Characterization of ground-based atmospheric pollution and meteorology sampling stations during the Lake Michigan Ozone Study 2017

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Introduction – Lake Michigan Ozone Study 2017 (LMOS 2017)

- Campaign Period: May 22 – June 23, 2017
- Investigate ozone air quality in Lake Michigan airshed
- High ozone levels along lake shore
- Poor air quality
  - Urban emissions
  - Chemical processing
  - Lake breeze transport
- Sampling at ground-based monitoring sites to intercept polluted lake breezes

Source: Wisconsin Department of Natural Resources
Objectives

- Characterize the types of airmasses that impact ground sites
- Analyze local vs. airshed influence
- Determine if Zion and Sheboygan met criteria for enhanced ground monitoring sites:
  - Sample air representative of larger portions of airshed
  - Minimal local impacts
  - Distance from lake shore
Methods and Data Collection

- Ground based measurements – Gas Phase Chemistry, Particle Size Distributions, Meteorology
  - Wind and Pollution Roses
  - Conditional Probability Function Plots
  - Back trajectories
  - Diel patterns
- Traffic impact: C-LINE model from the Community Modeling and Analysis System (CMAS)
- Large point sources: Continuous emission monitoring (CEM) systems data (CO$_2$, SO$_2$, and NO$_x$)
- Positive Matrix Factorization (PMF) – U.S. EPA PMF version 5.0
Pollution Roses and Back Trajectories - Zion

(a) All Hours

(b) Daytime

(c) Daytime

(d) Daytime

(e) Daytime

(f) Daytime

Ozone (ppb)

- 70 - 100
- 50 - 70
- 30 - 50
- 10 - 30
- 0 - 10

Nitric Oxide (NOx) (ppb)

- 20 - 30
- 12 - 20
- 6 - 12
- 3 - 6
- 1 - 3

Map showing back trajectories for different time periods and pollution levels.
Pollution Roses and Back Trajectories - Sheboygan

(a) All Hours
(b) Daytime Hours
(c) Daytime Event Days

(d) All Hours
(e) Daytime Hours
(f) Daytime Event Days
Local Source Impacts – Traffic and Powerplants

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Measured NO\textsubscript{x}</th>
<th>C-LINE Model NO\textsubscript{x} attributed to vehicle emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zion</td>
<td>2.126 ppb</td>
<td>0.23 ppb</td>
</tr>
<tr>
<td>Sheboygan</td>
<td>3.347 ppb</td>
<td>0.14 ppb</td>
</tr>
</tbody>
</table>

(a) Cumulative CO\textsubscript{2} Emissions

(b) CO\textsubscript{2} Emissions

3 km

3 km
Positive Matrix Factorization – Zion

Diagram showing time series data for various species such as SO2, BTEX, OVOCs, NOx, Isoprene, and OVOCs/Acetonitrile.
Conclusions

• Observed three distinct periods of air parcels enriched in ozone
• Ozone episodes coincide with lake breeze conditions
• Higher NO_x concentration observed at Zion – combustion sources and high NO_x plumes
• Zion ozone episodes associated with lake breeze plumes of ozone, photochemically processed gases, and secondary aerosols
• Sheboygan’s high ozone periods associated with lake breeze plumes that have undergone extensive oxidative processing over Lake
• Minimal local impacts from nearby point sources, roadways, and rail lines
• Results aid in measurement interpretation and will assist in model development
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We acknowledge Nishanthi Wijekoon of Wisconsin DNR for Figure 1. This work was funded in part by the National Science Foundation under Grant AGS-1712909, AGS-1713001, and AGS-1712828.

Select References:


