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

Dr. Dan Goldberg
Dr. Susan Anenberg
Dr. Gaige Kerr

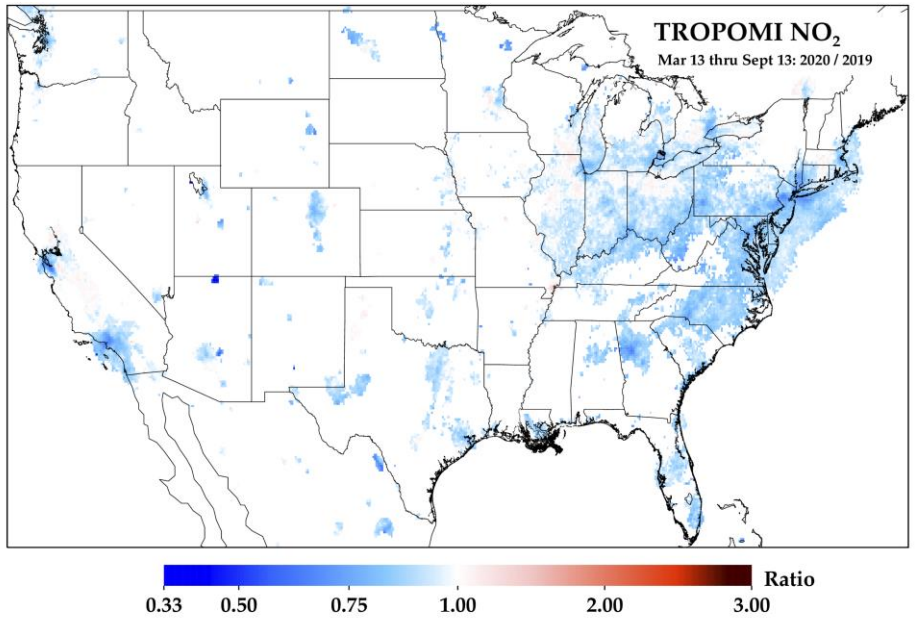
Project Aims:

1. **Evaluate how NO_2 concentrations changed in cities with different magnitude social distancing response to COVID-19**

2. **Disentangle the role of meteorology versus emissions in reducing NO_2 following social distancing measures**

3. **Identify contributions of different emission sources to the inconsistent trends in NO_2 concentrations in different cities following social distancing**

Aims 1 & 2



City	Changes
San Jose:	-33.6%
Los Angeles:	-30.0%
New York City:	-26.7%
Atlanta:	-26.5%
Boston:	-24.7%
Washington DC:	-24.5%
Philadelphia:	-21.5%
Toronto:	-20.4%
Seattle:	-19.5%
Chicago:	-18.7%
Detroit:	-17.1%
Denver:	-16.7%
Houston:	-16.4%
Miami:	-15.3%
Phoenix:	-13.1%
Minneapolis:	-12.6%
San Francisco:	-12.4%
Las Vegas:	-11.8%
Vancouver:	-10.4%
Portland:	-10.1%
Austin:	-8.8%
Dallas:	-7.9%
New Orleans:	-1.7%

Disentangling the Impact of the COVID-19 Lockdowns on Urban NO_2 From Natural Variability

Daniel L. Goldberg[1,2], Susan C. Anenberg[1], Debora Griffin[3], Chris A. McLinden[3], Zifeng Lu[2], and David G. Streets[2]

[1]Department of Environmental and Occupational Health, George Washington University, Washington, DC, USA, [2]Energy Systems Division, Argonne National Laboratory, Lemont, IL, USA, [3]Air Quality Research Division, Environment and Climate Change Canada (ECCC), Toronto, Ontario, Canada

Goldberg et al., 2020

TROPOMI: A Revolutionary New Satellite Instrument Measuring NO_2 Air Pollution

by Daniel L. Goldberg, Susan C. Anenberg, Gaige Hunter Kerr, Zifeng Lu, and David G. Streets

