Weekday and Weekend Air Pollutant Levels in Ozone Problem Areas in the United States

Douglas R. Lawson
National Renewable Energy Laboratory
Golden, Colorado

Charles Blanchard and Shelley Tanenbaum
Envair
Berkeley, California

DEER 2005 Conference

August 23, 2005

Acknowledgments

Summary of several research projects
funded by the following:

James Eberhardt, Chief Scientist
DOE's Office of FreedomCAR and Vehicle Technologies
through National Renewable Energy Laboratory

Lake Michigan Air Directors Consortium

Results from this study (NREL Project ES04-1) submitted for publication to the *Journal of the Air & Waste Management Association*, July 2005

Project peer reviewed

- Reviewed by government and industry groups, including the Coordinating Research Council (CRC)
- Reviewed by each of the state/local government agencies where ambient analyses were performed
  - One state reviewer's comment: "The over-arching conclusion that lower weekend concentrations of ozone precursors do not lead to lower ozone concentrations is impossible to dispute and has far reaching regulatory implications."

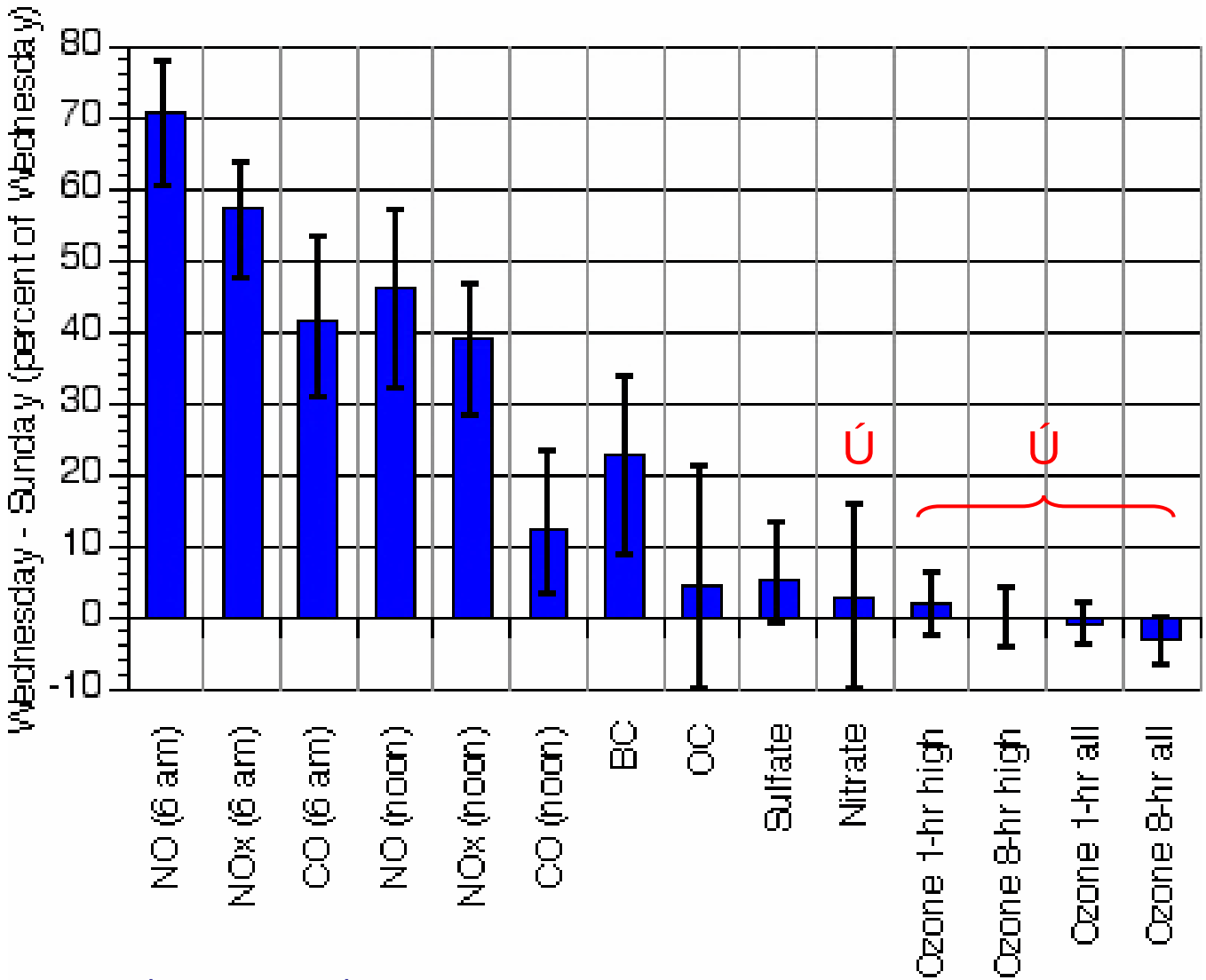
What was done?

