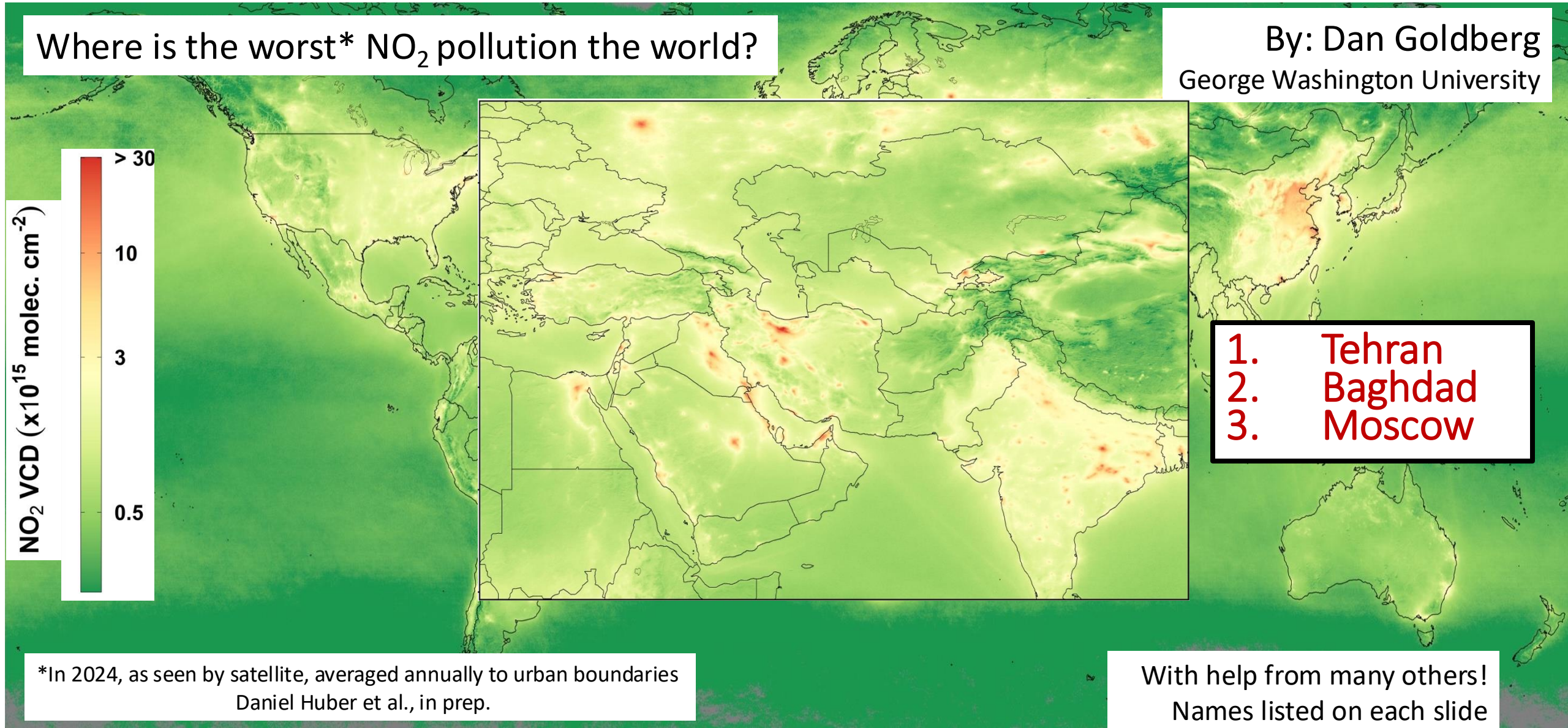
The many successes of satellite NO_2

Where is the worst* NO_2 pollution the world?

