Diurnal Change in NO_2 Columns over U.S. Cities: CMAQ vs. Satellite Data

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Introduction

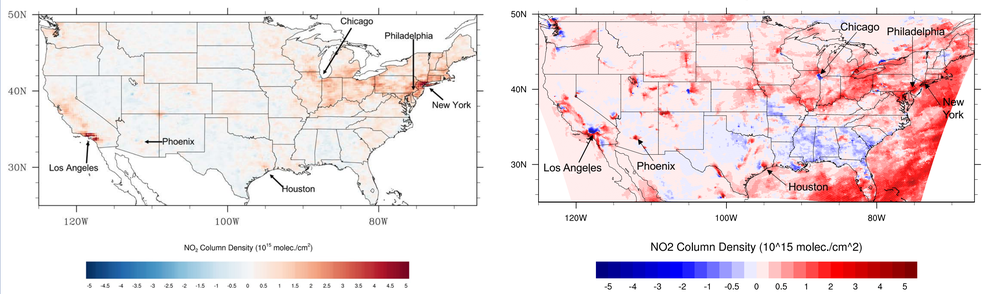
Image left: Smog over Los Angeles, from the *Daily Breeze* 4/19/17

- Nitrogen oxides (NO_x) are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x gases react in the atmosphere to form smog, acid rain, ground-level ozone, and particulate matter.
- In cities, cars and trucks are a major source of NO_x emissions, which vary over the course of the day due to traffic patterns. In addition, local meteorology and chemical environment affect NO_2 columns in urban areas.
- Co-author Elise Penn previously examined the diurnal cycle of NO_2 over the US during the summer of 2011 using satellite data. Here we compare these patterns with model results.

Data Sources

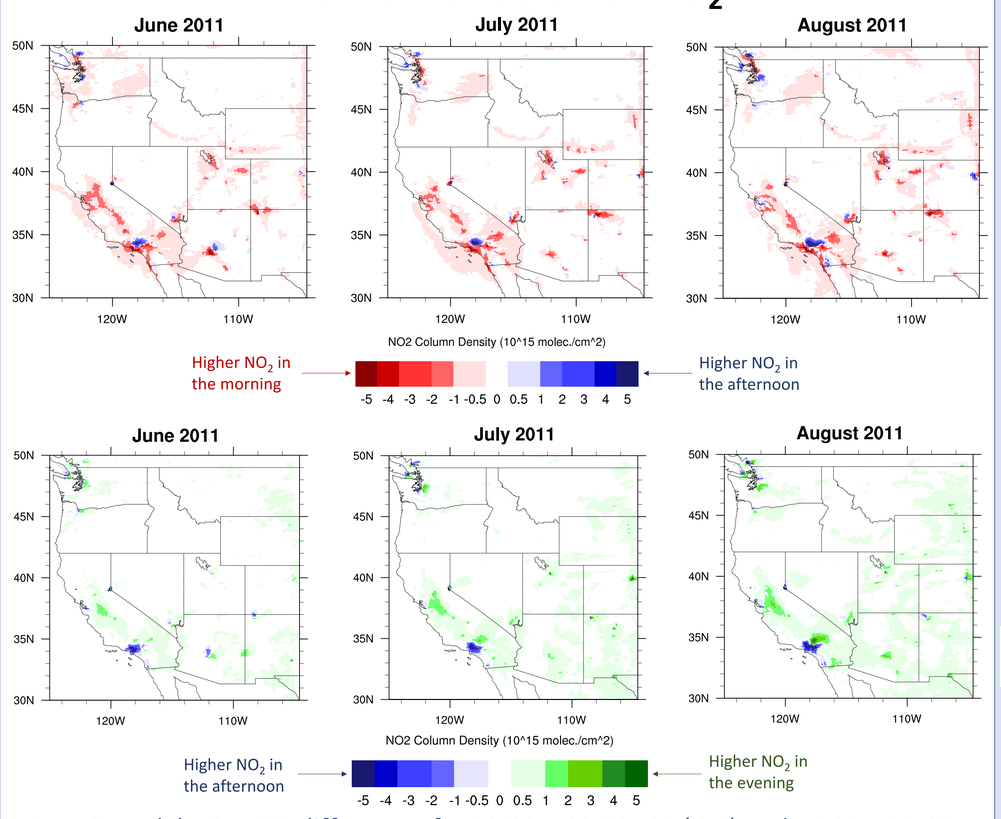
- The **C**ommunity **M**ultiscale **A**ir **Q**uality modeling system (**CMAQ**) is a tool created by the US EPA for conducting air quality simulations. Simulations here are for 2011 conditions, at 12 km x 12 km, using the National Emissions Inventory and meteorology from WRF.
- The ESA's **G**lobal **O**zone **M**onitoring **E**xperiment **– 2** (**GOME-2**) instrument retrieves NO_2 vertical column densities (VCDs) around 09:00 LST.
- NASA's **O**zone **M**onitoring **I**nstrument (**OMI**) retrieves VCDs around 13:00 LST.
- Model NO2 columns allow us to assess diurnal changes in VCD, in a manner that eliminates differences in instrument resolution or data products.

How does the model compare to the satellite?



A comparison of the 09:00 – 13:00 LST NO2 VCD difference provided by the OMI and GOME-2 satellites (left) and CMAQ modeling system (right) for the summer of 2011. Areas of high afternoon NO_2 concentration are indicated in blue and areas of high morning NO_2 concentration are indicated in red. Cities with large commuter-adjusted populations in the United States are labeled.

Diurnal Variation of NO_2



CMAQ model NO_2 VCD differences for 13:00 – 09:00 LST (top) and 17:00 – 13:00 LST (bottom) for June, July, and August of 2011.

Methods

- CMAQ NO_2 VCDs were plotted at **09:00 LST**, **13:00 LST**, and **17:00 LST** for June, July, and August of 2011.
- An average differencing NCL script was used to compute the 13:00 – 09:00 LST and 17:00 – 13:00 LST VCD differences.

Results

- Model simulations capture many of the same features as the GOME-2 – OMI comparison, including:
  - High morning concentrations of NO_2 over suburban areas (possible rush-hour traffic)
  - High afternoon concentrations of NO_2 over urban areas and power plants may be due to emissions, chemistry, and/or vertical transport
- Model framework will allow us to isolate processes and mechanisms contributing to diurnal change in urban NO_2 VCDs.
- Results from this study will inform future applications of geostationary satellite data, in terms of isolating the relationship between NO_2 VCD and urban emissions.

Image right: Rush hour traffic in Los Angeles, from CNN 2/27/18

Acknowledgements

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