- Studied day-of-week differences in ambient concentrations of ozone precursors, ozone and particulate nitrate
- March – October sampling period, 1998-2003
- 23 states, focus on 8 metropolitan areas
  - NE megalopolis: New York and Baltimore/Washington metro areas
  - Areas thought to be NOx-sensitive: Atlanta (high biogenic VOC emissions); Houston/southeast Texas (petrochemical industry VOC emissions)
  - For DEER 2005: Major metropolitan area with relatively little injection of fresh emissions downwind: Chicago/Gary and southern Lake Michigan
  - "Isolated" metro areas: Dallas/Fort Worth, Denver/Front Range, Phoenix

Why is this work important?

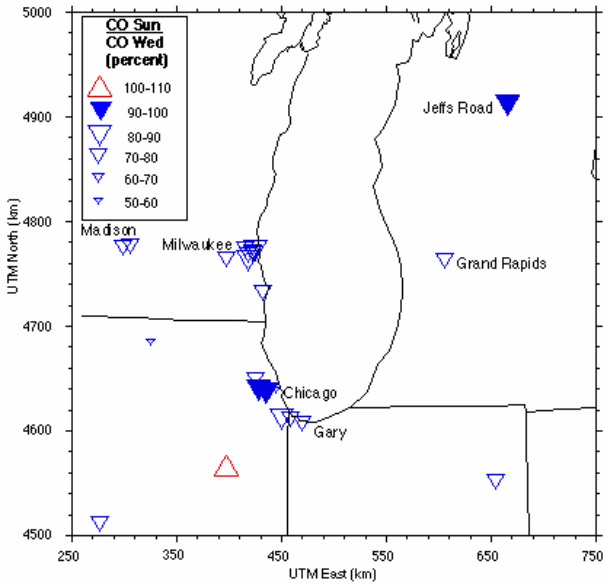
- Real-world experiment; allows for analysis of how the atmosphere responds to large changes in emissions, without having to use modeling
- Implications for effects of local emission changes on local (and downwind) ozone formation (e.g. Chicago/Lake Michigan region)
- → Projected emission reductions from 2005-2010 similar to today's weekend reductions of ozone precursor concentrations (future NO_x emission reductions > VOC emission reductions)

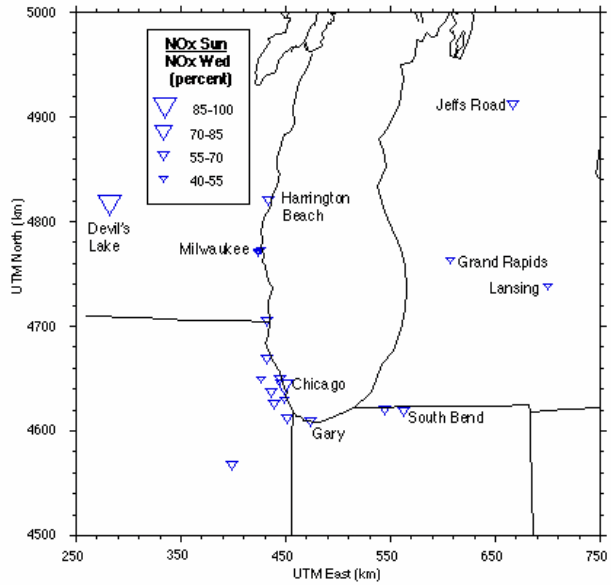
Median pollutant Wed/Sun decreases in 23 states, 1998-2003 data

