Characterization of nitrogen oxide emissions and trends

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NASA AQAST Meeting
June 4, 2013
Motivation: Influence of $\text{NO}_x$ inventory on $\text{O}_3$-precursor response

$\text{O}_3$ Sens to $\text{NO}_x$ as Function of Baseline $\text{ENO}_x$

(Harris County average, 9/1/2006, 3pm)

Xiao et al., JGR 2010
Ozone Monitoring Instrument (OMI)

- NO$_2$ spectral range (405-465 nm)
- Over-pass time: 13:45 local time
- Daily global coverage
- Spatial resolution: 13km × 24km (nadir-view)

Source: OMI Guide 2009; Courtesy to Dale Allen
Explorations of OMI NO$_2$

- Kalman Filter inverse modeling
- Soil NO emissions modeling
- Temporal trends to diagnose NO$_x$ sources
Inverse modeling of NO\textsubscript{x} in Texas

1. Photolysis Rates assimilated using GOES data (A. Pour-Biazar, U. Alabama-Huntsville)

2. NO\textsubscript{x} Emissions inverted from OMI and TexAQS-II data

3. Model how revised inputs affect ozone responsiveness

4. Provide results to TCEQ and stakeholders for upcoming SIP attainment planning
Similar to Napelenok et al (ACP, 2008), except:
• Higher-resolution OMI instead of SCIAMACHY
• Incorporate other observations (including TexAQS2)
• Incorporate lightning and aircraft NO
Discrete Kalman Filter inversion of NO$_x$ emissions based on OMI NO$_2$ over Texas

OMI Observations

A priori CAMx (with aircraft & lightning)

CAMx with DKF inversion

June 2006 Episode

DKF inversion scales up emissions to match OMI observed NO$_2$ over rural regions

Tang et al., in prep for ACP, 2013
Base model overpredicts surface NO$_2$ at night & early morning

Tang et al., in prep for ACP, 2013
Discrepancy between OMI- and ground-based inversions

June 3 to July 1, 2006

NO\textsubscript{x} emissions (tons/day)

- Base case
- Prior: base case w/ additional NOx sources
- Posteriori: OMI-based DS inversion
- Posteriori: OMI-based DKF inversion
- Posteriori: Ground-based DKF inversion

Inversion regions:
- HGB
- DFW
- BPA
- N Texas
- Aus/SanA
- N Rural
- S Rural

Tang et al., in prep for ACPD, 2013
Implementation of Berkeley-Dalhousie soil NO\textsubscript{x} in CMAQ

• Scheme introduced by Hudman et al. in GEOS-Chem
  – ~2x emissions of Yienger & Levy
  – More realistic response of emissions to temperature, moisture, fertilizer, & deposition

• Build upon inline biogenics in newest CMAQ

• Future extensions to dynamic fertilizer data, soil HONO, and bidirectional exchange?
Soil fraction of total NO$_2$ column in GEOS-Chem

Hudman et al., ACP
Preliminary CMAQ-BDSNP results: Soil NO contribution to surface NO$_2$
Fertilizer Soil NO$_x$ (Central US)

Hudman et al., ACP
Can NO$_2$ observations indicate their source?

**Hypothesized Temporal Trends**

<table>
<thead>
<tr>
<th>Source</th>
<th>Interannual</th>
<th>Seasonal peak</th>
<th>Weekly peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile</td>
<td>↓</td>
<td>Winter</td>
<td>Weekdays</td>
</tr>
<tr>
<td>Industrial</td>
<td>↓</td>
<td>Winter</td>
<td>None</td>
</tr>
<tr>
<td>Soil &amp; lightning</td>
<td>↔</td>
<td>Summer</td>
<td>None</td>
</tr>
</tbody>
</table>
Russell et al. showed long-term decline and seasonal trend in California NO₂.

Russell et al., ES&T 2006
Interannual NO$_2$ Trends
(BeHR, 2005-2009, p<0.10)

Average Yearly Percentage Change of NO$_2$ Column Density, from 2005 to 2009, at 10% Significance Level
Summer*/Non-summer ratio in BeHR NO₂ data

Summer Average Divided By Non Summer Average, 2005–2009

*"Summer" = May - September
Interannual Trends in BeHR NO$_2$

Washington – Baltimore
-12.7%/year
(77.25 – 76.25 W, 38.5 – 39.5 N)

Nebraska & Dakotas
-3.5%/year
(104.25 – 95.5 W, 39.75 – 49.25 N)
Seasonal cycle in BeHR NO₂

Washington - Baltimore
(77.25 – 76.25 W, 38.5 – 39.5 N)

Nebraska & Dakotas
(104.25 – 95.5 W, 39.75 – 49.25 N)
Next step: Compare day of week trends in NO$_2$ data

FIGURE 3. Average weekly profiles of NO$_2$ for summer months (June-August) from OMI (solid) and CARB monitoring sites (dashed) normalized to the average weekday (Tuesday-Friday) value. CARB data is for 2005-2007, whereas OMI data is for 2005-2008. Points show averages for individual years normalized to average weekday value for that year.

Russell et al., ES&T 2010