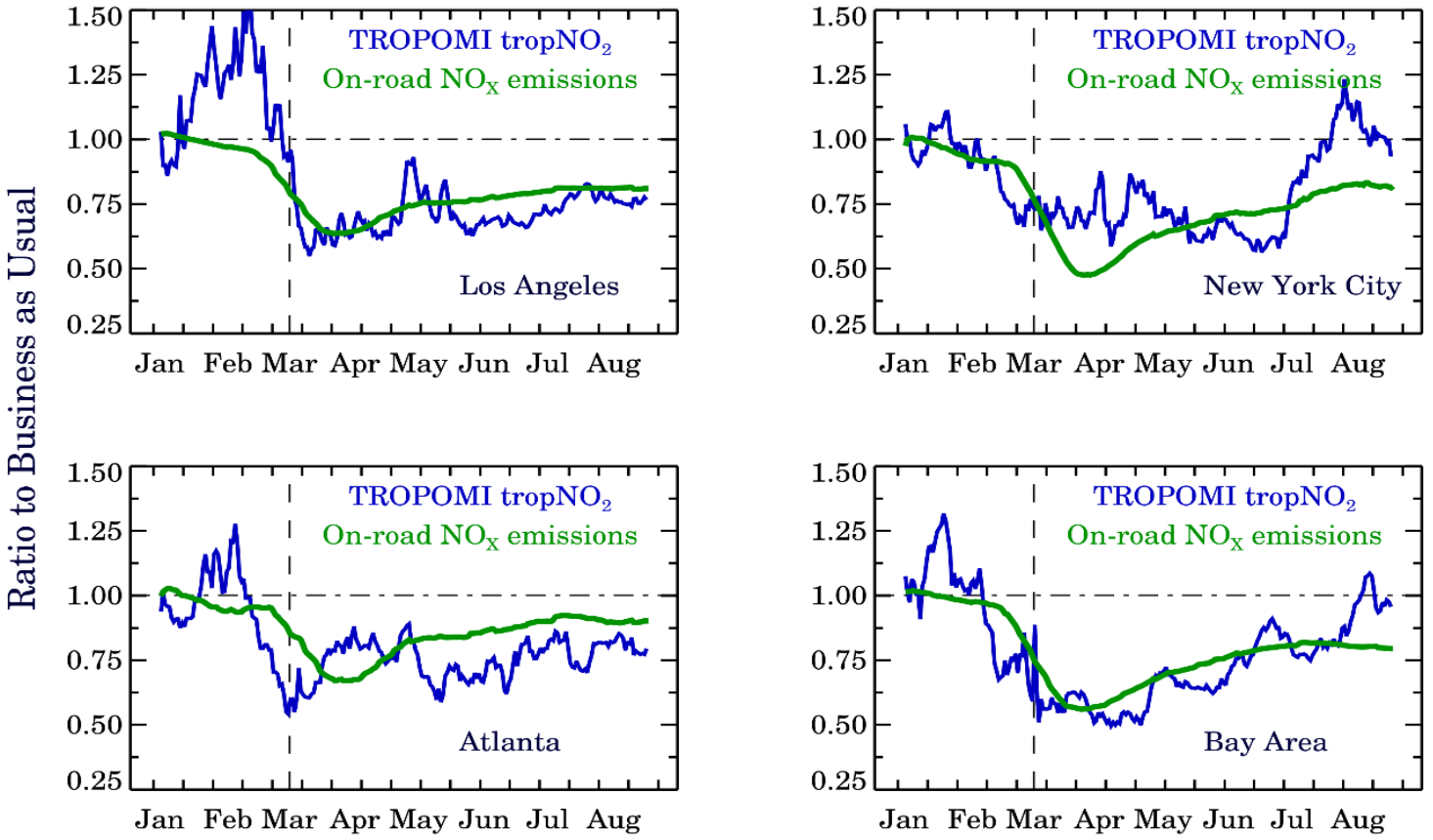
Goldberg et al., 2021

Accounting for weather & comparing to fuel sales (Aims 1 & 2)