By: Dan Goldberg
George Washington University



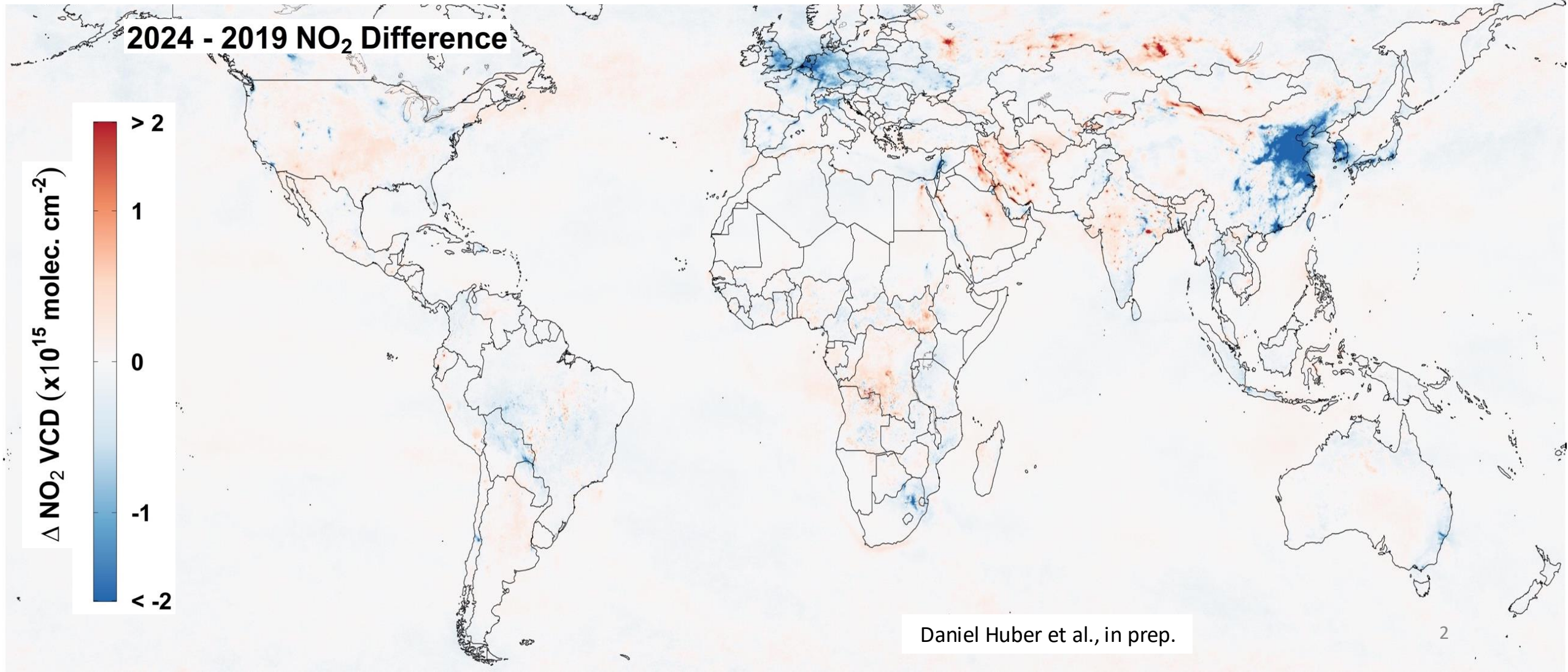
1. Tehran
2. Baghdad
3. Moscow

*In 2024, as seen by satellite, averaged annually to urban boundaries
Daniel Huber et al., in prep.

With help from many others!
Names listed on each slide

Satellite NO_2 data can track global patterns
Recent trends in NO_2 pollution (2019 vs. 2024)

Large NO_2 reductions in China, reductions in Europe, increases in tropics, mixed but mostly down in the U.S.



Daniel Huber et al., in prep.

Satellite NO_2 data can be used to estimate surface concentrations
How does column NO_2 compare to the surface NO_2?