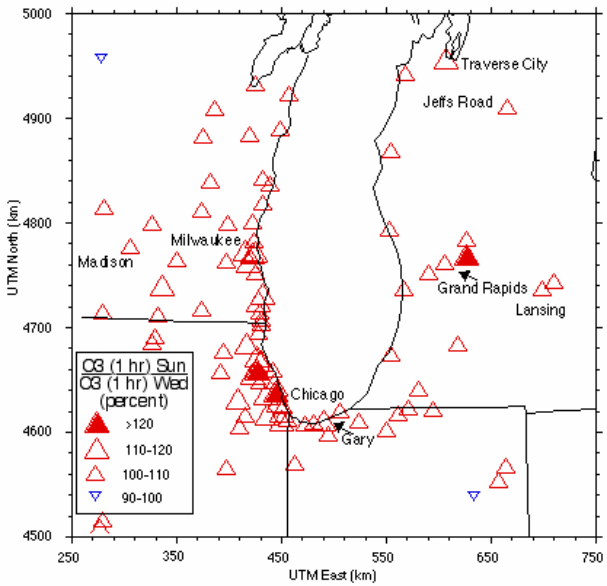


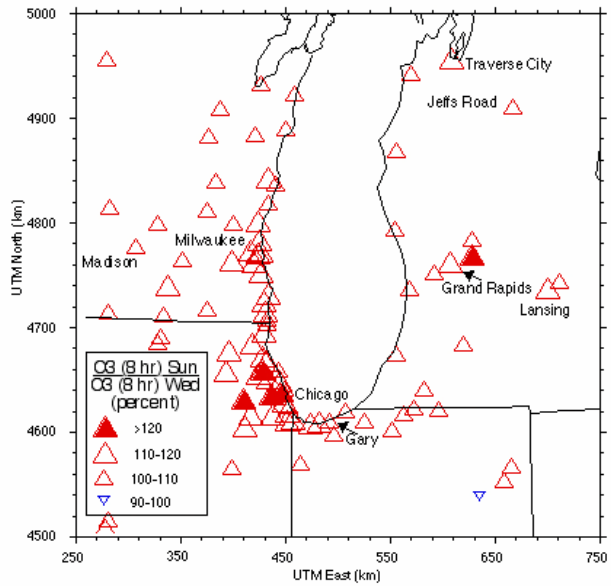
Ranges denote 25th and 75th percentiles

Mean Sunday/Wednesday Ratios, Precursors and Ozone – DEER 2005 region



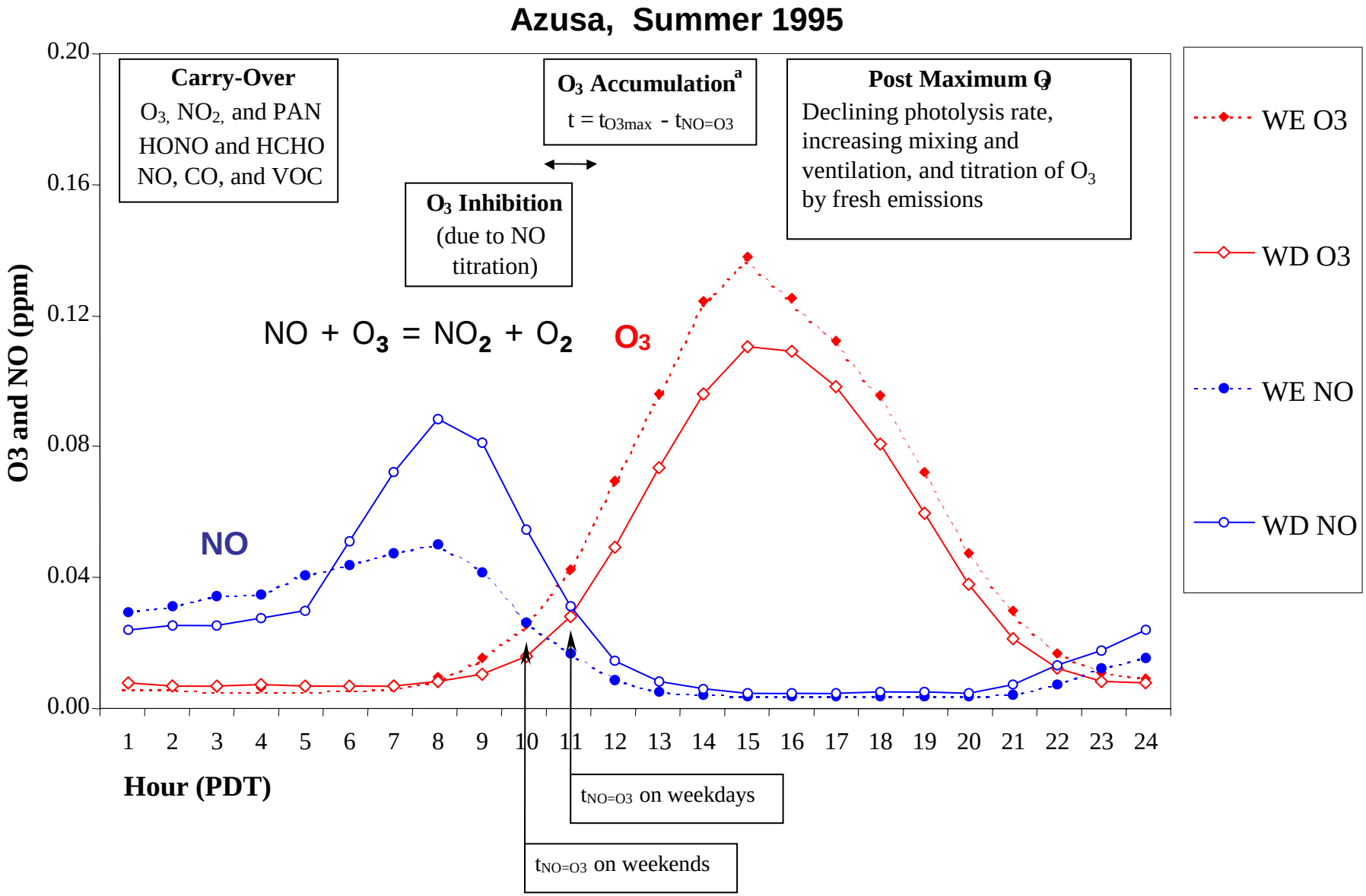






Reasons for weekend effect

- Much lower emissions of VOC, CO, and NOx on weekends, with larger NOx reductions than VOC and CO reductions
  - Up to 80% fewer trucks and buses and ~15% less light-duty traffic on roads in urban areas on weekends
