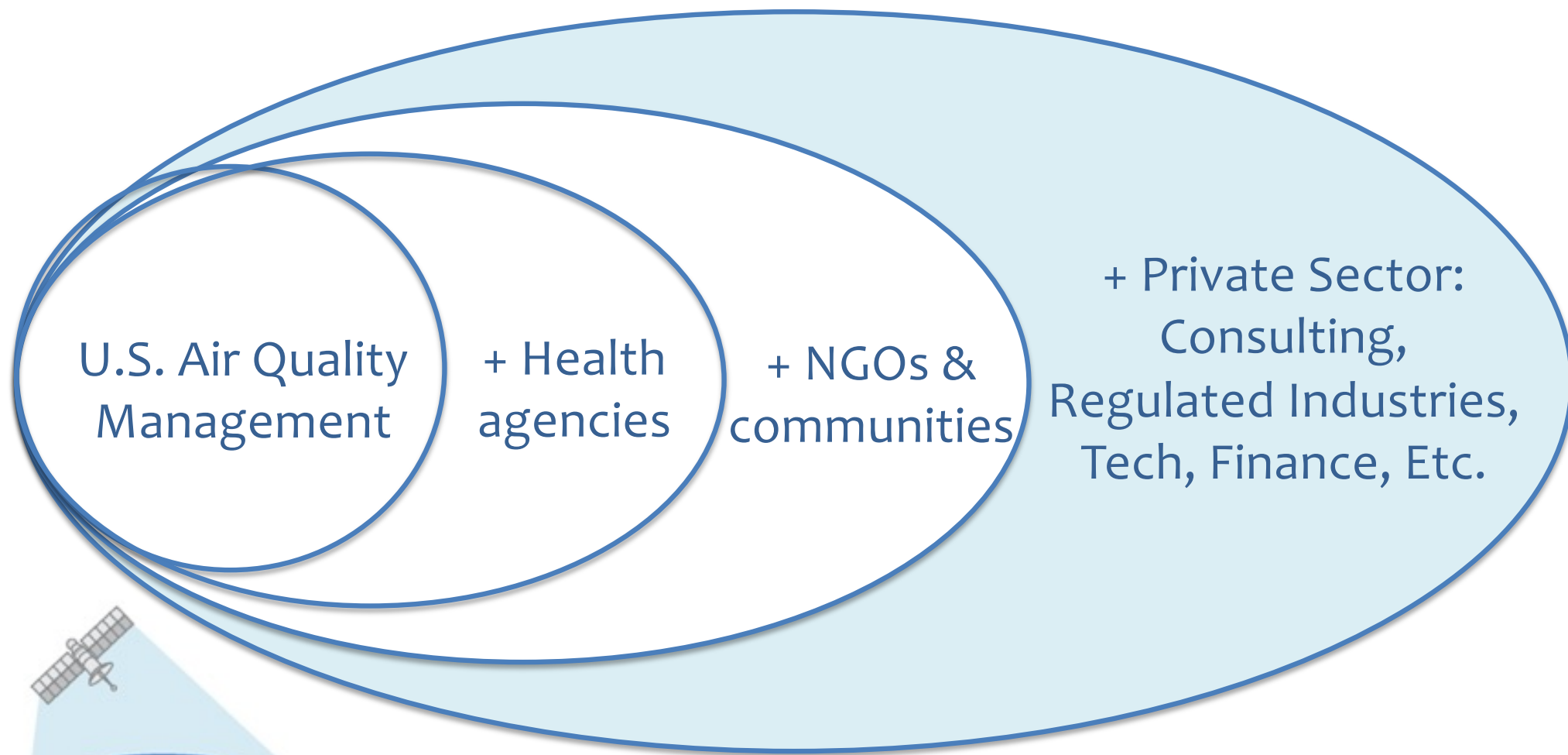




Satellite Data for Environmental Consulting (and More)

Tracey Holloway
University of Wisconsin—Madison





2025 A&WMA CRITICAL REVIEW



Satellite data to support air quality assessment and management

Tracey Holloway ^{a,b}, Jennifer R. Bratburd ^a, Arlene M. Fiore ^c, Gaige H. Kerr ^d, and Jingqiu Mao ^e

