Summary of Boundary Conditions/Transport Study

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Introduction

• Grant to University of Houston

• Two subcontractors:
  – Harvard University: Global modeling with GEOSChem to derive baseline and future-case boundary conditions for CAMx
  – NASA Jet Propulsion Lab (JPL): Characterizing ozone transport into Texas using satellite observations
New Boundary Conditions for Photochemical Modeling

- New boundary conditions for modeling 2005 and 2006 episodes.
- Previous modeling included boundary conditions from global models for base case and baseline modeling only.
- New SIP modeling will now have boundary conditions specific to Houston/Galveston/Brazoria (HGB) attainment date of 2018.
- For intermediate attainment years (to be determined when the new ozone standard is eventually announced), we can interpolate between 2005-6 and 2018.
GEOS-Chem Modeling

- GEOS-Chem (Goddard Earth Observing System Chemistry Model) was used to simulate ozone and ozone precursor concentrations for 2005, 2006, and 2018.
- Base case modeling inventory was derived from several sources, scaled to 2005:
  - Global Emissions Inventory Activity (GEIA)
  - Emissions Database for Global Atmospheric Research (EDGAR)
  - EPA’s National Emissions Inventory (NEI)
  - Big Bend Regional Aerosol and Visibility Observational Study (BRAVO)
  - European Monitoring and Evaluation Programme (EMEP)
  - Canada’s Criteria Air Contaminants (CAC) database
  - Other sources
Future-case modeling inventory was projected to 2018 using the Intergovernmental Panel on Climate Change (IPCC) A1B scenario.

The A1B scenario was chosen because it most closely approximates the median of the six growth scenarios in the IPCC Special Report on Emission Scenarios (SRES).

- The SRES scenarios do not explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.
GEOS-Chem Modeling

• The A1B scenario describes a world of moderate socioeconomic growth and technology driven by a balance of fossil-fuel and alternative energy sources.

• Meteorology from 2005-6 was not modified in the 2018 simulations to account for any climate-change projections.
### Percentage changes in anthropogenic emissions from 2005 to 2018

<table>
<thead>
<tr>
<th>Species</th>
<th>Global</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>+9</td>
<td>-5</td>
</tr>
<tr>
<td>CO</td>
<td>+20</td>
<td>-14</td>
</tr>
<tr>
<td>CH2O, aldehydes</td>
<td>+26</td>
<td>-6</td>
</tr>
<tr>
<td>C2H6</td>
<td>+56</td>
<td>-10</td>
</tr>
<tr>
<td>C4, C5 alkanes</td>
<td>+29</td>
<td>-9</td>
</tr>
<tr>
<td>Propene</td>
<td>+31</td>
<td>-15</td>
</tr>
<tr>
<td>Propane</td>
<td>+51</td>
<td>-5</td>
</tr>
<tr>
<td>Acetone</td>
<td>+16</td>
<td>+1</td>
</tr>
</tbody>
</table>
Fractional change (ppbv) in anthropogenic emissions for selected ozone precursors, 2005 to 2018

1Here VOC signifies formaldehyde and other aldehydes.
GEOS-Chem Modeling

- GEOS-Chem version 8.03.02 was run with 2° latitude X 2.5° longitude resolution
- Four Simulations:
  - a. 2005 meteorology with 2005 base-year emissions
  - b. 2005 meteorology with 2018 future-year emissions
  - c. 2006 meteorology with 2006 base-year emissions
  - d. 2006 meteorology with 2018 future-year emissions
- Sent to TCEQ:
  - Time series of 54 tracers and grid box heights
  - One-hour resolution for the bottom 40 model layers
  - Rectangular domain bounded by 136° W and 59° W and by 18° N and 62° N.
Modeled Global Mean Summer Afternoon Surface Ozone Concentrations

JJA for 03 – present (2006)

JJA for 03 – future (2018)

Difference (future-present)

Ratio (future/present)

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Modeled North America Mean Summer Afternoon Surface Ozone Concentrations

JJA for O3 – present (2006)

JJA for O3 – future (2018)

Difference (future – present)

Ratio (future/present)
The approximately 10% increase in ozone precursor concentrations in the northern Rockies represents only about 0.2 ppb increase in both NO\textsubscript{X} and CH\textsubscript{2}O (formaldehyde) concentrations and about 20 ppb increase in CO. This localized increase is associated with projected land clearing as forested areas are cleared for agriculture.
Boundary Conditions - Next Steps

- Boundary conditions for the CONUS (continental US) domain for 2005-6 and 2018 must be extracted from the concentration files delivered by Harvard.
Transport Analysis Using OMI and TES Satellite Data

- The purpose of this subcontract was to demonstrate use of satellite data, combined with other tools, to assess the sources of air pollution in Texas.

- The analysis used:
  - Two instruments aboard NASA’s Aura spacecraft:
    - Ozone Monitoring Instrument (OMI);
    - Tropospheric Emission Spectrometer (TES);
  - Surface and sonde observations; and
  - Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model.
Transport Analysis Using OMI and TES Satellite Data

• Candidate dates examined were:
  – July 31-August 2, August 4, and August 6, 2005
  – July 6-8 and 22, 2006
  – August 5-7 and 24, 2006
  – June 1, 2009

• In-depth analysis of
  – August 2, 2005
  – July 6, 2006
  – July 22, 2006
Transport Analysis Using OMI and TES Satellite Data

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Aura Ground Track, August 2, 2005
TES O₃ Concentrations, August 2, 2005

TES Nadir Retrieval Result: Ozone, 2005-08-02

Cross Section Along Orbit Track: RunID=3006, Seq=1-6, Scan=0-24, UTCtime=19:42:46-20:00:34

Near DFW Area

Ozone Volume Mixing Ratio (ppb)

Pressure (hPa)

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4-Day Back Trajectories Ending August 2, 2005

NOAA HYSPLIT MODEL
Backward trajectories ending at 2000 UTC 02 Aug 05
EDAS Meteorological Data
OMI Tropospheric Column Measurements, August 2, 2005

**NO₂**

**O₃**

$10^{15}$ molec cm$^{-2}$
Transport Analysis
Summary and Conclusions

- August 2, 2005 imagery shows broad areas of ozone and NO$_2$ across the Southeast and Mid-Atlantic. Back trajectories ending in Dallas/Fort Worth show that these pollutants likely influenced ozone concentrations across Northeast Texas.

- Combining satellite and *in situ* data and modeling tools can provide more quantifiable and accurate information for developing effective State Implementation Plans.