

Air Management Advisory Group Quarterly Meeting

March 5, 2026



Hybrid Meeting Guidelines

- Please sign in if attending in person.
- Attendees in the room can raise their hand and will be called on.
- Online attendees should use the raise hand feature and will be called upon by the meeting host
- The host will attempt to respond to all messages received
- Participants will join the meeting with their video disabled. We ask that you keep your video disabled for the duration of the meeting, unless called on by the host.

Air Management Advisory Group Quarterly Meeting Agenda

- Hiring/Admin Update
- Proposed guidance, rules and legislative update
- Member Updates
- Ozone Litigation Update
- LADCO Nonattainment Area Messaging
- Satellite Data
- Next Meeting Date
- Adjourn

Operational Updates

Gail Good, Air Management Program Director

Proposed Guidance, Rules and Legislative Update

Ron Binzley, Permits and Stationary Source Modeling Section Manager

Brianna Denk, Air Quality Planning and Standards Section Manager

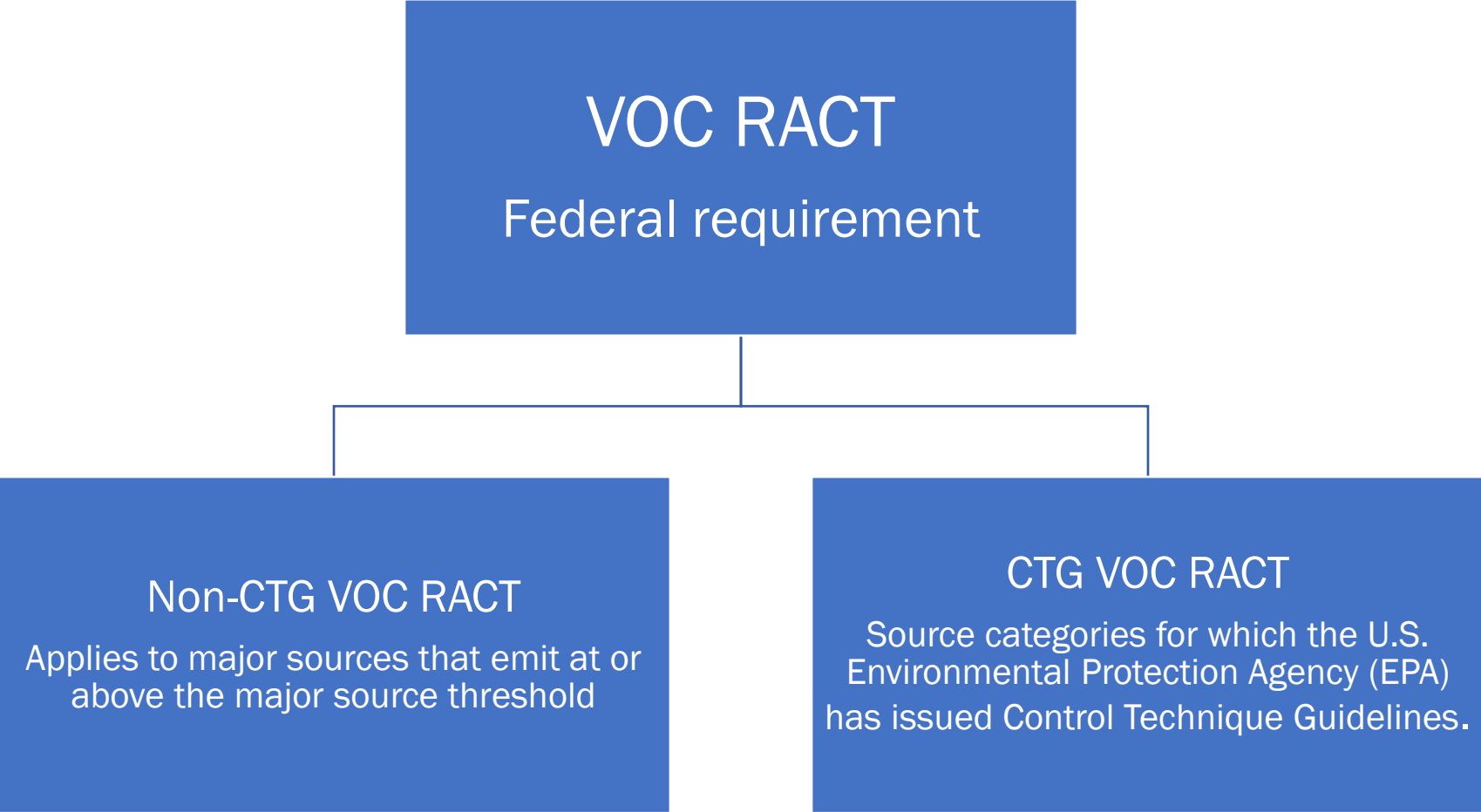
Gail Good, Air Management Program Director

Proposed/Final DNR Rules

Proposed DNR rule	Description	Phase
AM-10-23 NSR Fee Rule	Updates to construction permit fees to assure compliance with Clean Air Act requirements and to meet business needs of permitted sources. NR410 Rulemaking Wisconsin DNR	Rule effective: 4/1
AM-15-25 VOC RACT Rule	Updates to VOC regulations in ch. NR 419 through NR 425 to ensure compliance with federal VOC RACT requirements are met.	Scope of Rulemaking Approved by NRB 1/28

VOC RACT Rulemaking

- The Clean Air Act requires states that are classified as Moderate nonattainment or above to implement Reasonably Available Control Technology (RACT) to limit emissions of VOCs.
- RACT establishes emission requirements for major sources based on available control technologies and cost-effectiveness.
- VOC RACT applies to two groups of emission sources.
 - Source categories for which the EPA issues Control Technique Guidelines (CTGs)
 - Other sources that emit VOCs at or above the major source threshold known as “non-CTG major sources”
- EPA has determined that collectively, VOC regulations in NR 419 through 425 are not meeting VOC RACT requirements and need to be updated.

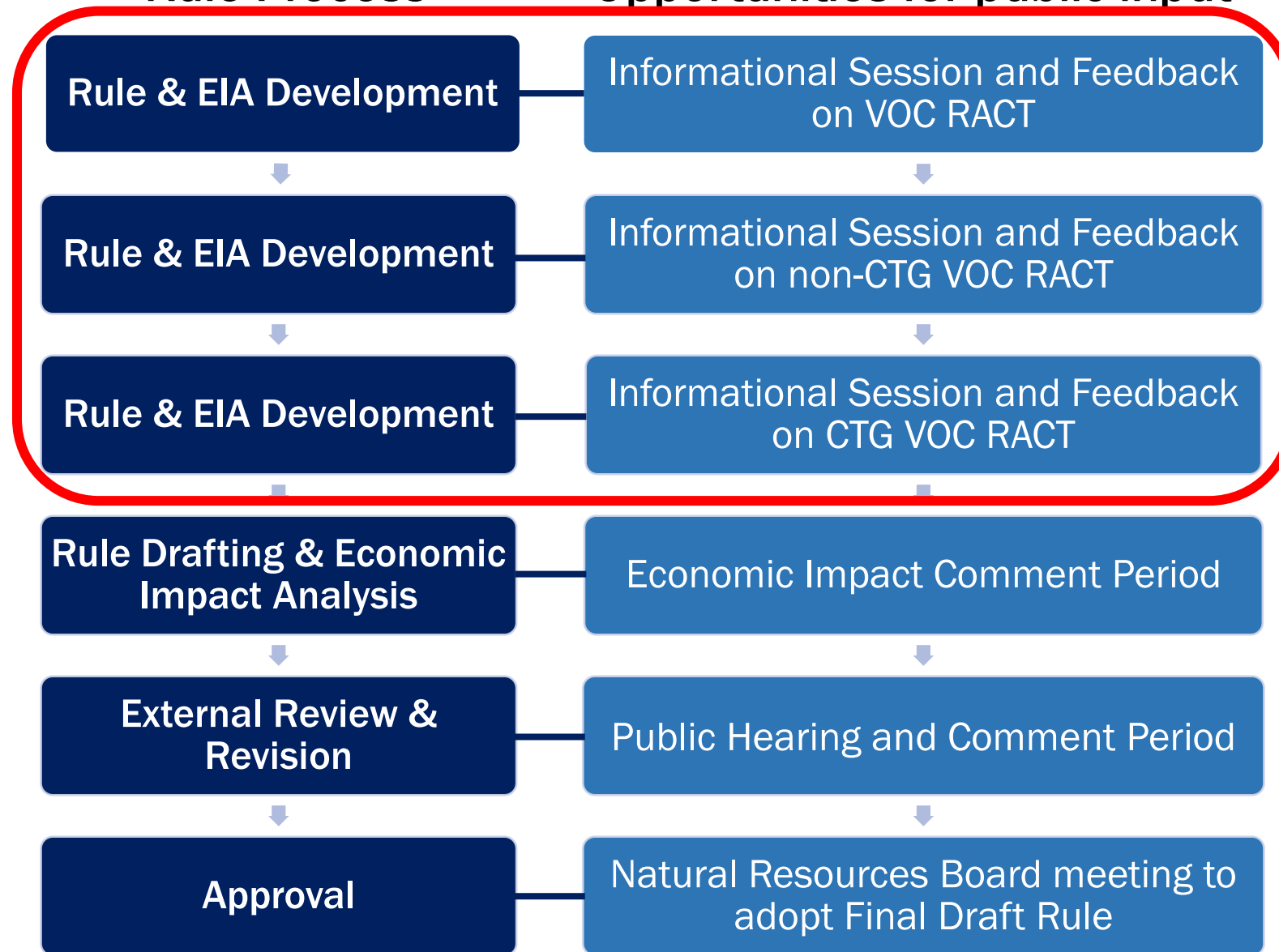


Purpose of this Rulemaking

- Meet federal requirements – approvable VOC RACT program.
- Limit emissions of ozone-forming VOCs and protect air quality in nonattainment areas.
- Streamline and modernize chapters NR 419 through 425 Wis. Adm. Code.
- Without this rulemaking, nonattainment areas will be ineligible for redesignation even if air quality meets the National Ambient Air Quality Standard (NAAQS).
- This rule will help limit ozone-forming substances and meet Clean Air Act requirements.

Rule Process

Opportunities for public input



Informational Session Times



VOC RACT Informational Session – April



Non-CTG VOC RACT **Input** Session – May



CTG VOC RACT **Input** Session – June

Information and Feedback Sessions

- Information from DNR
 - Background of VOC RACT Rules
 - Rule revisions the DNR is planning
- Questions for Stakeholders
 - Opportunities to streamline NR 419 through NR 425
 - Rule language that confusing or difficult to implement

Final NR 410 Rule

- Clearing House Rule No. CR 24-057 revised fees for construction permit actions contained in ch. NR 410 of the Wisconsin Administrative Code; the rule is effective on April 1, 2026
- Most construction permit fees increase by 20%; some fees will increase by more or less than this amount to better reflect the workload for the activity with which the fee is associated.
- Several new fees are added for activities that were not previously charged.
- Further details on the fee revisions as well as a Frequently Asked Questions document can be found on the new [Construction Permit Fees](#) webpage

EPA Rules/Guidance

EPA Action	Link	Status
Rule: Oil and Natural Gas Sector Climate Review: Extension of Deadlines in Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources	90 FR 55671	Rule effective 12/3/25
Rule: National Emission Standards for Hazardous Air Pollutants for Coke Ovens: Pushing, Quenching, and Battery Stacks, and Coke Oven Batteries; Rescission of Extension of Compliance Deadlines for Coke Oven Facilities	90 FR 56010	Rule effective 12/5/25
Rule: Congressional Review Act Revocation of 2024 Review of Final Rule Reclassification of Major Sources as Area Sources Under Section 112 of the Clean Air Act	91 FR 58	Rule effective 1/2/2026
Rule: State Implementation Plan: Due Date for the Regional Haze Third Implementation Period	91 FR 331	Rule effective 3/9/26
Rule: New Source Performance Standards Review for Stationary Combustion Turbines and Stationary Gas Turbines	91 FR 1910	Rule effective 1/15/26
Proposed Rule: Interstate Transport Plan Review for the 2015 Ozone NAAQS	91 FR 4026	Comment deadline extended through 3/23/26
Rule: Rescission of the Greenhouse Gas Endangerment Finding and Motor Vehicle Greenhouse Gas Emission Standards Under the Clean Air Act	91 FR 7686	Rule effective 4/20/26

Status of 2024 PM_{2.5} NAAQS

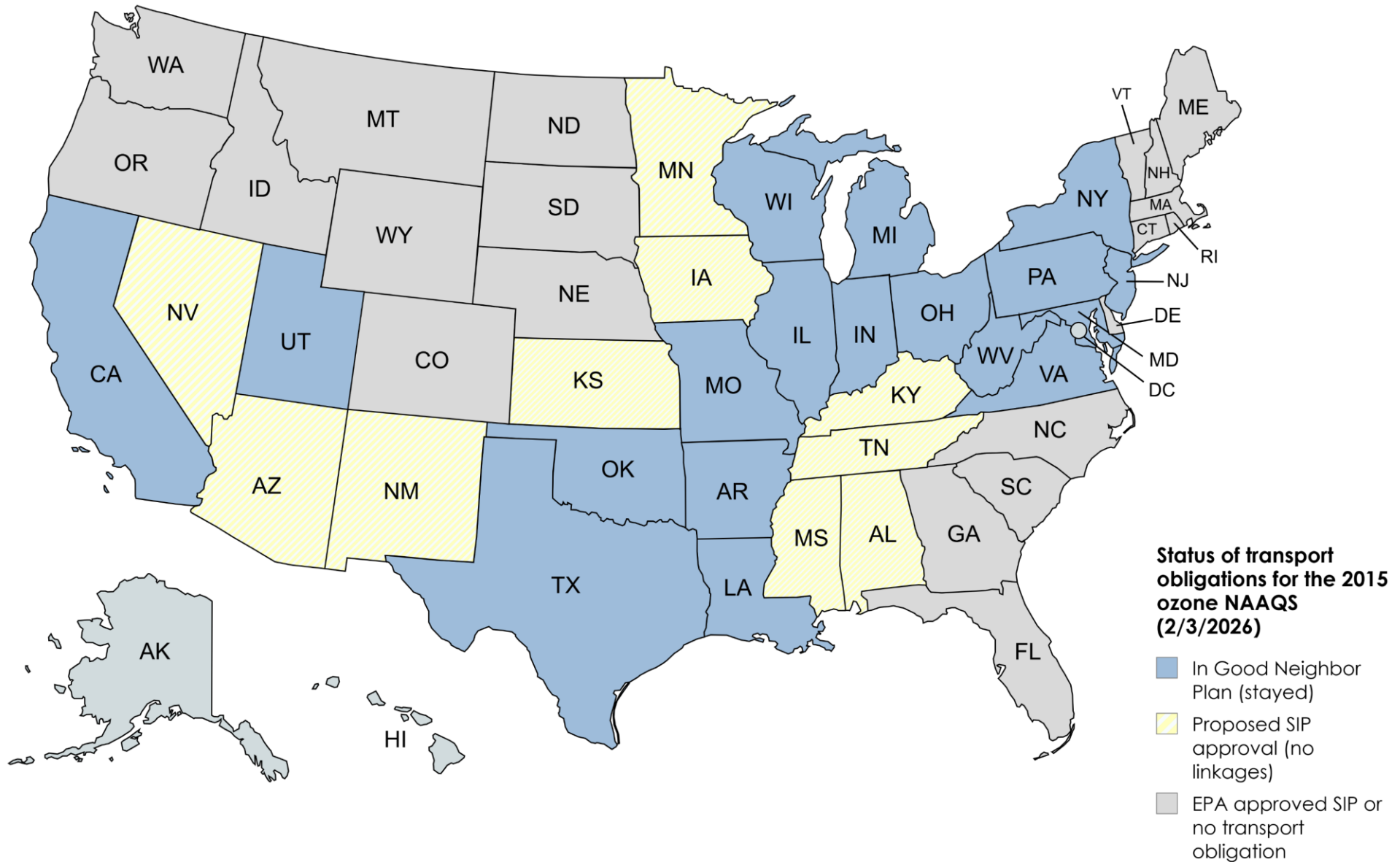
- EPA revised the annual PM_{2.5} NAAQS to 9 µg/m³ in February 2024
 - February 7, 2025: State attainment designation recommendations
 - February 7, 2026: EPA area attainment designations
- In December 2025, as part of ongoing litigation in the D.C. Circuit, EPA requested vacatur of the revised standard
- On February 10, 2026, a notice of intent to sue was filed alleging the EPA failed to designate areas by February 7, 2026
- The revised 2024 standard remains in effect, pending additional action from EPA or the Court

GHG Endangerment Finding and Vehicle Emission Standard Repeal

- On February 12, EPA announced the repeal of the Greenhouse Gas (GHG) Endangerment Finding and all federal GHG emissions standards for vehicles model year 2012 to 2027 and beyond
- An Endangerment Finding for GHGs is a prerequisite for implementing GHG emission standards for vehicles and other sectors under the Clean Air Act (CAA)
- Recission based on legal basis and reinterpretation of EPA's authority, not on climate science
- Reducing greenhouse gas emissions from mobile sources also reduces ozone and particulate matter

Proposed “phase 1” transport rule for 2015 Ozone NAAQS

- Approves transport SIPs for ten states largely based on original submittals
 - Remaining states to be addressed in future “phase 2” rule
- Reflects several policy changes:
 - Evaluates transport using a past analytic year (2023)
 - Gives primacy to submitted state modeling (circa 2018) – uses new EPA modeling results selectively
 - States are linked at 1 ppb, not 1% of NAAQS (0.70 ppb)
- DNR comments:
 - Identify where changes appear to be inconsistent with case law
 - Reflect concerns that these changes will limit number of states that must address transport impacts on Wisconsin



EPA Permitting Reform Agenda

- The EPA has prioritized NSR permitting reform as part of its effort to facilitate the development of data centers and AI
- Revisiting historic EPA policy regarding activities allowed before obtaining an NSR permit is a key reform objective
- A proposed rule altering the definition of “Begin Actual Construction” in the major NSR regulations is expected from the EPA this Spring.

Ozone Litigation Updates

Phil Bower, Air Management Attorney

Member Updates



LADCO | LAKE MICHIGAN
AIR DIRECTORS CONSORTIUM

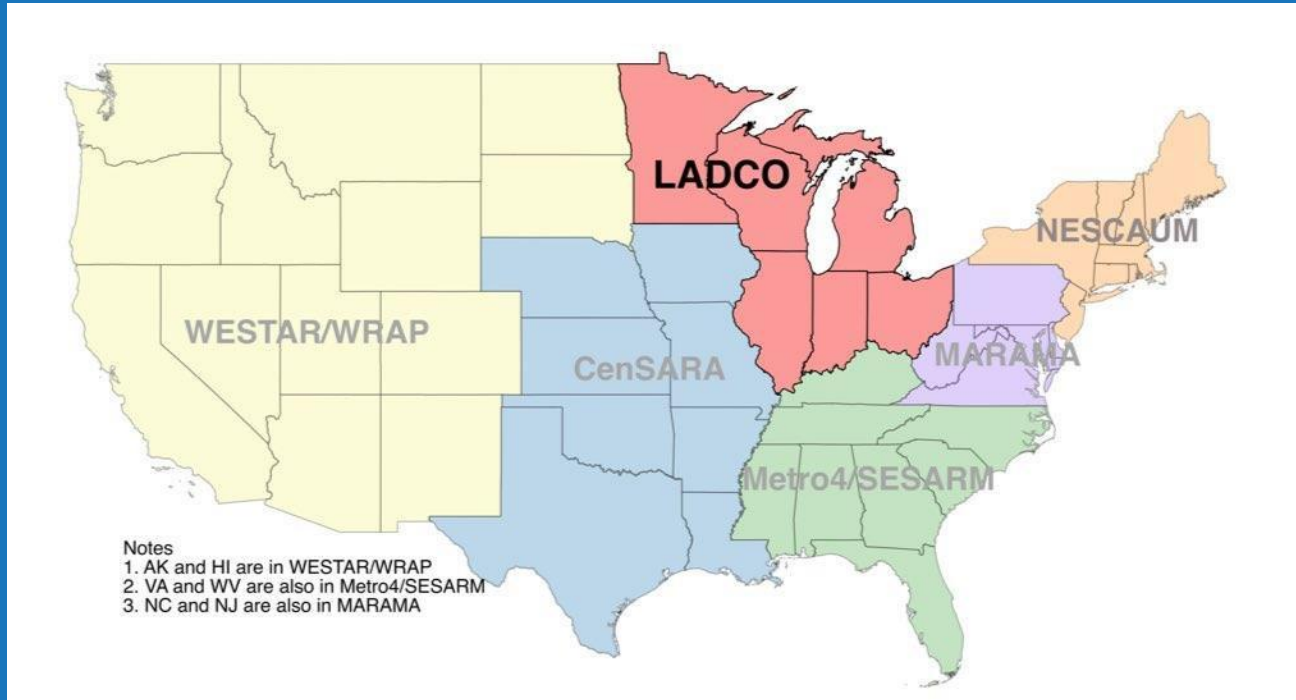
Trends in Ozone and PM_{2.5} Concentrations and Precursor Emissions in Wisconsin

Angie Dickens and Zac Adelman
LADCO Data Scientist & Executive Director

Wisconsin Air Management Advisory Group Meeting
March 5, 2026

What is LADCO?

Lake Michigan Air Directors Consortium



LADCO is funded primarily by U.S. EPA grants to the states under [Section 105](#) of the Clean Air Act.

- Formed in 1989 to bring Michigan, Indiana, Illinois, and Wisconsin together to address ozone (O₃) pollution (aka smog)
 - Ohio joined in 2004; Minnesota joined in 2012
- Governed by state air agency directors
- Scope
 - Forum for state agency planners
 - Air pollution modeling and data science
 - Training

LADCO does not provide policy guidance to our membership, only technical guidance and support

Today's Presentation

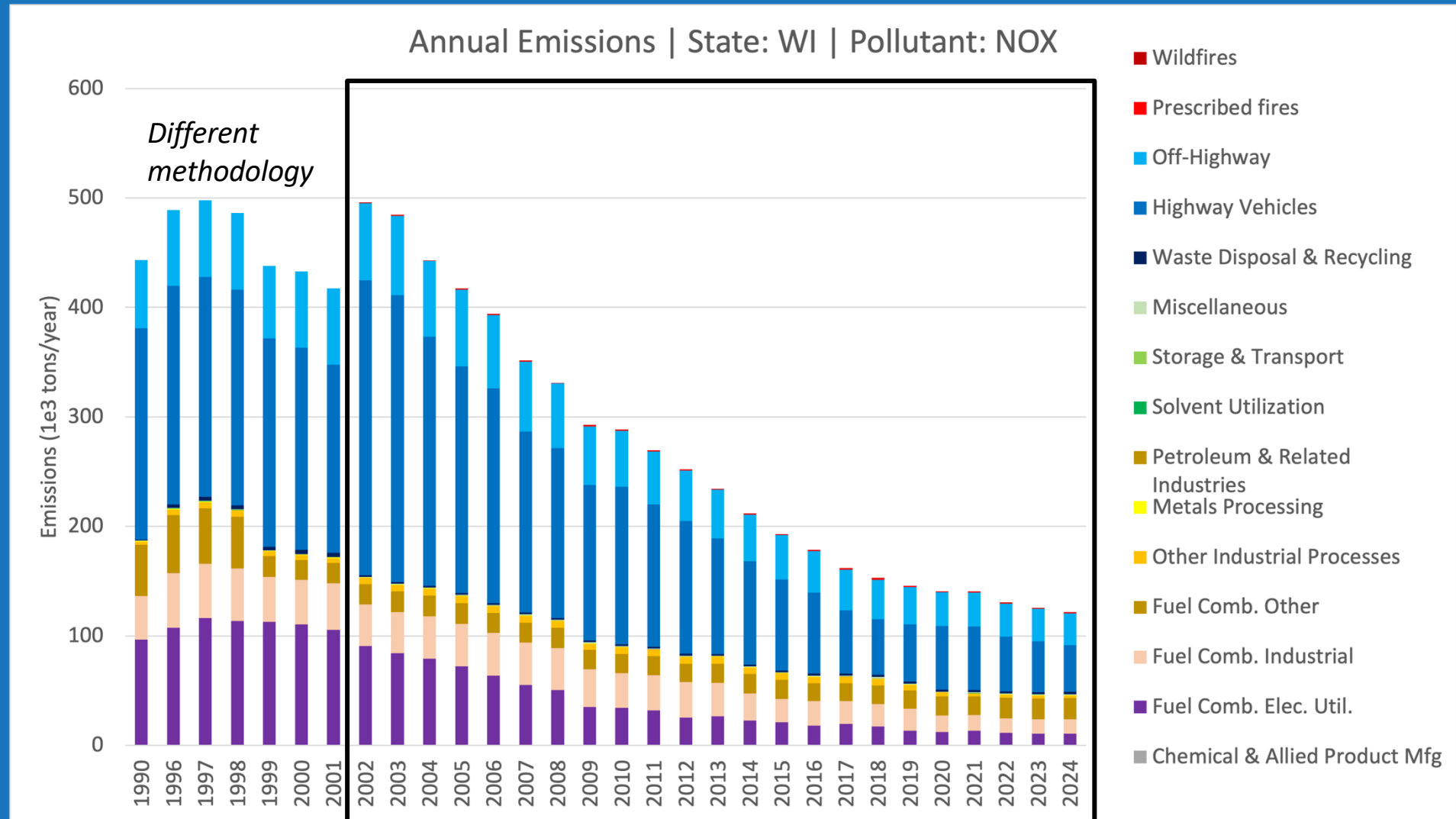
- Recent trends in air emissions and pollution for Wisconsin
- Engagement on improving air pollution in the Great Lakes region
- Q&A

Emissions: Nitrogen Oxides (NO_x)