- In urban areas, NOx reductions increase ozone production; VOC (and CO) reductions decrease ozone production. For ozone production, these emission reductions offset each other.
- NO/O_3 crossover point occurs one hour earlier on weekends (analogy is getting an additional hour of sunlight)
- Higher VOC/NOx ratio on weekends makes the atmosphere slightly more reactive

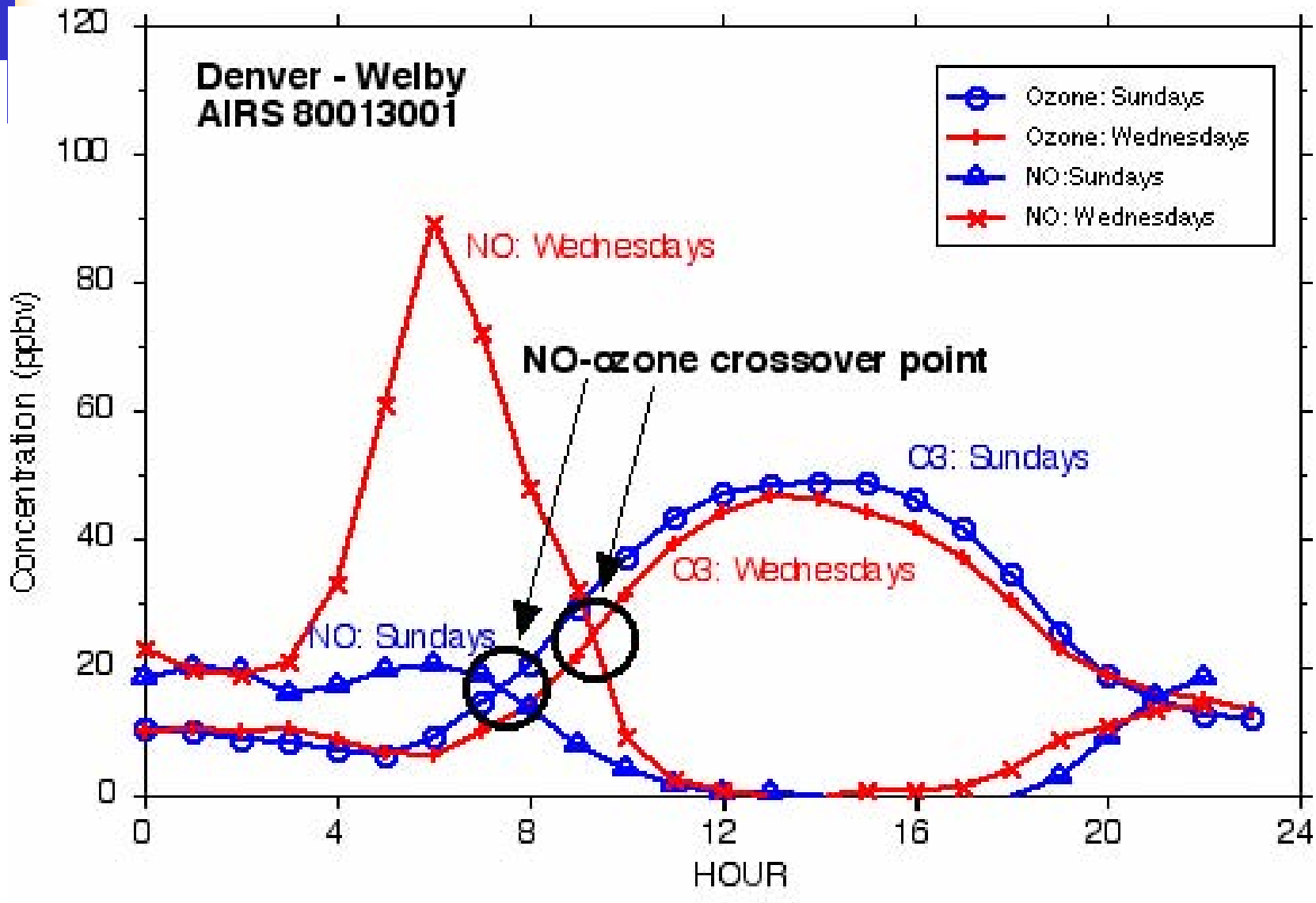


"Fujita point"

