy-relevant regulatory issues
- We are coordinating OHVT's ES&HE Program with other interested sponsors