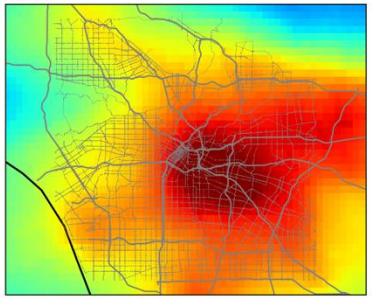
Surface NO_2 patterns are generally captured by satellite columns but ideally merging of EPA AQS + land-use variables + satellite is best

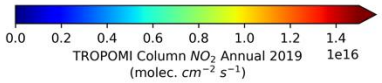
*****Colorbars are different between cities*****

r^2 = 0.72 between surface NO_2 and ground monitors across U.S.

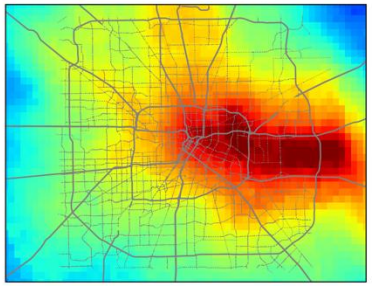
Column NO_2

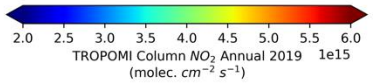
Los Angeles



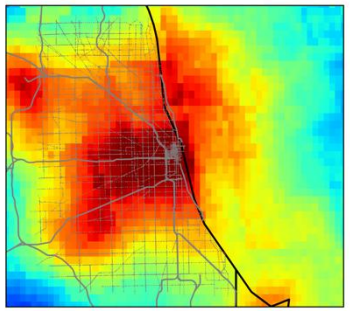


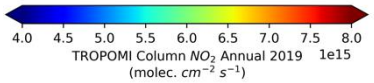
Houston



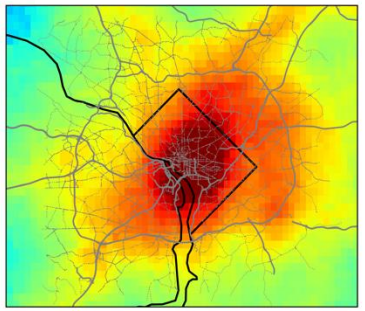


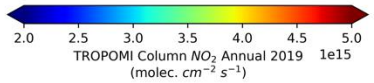
Chicago



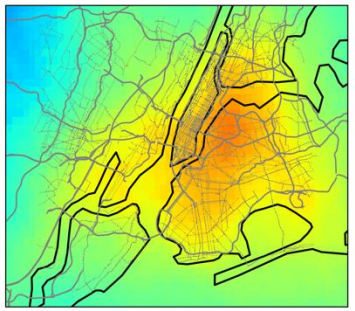


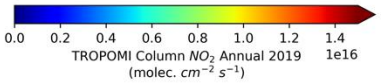
Washington, DC





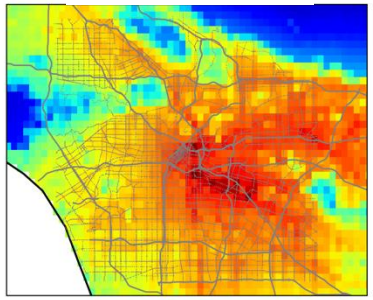
New York City

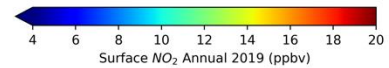




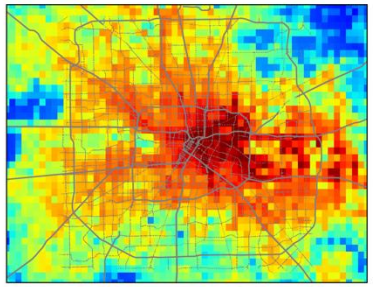