NO_x = NO + NO₂

Precursors to PM_{2.5} &
ozone

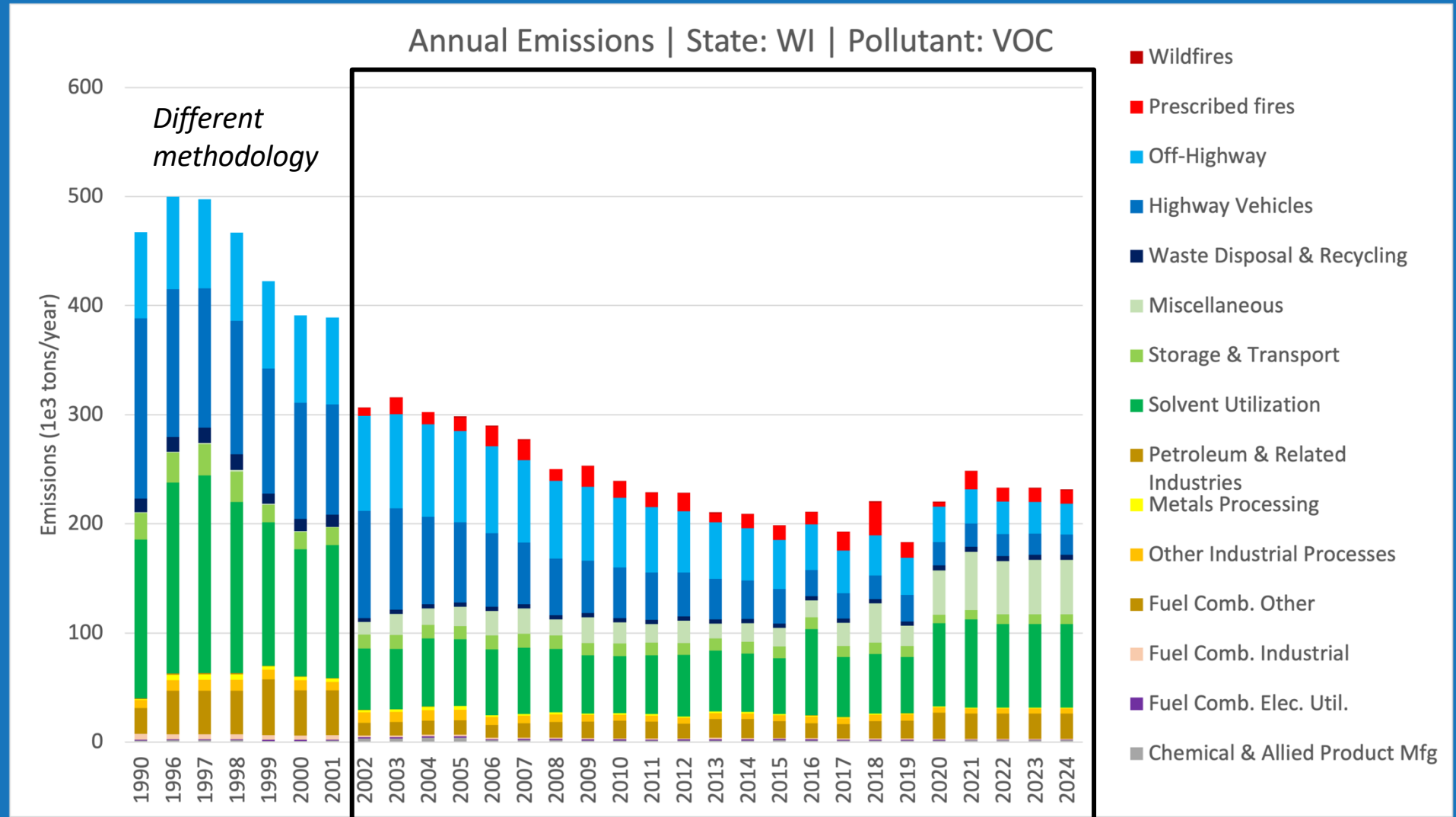
NO₂ is a NAAQS pollutant



Emissions: Volatile Organic Compounds (VOC)

Precursors to PM_{2.5} & ozone

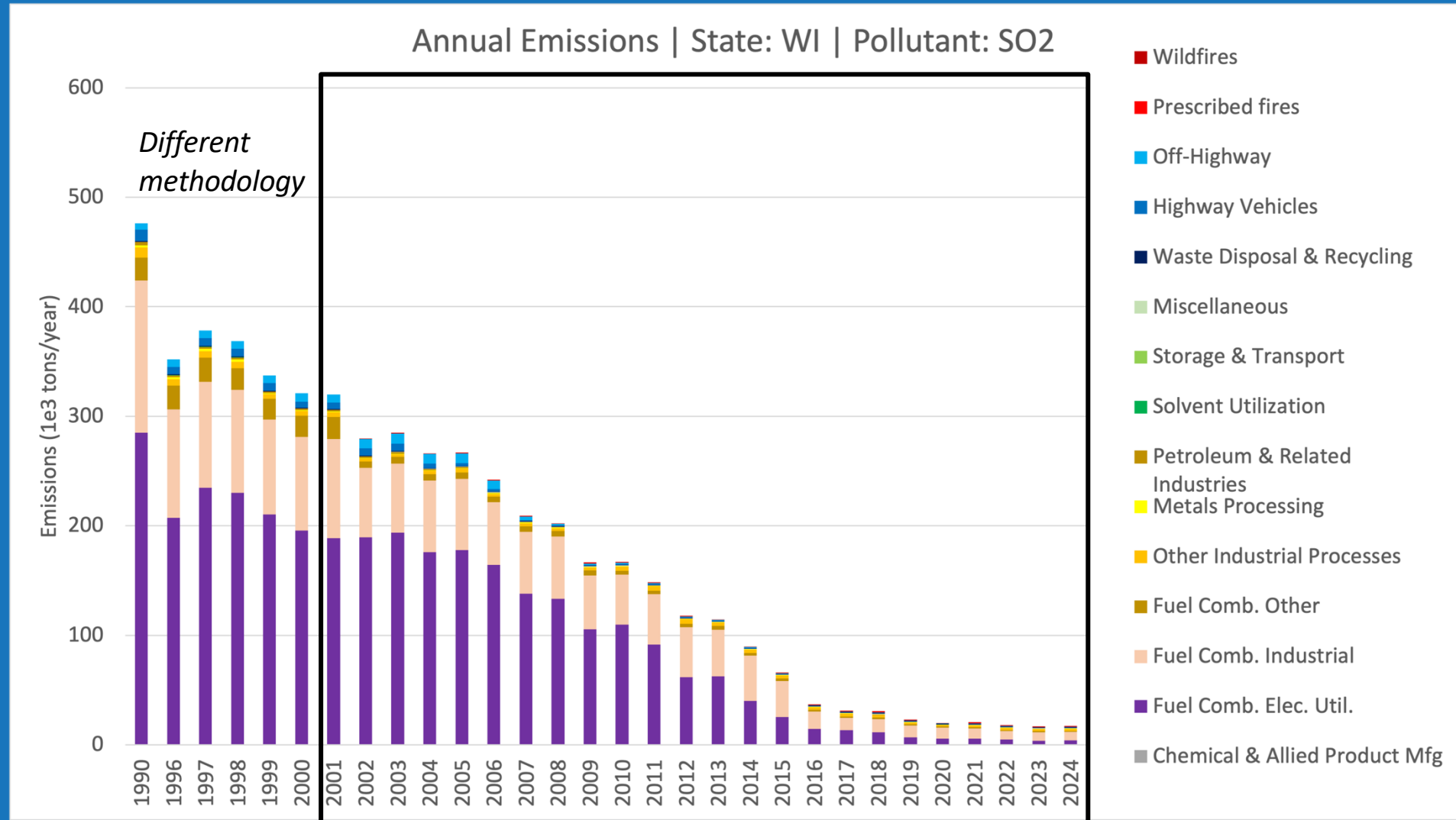
VOCs include air toxics



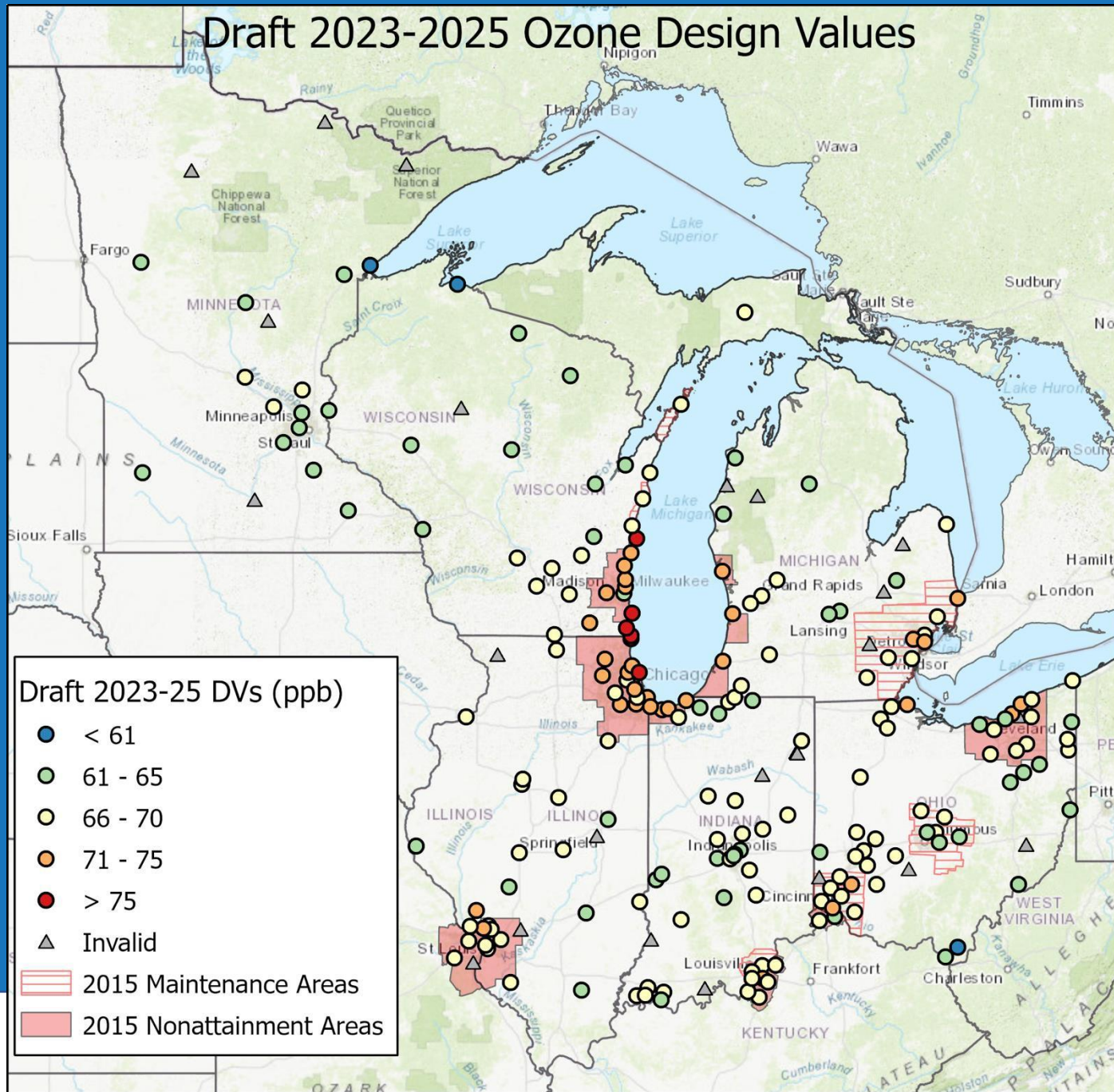
Emissions: Sulfur Dioxide (SO₂)