COVID-19 Induced Fingerprints of a New Normal Urban Air Quality in the United States

S. Kondragunta[1], Z. Wei[2], B. C. McDonald[3], D. L. Goldberg[4], and D. Q. Tong[5]

Kondragunta et al., 2021



TROPOMI tropNO2–from Goldberg et al. (2020)

On-road NO_X emissions – derived from gasoline and diesel fuel sales Harkins et al. (2021)

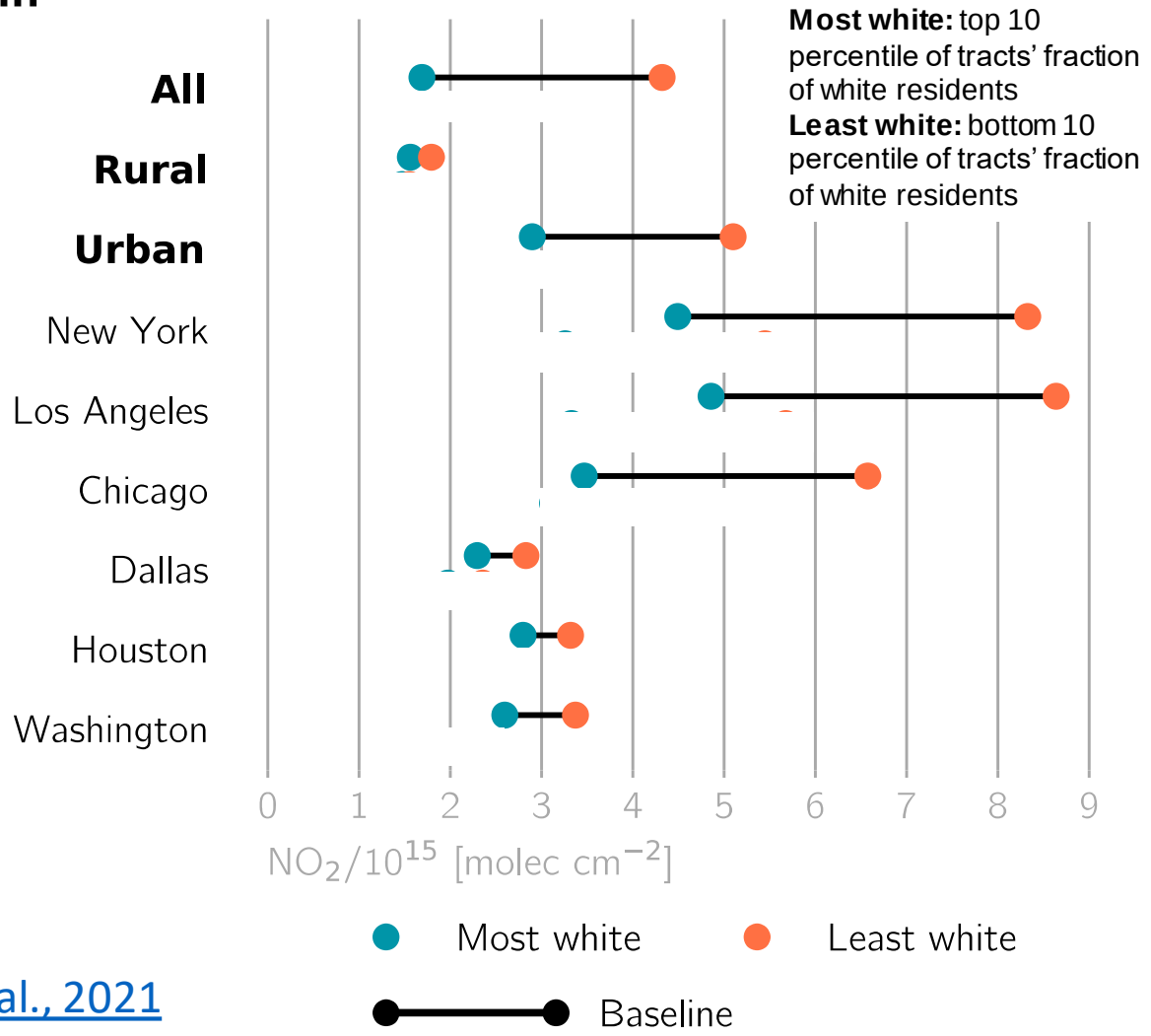
Generally good correlation between on-road NOx emissions and TROPOMI after normalizing for the weather