Ref: Fujita *et al.*, 2003; Lawson, 2003

Urban Ozone Formation - Begins Earlier on Weekends

(analogy: 1 extra hour of sunlight)



Mean hour for NO/O_3 "crossover"

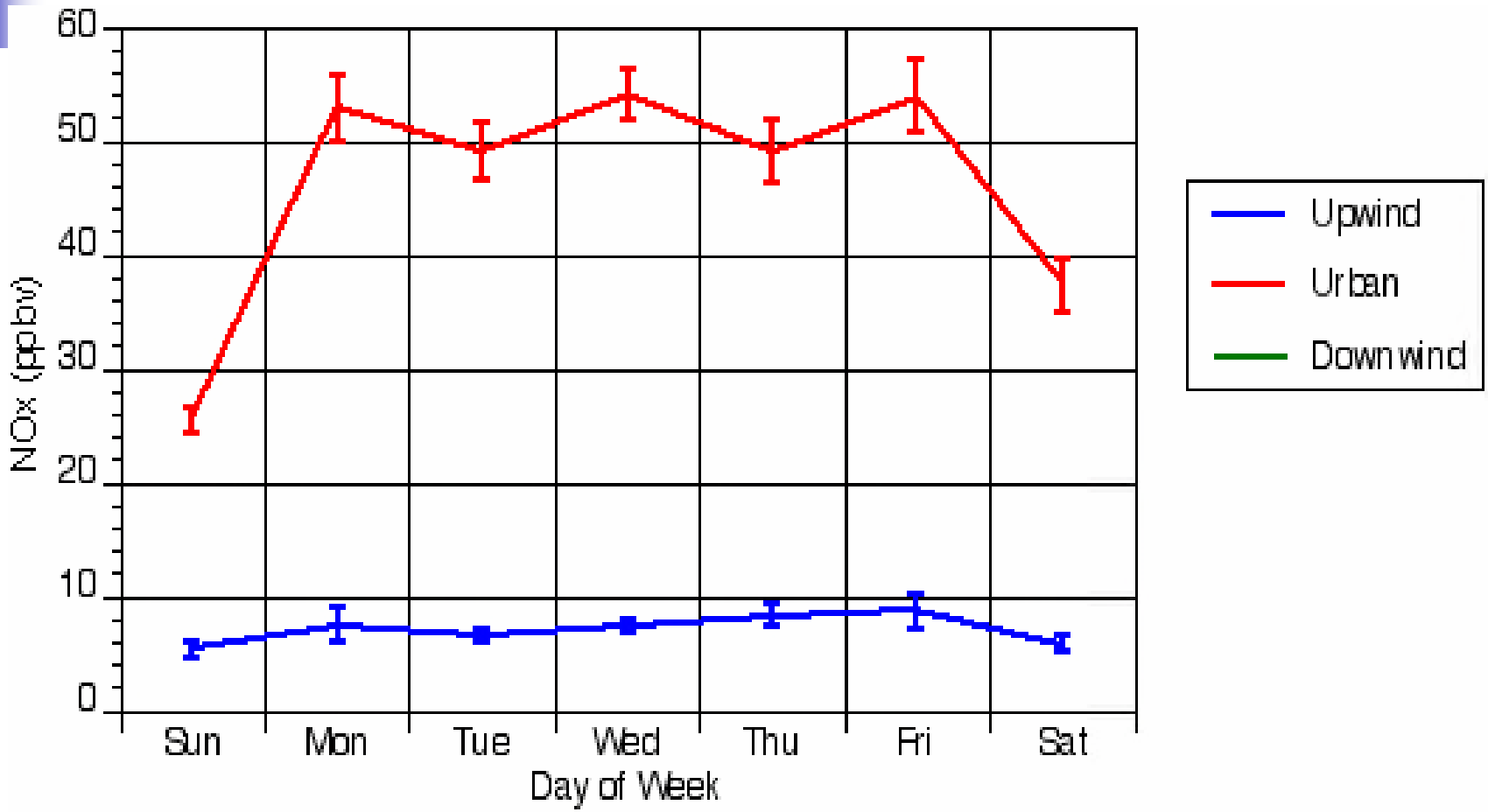
Urban Area	No. of Sites	Sun. (hr)	Wed. (hr)	Wed/Sun difference, hours
Atlanta	1	7.99	9.06	1.07
Chicago	3	8.76	10.21	1.45
Baltimore	1	8.04	8.77	0.73
New York	1	9.40	10.30	0.90
Houston	2	7.94	8.65	0.71
Dallas	2	7.41	8.07	0.66
Denver	1	8.03	8.89	0.87
Phoenix	2	7.56	8.47	0.92