Precursor to PM_{2.5}

SO₂ is a NAAQS pollutant



Draft 2023-2025 Ozone Design Values

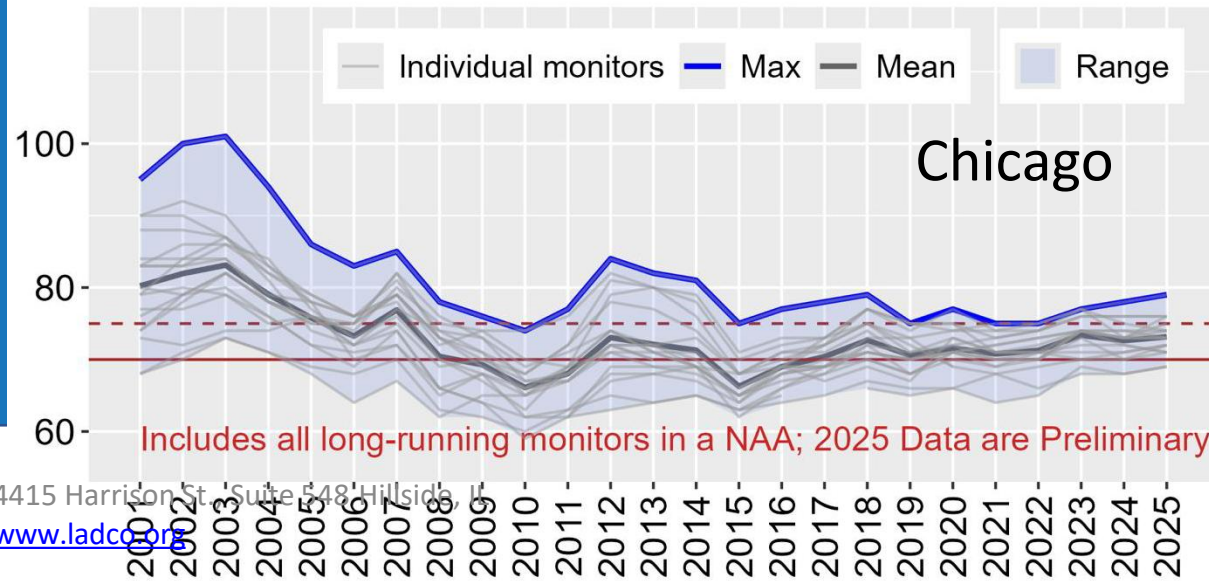
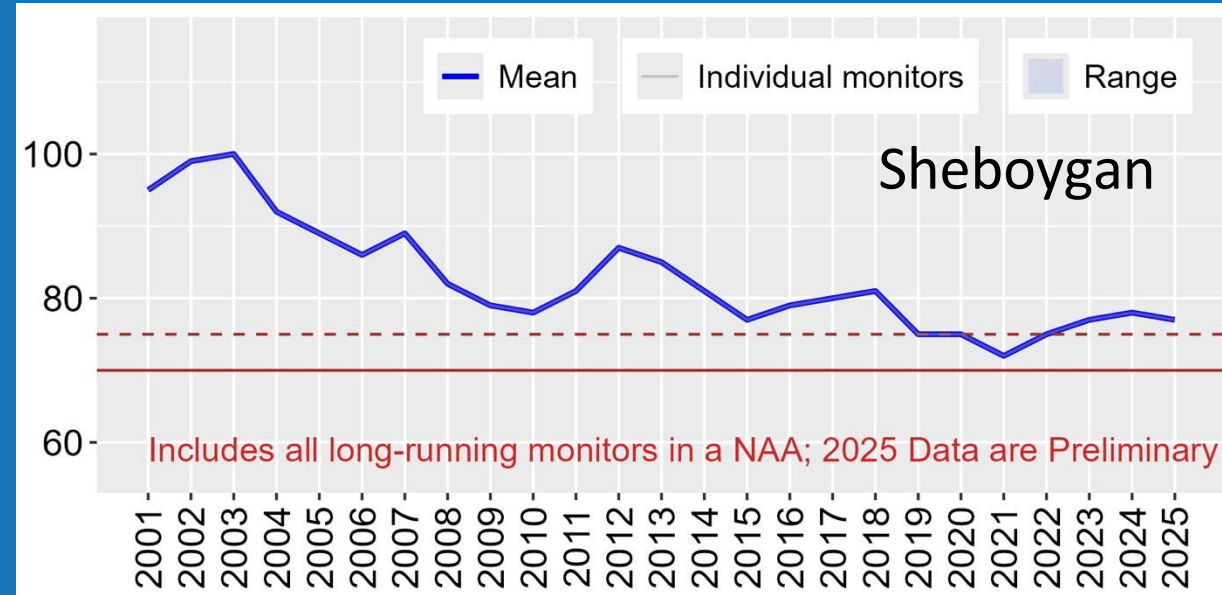
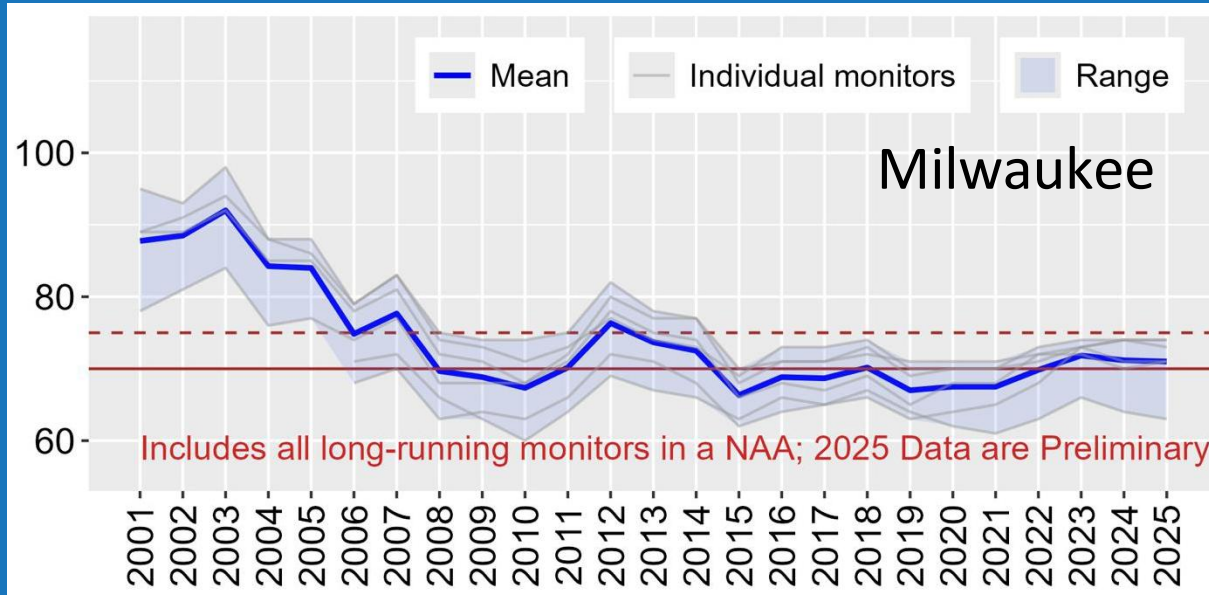


Current 2023-2025 Ozone Design Values

- Mostly follow typical spatial patterns
 - High around Lake Michigan and in major urban areas
 - Wisconsin & Chicago have the highest values in the region

Current 2023-2025 Ozone Design Values

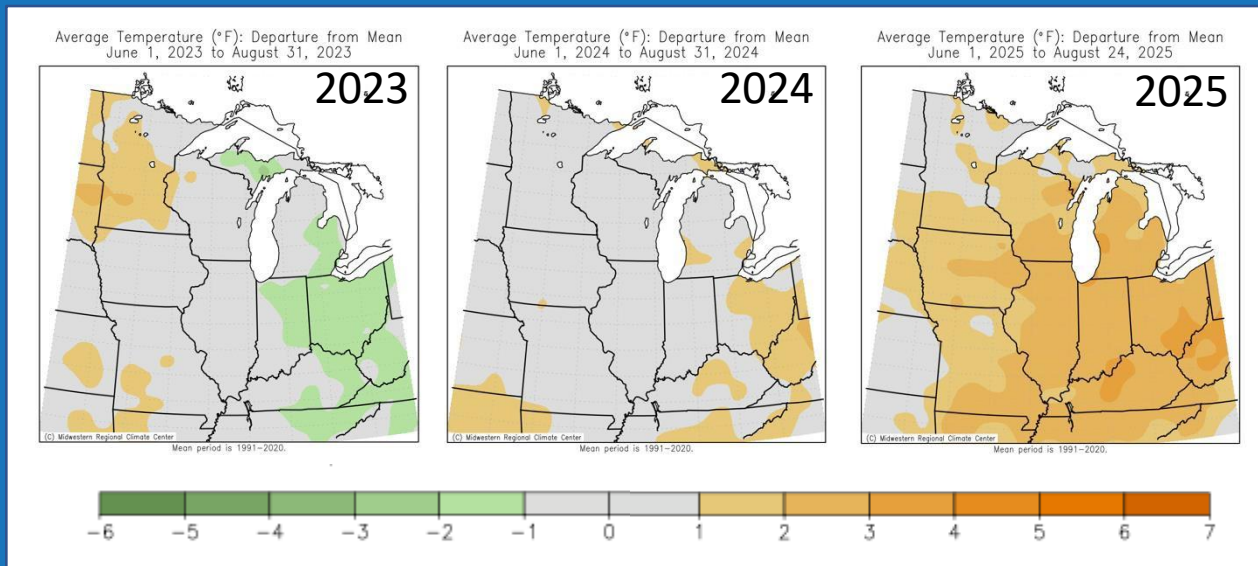
Ozone Design Values (ppb)



