Reality Check:
Evaluating the Model the Way It's Used

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CMAQ appears to be too rigid, stiff, stubborn, non-responsive

- 2003 Blackout vs. Georgia Tech simulations
- Dynamic range of the model vs. surface observations
- 2002 vs. 2004 NOx SIP Call teaser
The Problem

- **We do not use the model the way we evaluate it**
  - We compare the model to observations, not changes!!
  - Static comparison, not dynamic
  - Model development affected
- **We use the model to predict changes in ozone due to a change in emissions**
  - The “response surface” is what matters: slopes
Problem #2

- Sudden changes in emissions are rare:
  - Blackout
  - NOx SIP Call
- Using the observations differently helps
  - Emphasize diagnostics, not absolute numbers
DMSP F15
15 August 2003
0114Z
~7 hrs after Blackout

Brightness in Boston is unchanged
Brightness in Long Island is MUCH reduced
Comparisons

- Same day, different place
- Different day, same place
- Climatology of ozone flights
Same Place, Different Day
BUT the new day is after the NOx SIP Call’s implementation!
O3 Profiles over Selinsgrove, PA

- Blackout Aug 15 2003
- Control Aug 4 2002
- Control Aug 3 2005
Climatology

- Compare with historical ozone flights under similar meteorological conditions
- Cluster back-trajectories
- Compare to statistical summary of all flights within the cluster that contains the blackout flight
O₃ Median (10% & 90%) for afternoon Cluster 1 (62 profiles)
Flights during Blackout in color.
Dynamic evaluation of the model

- CMAQ does not reproduce diurnal cycles well
  - Nighttime poor, but perhaps expected?
  - Daytime peaks poor as well
- Statistics like mean error and bias necessarily make you look at average performance
  - Model development geared towards these measures!
  - Time to look at some new measures
o3 ts at VDMP sites 20020701–20020714

Measurements (———)
CMAQ (— — —)

O3 (ppbv)

Date (2002MMDD)
Rural areas performance poorer

![Graph showing NOx emissions in 80 km radius (tons/season)]
Aloft performance

- CMAQ generally overpredicts ozone at the surface and underpredicts aloft
- Transport likely underrepresented
- Better than in the past, still not right.
Dynamic Response Missing

- Generally falls short of peaks
  - Peaking units? Dynamics? Chemistry?
- Generally overpredicts nighttime minima
  - NOx titration, sure, but:
    - Everywhere?
    - What about the odd shape?
- Model lacks dynamic range.
- Lack of response due to…?
Long-term response to emissions

- At least in New Jersey, 2009 design values are here!
- Still more emissions reductions to come
## The Papalski Factor

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>OZONE MONITOR</th>
<th>2004-2006 DESIGN VALUE</th>
<th>Modeled Predicted O3 Concentration (BOTW-v.3)</th>
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<tr>
<td>Atlantic</td>
<td>Nacote Creek</td>
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<td>Chester</td>
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<td><strong>Average</strong></td>
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<td><strong>85</strong></td>
<td><strong>85</strong></td>
</tr>
</tbody>
</table>
Response to the NOx SIP Call

- EPA and collaborators are modeling 2002 and 2004 met, emissions, CMAQ
- Look at CMAQ’s response to the NOx SIP Call
- Awaiting final results and interpretation…stay tuned!
Conclusions

- **Blackout:**
  - Using the 2005 reference day: A minimum of 7 ppbv ozone throughout a deep column, likely higher.
  - Using comparisons to areas outside the blackout on the same day: 10 ppb, possibly 20-25 ppb.
  - Using comparisons to climatology: a very unusual day.
  - Hu et al.: 4%: some from power plants, more from assumed weekend traffic patterns (~2 ppb).
  - Measurement-based estimates predict at least double the change due to blackout.
Conclusions

- Dynamic model evaluation
  - Model underpredicts the peaks, overpredicts nighttime lows: lack of response to change
  - Performance poorer in upwind rural areas

- Papalski effect
  - 2009 design values at the highest monitors (New Jersey) are already here
Why?

- $j\text{NO}_2$ should increase aloft, decrease near surface to due scattering from aerosols
- Alkyl nitrates ($\text{NO}_3 + \text{alkanes}$) are very efficient at soaking up NOx in cities, e.g. 1.5 ppb NOx/day at Essex out of 5-10 ppb NOx.
  - Spreads out city plumes, makes power plants more important
Thank You!
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