Note: Sites selected having 3 years of data from 1998 through 2002

Ozone and precursor transport

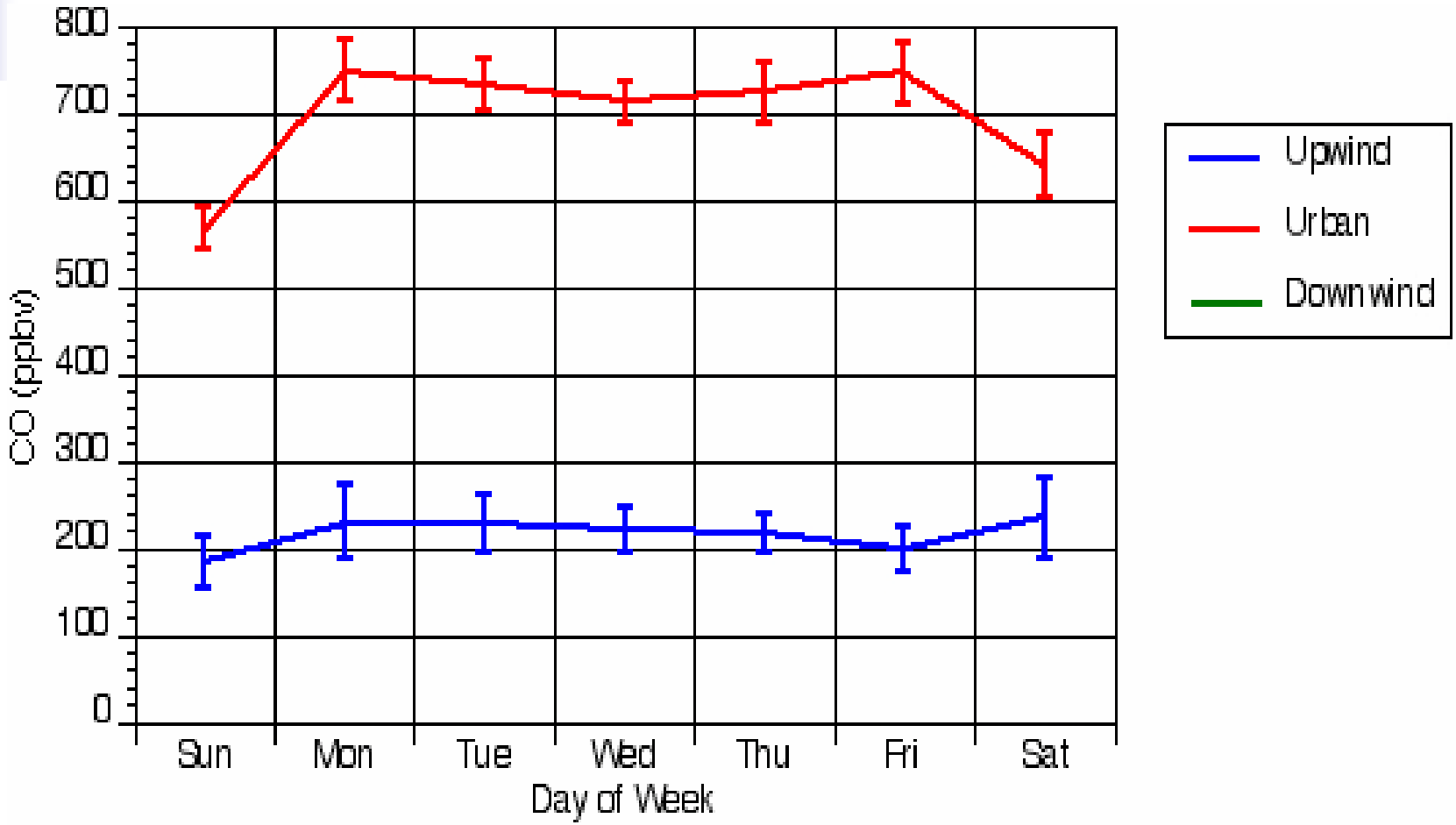
- Compared day-of-week averages at upwind, downwind, and urban locations
- Focus on Chicago/Lake Michigan region for DEER 2005
- Regional ozone predominates
- Local ozone formation unchanged on weekends despite large precursor emission reductions
- Downwind ozone levels do not appear to be sensitive to changes in NOx emissions (downwind ozone has traditionally been thought to be sensitive to changes in NOx emissions)

