**Motivation**

The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument will be the first NASA mission to make atmospheric composition observations from geostationary orbit and partially fulfills the goals of the Geostationary Coastal and Air Pollution Events (GEO-CAPE) mission.

Follette-Cook et al. (2015, *Atmos. Environ.*) related observed and simulated variability to the precision requirements defined by the science traceability matrices of these space-borne missions. In that work, they quantified the spatial and temporal variability of column integrated and in-situ observations of trace gases over the Baltimore/Washington, DC area using output from WRF/Chem for the entire month of July 2011, coinciding with the first deployment of the NASA Earth Venture program mission DISCOVER-AQ (Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality).

Here, we expand that analysis to include the other three deployments of DISCOVER-AQ.

**Maryland Analysis Highlights – Follette-Cook et al. (2015)**

Follette-Cook et al. (2015) quantified the variability seen in the Maryland/DC DISCOVER-AQ P-3B trace gas data and found it compared well with our WRF/Chem simulation. Questions addressed in that analysis:

- **How much does each species vary spatially and temporally throughout the campaign? (i.e. one month)**
- **How much of that variability would a TEMPO-like instrument see?**
- **Is the resolvable variability sufficient to answer the relevant science questions?**

**Precision Requirements (PR) for GEO-CAPE/TEMPO**

<table>
<thead>
<tr>
<th>Species</th>
<th>Altitude range</th>
<th>STFM Precision</th>
<th>Temporal Revisit</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₃</td>
<td>0-2 km</td>
<td>10 ppbv</td>
<td>1.7 DEC*</td>
</tr>
<tr>
<td>O₃ Tropospheric column</td>
<td>0-2 km</td>
<td>10 ppbv</td>
<td>4.2 DEC*</td>
</tr>
<tr>
<td>CO</td>
<td>0-2 km</td>
<td>20 ppbv</td>
<td>0.61×10¹⁵ molec/cm²*</td>
</tr>
<tr>
<td>CO</td>
<td>2 km - tropopause</td>
<td>20 ppbv</td>
<td>2.5×10¹⁵ molec/cm²*</td>
</tr>
<tr>
<td>NO₂</td>
<td>Tropospheric column</td>
<td>3.4×10¹⁶ molec/cm²*</td>
<td></td>
</tr>
<tr>
<td>NO₂ Tropospheric column</td>
<td>4×10¹⁴ molec/cm²*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₂</td>
<td>Tropospheric column</td>
<td>1×10¹⁵ molec/cm²</td>
<td></td>
</tr>
<tr>
<td>SO₂</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Can WRF/Chem reproduce the variability in O₃ well? Slightly overestimates the variability of CO and NO₂ Underestimates the variability in HCHO

**Structure Functions**

Structure functions are a useful way to quantify variability in both space and time:

\[
\langle f(x,y) \rangle = \frac{1}{Z(x+y)} \sum_{x+y} f(x,y)
\]

- \(Z = \text{variable of interest at given location}\)
- \(< > = \text{the average of data pairs separated by distance} \ y\)
- \(Z = \text{variable of interest at given location} \ x\)
- \(q = \text{scaling exponent (here } q = 1)\)

**Future Work**

- **Results from an in-depth analysis of trace gas variability in MD indicated that the variability in this region was large enough to be observable by a TEMPO-like instrument.**
- **The variability observed in MD is relatively similar to the other three deployments with a few exceptions.**
  - CO variability in CA was much higher than in the other regions; HCHO variability in CA and CO was much lower; MD showed the lowest variability in NO₂.
  - All model simulations do a reasonable job simulating O₃ variability. For CO, the CACO simulations largely underestimate the variability in the observations. The variability in HCHO is underestimated for every campaign. NO₂ variability is slightly underestimated in MD, more so in CO. The TX simulation underestimates the variability in each trace gas. This is most likely due to missing emissions sources (C. Loughner, manuscript in preparation).
  - **Future Work:** Where reasonable, we will use these model outputs to further explore the resolvability from space of these key trace gases using analyses of tropospheric column amounts relative to satellite precision requirements, similar to Follette-Cook et al. (2015).