- Design values (DVs) are above the level of the NAAQS in all three areas
- DVs have increased in the last few years
 - Likely due to smoke-enhanced ozone formation

Ozone: Major Drivers

- Temperature (hot = more ozone)
- More precursors (NO_x & VOCs; more = more ozone)
- Also:
 - Humidity (humid = less ozone)
 - Transport from high-emissions regions



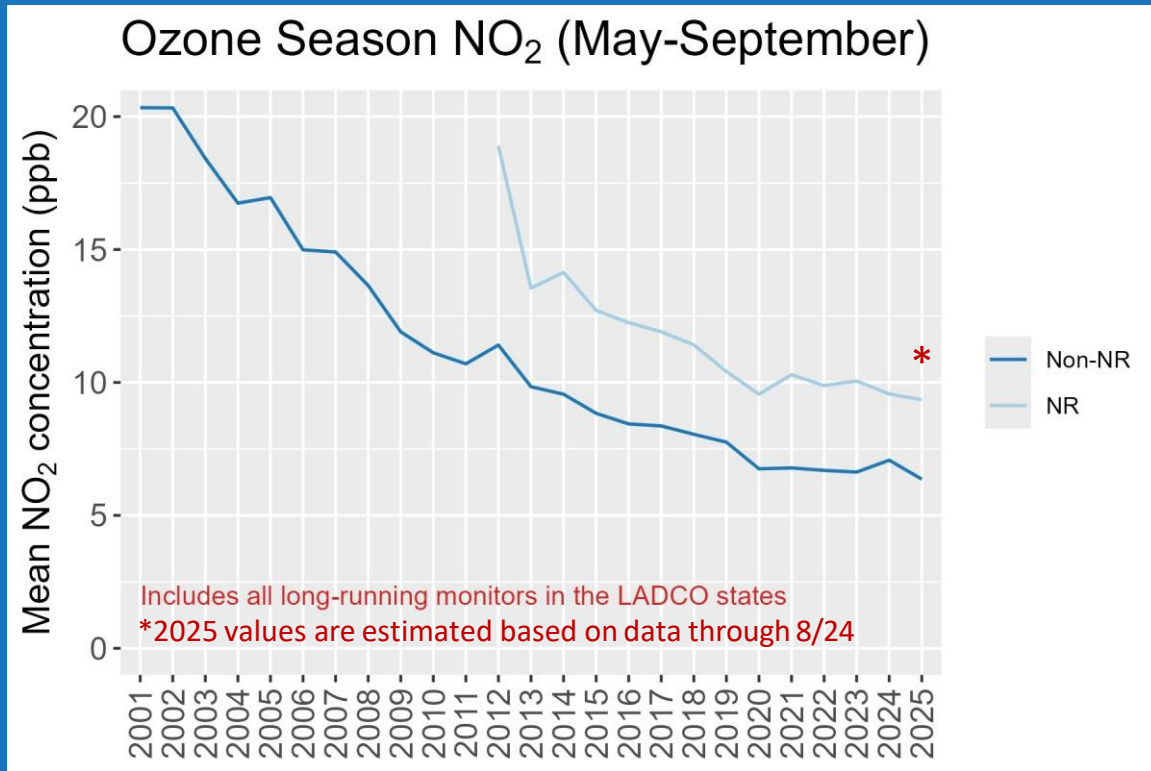
June-August Temperatures:

- Above average temperatures across almost the whole region in 2025
- 2023 & 2024 were close to average in WI

Shows departure from the average temperature (1991-2020)

Ozone: Major Drivers

Monitored NO₂ Concentrations:



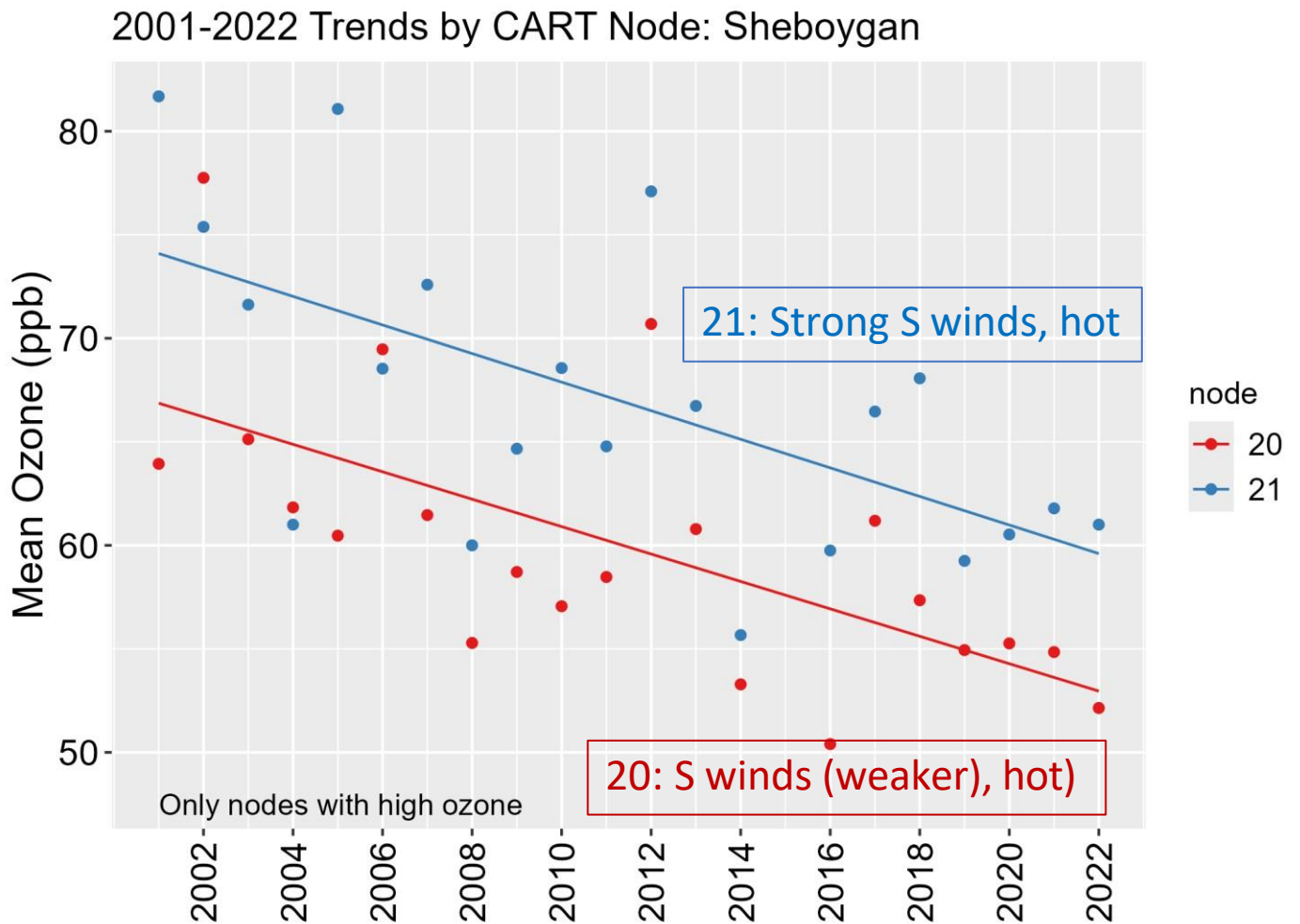
NR = near-road monitor

- NO₂ increased slightly in 2024
- 2025 continues trend of very slowly decreases in NO₂
 - ➔ Could help ozone slightly
- Generally: flattening out of NO₂ will cause flattening of ozone concentrations

