NREL National Renewable Energy Laboratory

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The Weekend Ozone Effect in U.S. Ozone Problem Areas Outside of California

Abstract

We evaluated day-of-week differences in mean concentrations of ozone precursors [nitric oxide (NO), nitrogen oxides (NOx), volatile organic compounds (VOC) and carbon monoxide (CO) at monitoring sites in 23 states comprising seven geographic focus areas for the years 1998-2003. We used Wednesdays to represent weekdays and Sundays to represent weekends; we also analyzed Saturdays. Statistical t-tests applied to every monitor showed substantial and statistically significant differences between Wednesday and weekend mean concentrations of ozone precursors in all study areas. At half the sites, nine-hour (6 am through 3 pm) mean concentrations of NO, NOx, and CO declined by at least 65, 49, and 28 percent, respectively, from Wednesdays to Sundays. Large reductions in mean concentrations of ozone precursors on weekends did not reduce mean concentrations of peak ozone significantly, and in many areas, mean peak ozone increased on weekends. Ozone accumulation began earlier on Sundays than on Wednesdays, on average. We also evaluated day-of-week differences in mean concentrations of fine particle and nitrate at available monitoring sites for the same time period and same geographic focus areas. Based on the monitors' differences in Wednesday and Sunday means, PM nitrate showed almost negligible weekend decline, despite large NO and NOx declines.

Why We Did This Work

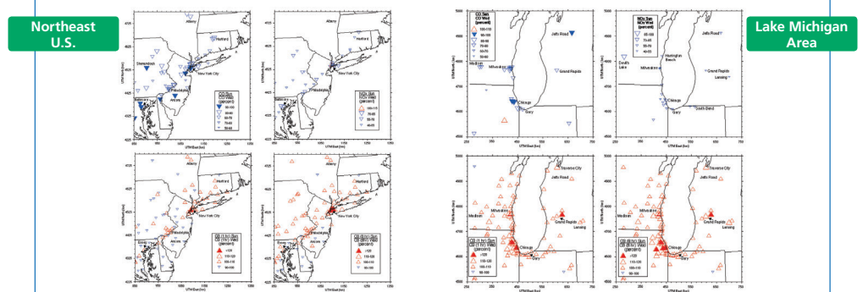
- We need to understand the implications of EPA's HD NOx emission standards on ambient ozone and particulate matter ($PM_{2.5}$)
- For many years there has been a controversy regarding the least costly and most effective way to reduce ambient ozone levels
  - Debate has centered around NOx vs. VOC controls to reduce ambient ozone
- The analysis of ambient air quality data is the best way to answer the question: "What is the most effective means to reduce ambient ozone levels?"
  - The weekend effect is a natural emissions control experiment

What We Did

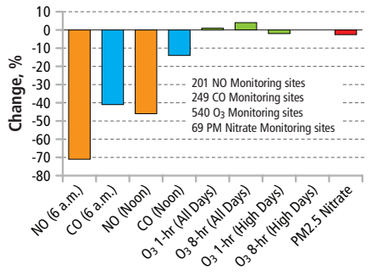
- Obtained ambient air quality data from ozone problem areas in 23 states
- Analyzed data from 1998 through 2003 for NO, NOx, CO, ozone, and particulate nitrate
- Analyzed weekday-weekend differences for pollutant species
  - For NO, NOx, VOC, CO, and ozone, evaluated March-Oct. ambient hourly data; for particulate nitrate evaluated annual 24-hour data

Sunday to Wednesday Pollutant Ratios

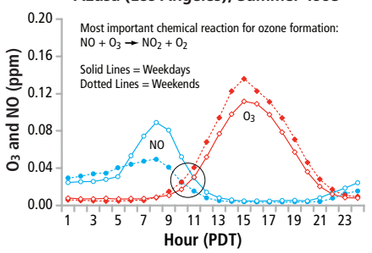
6 a.m.–3 p.m. CO, NOx and daily one-hour and eight-hour ozone fractons, all days, March–October, 1998–2003

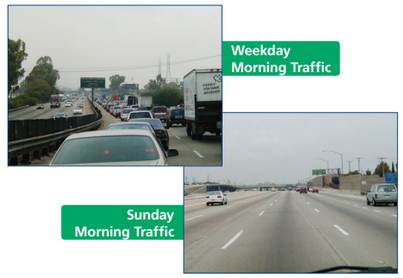


Wednesday to Sunday Pollutant Changes
Median Values, 23 States, 1998–2003



Azusa (Los Angeles), Summer 1995





Implications

Weekends provide a natural experiment for understanding how urban ozone and PM nitrate respond to large reductions in precursor emissions. The data suggest that VOC emission reductions reduce peak ozone, while NOx emission reductions increase ambient ozone levels at most urban U.S. locations; there is little change in PM nitrate concentrations on weekends. Emission reductions projected to take place by 2010 are similar in magnitude to current weekend reductions in ozone precursor emissions. The findings from this study may require rethinking present control strategies to reduce urban ozone and PM nitrate exposure and ozone transported downwind of urban locations.

Note: Additional work investigating the weekend ozone effect currently is being conducted in the Southeast Michigan region.

Engine Lubricants and Their Impact on Mobile Source Emissions

Background

- DOE's Comparative Toxicity Study showed that high emitters (gas and diesel) were more toxic on a per unit mass basis than "normal" emitters
- Three different profiles of high-emitting gasoline vehicles observed in DOE's Gasoline/Diesel PM Split Study; one profile linked to lube oil
- A focused study is timely and relevant to investigate lube oil effects on PM, including ultrafine and nanoparticles

Not Just a Diesel Issue

- Light-duty, spark-ignited engines emit PM
  - Malfunctioning vehicles, cold start, high speed, hard accelerations
- Compressed Natural Gas engines
- Current Diesel: 65% EC/35% OC
  - EC fraction to decrease with DPFs
- Ultrafines also may be an issue; their source has not been determined

Experimental Test Matrix

	Lubricant A		Lubricant B	
Vehicle Technology	**30°F**	**72°F**	**30°F**	**72°F**
Gasoline (normal emitter)	✔	✔	✔	✔
Gasoline (high emitter)	✔	✔	✔	✔
Diesel (normal emitter)	✔	✔	✔	✔
Diesel (high emitter)	✔	✔	✔	✔
CNG (normal emitter)	✔	✔	✔	✔
CNG (high emitter)	✔	✔	✔	✔

What's Next

- NREL/SCAQMD/CARB are initiating a systematic study to evaluate the influence of lubricating oil on motor vehicle exhaust
- Phase I - Scoping Study
- Phase II - Detailed investigation contingent on early results
- RFP issued in June; bids now being reviewed

1995 Jeep Cherokee - 45,359 miles