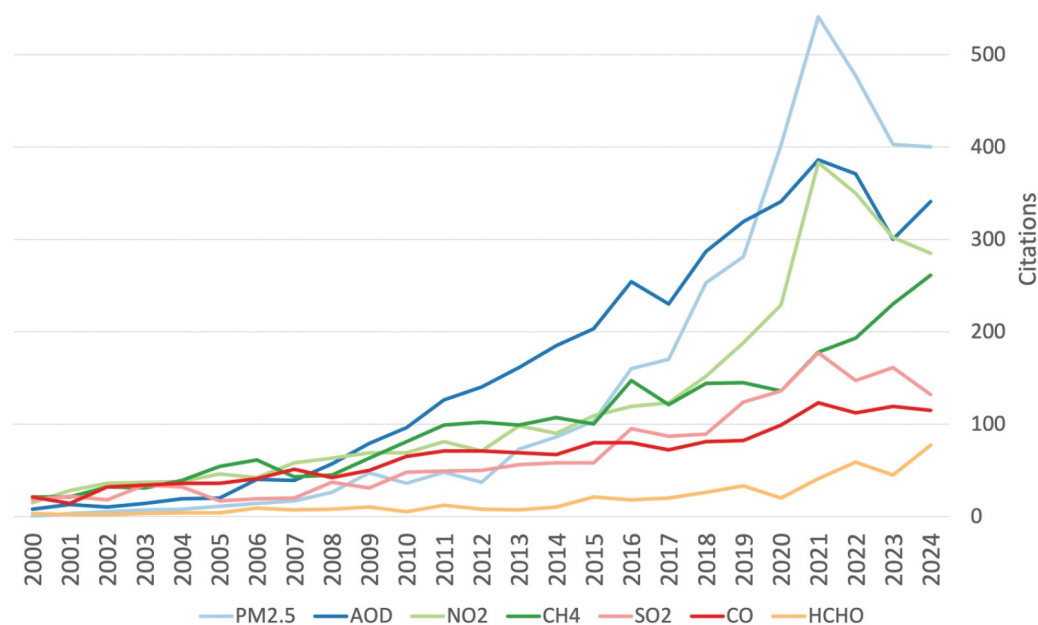


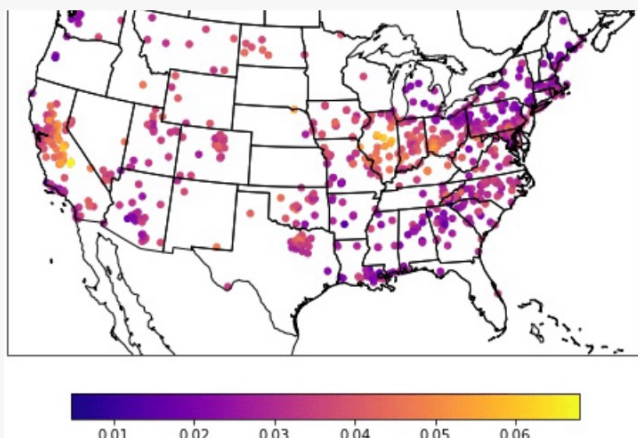
Figure 3. Comparison of citations from Web of Science, based on queries with keywords "PM2.5," "AOD," "NO2," "CH4," "SO2," "CO," "HCHO," and "satellite" over time. All terms searched in web of science (March 6, 2025) as the pollutant term itself with "AND satellite."

Table 1. Instruments relevant to air quality management, discussed in this paper, organized based on common use for AOD and/or for gas-phase species NO₂, HCHO and SO₂. Relevance to other chemical species is noted. We have generalized some domain and resolution information, which may vary depending on retrieval version or changes in operations.

Major Product for Air Quality Applications	Instrument(s) and Satellite(s)	General Domain and Resolution*
NO₂, HCHO & SO₂ (+ ozone + profiles, BrO, OCIO, aerosols + aerosol characterization, cloud properties) aura.gsfc.nasa.gov/omi.html .	Instrument: Ozone Monitoring Instrument (OMI) Satellite: NASA Aura satellite 2004 - Present	Global, daily at 1:30 PM 13 km x 24 km
NO₂, HCHO & SO₂ (+ CO, CH ₄ , AOD + aerosol vertical structure via O ₂ A bands or A & B bands) https://www.tropomi.eu/ .	Instrument: TROPOspheric Monitoring Instrument (TROPOMI) Satellite: ESA Copernicus Sentinel-5 Precursor 2017 - Present	Global, daily at 1:30 PM 5.5 km × 3.5 km [‡]
NO₂, HCHO & SO₂ (+ ozone, aerosol index + reflectivity, cloud parameters) https://acsaf.org/gome-2.php .	Instrument: ESA Global Ozone Monitoring Experiment 2 (GOME-2); Infrared atmospheric sounding interferometer (IASI) Satellites: EUMETSAT Metop-A -B and -C Metop-A: 2006–2021; Metop-B: 2012 - Present; Metop-C: 2019 - Present	Global, every 1.5 days at 9:30 AM 40 × 40 km ² on Metop-A 80 × 40 km ² on Metop-B and -C

Table 1. Instruments relevant to air quality management, discussed in this paper, organized based on common use for AOD and/or for gas-phase species NO₂, HCHO and SO₂. Relevance to other chemical species is noted. We have generalized some domain and resolution information, which may vary depending on retrieval version or changes in operations.

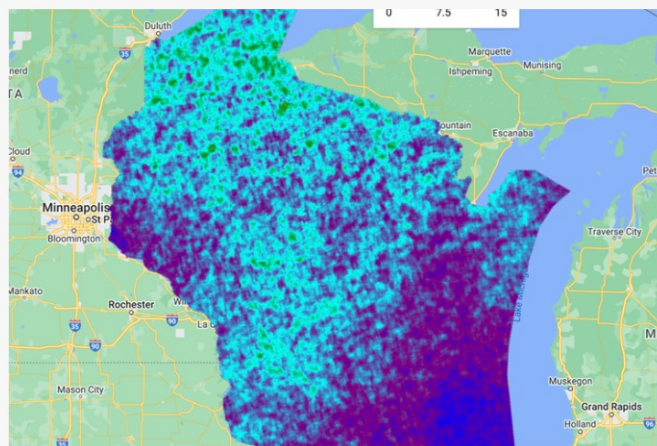
Major Product for Air Quality Applications	Instrument(s) and Satellite(s)	General Domain and Resolution*
Geostationary		
AOD (+ related aerosol characteristics) www.goes-r.gov .	Instrument: Advanced Baseline Imager (ABI) Satellite Series: NOAA Geostationary Operational Environmental Satellites (GOES-R) GOES-16/GOES-East: 2017 - Present, Centered over 75.2° W GOES-18/GOES-West: 2023 - Present, Centered over 137.2° W GOES-17 serves as backup <i>GeoXO planned as next generation 2030s</i>	North America, full disk every 15 minutes, continental United States every 5 minutes 2 km x 2 km
AOD www.data.jma.go.jp/mscweb/en/himawari89/space_segment/spsg_ahi.html .	Instrument: Advanced Himawari Imager (AHI) Satellites: Japanese Space Agency Himawari-8 and Himawari-9, over 140.7° E, Himawari-8: 2014 - Present Himawari-9: 2016 - Present	Asia, Full disk every 10 minutes 2 km x 2 km
NO₂, HCHO & SO₂ (+ AOD, aerosol layer height via O ₂ -O ₂ dimer, ozone)	Instrument: Geostationary Environment Monitoring Spectrometer (GEMS) Satellite: KARI's Geostationary Korea Multipurpose Satellite (GEO-KOMPSAT-2B), over 128.2° E 2020 - Present	Asia, hourly (during daylight) 3.5 km x 8 km
NO₂, HCHO & SO₂^s (+ AOD ^s , ozone) https://tempo.si.edu/ .	Instrument: NASA Tropospheric Emissions: Monitoring of Pollution (TEMPO) Satellite: Intelsat 40e (commercial satellite), over 91° W 2023 - Present	North America, hourly (during daylight) 2 km x 4.75 km



Python Tutorials for Atmospheric and Geophysical Sciences

Designed for undergraduate and graduate students with no or minimal prior coding experience, these atmospheric and geophysical science Python tutorials are targeted toward students with an interest in air quality and the atmospheric sciences.

