Technical Analyses to Support SIP Planning for 2006 PM$_{2.5}$ & 2008 O$_3$ Standards

February 11, 2009

Michael Koerber
Lake Michigan Air Directors Consortium
Overview

- Description of regional air quality problems
- Conceptual model for ozone
- Conceptual model for daily PM$_{2.5}$
- Air quality modeling
- Next steps
PM$_{2.5}$ Design Value: Daily Standard

Color:
- $> 40$ ug/m$^3$
- $36 - 40$ ug/m$^3$
- $31 - 35$ ug/m$^3$
- $25$ to $30$ ug/m$^3$
- $< 25$ ug/m$^3$

2005-2007
Ozone Design Value: 8-Hour Standard
Milwaukee
Schedule

2009 2010 2011 2012 2013 2014

PM$_{2.5}$ SIP
Haze P.R. $O_3$ SIP
Schedule

Timeframe for state rulemaking
Schedule

Timeframe for state rulemaking

2009
1st version
2008 BY inventory

2010
Complete initial strategy modeling

2011

2012
PM$_{2.5}$ SIP

2013
Haze P.R. O$_3$ SIP

2014
Principles

• Data, data, data
• Multi-pollutant
• Weight-of-evidence
Conceptual Model of Ozone

Presented to LADCO Project Team
April 16, 2008
Conceptual Model: Key Points

• Spatially, higher 8-hr ozone concentrations occur downwind of major urban areas: Cincinnati, Cleveland, Detroit, Chicago/Gary/Milwaukee, and St. Louis
  • With new (lower) standard, broader area affected (other sites affected by large wave of regional ozone and ozone precursors – sites rise/fall together)

• Temporally, higher 8-hr ozone concentrations occur during the summer
  • With new (lower) standard, additional “exceedance” days occur during summer, but not clear if ozone monitoring season needs to be extended

• Ozone levels strongly influenced by meteorology
  • Ambient temperature is key factor (e.g., higher ozone concentrations and more “exceedance” days during hot summers)
  • Transport patterns affected by synoptic-scale and local-scale winds (e.g., lake breezes)

• Over past couple decades (especially, since early 2000’s), ozone levels have improved significantly in the region
  • Improvement attributable to emission reductions
Weather data from O'Hare International Airport. Exceedance days are days per year when NAAQS was exceeded at any site, among a selected set of longest running monitors.
Conceptual Model of Daily PM$_{2.5}$

A collaborative effort by the PM Data Analysis Workgroup, including:
Michele Boner, Brian Callahan, and Sarah Raymond, IDEM
Michael Compher, R5 EPA
Jim Haywood and Cindy Hodges, MDEQ
Sam Rubens, Akron Regional AQMD
Bart Sponseller and Bill Adamski, WDNR
Donna Kenski, LADCO

Presented to Regional Air Quality Workshop
October 16, 2008
Elements

- Current concentrations and trends
- Frequency and timing of elevated concentrations
  - Seasonality
  - Day of week
- Spatial extent of high concentrations
- Urban-rural differences during high concentration events
- Chemical composition of elevated concentrations and seasonal patterns in composition
- Source apportionment; what sources contribute disproportionately during events?
- Meteorological conditions associated with high concentrations
  - Wind roses
  - Synoptic analysis
  - CART
  - Trajectories
PM2.5 98th %ile Trends, LADCO States, 1999—2007
PM$_{2.5}$ Trends: Met-Adjusted

Chicago

Milwaukee

Detroit

Indianapolis

Cincinnati

Cleveland
Near Threshold: 30 – 35 µg/m³; Above Threshold: >35 µg/m³
Conclusions

• 57 of 126 PM$_{2.5}$ monitors in LADCO states exceeded the 24-hr NAAQS in 2005-2007 (complete data only)

• Concentrations on highest 90% days have fallen by $\sim$ 0.5 ug/m$^3$/year
  • Met-adjusted trends are flat, suggesting that actual trends driven more by year-to-year changes in meteorology than by changes in emissions

• High daily concentrations associated with...
  • Specific met conditions: stagnant air masses with high pressure, slow wind speeds, high relative humidity, southerly winds
  • Regional events driven primarily by higher levels of sulfate, especially in summer, and higher levels of nitrate in winter
  • Impacts from local pollution sources in heavily industrial areas
White Paper: Approaches for Attaining the PM$_{2.5}$ Daily Standard

- Regional reductions in SO$_2$ should be effective year-round
  - LADCO regional inventory shows 80% SO$_2$ from EGUs, 15% from non-EGUs

- Regional reductions in NH$_3$ (and NOx) most effective in the winter (stay tuned for more info on winter chemistry)

- Urban reductions in OC, SVOC, and EC
  - OC is 15-30%(?), is biogenic in summer, lesser % in winter

- In a few locations, reductions in local source emissions important
On-Going PM$_{2.5}$ Research

- Biomass Burning Study (Colorado State University)
- Organic Carbon, Molecular Marker Study (University of Wisconsin)
- Analysis of Midwest Ammonia Data (C. Blanchard)
- Winter Nitrate Study (ARA, Inc.)
2004 PM2.5 Average Composition

