Linking global to regional models to assess future climate impacts on surface ozone levels in the United States

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• **CI RAQ**: Climate Impacts on Regional Air Quality
  - Expected future emission reductions have the largest impact on air quality
  - Impact of climate on air quality is obscured by uncertainty in future regional climate simulations

• Ongoing and future work
**CI RAQ: Climate Impacts on Regional Air Quality**

95\textsuperscript{th} Percentile O$_3$ Concentration
Change in 2050 due to Climate Change

SUMMER (June - August)

(a)

(b)

Future O$_3$ Concentration

\Delta$O_3$ Concentration
Surface radiation (cloudiness) appears to be strongest driver of modeled change in O$_3$ concentrations.
Future change in surface radiation

A recent analysis of different combinations of global and regional climate models showed differences in the regional spatial patterns of simulated future changes.

**Future work:**
- Improved understanding of connections between regional and global climate
- Ensemble approach

Source: Weaver et al, BAMS, *in press*
Future emissions *inspired* by SRES A1B
Implemented as domain-wide emission changes

<table>
<thead>
<tr>
<th>Species</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoprene</td>
<td>+22%</td>
</tr>
<tr>
<td>CO</td>
<td>-46%</td>
</tr>
<tr>
<td>Non-Methane VOCs</td>
<td>-21%</td>
</tr>
<tr>
<td>$\text{NO}_x$</td>
<td>-45%</td>
</tr>
<tr>
<td>$\text{SO}_2$</td>
<td>-63%</td>
</tr>
<tr>
<td>$\text{NH}_3$</td>
<td>unchanged</td>
</tr>
</tbody>
</table>
95th Percentile O₃ Concentration
Change in 2050 due to Climate Change and Future Emissions

SUMMER (June – August)
Ongoing & Future Work

• Improved regional climate simulations
  – Driven by GISS ModelE and Representative Concentration Pathways
  – Downscaling using WRF

• Improved U.S. emission scenarios

• Impact of U.S. emission changes on global concentrations of short-lived, radiatively active species and on global climate
Improved Regional Climate Simulations

GISS ModelE and WRF – Total Precipitation (1 Month)

The method of driving the regional climate model has significant impacts on the simulation.
Improved U.S. Emission Scenarios
Technology-based, 9-Region MARKAL
Comparing Clean Air Interstate Rule (CAIR) Scenario Options

Air Quality Policy (includes CAIR)

Climate Policy (does not include CAIR)

These scenarios are meant to illustrate feasible future conditions, not certain predictions.
Percent emission change from 2000 to 2050
Electricity Generation Sector

- **SO₂**
  - Climate Policy: -100%
  - Air Quality Target: -60%

- **NOₓ**
  - Climate Policy: -100%
  - Air Quality Target: -60%
### Comparison to earlier A1B scenario

<table>
<thead>
<tr>
<th>Change in all emission sectors</th>
<th>Air Quality Policy Scenario</th>
<th>Climate Policy Scenario</th>
<th>A1B</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>-56%</td>
<td>-62%</td>
<td>-46%</td>
</tr>
<tr>
<td>Non-Methane VOCs</td>
<td>-27%</td>
<td>-29%</td>
<td>-21%</td>
</tr>
<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>-37%</td>
<td>-40%</td>
<td>-45%</td>
</tr>
<tr>
<td>SO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>-49%</td>
<td>-59%</td>
<td>-63%</td>
</tr>
<tr>
<td>NH&lt;sub&gt;3&lt;/sub&gt;</td>
<td>+6%</td>
<td>+1%</td>
<td>-</td>
</tr>
</tbody>
</table>

Emission changes are similar in magnitude. MARKAL modeling provides a description of what technologies are needed to achieve these emission reductions.
Conclusions

• Over the U.S., future emission reductions can have the largest impact on peak ozone concentrations

• It is feasible that these emission reductions can be achieved by implementing a carbon policy [air quality co-benefits], but this depends on the mix electricity generation and transportation technologies

• Ongoing and future work is directed towards
  – Improved regional climate modeling
  – Improved emission scenarios that reflect real trade-offs
  – Understanding the impact of US emission changes on global atmospheric composition and climate