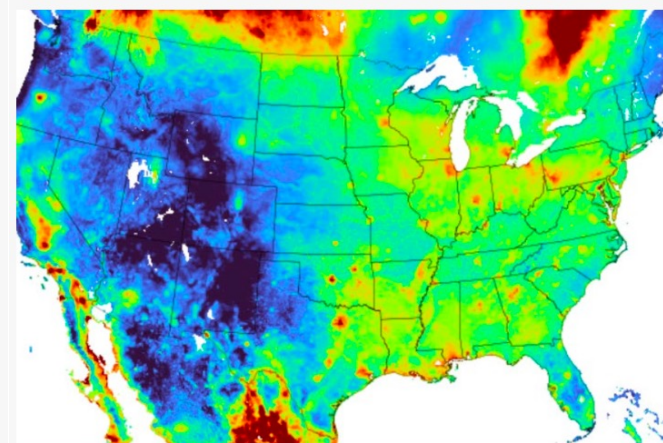
May 3, 2023



Plotting the Ratio of TROPOMI Formaldehyde and Nitrogen Dioxide Satellite Data: An Indicator of Ozone Sensitivity

User friendly tutorials using Google Earth Engine to plot the ratio of formaldehyde to nitrogen dioxide that can be used to assess ozone sensitivity.

Apr 20, 2023



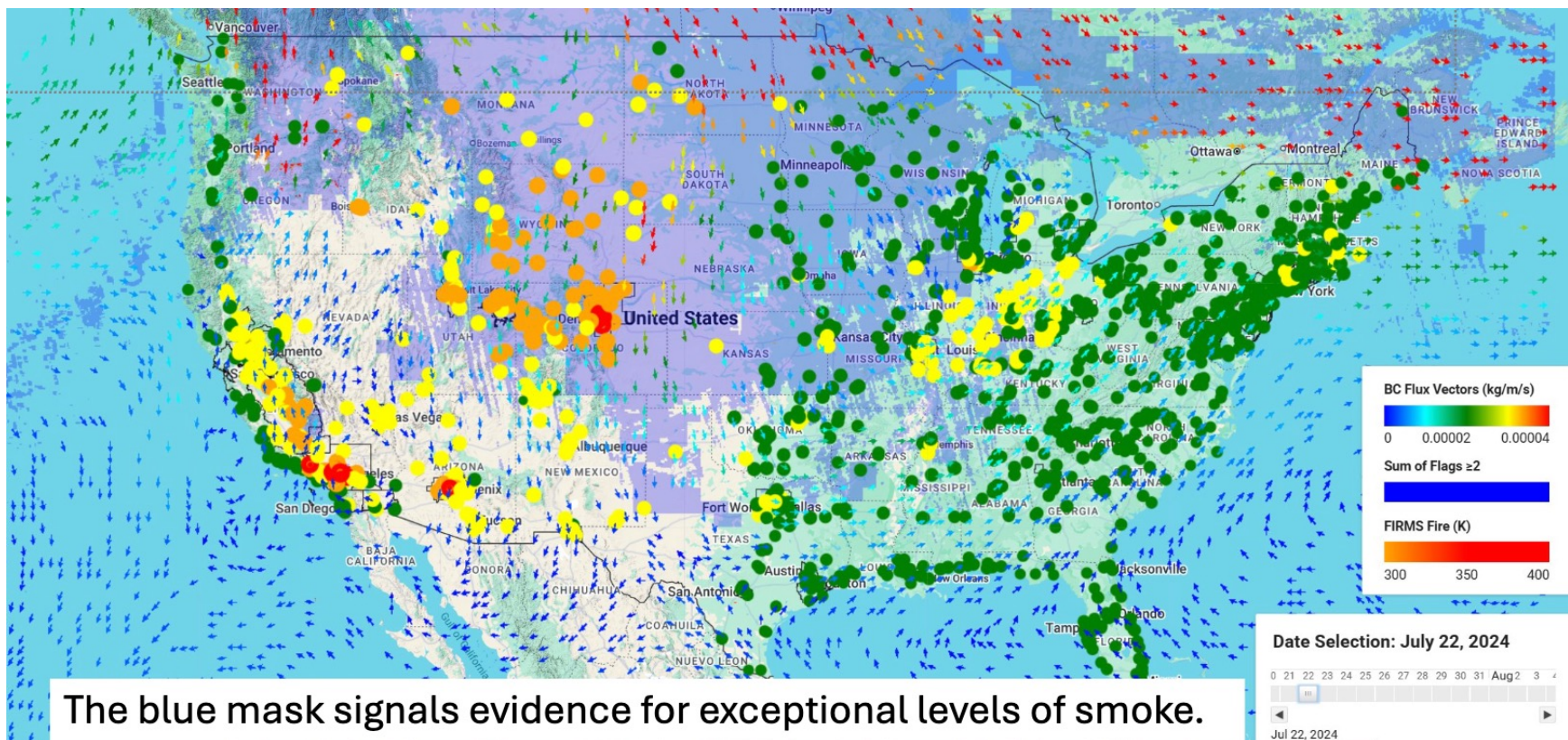
Mapping Washington University in St. Louis Particulate Matter Data in Google Colab