- Northbrook: avg PM2.5 = 11.9 ug/m³
- Bondville: avg PM2.5 = 10.3 ug/m³
- Allen Park: avg PM2.5 = 14.7 ug/m³
- Dearborn: avg PM2.5 = 19.0 ug/m³
- Orange: avg PM2.5 = 17.5 ug/m³
- Tikhon: avg PM2.5 = 17.2 ug/m³
- Lorain: avg PM2.5 = 17.2 ug/m³
- Indianapolis: avg PM2.5 = 15.8 ug/m³
- Cincinnati: avg PM2.5 = 14.9 ug/m³

Legend:
- Soil
- Elemental Carbon
- Organic Mass
- AmmSulfate
- AmmNitrate

Note: OM = 1.8 * OC blank corrected at STN sites using average blank value over sampling period.
Urban Organics Study (2004)
Biomass and OC Speciation Monitoring Sites

Boundary Waters
Mayville, Wis
Chicago (ComEd)
Detroit
Cleveland
Mingo Junction

- Biomass
- OC speciation -1/6
- Intensive OC - 3 sites, 1/1

Locations:
- Boundary Waters
- Mayville, Wis
- Chicago (ComEd)
- Detroit
- Cleveland
- Mingo Junction
OC Source Contributions
(University of Wisconsin)

July 2007 data (5 weekday, 4 weekend days)
Midwest NH$_3$ Monitoring Sites

Sites
- IMPROVE
- Meteorological
- Midwest Network
- STN

Allen Park MI
Athens OH
Pleasant Green MO
Mammoth Cave KY
Lake Sugema IA
Reserve KS
Great River Bluffs MN
Blue Mounds MN
Mayville WI
Bondville IL
Indianapolis IN
Cincinnati OH
Quaker City OH
Athens OH
Holdenville OK
Cherokee Nation OK
Seiling OK
Mean Predicted Winter PM$_{2.5}$ Mass

Scale
Bars are marked at increments of 5 $\mu$g m$^{-3}$
Winter Nitrate Study

Purpose: Improve understanding of role of ammonia and meteorology in winter PM$_{2.5}$ episodes

Tasks
(1) Sampling: Collect continuous measurements of NH$_3$, HNO$_3$, NOy, sulfates, and nitrates at two sites in Wisconsin (December 2008 – March 2009)

(2) Data Analysis: Examine spatial and temporal relationships of ammonia and particulate nitrate, and assess relative effectiveness of reductions in ammonia and nitric acid on PM$_{2.5}$
Air Quality Modeling
## Modeling Overview

<table>
<thead>
<tr>
<th></th>
<th>1997 NAAQS</th>
<th>‘06/’08 NAAQS</th>
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<tbody>
<tr>
<td><strong>Model</strong></td>
<td>MM5/EMS/CAMx</td>
<td>MM5(?)/CONCEPT/CAMx</td>
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<tr>
<td><strong>Baseyear</strong></td>
<td>2002, 2005</td>
<td>2008(?)</td>
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<tr>
<td><strong>Met years</strong></td>
<td>2002, 2005</td>
<td>2005-2009(?), at least 2-3 yrs</td>
</tr>
<tr>
<td><strong>Future years</strong></td>
<td>2009, 2012, 2018</td>
<td>2013, 2015, 2018, 2028(?)</td>
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<tr>
<td><strong>Domain</strong></td>
<td>Sub-RPO</td>
<td>Expanded sub-RPO(?)</td>
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<tr>
<td><strong>Grid Spacing</strong></td>
<td>36 km PM$_{2.5}$/haze, 12 km O$_3$</td>
<td>36 (12?) km PM$_{2.5}$/haze, 12 (4?) km O$_3$</td>
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Modeling Domain (Current)
# Emissions Inventory (Current)

<table>
<thead>
<tr>
<th>Sector</th>
<th>LADCO States</th>
<th>Non-LADCO States</th>
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</thead>
<tbody>
<tr>
<td>EGU Point</td>
<td>State-supplied</td>
<td>Used RPO data (MANE-VU v. 3.1, VISTAS Base F, CENRAP Base F, WRAP pre2002d)</td>
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<td>Non-EGU Point</td>
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<td>Area</td>
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<td>Off-road</td>
<td>NMIM2005 model</td>
<td>Used RPO data</td>
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<td>Updated rail, marine</td>
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<td>CONCEPT w/ HPMS data</td>
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<td>Biogenics</td>
<td>CONCEPT/MEGAN</td>
<td>CONCEPT/MEGAN</td>
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<tr>
<td>Ammonia</td>
<td>CMU model w/ temporal from process-based model</td>
<td>CMU model w/ temporal from process-based model</td>
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Future Year Ozone

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<tr>
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July 11, 2007: EPA requested comment on secondary standard within range of 7 to 21 ppm-hours (72 FR 37818)
Future Year PM$_{2.5}$ Daily

<table>
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<tr>
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Next Steps

- Monitoring
  - Complete winter nitrate study

- Data Analysis
  - Complete final reports for OC studies
  - Analyze winter nitrate study data

- Emissions
  - Compile 2008 base year inventory
  - Continue ERTAC projects

- Modeling
  - Prepare modeling protocol