Chicago/Lake Michigan Area - NO_x Largely Urban, Large Weekend Drop



Ranges denote 1 SE of the mean

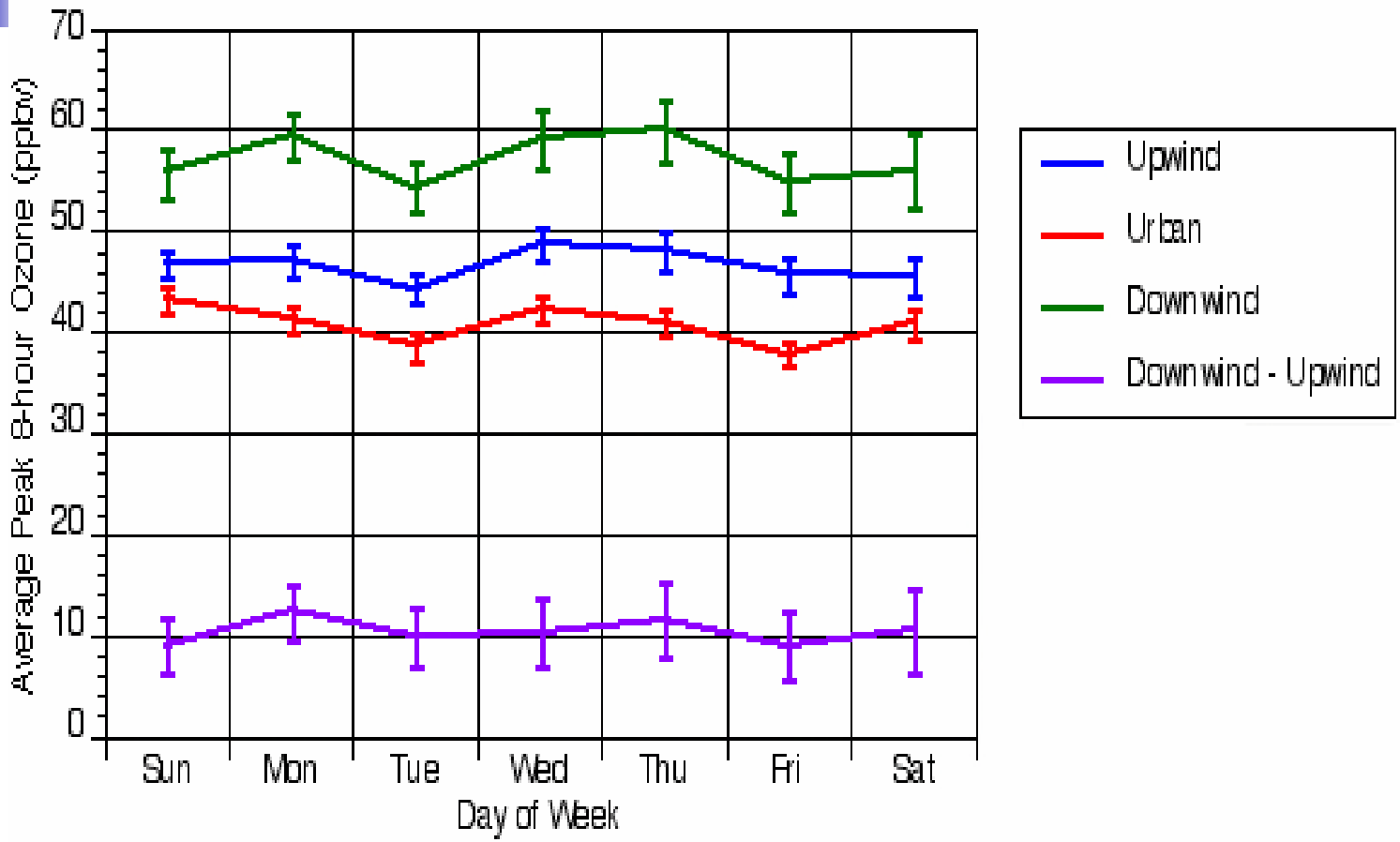
Chicago/Lake Michigan Area (cont'd.) - CO Mostly Urban, Large Weekend Drop