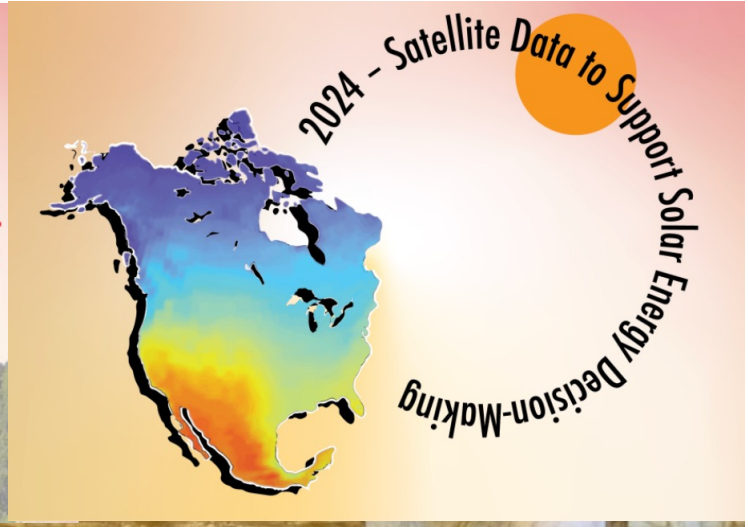
A tutorial on how to download the Washington University in St. Louis (WashU) satellite derived particulate matter (PM2.5) data and upload it into Google Colab.

May 12, 2025

<https://hollowaygroup.org/tutorials>

Smoke Console in Google Earth Engine for Exceptional Event Demonstrations (Pat Reddy – coming soon to HAQAST.org)







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Projects and Partners



Alliant Energy

UW-Madison students worked with Alliant Energy to develop the institution's first solar and agricultural research pilot



American Lung Association

The American Lung Association is working with Project Lead Tracey Holloway



Trek Bikes

Trek supported UW Professor Jonathan Patz to research these health and environmental benefits using

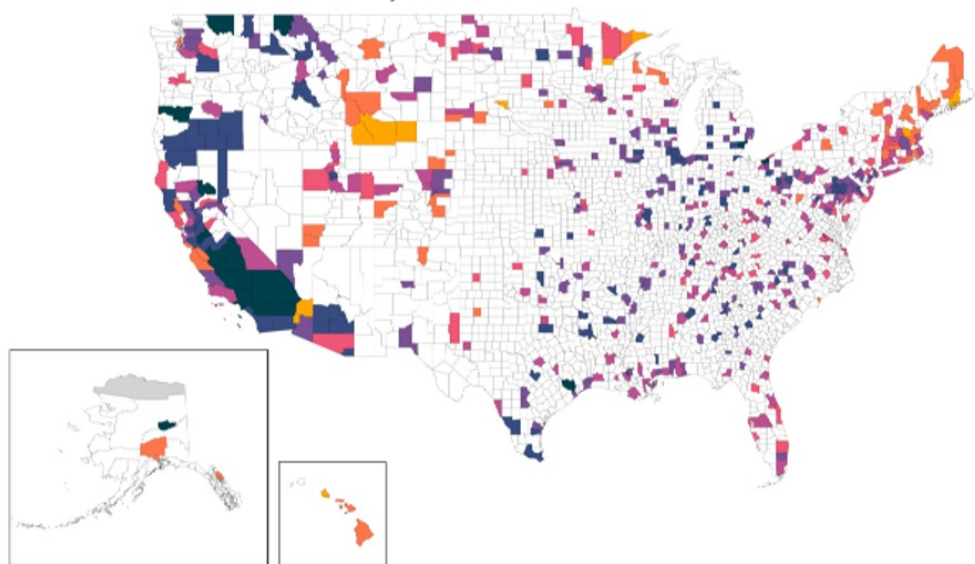
Something in the Air Reports

A series of reports highlighting the promising potential of satellite data to complement and enhance the United States' existing air quality monitoring network.

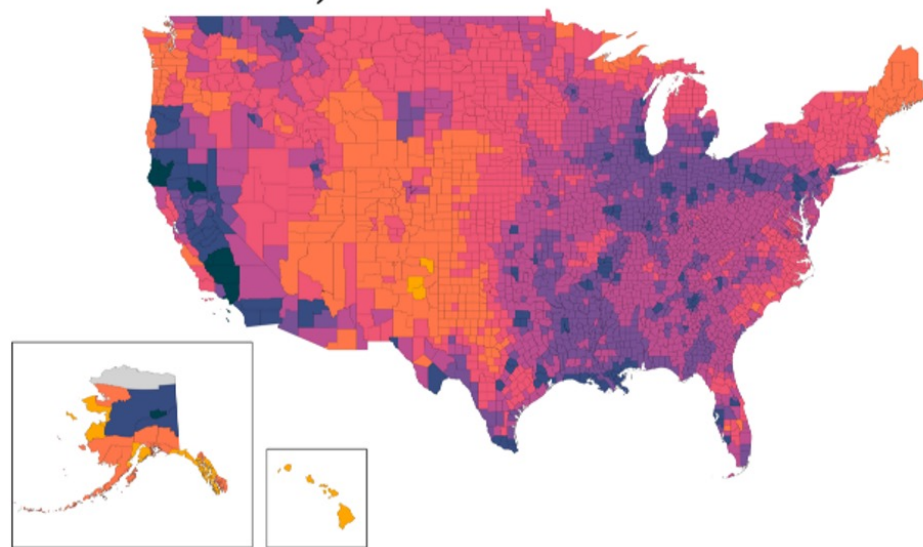


As a nation, we make great strides cleaning up air pollution—but not all communities benefit equally.