Lockdowns did not eliminate, or in several cities significantly reduce, NO_2 disparities (Aims 1 & 3)

COVID-19 pandemic reveals persistent disparities in nitrogen dioxide pollution

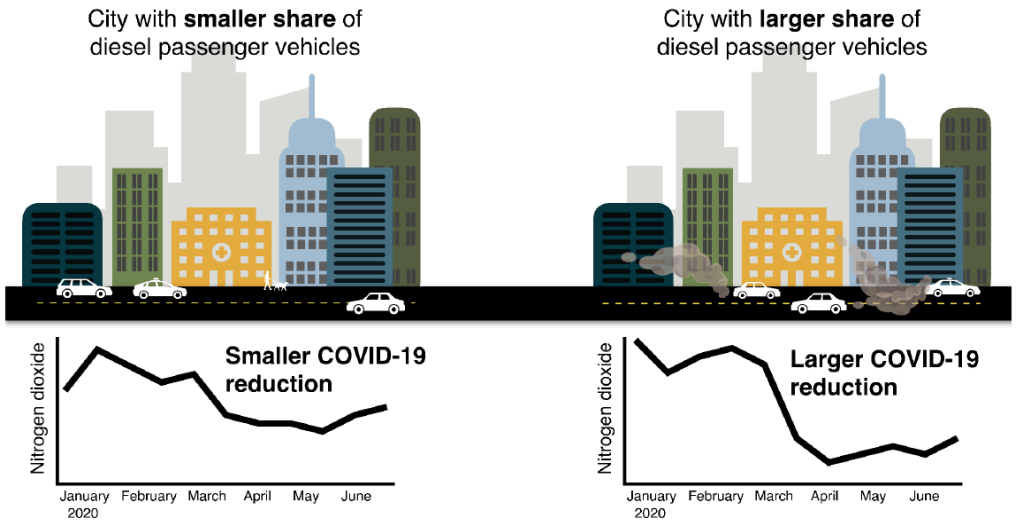
Gaige Hunter Kerr[a,1], Daniel L. Goldberg[a,b], and Susan C. Anenberg[a]

- NO_2 levels in the least white urban census tracts were ~1.7 times higher than levels in the most white tracts prior to the pandemic.
- NO_2 concentrations dropped substantially during the pandemic, but disparities persisted.
- **The least white communities experienced higher levels of NO_2 during the pandemic (~50% removal of personal vehicles) than the most white communities faced prior to the pandemic.**