Ranges denote 1 SE of the mean

Chicago/Lake Michigan Area (cont'd.) - Regional Ozone Predominates All Week

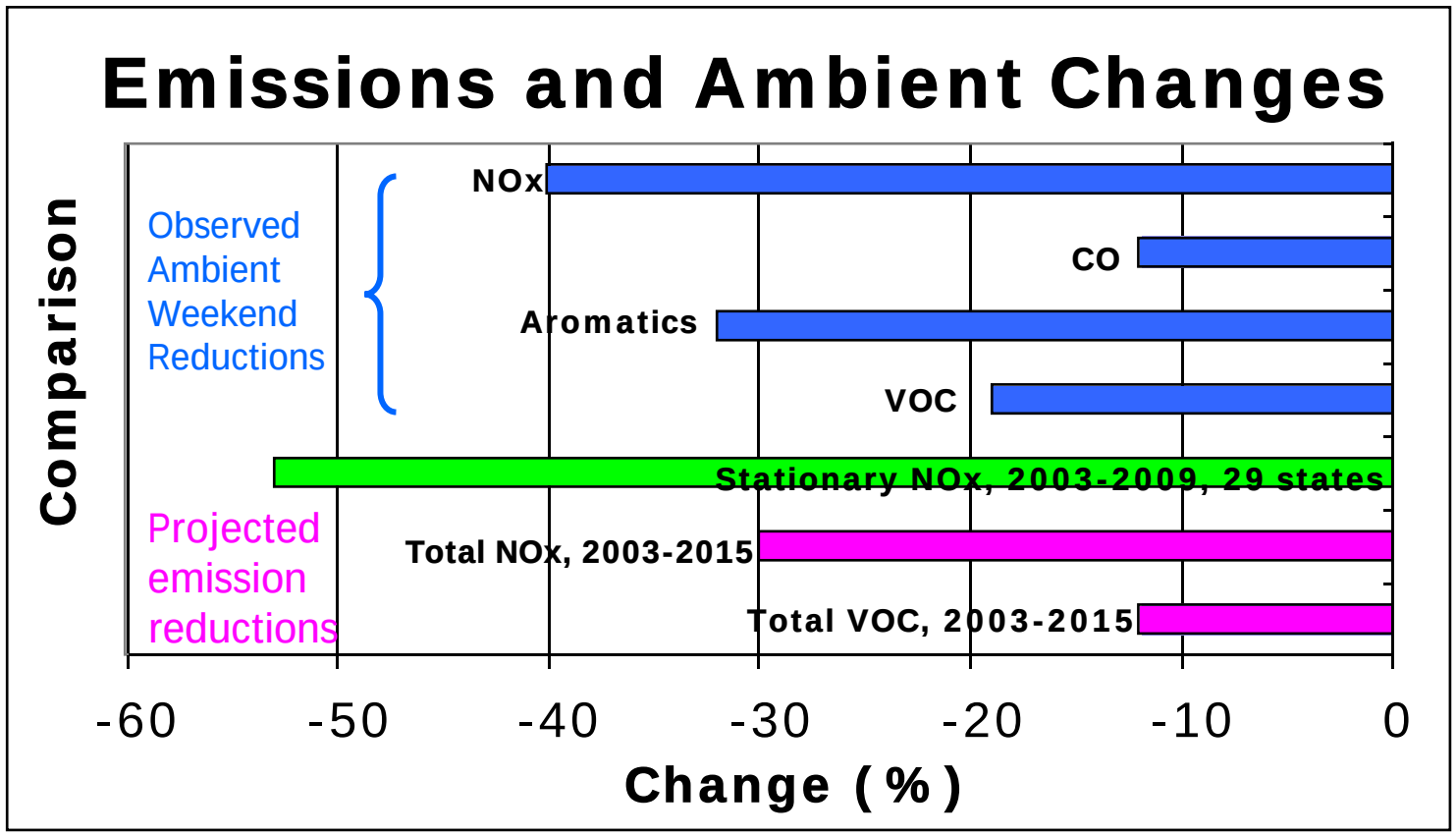
Similar amounts of ozone produced by Chicago all days of the week, despite large precursor emission reductions



Ranges denote 1 SE of the mean

Projected Emissions Changes –

Future projected weekday emission reductions are similar to today's weekend emission reductions.



Implications and Questions

- NOx reductions in urban areas currently do not reduce, and usually increase, ambient ozone
- PM nitrate is reduced less than 3% ($PM_{2.5}$ "brown cloud" over urban areas and regional haze)
  - Will present emission control strategies - with greater reductions of NOx than VOCs - reduce peak ozone and PM nitrate levels in urban areas and in urban plumes?
- Urban plumes appear to contribute substantially to regional background.
  - If the urban plume's ozone is unaffected by NOx reductions, how will regional "background" be affected by planned emission reductions?
- Can the weekend effect be modeled to test models' accuracy?
- What are the implications for SIPs, when more episodes occur on weekends than on weekdays?

New work: With support from DOE/OFCVT, NREL is initiating a weekend ozone proximate modeling study for southeast Michigan