Surface NO_2

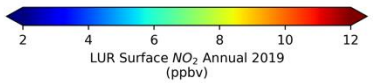
Los Angeles



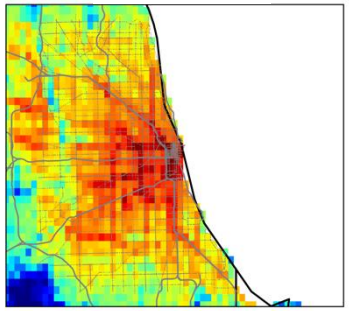


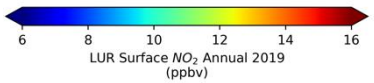
Houston



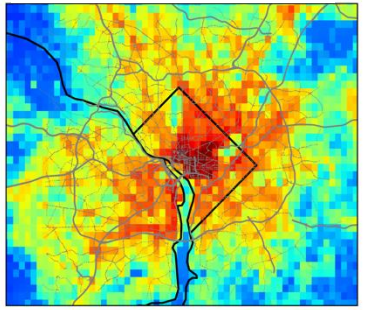


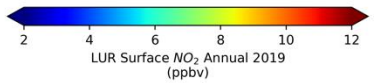
Chicago



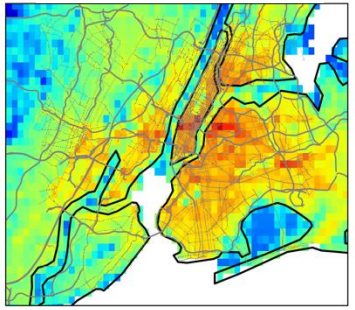


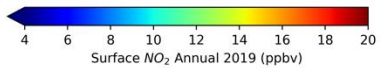
Washington, DC



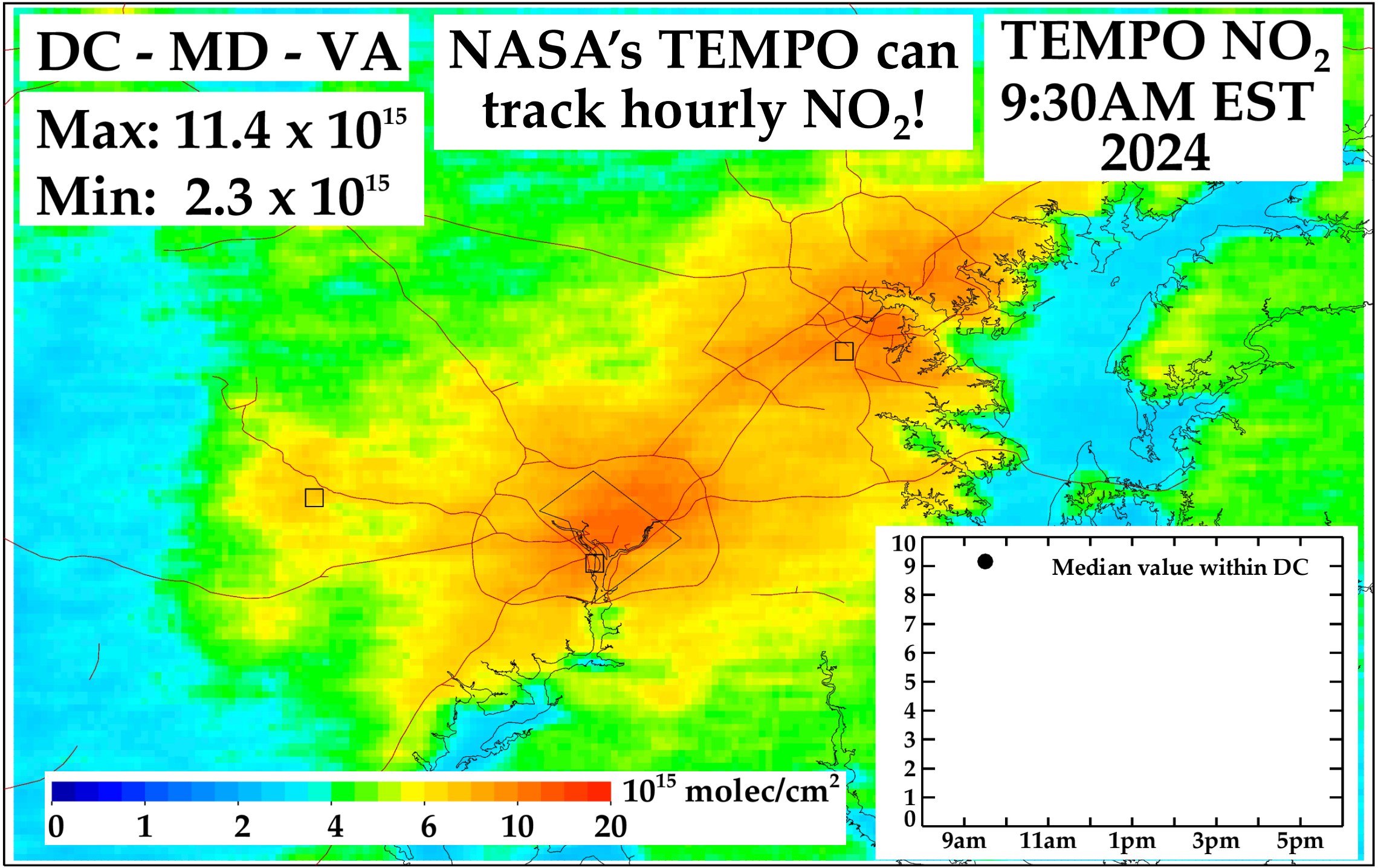


New York City

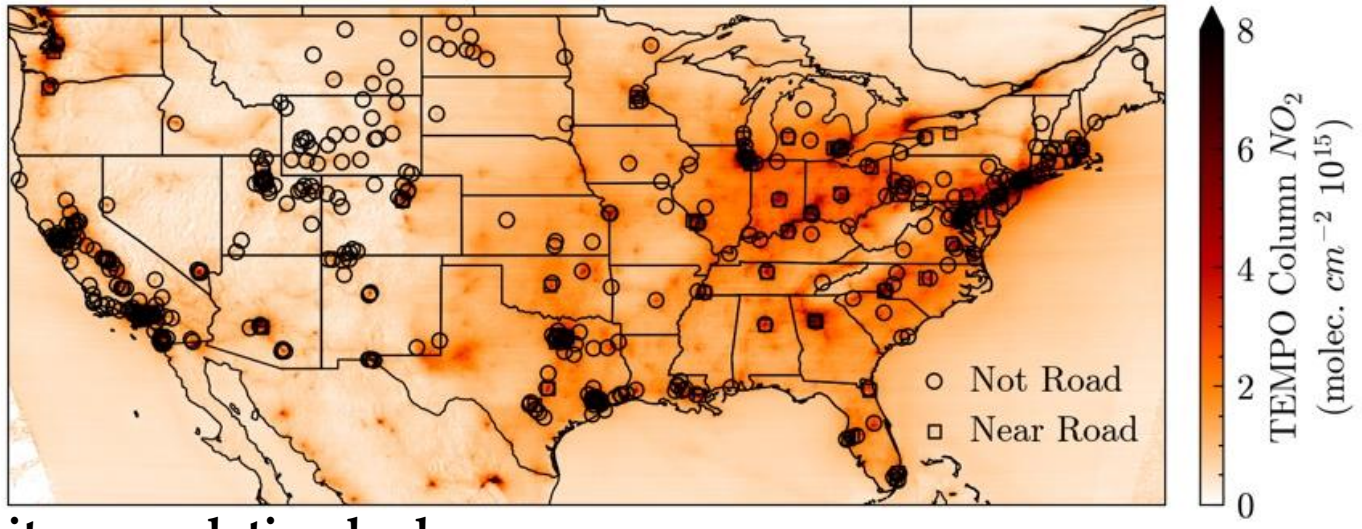




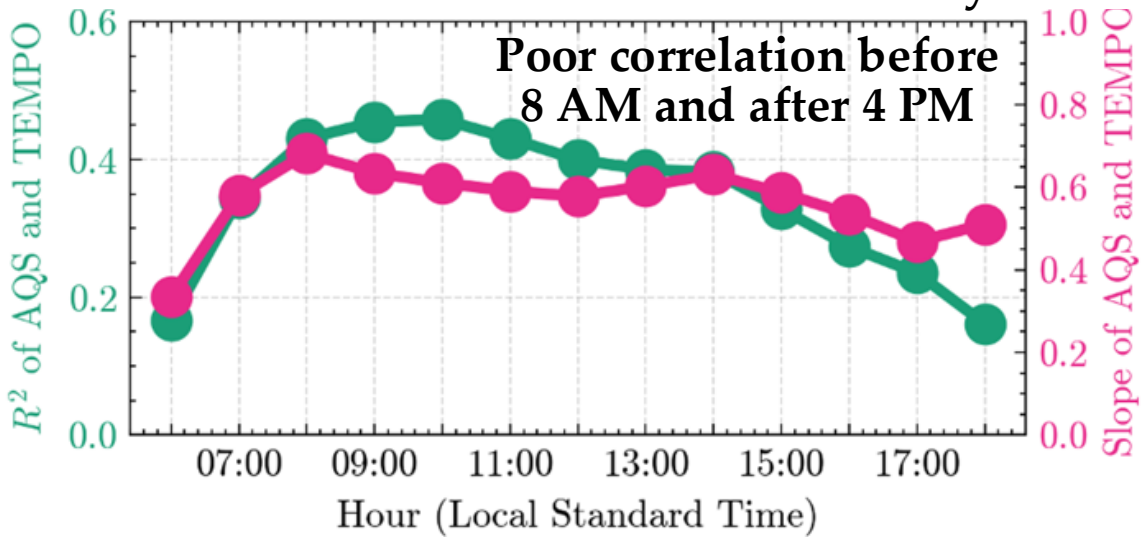
Omar Nawaz et al., 2025


DC - MD - VA
Max: 11.4 x 10^15
Min: 2.3 x 10^15
NASA's TEMPO can track hourly NO2!
TEMPO NO2
9:30AM EST
2024
10^15 molec/cm^2
0
1
2
4
6
10
20
Median value within DC
10
9
8
7
6
5
4
3
2
1
0
9am
11am
1pm
3pm
5pm

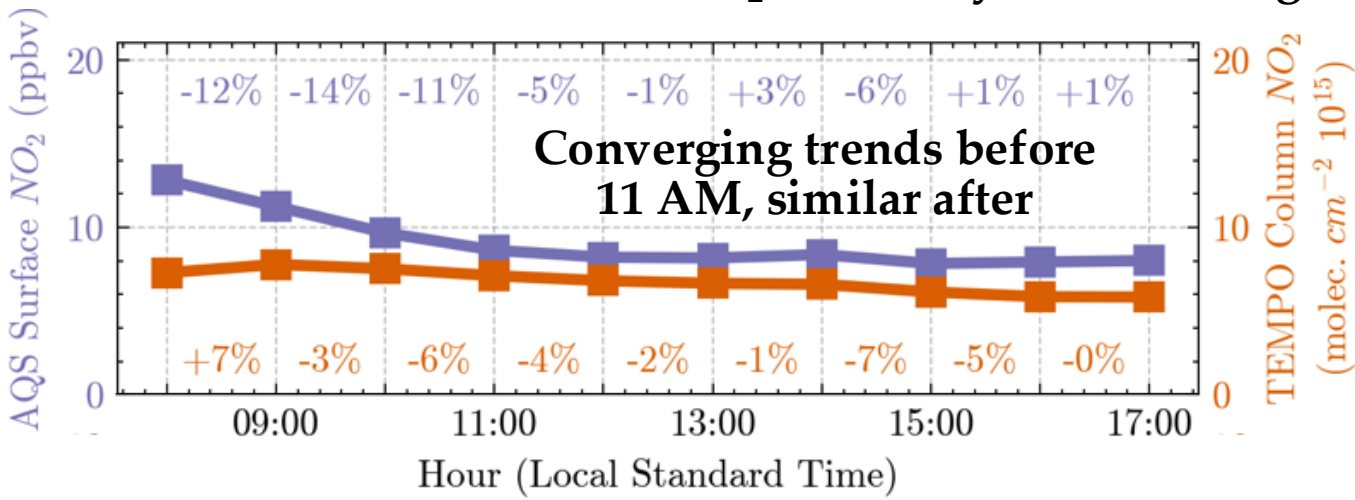
Correlation between column TEMPO NO_2 and surface NO_2 EPA AQS monitors



TEMPO vs. Ground monitor correlation by hour



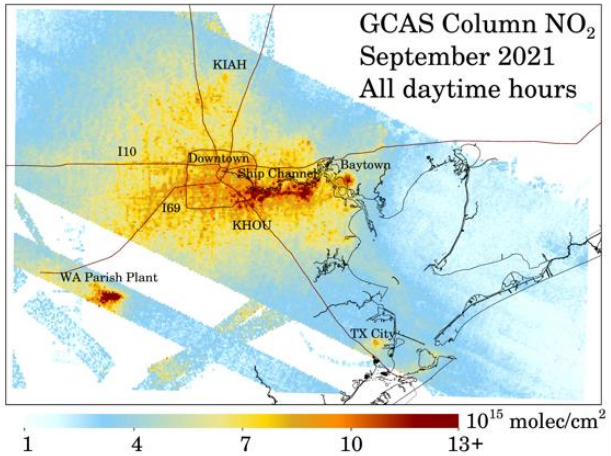
TEMPO vs. Ground monitor NO_2 diurnal cycles in Chicago



Omar Nawaz et al., in prep.

Use of remote sensing to constrain sector NOx in Houston

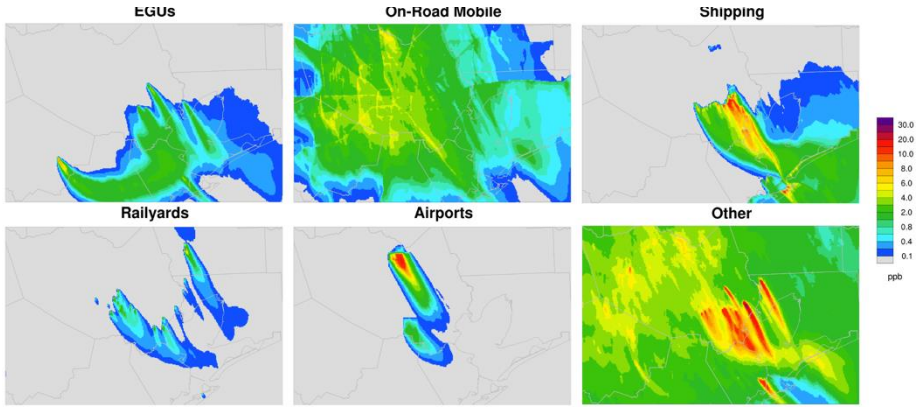
(Goldberg et al., 2024 ES&T Air; Funding from Texas Air Quality Research Program)

