The Distribution Dilemma:

Assessing Warehouse-Associated Air Pollution using CMAQ and TROPOMI NO_2

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Why Warehouses?

[1]Data from US Census Bureau Feb. 2023 Quarterly Retail E-Commerce Sales Report (https://www.census.gov/retail/ecommerce.html)

- Increased E-commerce has led to increasing numbers of warehouses/distribution centers to meet demand
- With the ideal location of these warehouses being near urban cities, air quality concerns arise
- Potential inequities in warehouse citing may also be of concern
- Current uncertainty about best methodology to quantify impacts of diesel truck activity given long idling periods

The goal of this research is to better understand present capability to quantify warehouse associated emissions and air quality impacts using CMAQ and satellite data

Methods

Community Multiscale Air Quality Modeling (CMAQ)

- 4-km resolution model with domain covering South Coast Air Basin
- 2017 NEI emissions used with business-as-usual for 2020
- WRF offline; BEIS online

TROPOspheric Monitoring Instrument (TROPOMI)

- 4-km oversampled NO_2 VCDs with CMAQ AMFs were used to compare with CMAQ base model

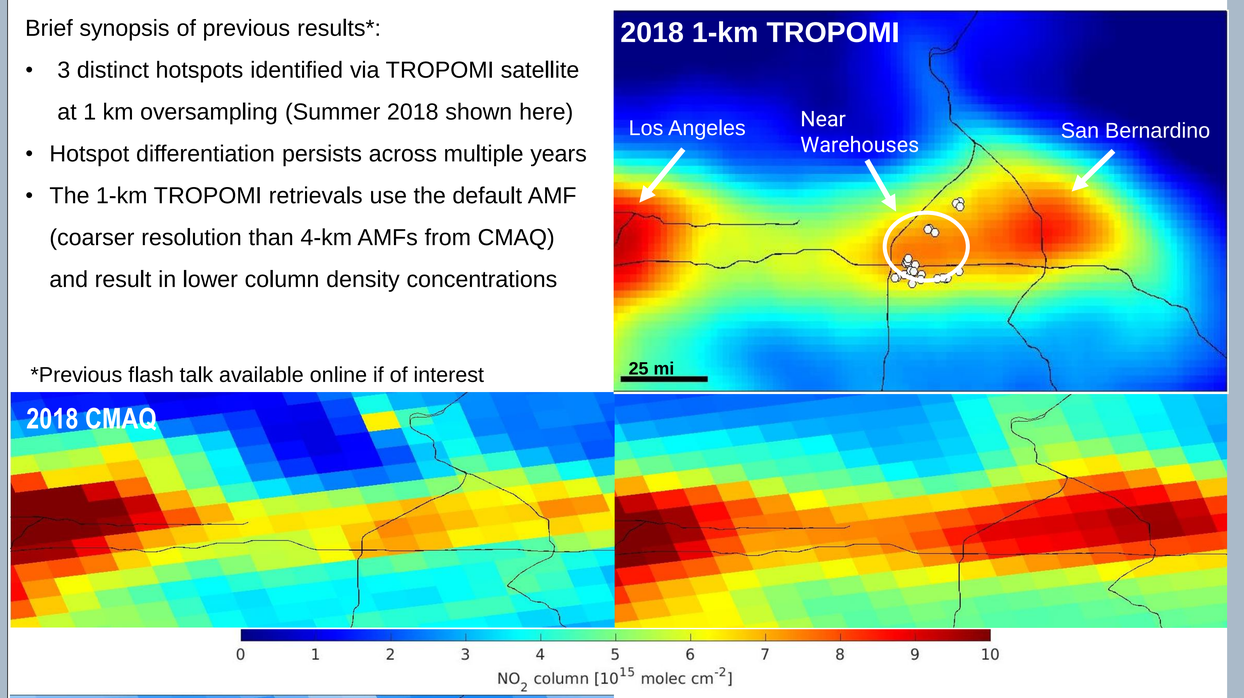
Results focused on Fontana, CA because of a high density of warehouses with less expected NOx sources compared to downtown LA

