Inconsistent effects of COVID-19 social distancing on air quality in global cities: Lessons for protecting near-term public health and designing longer-term urban transportation policies

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THE GEORGE WASHINGTON UNIVERSITY
Objectives

1. How are $NO_2$ concentrations changing in cities due Covid-19 precautions, and how does this affect environmental justice issues?

2. What is the role of weather versus emissions in the observed $NO_2$ declines in different cities following social distancing?

3. What is the role of changes in different emissions sources, in the inconsistent trends in $NO_2$ concentrations in different cities during social distancing?

Technical approach

• Utilize oversampled images (averages over many days) from TROPOMI to identify $NO_2$ changes in North American cities

• Couple the TROPOMI $NO_2$ data to ERA-5 re-analysis to disentangle the effects of meteorology on urban $NO_2$, in order to isolate the anthropogenic signal

• Use granular traffic data for individual cities to tease out the effects of changing transportation patterns on urban $NO_2$

• Discuss with stakeholders (C40 and International Council on Clean Transportation) along the way, getting feedback on a monthly basis.
Project team and organization

• Co-PI’s: Dr. Susan Anenberg & Dr. Daniel Goldberg
• Postdoctoral scientist: Dr. Gaige Kerr
• Collaborators:
  • Dr. Zifeng Lu, Argonne National Laboratory
  • Dr. Debora Griffin, Environment & Climate Change Canada
  • Dr. Chris McLinden, Environment & Climate Change Canada
  • Dr. Bryan Duncan, NASA Goddard Space Flight Center
  • Ray Minarjes, International Council of Clean Transportation
  • Josh Miller, International Council of Clean Transportation
  • Joel Dreessen, Maryland Department of the Environment
• Stakeholder organizations:
  • C40 cities
  • International Council of Clean Transportation
  • State environmental agencies (e.g., Maryland)
TROPOMI NO$_2$: Difference between 2019 vs. 2020

• As compared to 2019, the first three months of the 2020 COVID-19 lockdowns caused NO$_2$ to decrease in North American cities, but to varying degrees.

• Three questions arose to us:
  1. How does this affect environmental justice issues related to air quality?
  2. How would this look like if meteorology was “normalized” out?
  3. How did varying degrees of social distancing and urban transportation changes cause these NO$_2$ decreases?
During COVID-19 precautions, less educated, minority communities experience the largest decreases in NO₂.
Despite decreases for communities that are less White, lockdowns did not eliminate disparities by race

- In many cities, the post-lockdown NO$_2$ amounts in the Least white communities are still larger than the pre-lockdown NO$_2$ amounts in U.S. cities (NYC, LA & Chicago are examples)
Isolating the anthropogenic signal using TROPOMI NO$_2$: Warm season vs. cold season

- NO$_2$ amounts are always less during the summer as compared to winter. This is due to the shorter NO$_2$ during summer.

- If we were to directly compare February 2020 NO$_2$ concentrations to July 2020 NO$_2$ concentrations, some fraction of this change would be due to lifetime changes.
Isolating the anthropogenic signal using TROPOMI NO$_2$: Effects of wind speed & direction

- Similarly, wind speed and direction can have dramatic effects on NO$_2$ concentrations in urban areas
Estimated changes in anthropogenic NO\textsubscript{X} due to COVID-19 precautions (through April 30, 2020 only)

Largest NO\textsubscript{2} drops in San Jose, Los Angeles, & Toronto

Smallest NO\textsubscript{2} drops in Dallas, Miami & Minneapolis

Weather favorable for lower NO\textsubscript{2} (e.g., winder): Washington DC & Miami

Weather favorable for larger NO\textsubscript{2} (e.g., stagnant): Montreal, New Orleans & Las Vegas
Scientific accomplishments so far

1. Near real-time documentation of NO$_2$ changes in global cities (https://so2.gsfc.nasa.gov/tropno2/tropno2_index.html)
2. Investigated how NO$_2$ changes in disadvantaged communities compare to changes in other communities
3. Developed a methodology to isolate meteorological effects on urban NO$_2$ in order to isolate the anthropogenic change in cities
Partners at C40 are in contact with the local governments of 13+ cities worldwide to gauge interest on collaboration and to better understand how our work can be policy-relevant.

- **Auckland** - Waiting for update on activity and fuel mix details
- **Barcelona** - Has already accounted for meteorological and emission changes in the city's original COVID-19 assessment thus the GW project won't add value - city was not included in the first round of calls.
- **Berlin** - We have everything we need
- **Bogota** - We have everything we need
- **Durban** - Waiting for update on activity and fuel mix details
- **Lima** - Waiting for update on activity and fuel mix details
- **London** - We have everything we need
- **Los Angeles** - We have everything we need
- **Medellin** - Waiting for update on activity details
- **Mexico City** - They rely on Waze and TomTom for traffic data since August 2019 - otherwise we have everything we need
- **Milan** - Waiting for activity and fuel mix details
- **Paris** - We have everything we need
- **Santiago** - Waiting for activity and fuel mix details
Successes and challenges

• **Successes:**
  – Quick turn-around of information; critical for stakeholder organizations
  – Somewhat surprising results regarding environment justice work; did not expect NO₂ drops in disadvantaged communities to be so large
  – Implemented a strategy to account for meteorological effects on NO₂ in near-real-time

• **Challenges:** obtaining traffic & fuel data in cities worldwide; changing stringency of lockdowns sometimes on a weekly basis and can vary dramatically by region & country

• **Next priorities:** teasing out impacts of social distancing & urban transportation on NO₂ concentrations and NOₓ emissions

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Manuscript/Publications