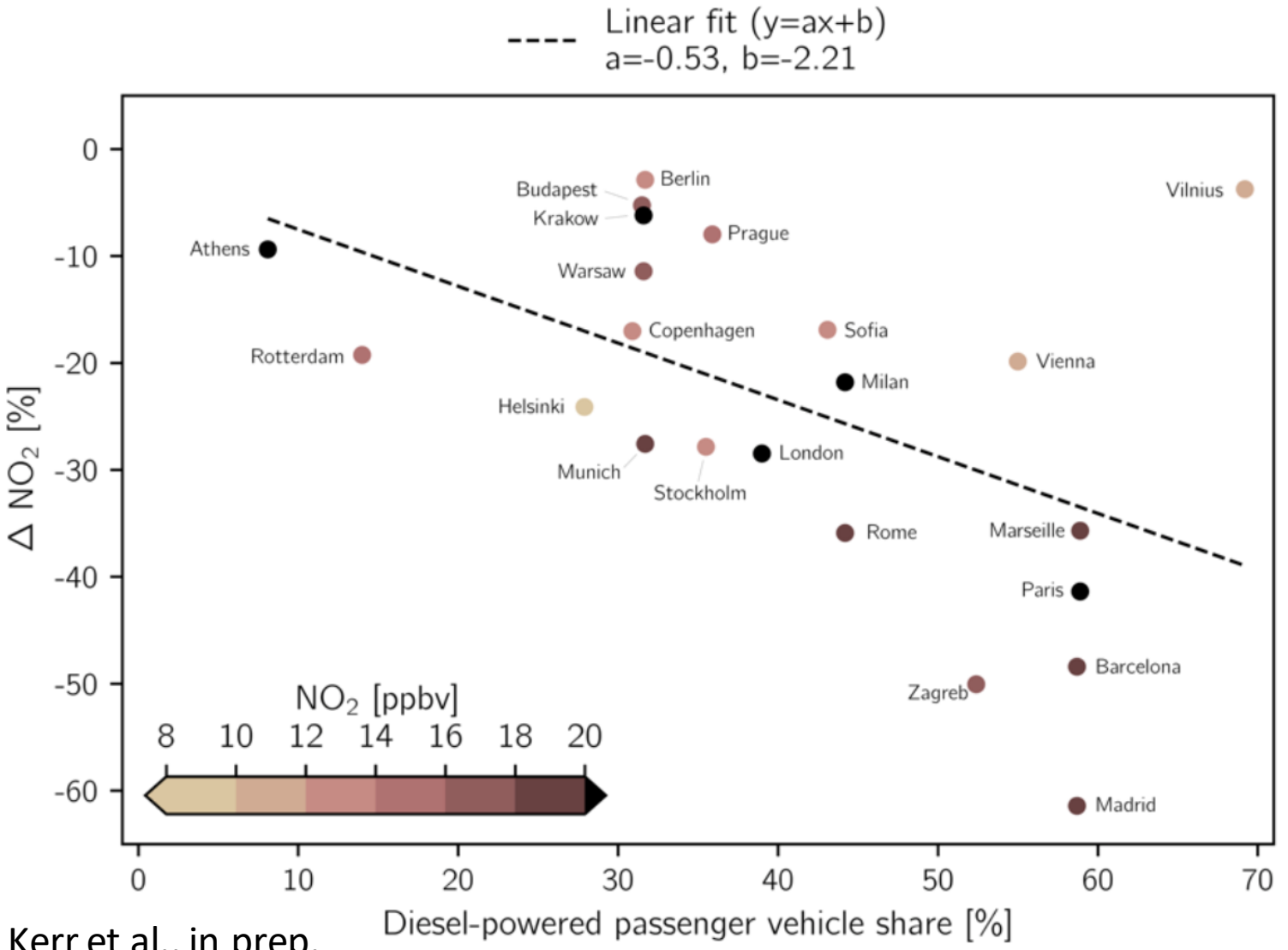


Kerr et al., 2021

Diesel passenger vehicle shares influenced COVID-19 changes in NO2 pollution (Aims 1, 2 & 3)



- 5% reduction in NO_2 during the lockdowns for each additional 10% *diesel* vehicle fraction
- Also a function of age of vehicle fleet
- Transitioning diesel vehicles, *especially older diesel vehicles*, to electric vehicles should be the highest priority for urban governments



Kerr et al., in prep.

