Modeling oxidant chemistry in a high-isoprene atmospheric environment: sensitivity to model resolution and constraints from aircraft observations

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IGC7
Computation expense of tropospheric chemistry simulations requires evaluation of benefits of increasing grid resolution

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<th>Resolution</th>
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- Effect of grid resolution on NO$_x$-saturated vs. NO$_x$-limited regime has been extensively studied.
- As NO$_x$ emissions decline, it becomes increasingly important to evaluate model ability to represent interaction of biogenic and anthropogenic emissions.

How does grid resolution affect model representation of high-NO$_x$ vs. low-NO$_x$ regimes?
Evaluate GEOS-Chem run at $4^\circ \times 5^\circ$, $2^\circ \times 2.5^\circ$ and $0.25^\circ \times 0.3125^\circ$ resolutions against SEAC4RS observations

GEOS meteorology at $0.25x0.3125$ resolution

- 4x5 global, starting January 2013
- 2x2.5 global, start January 2013
- 0.25x0.3125 N. America with 4x5 boundary conditions, start run August 2013
Evaluate GEOS-Chem run at 4°x5°, 2°x2.5° and 0.25°x0.3125° resolutions against SEAC4RS observations

GEOS meteorology at 0.25x0.3125 resolution

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Observations from SEAC4RS aircraft campaign

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<th>Measurement</th>
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<tr>
<td>CSD CL (T. Ryerson)</td>
<td>Ozone</td>
</tr>
<tr>
<td></td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>NO₂</td>
</tr>
<tr>
<td>PTRMS (A. Wisthaler)</td>
<td>Isoprene</td>
</tr>
<tr>
<td>CAMS (A. Fried)</td>
<td>Formaldehyde</td>
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Boundary layer comparisons
Emissions of NO\textsubscript{X} and isoprene in Southeast US show high granularity and spatial anti-correlation

Figure 1. Emissions of anthropogenic NO\textsubscript{X}, soil + fertilizer NO\textsubscript{X}, lightning NO\textsubscript{X}, and isoprene at each resolution for August 2013. Anthropogenic NO\textsubscript{X} emissions are from the NEI2008 inventory. Soil and fertilizer NO\textsubscript{X} are computed using the parameterization of Hudman et al. [2012]. Lightning NO\textsubscript{X} computed based on satellite data as in Murray et al. [2012]. Isoprene emissions from MEGAN [Guenther et al., 2012].
Emissions of NO$_x$ and isoprene in Southeast US show high granularity and spatial anti-correlation

**NOx emissions at 0.25x0.3125**

**Isoprene (0.25x0.3125)**

**0.25x0.3125**

$r = -0.15$

**2x2.5**

$r = 0.10$

**4x5**

$r = 0.76$
Probability distributions for primary and secondary species

- Effect of grid resolution more apparent for highly skewed distributions: resolution of small-scale features allows for more extreme tail values
- Resolution differences for secondary species related to differences in chemical pathways
AQS surface measurements provide additional information on air quality in the Southeast US

- Increasing grid resolution improves representation of high tail compared against AQS measurements
- AQS measurements in the high tail are primarily urban, unlike in the SEAC⁴RS data.
Global models are unable to distinguish high NO$_x$ from high isoprene environments, resulting in a higher fraction of peroxy radicals reacting via high-NO$_x$ pathway.
Effect of grid resolution on regional mean concentrations is small

**NOx lifetime (wrt conversion to HNO\textsubscript{3})**

- 4x5
- 2x2.5

**Mean ozone biases**

- 4x5
- 2x2.5
- 0.25x0.3125

**Mean PAN mixing ratio**

- DC8
- 4x5
- 2x2.5
- 0.25x0.3125

- ppt
- 0 100 200 300

Days

- 0.0
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6