Meteorological Adjustment of Ozone via CART

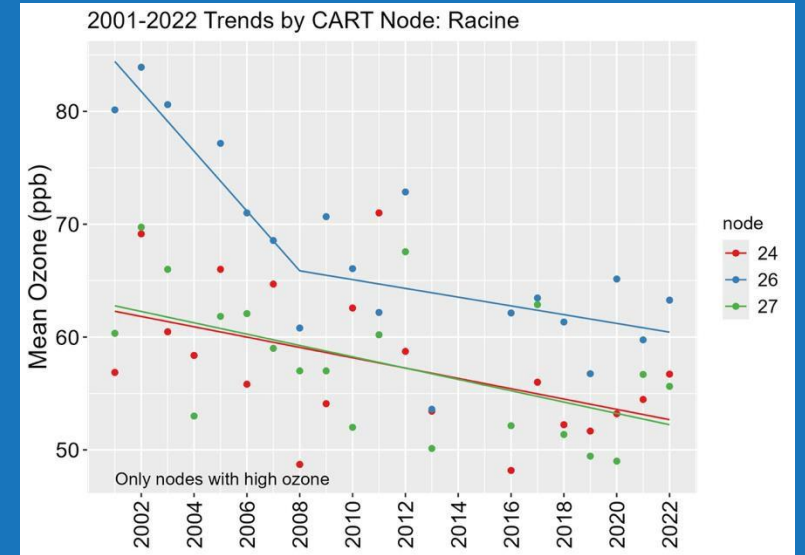
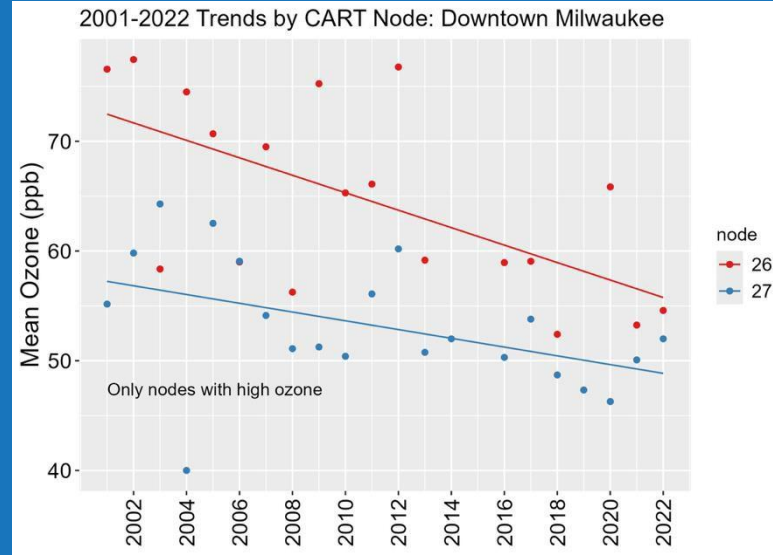
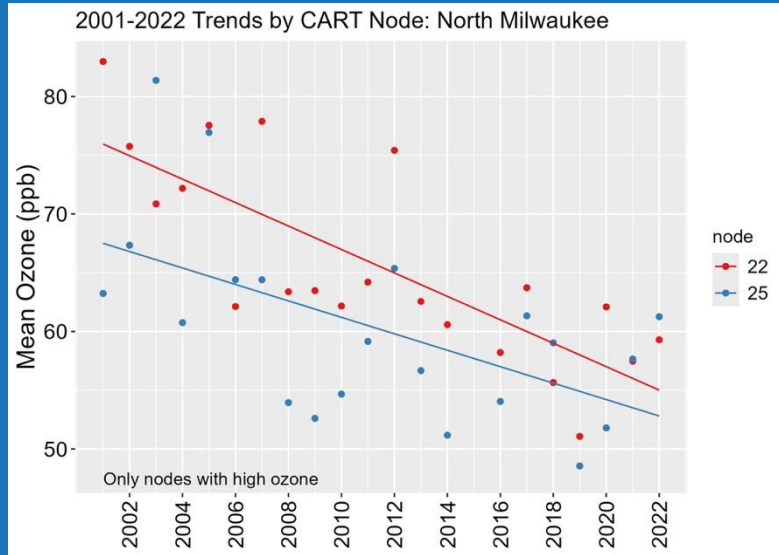
- Uses a statistical tool to classify data*
- Used to determine meteorological conditions on high-ozone days
- Examine trends in ozone on meteorologically similar days
 - Allows examination of trends in ozone as a result of non-meteorological factors, such as emissions changes
- Applied CART to data from 2001-2023
 - Removed 2023 because of extreme impacts from smoke
 - Applied segmented regression or linear regression to fit the data
- Report with the complete analysis: https://www.ladco.org/wp-content/uploads/Projects/Ozone/LADCO_O3_CART-Analysis_2025_v2.pdf

CART – Sheboygan, WI



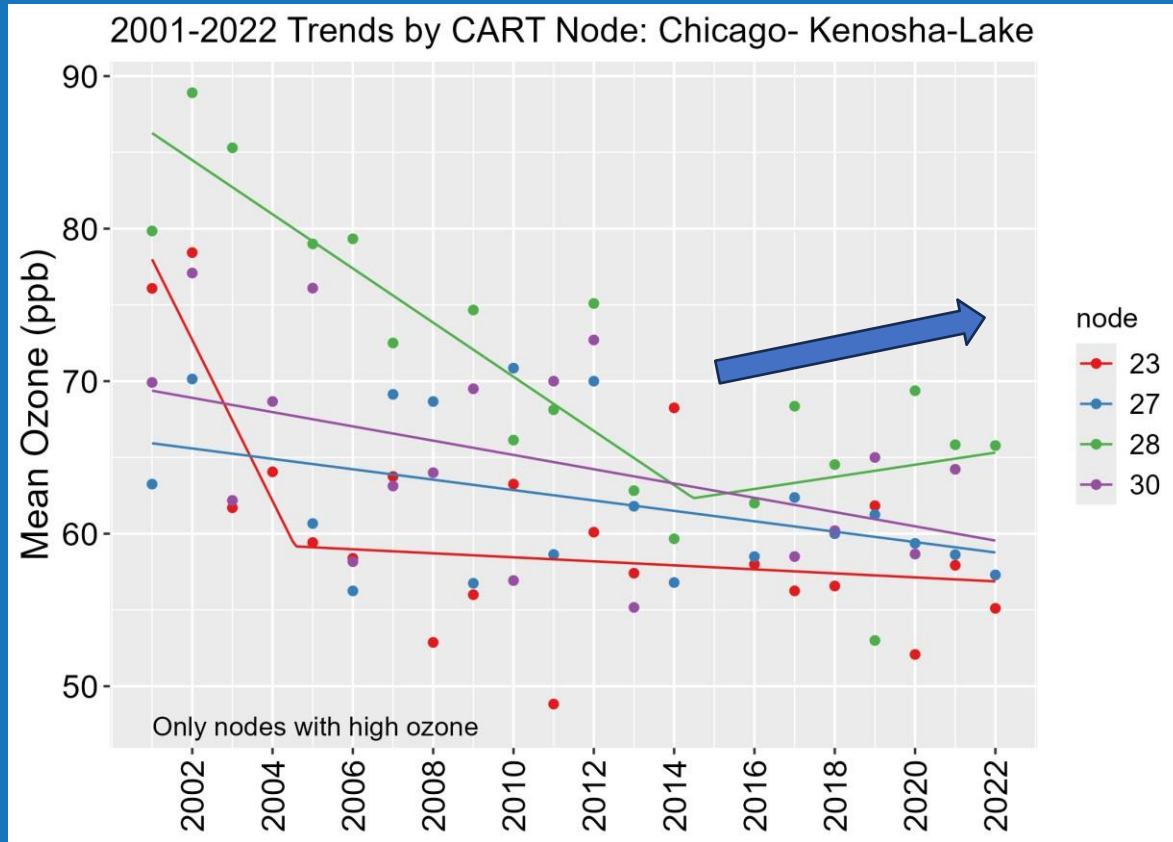
Continued reductions in O₃ on O₃-conducive days (through 2022)

CART – Milwaukee



- Ozone is continuing to decrease when adjusting for meteorology in Milwaukee through 2022
- True for most parts of the region

CART – Chicago



- Different trend for Chicago (showing Chiwaukee & Zion)
 - Meteorologically-adjusted ozone on the highest ozone days is increasing
 - Due to complex chemistry in Chicago because of high levels of NO_x pollution (“VOC sensitivity”/ “NO_x suppression”)
- Similar for other parts of Chicago
 - Cook County & NW Indiana

What does this mean for ozone in Wisconsin?