a) EPA CDVs



d) All U.S. CDVEs



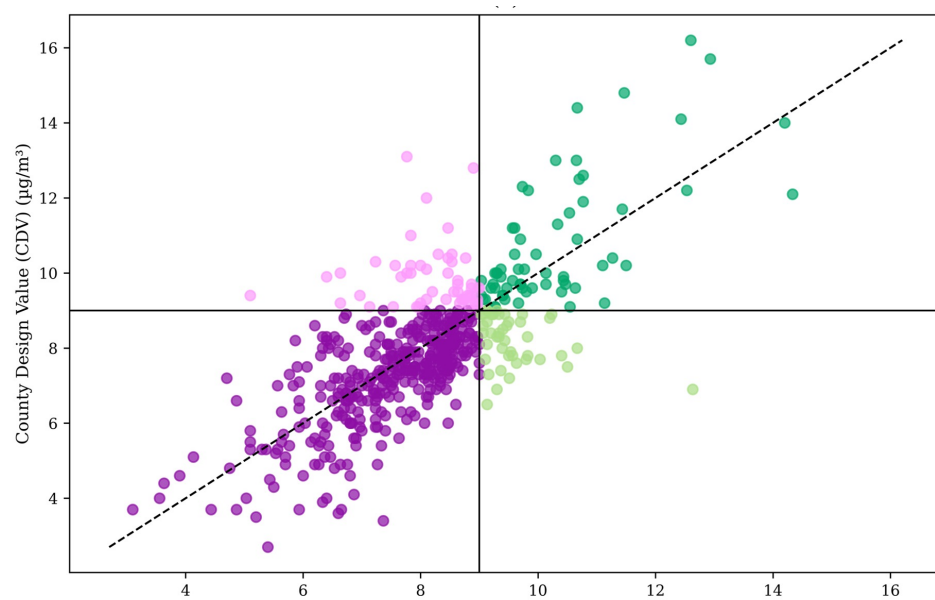
County Design Value (CDV) – highest 3-year annual $\text{PM}_{2.5}$ monitor in county

CDV-Equivalent (CDV-E) – highest 90th percentile satellite-derived $\text{PM}_{2.5}$ grid in county

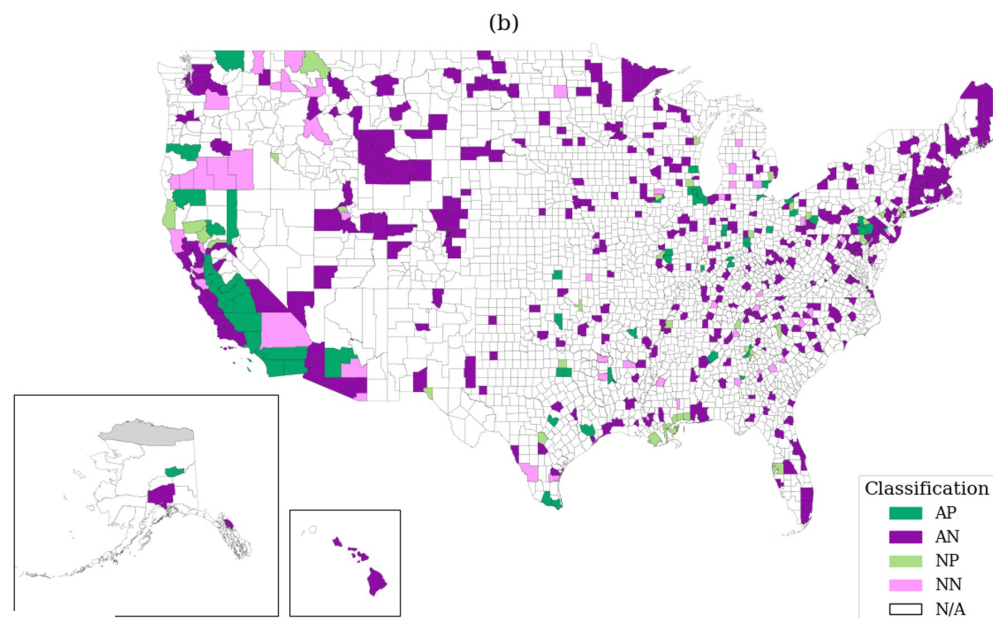


Applying Satellite-Derived $\text{PM}_{2.5}$ Data to Policy-Relevant Air Quality Metrics

Tracey Holloway^{1,2*}, Summer Acker¹, Lizzy Kysela^{1,2}, Colleen Heck^{1,2}, Aaron van Donkelaar³, Randall V. Martin³, Kevin Stewart⁴, Katherine Pruitt⁴



● AP ● AN ● NP ● NN

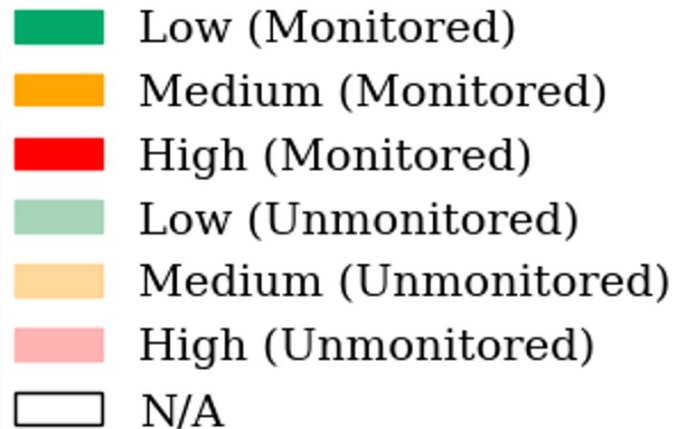


manuscript submitted to *GeoHealth*

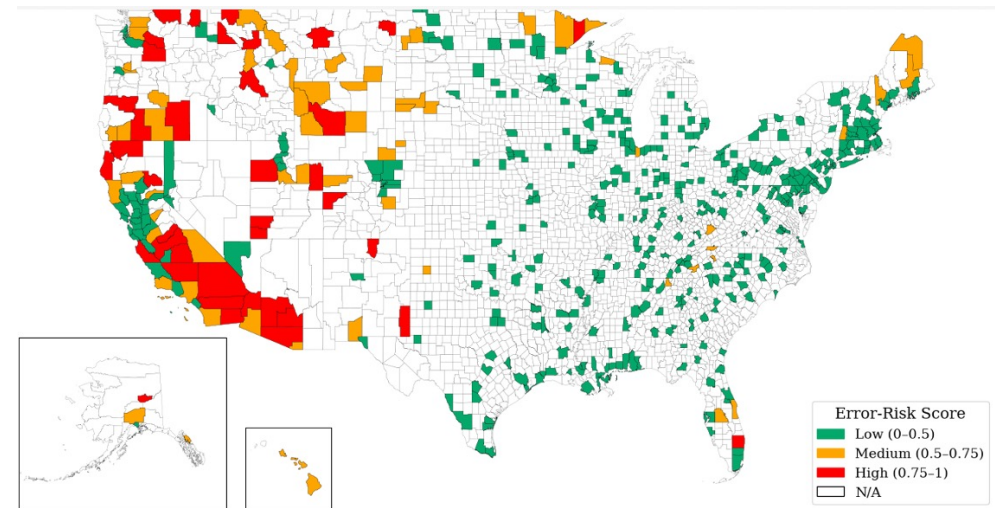
Comparison of policy-relevant air quality metrics calculated with sparse in situ monitoring and contiguous satellite-derived data

Summer Acker^{1*}, Tracey Holloway^{1,2}, Kevin Stewart⁴, Aaron van Donkelaar³, Randall V. Martin³

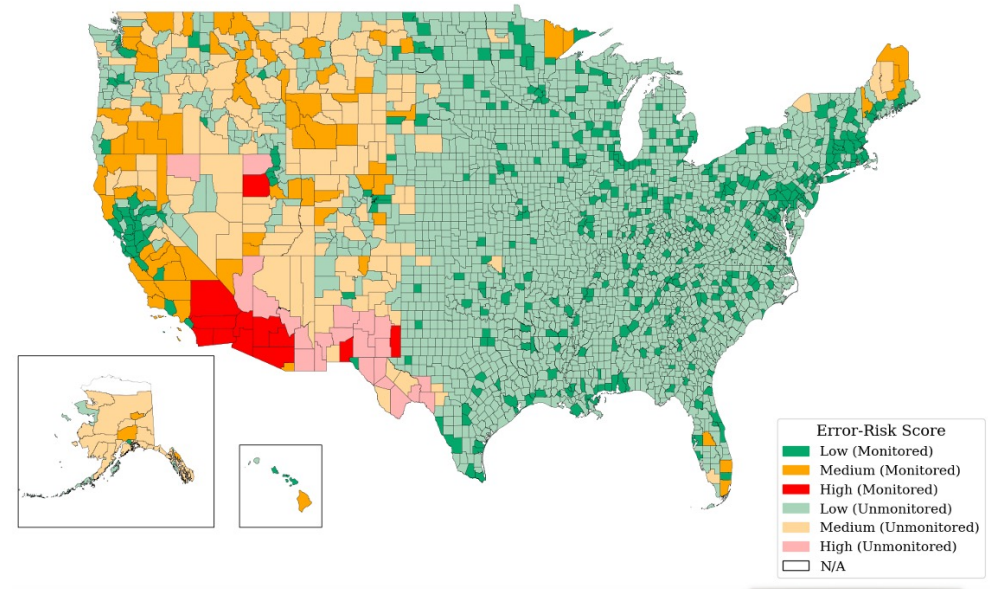
Error-Risk Score



CDV and CDVE are more likely to be **non-aligned** in counties with deserts, mountains, and non-urban land use



b) All Counties



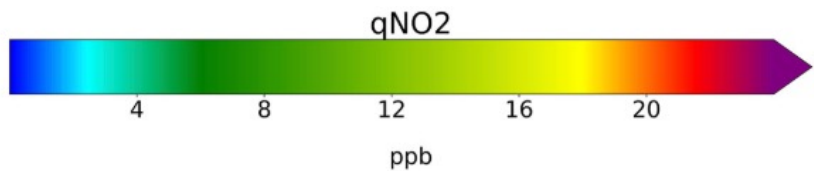
Simulated Surface-Column NO₂ Connections for Satellite Applications

M. Harkey✉ T. Holloway

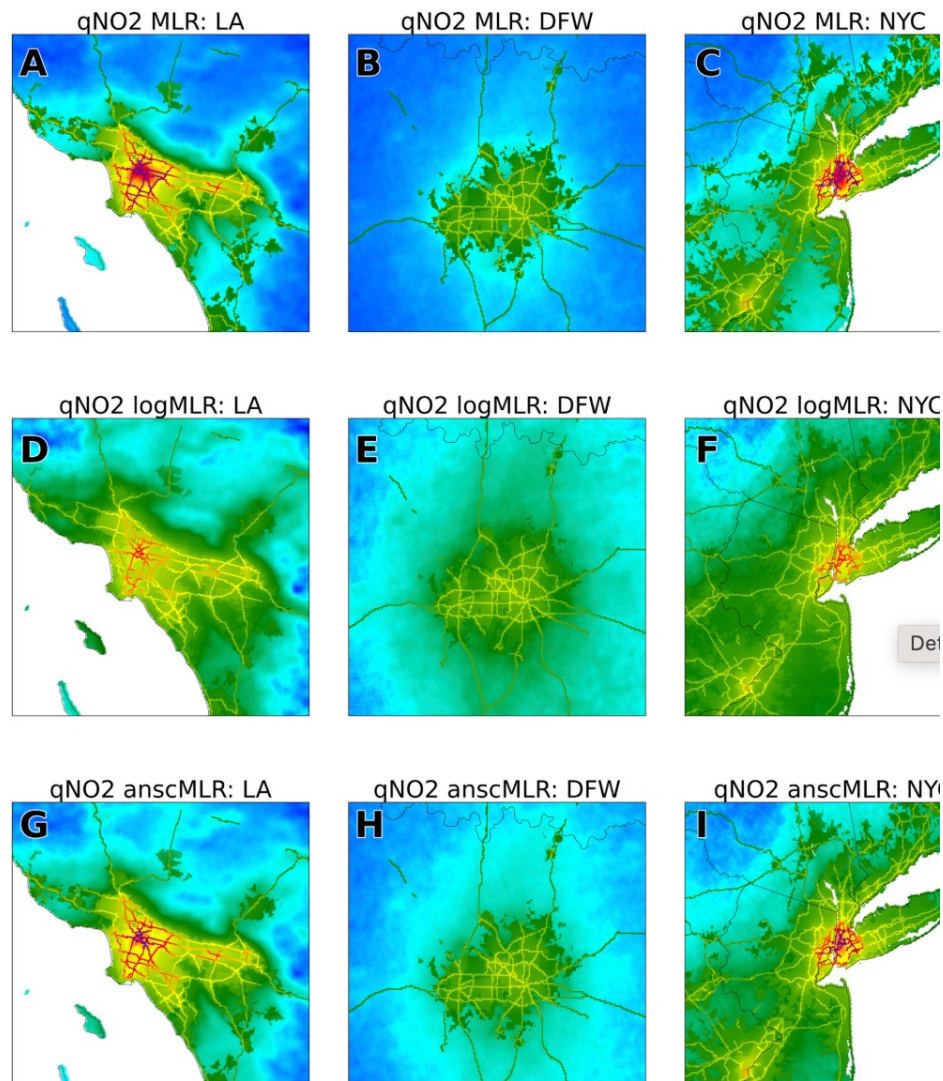
A Comparison of Regression Methods for Inferring Near-Surface NO₂ With Satellite Data