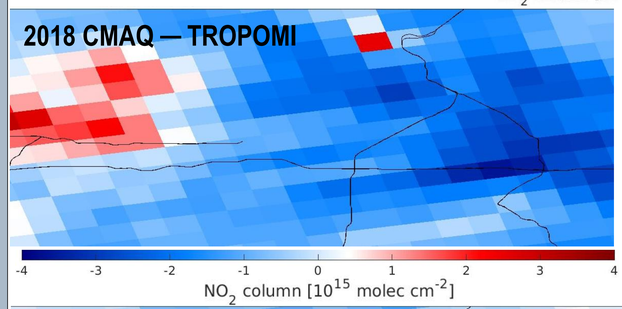
Summer NO_2 Results

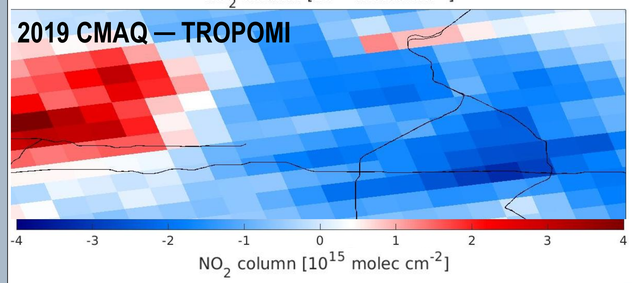
Brief synopsis of previous results*:

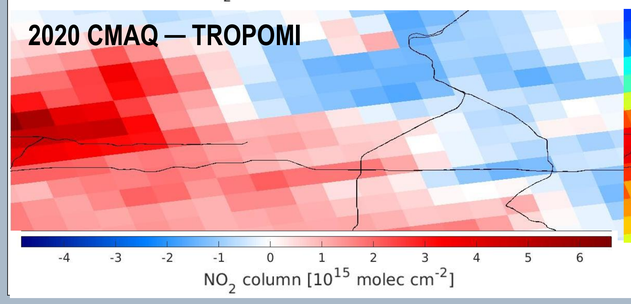
- 3 distinct hotspots identified via TROPOMI satellite at 1 km oversampling (Summer 2018 shown here)
- Hotspot differentiation persists across multiple years
- The 1-km TROPOMI retrievals use the default AMF (coarser resolution than 4-km AMFs from CMAQ) and result in lower column density concentrations

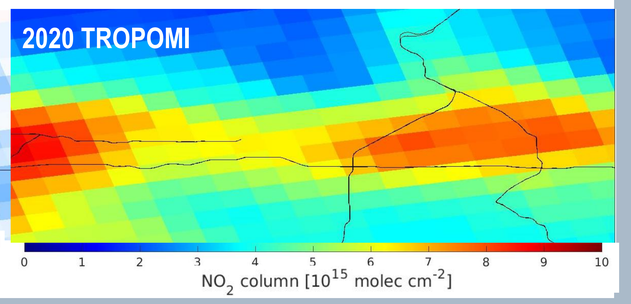
*Previous flash talk available online if of interest











- At 4-km resolution, TROPOMI can not differentiate between hotspot over downtown San Bernardino and Fontana
- Compared to TROPOMI, 2018 and 2019 CMAQ is biased high over Los Angeles but biased low over Fontana and part of San Bernardino
- 2020 TROPOMI shows that hotspot activity persists through COVID.
- High bias expected as 2020 CMAQ was not run with COVID considerations. Unexpected low bias near downtown San Bernadino is still seen

Conclusions

- Spatial distribution of NO2 hotspots agree between CMAQ and TROPOMI
- Due to 4 km resolution, the separation between plumes is not as evident as in 1-km TROPOMI
- For 2018-2019, CMAQ biased low compared to TROPOMI retrievals for Fontana and San Bernadino
- Biases could be due to incorrect spatial allocation of vehicles in NEI emissions OR could be another example of CMAQ's tendency to overestimate the center of metropolitan emissions[2]
- San Bernadino bias in 2020 CMAQ results suggests a source is not well accounted for in the model

[2]Kim et al. 2020. Fine-Scale Columnar and Surface NO_x Concentrations over South Korea: Comparison of Surface Monitors, TROPOMI, CMAQ and CAPSS Inventory.

Future Work

- Use traffic count data to compare with results (would help confirm or deny spatial misallocation possibility)
- Run CMAQ simulations with increased emissions at high-density warehouse areas
- Evaluate potential confounding of warehouse air impact estimates by changing associated emissions of large nearby sources, e.g. airports
- Conduct similar analyses in Atlanta with the addition of ground-based measurements
- When available, use TEMPO to evaluate if CMAQ biases are consistent throughout the day

Acknowledgement

This work is part of a rapid response team led by George Washington University, Georgia Institute of Technology, and Emory University in collaboration with Environmental Defense Fund, International Council on Clean Transportation, Lake Michigan Air Directors Consortium, and South Coast Air Quality Management District

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