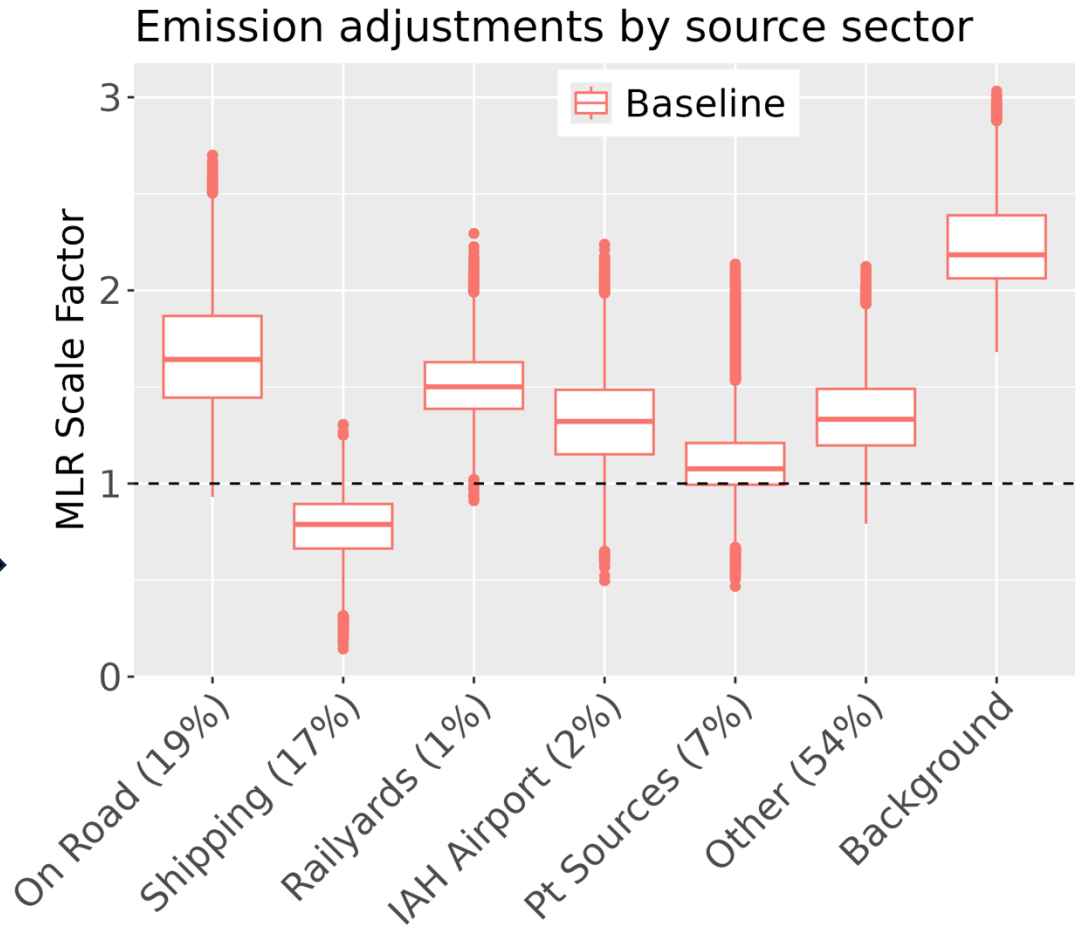


GCAS Aircraft NO_2 Data (could be TEMPO in future)

Multiple linear regression

Model NO_2 Source Apportionment





On Road NOx in model needs to be *increased*

Shipping NOx in model needs to be *decreased*

Background NO_2 in model needs to be *increased*

Thank you! Some more resources…

"Live" TEMPO NO_2 data can be viewed here: https://tempo.si.edu/data_for_public.html
"Live" TROPOMI NO_2 data can be viewed here: https://tropomino2.us

TEMPO data can be downloaded here: https://search.earthdata.nasa.gov/search?q=TEMPO NO2 PROVISIONAL
Gridded Level 3 data must still be cloud filtered!

YouTube tutorials on downloading and understanding TEMPO NO_2 files:
1. **How to download TEMPO data: https://www.youtube.com/watch?v=EGCueSM1dik&ab**
2. **Which TEMPO variable names are relevant: https://www.youtube.com/watch?v=-ZUmt9bvsn0&ab**

TROPOMI NO_2 Monthly, Seasonal, and Annual Averages of column NO_2 (May 2018 – Dec 2024), can be downloaded here:
Continental U.S. at 0.01° × 0.01°: https://search.earthdata.nasa.gov/search?q=HAQ_TROPOMI_NO2_CONUS
Global at 0.1° × 0.1°: https://search.earthdata.nasa.gov/search?q=HAQ_TROPOMI_NO2_GLOBAL

New paper on estimating surface NO_2 using TROPOMI: https://pubs.acs.org/doi/full/10.1021/acsestair.4c00153

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