Contrasting Spatial Responses in Air Pollution to Hourly Anthropogenic Emissions in the Contiguous United States

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Research Questions

Motivation: Accurate simulations of air pollutant concentrations and variations are essential for model applications in attributing pollution sources and assessing exposure risks, with anthropogenic emissions being an essential component.

For July 2018 over the Contiguous U.S. (CONUS):

How do the temporal characteristics of anthropogenic emissions, including weekday versus weekend differences and diurnal patterns, affect the concentrations of ozone (O3) and its precursors, as well as their diurnal variations across different regions?

Impact of Incorporating Daily and Hourly Nitric Oxide (NO) Emissions

*Surface NO, NO2, and O3 concentrations respond differently despite similar changes in emissions diurnal cycles.

- In West Coast urban regions such as Los Angeles, during daytime hours, monthly mean surface concentrations of NO and NO2 increase by up to 8 ppb and 6 ppb, respectively, while O3 decreases by up to 7 ppb.
- Conversely, in Northeast urban regions such as New York, monthly mean surface NO2 during daytime hours decreases by up to 1 ppb, and O3 decreases by up to 2 ppb. The changes in time mean are considerably smaller compared to those observed in Los Angeles.

**Spatial variations in the impact of including diel cycles in anthropogenic emissions on model evaluation with observations.

- MUSICAv0 captures some of the spatial variation (r > 0.5), but performance varies by region. Surface O3 and column HCHO are biased high, while column NO2 is typically biased low.
- MUSICAv0 overestimates the daily range in both surface O3 and NO2 concentrations compared to SLAMS observations. The modeled weekday-weekend differences are more aligned with observed conditions after incorporating daily and hourly variations in emissions.

Changes in surface NO concentrations due to switching to daily (green: NEI_daily_NO – NEI_monthly) and then hourly (pink: NEI_hourly_NO – NEI_daily_NO) NO emissions, alongside hourly NEI NO emissions (gray) approximated at two urban monitoring stations. Weekends are shaded gray. The shift from daily mean to hourly varying emissions typically increases daytime NO and decreases nighttime NO, with more pronounced differences on weekdays.

Daytime (9AM-5PM) July Mean NEI_hourly_NO – NEI_daily_NO Surface NO2 Surface O3

The spatial changes in NO (not shown) are similar to those of surface NO2.

Implications and Future Directions

- The sensitivity of monthly mean NO2 concentrations to the hourly variations in NO2 emissions underscores the importance of careful accounting for diurnal changes when inferring emissions from concentrations.
- Additional work is necessary to identify the specific factors driving these different regional photochemical environments.

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