Eliot J. Kim✉, Tracey Holloway, Ajinkya Kokandakar, Monica Harkey, Stephanie Elkins, Daniel L. Goldberg, Colleen Heck

First published: 12 August 2024 | <https://doi.org/10.1029/2024JD040906> | Citations: 1



2019 qNO₂ Case Studies

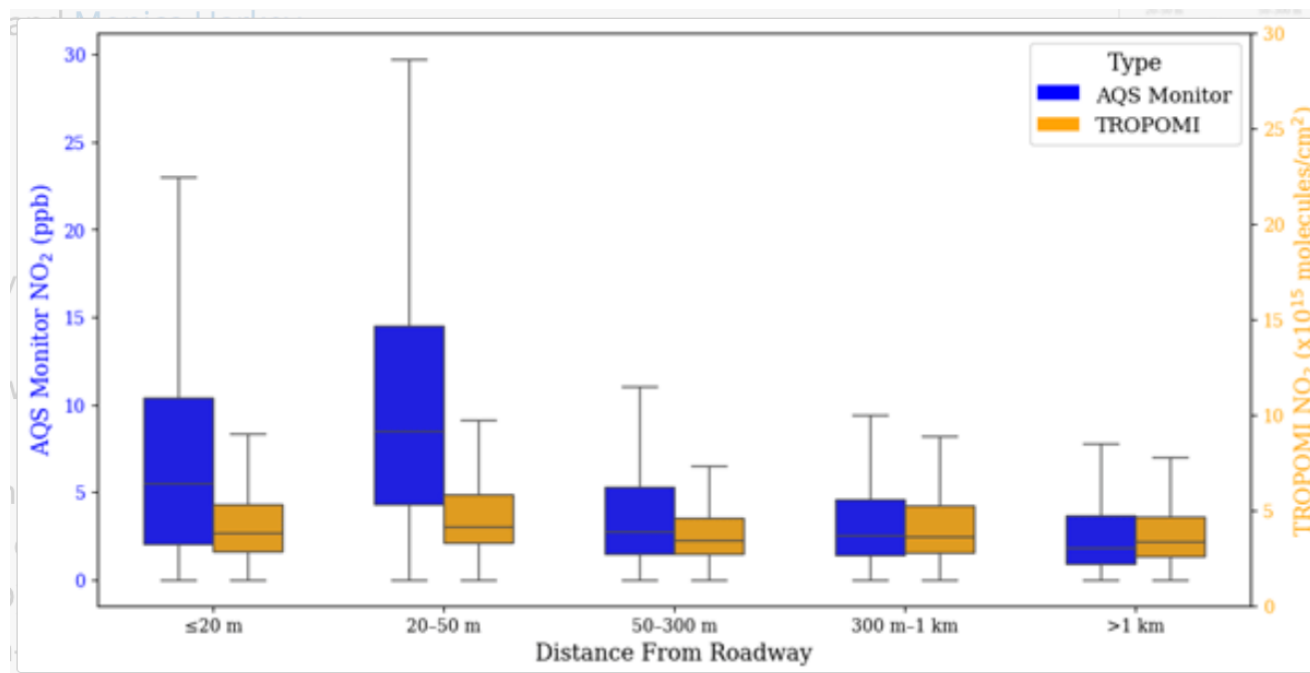


Satellite detection of NO₂ distributions using TROPOMI and TEMPO and comparison with ground-based concentration measurements