Engagement with Stakeholders & Conclusions

Engagement with stakeholders

- Routine engagement with C40. Workshop in early September with six C40 cities to discuss path forward
- Presentation to Ozone Transport Commission; Mid-Atlantic Regional Air Management Association; University of California - Riverside; and Online Summer Workshop in Environment, Energy, and Transportation
- Interviews with Nature, NYTimes, Washington Post, NPR Radio (WAMU 88.5), ABC News, WSB-TV Atlanta, The Weather Channel, Science Sessions podcast, COVIDCalls, and others
- Outreach to congressional and executive offices (Rep. McNerney, Sen. Markey, House SS&T, and White House Council on Environmental Quality) to discuss air inequality

Conclusions

- NO_2 drops attributed to COVID-19 lockdowns ranged between 9%-43% among 20 cities in North America, with a mean of 22%.
- Racial disparities in NO_2 concentrations in the U.S. persisted through the pandemic. NO_2 in the most-white neighborhoods pre-pandemic was still lower than NO_2 in least-white neighborhoods post-pandemic.
- We link persistent NO_2 disparities to heavy-duty *diesel* traffic emissions; future policies to mitigate disparities should target this sector.

Manuscripts published:

5 first-author, 5 co-author

1. **Goldberg, D. L., Anenberg, S. C.,** Griffin, D., McLinden, C. A., Lu, Z. and Streets, D. G.: Disentangling the Impact of the COVID-19 Lockdowns on Urban NO_2 From Natural Variability, *Geophys. Res. Lett.,* 47(17), doi:10.1029/2020GL089269, **2020.**
2. Gorris, M. E., **Anenberg, S. C., Goldberg, D. L., Kerr, G. H.,** Stowell, J. D., Tong, D. and Zaitchik, B. F.: Shaping the future of science: COVID-19 highlighting the importance of GeoHealth, GeoHealth, 5(5), e2021GH000412, doi:10.1029/2021gh000412, **2021.**
3. **Kerr, G. H., Goldberg, D. L. and Anenberg,** S. C.: COVID-19 pandemic reveals persistent disparities in nitrogen dioxide pollution, *Proc. Natl. Acad. Sci.,* 118(30), e2022409118, doi:10.1073/pnas.2022409118, **2021.**
4. Kondragunta, S., Wei, Z., McDonald, B. C., **Goldberg, D. L.** and Tong, D. Q.: COVID-19 Induced Fingerprints of a New Normal Urban Air Quality in the United States, J. *Geophys. Res. Atmos.*, e2021JD034797, doi:10.1029/2021JD034797, **2021.**
5. **Goldberg, D. L., Anenberg, S. C., Kerr,** G. H., Lu, Z. and Streets, D. G.: TROPOMI: A revolutionary new satellite instrument measuring NO2 air pollution, *Environ. Manag.,* link, **2021.**
6. **Anenberg, S., Kerr, G. H. and Goldberg, D. L.:** Leveraging satellite data to address air pollution inequities, *Environ. Manag.,* link, **2021.**
7. Laughner, J. L., …, **Anenberg, S, C., Goldberg, D. L.,** …, Zeng, Z.-C.: Societal shifts due to COVID-19 reveal large-scale complexities and feedbacks between atmospheric chemistry and climate change, *Proc. Natl. Acad. Sci.,* link, accepted.
8. Tzortzoiu, M., Kwong, C., **Goldberg, D. L.,** Schiferl L., Commane R., Abuhassan N., Szykman J. J., Valin L. C.: Declines and exceedances in column NO_2 amounts in the coastal megacity of New York, during and post the COVID-19 lockdowns, link, submitted.
9. Jing, P., and **Goldberg D. L.:** Ozone in Chicago during the COVID-19 Lockdowns in Summer 2020, submitted.
10. **Kerr, G. H., Goldberg, D. L., Anenberg, S. C.,** … : Diesel passenger vehicle market shares influenced COVID-19 changes in nitrogen dioxide pollution in global cities, in prep.