Investigation of the Community Multiscale Air Quality (CMAQ) model using the Climate Penalty Factor (CPF)

Linda Hembeck*, Kyle Hosley*, Ross Salawitch*, Timothy Canty*, Pius Lee+, Yunsoo Choi*

* University of Maryland, College Park, MD
+ NOAA Air Resources Laboratory, Silver Spring, MD

1. Motivation

- Decrease in sensitivity of ozone to temperature since NOx emission reduction (SIP call)

  Specifications are:
  - 2002: CMAQ Model v4.7.1, CB05, MM5, 12x12 Grid, emissions from 2002, run by UMD
  - 2007: CMAQ Model v4.7.1, CB05, WRF, 12x12 Grid, emissions from 2007, run by UMD
  - 2011: CMAQ Model v4.6, CB05, WRF/NMM, 12x12 Grid, emissions from 2009, run by ARL

- 3°C temperature bins across the range 19 to 37°C for the 5th (black), 25th (blue), 50th (cyan), 75th (green) and 95th (red) percentiles of the distributions before (dashed lines) and after 2002 (solid lines)

- "Solid circles" indicate data points in the post 2002 time period and “plus signs” indicate the pre 2002 values.

- Climate Penalty Factor (CPF) is average of the 5 slopes [Bloomer et al., 2009].

- Does ozone in CMAQ have a similar relationship with temperature?
- What is the time evolution of the CPF in CMAQ?

2. CMAQ - Model

- CPF from CMAQ for 2002 and 2007 is lower than observed whereas CPF from CMAQ for 2011 is higher than observed.

- The 2011 CMAQ simulation has a smaller spatial domain than the 2002 and 2007 CMAQ simulations

3. Approach

- 13 EPA ground stations in MD, VA, and DC were selected, based on availability of O3 measurements at least since 2001
- CPF calculated for each July using daytime data

- CMAQ is sampled using ozone output from the closest grid point to each ground station
- CPF calculated for July 2002, 2007 and 2011 from CMAQ output in an identical manner as the empirical CPF

4. Results

- CPF from EPA ground stations (urban locations) shows a decrease over this time period with the largest drop occurring after 2007. Bloomer et al. analysis of CPF from CASTNET ground stations (rural locations) revealed the largest drop in 2002.
- CPF from CMAQ for 2002 and 2007 is lower than observed whereas CPF from CMAQ for 2011 is higher than observed.
- Comparison suggests observed sensitivity of surface ozone to temperature for particular years is not fully captured within CMAQ, although the mean CMAQ CPF (2002, 2007 & 2011) is closer to the mean observed CPF.

5. Further Evaluation of CMAQ

- The NASA DISCOVER-AQ field campaign provided a wealth of observations that can be used to evaluate CMAQ.
- Below we show a very favorable comparison of NOx and O3 from CMAQ to airborne and ground-based observations as well as a not so favorable comparison.

- These comparisons are representative of the range (sometimes excellent; sometimes poor) we typically find when evaluating CMAQ O3, NOx, CO, etc. using DISCOVER-AQ data. A concerted effort is taking place to establish how CMAQ can be improved based on DISCOVER-AQ comparisons

6. Future Plans

- Calculate CPF from CMAQ for more summers
- Investigate the reasons for large differences between measured and modeled O3 and NOx on some days despite good agreement on other days using comparisons such as shown in Box #5 for the entirety of DISCOVER-AQ as well as comparisons of modeled and measured CO, VOCs, boundary layer height, etc. (available but not shown)
- Determine whether improvements between measured and modeled NOx, CO, VOCs, boundary layer height, etc. resulting from improved estimates of emissions, model transport, and chemistry lead to more realistic simulations of the CPF

7. References and Acknowledgments


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