Summer Acker, Tracey Holloway [✉](#), and Monica Harkey

Atmospheric Chemistry and Physics

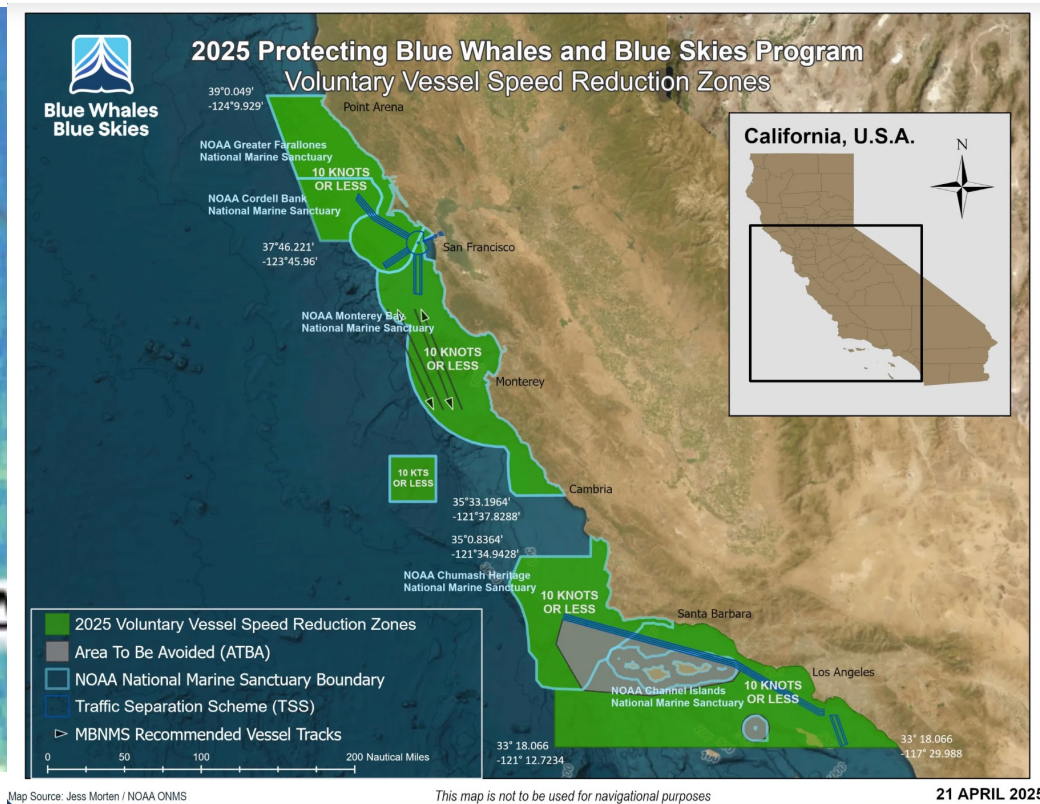
Figure 1 Median, IQR, and 1.5 x IQR daily 2019 to 2023 NO₂ from AQS monitors (blue) and TROPOMI (orange) across various; No outliers are shown.



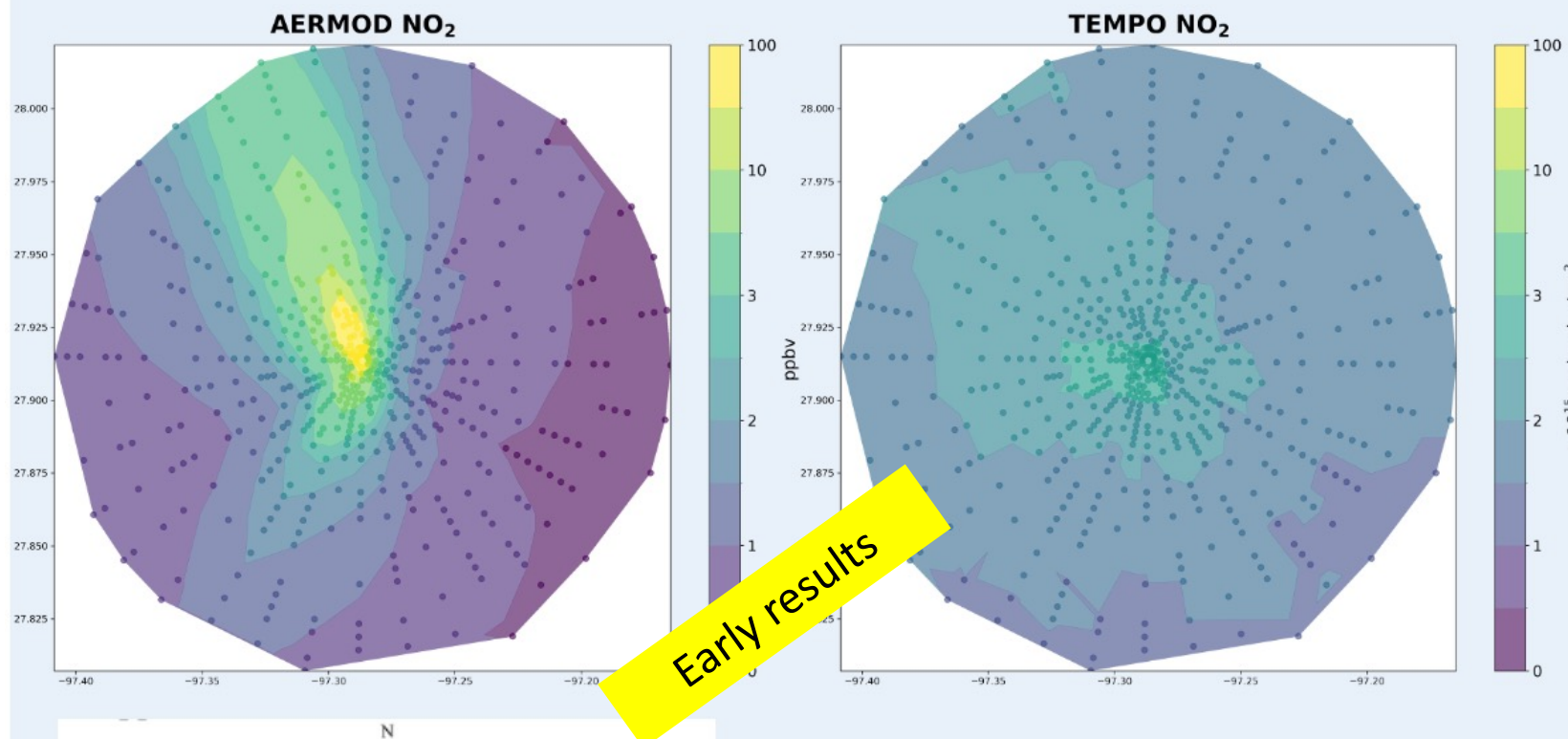
Just starting: Evaluating Vessel Speed Reduction Impacts on Air Quality



Illustrative data from TEMPO



❖ TEMPO-AERMOD Comparison



Integrating AERMOD and TEMPO Satellite Observations for Plume-Level Air Quality Modeling and Evaluation

Xinran Wu¹, Tracey Holloway^{1,2}, Monica Harkey¹

¹ Nelson Institute Center for Sustainability and the Global Environment (SAGE), UW-Madison

² Department of Atmospheric and Oceanic Sciences, UW-Madison



LINKING AIR QUALITY WITH ENERGY & PUBLIC HEALTH

The Holloway Group Advances Air Quality Research To Inform
Science And Policy. We Partner With Organizations To Ensure The
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[HAQAST.org](https://haqast.org)

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