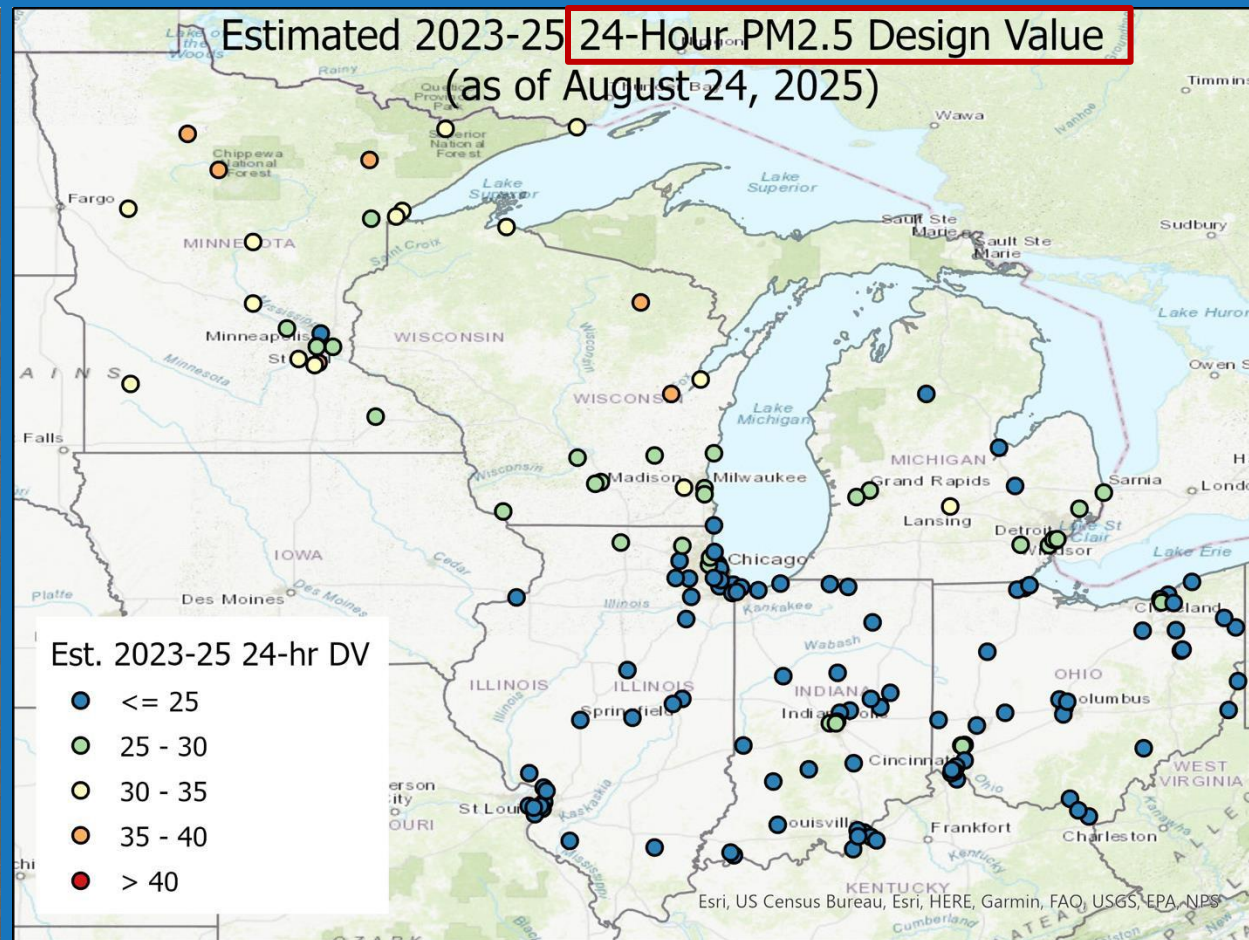
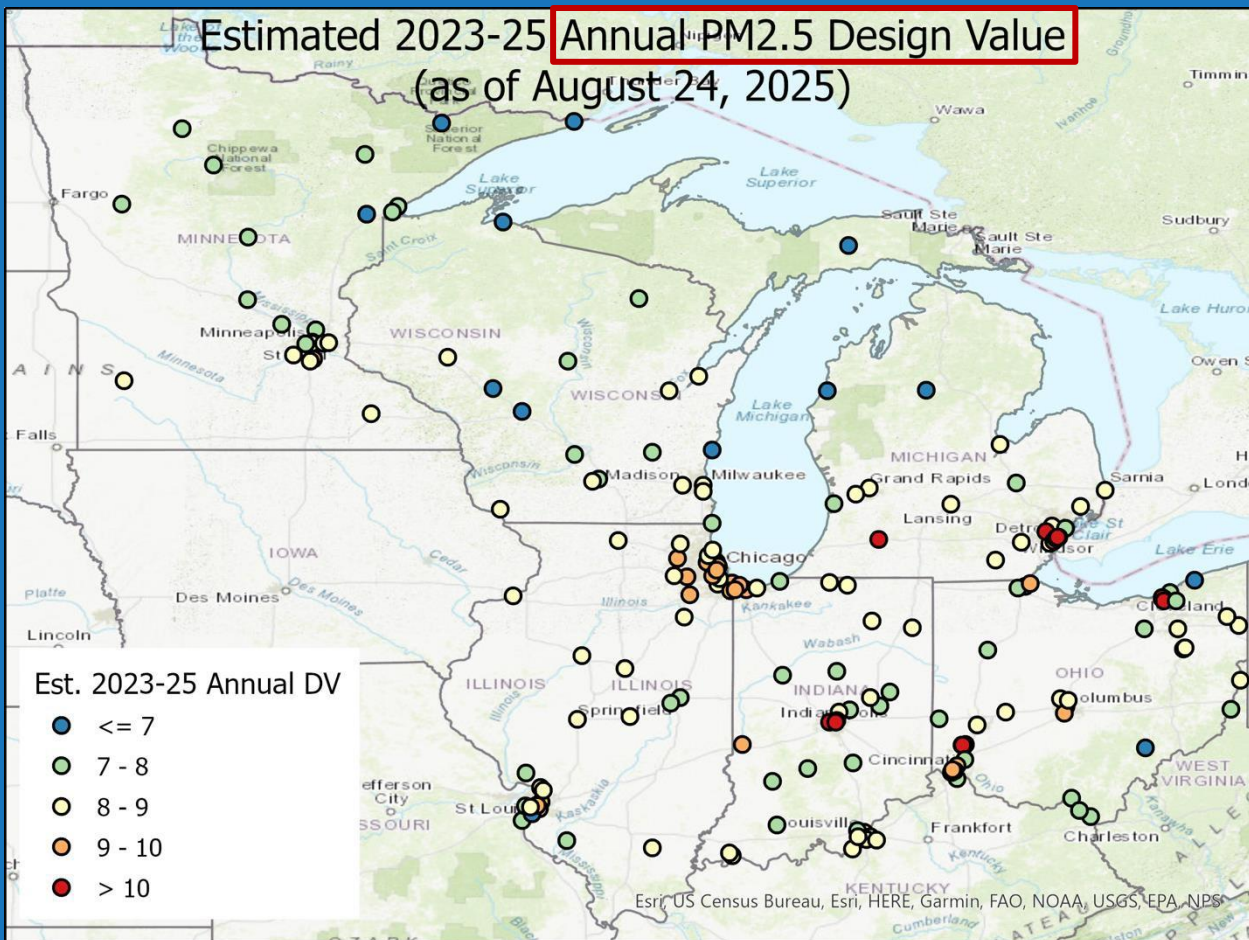
- Most areas of the state have decreasing ozone, particularly when adjusted for meteorology
 - Including Sheboygan & Milwaukee nonattainment areas
 - Suggests ozone will continue to decrease as long as emissions reductions continue at a similar pace
- Ozone is increasing across much/most of Chicago
 - Due to VOC-sensitive chemistry
 - VOC controls along with NOx controls are needed to decrease concentrations
 - Continued NOx controls will eventually lower ozone
 - (Chemistry will shift to NOx-sensitive as NOx continues to decrease)
- Need continued reductions in emissions to decrease ozone

Estimated 2023-2025 PM_{2.5} Design Values

3-year averages of yearly metrics → signals from any extreme year are muted

Estimated 2023-25 Annual PM_{2.5} Design Value
(as of August 24, 2025)

Estimated 2023-25 24-Hour PM_{2.5} Design Value
(as of August 24, 2025)



Annual: peak values in urban areas in east:

- Indianapolis, Cincinnati, Detroit, Kalamazoo, & Cleveland

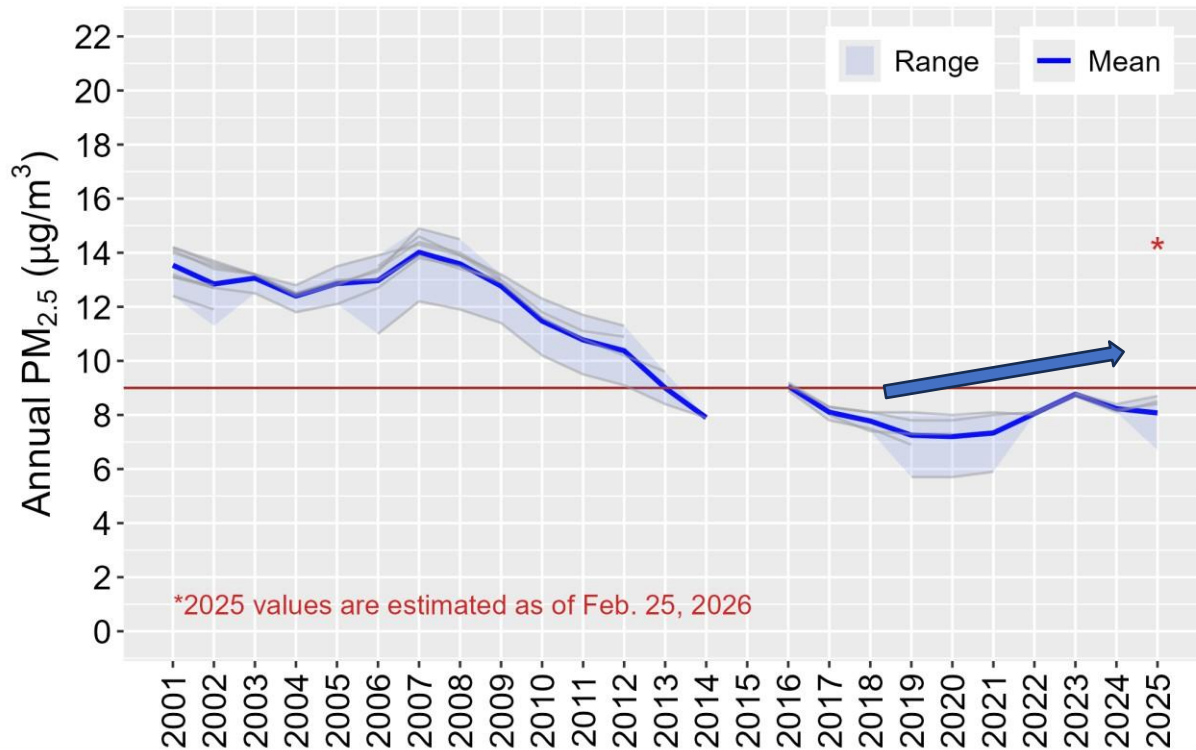
6 sites are above the NAAQS in MN and WI due to smoke

- Designations are done, so no regulatory impact

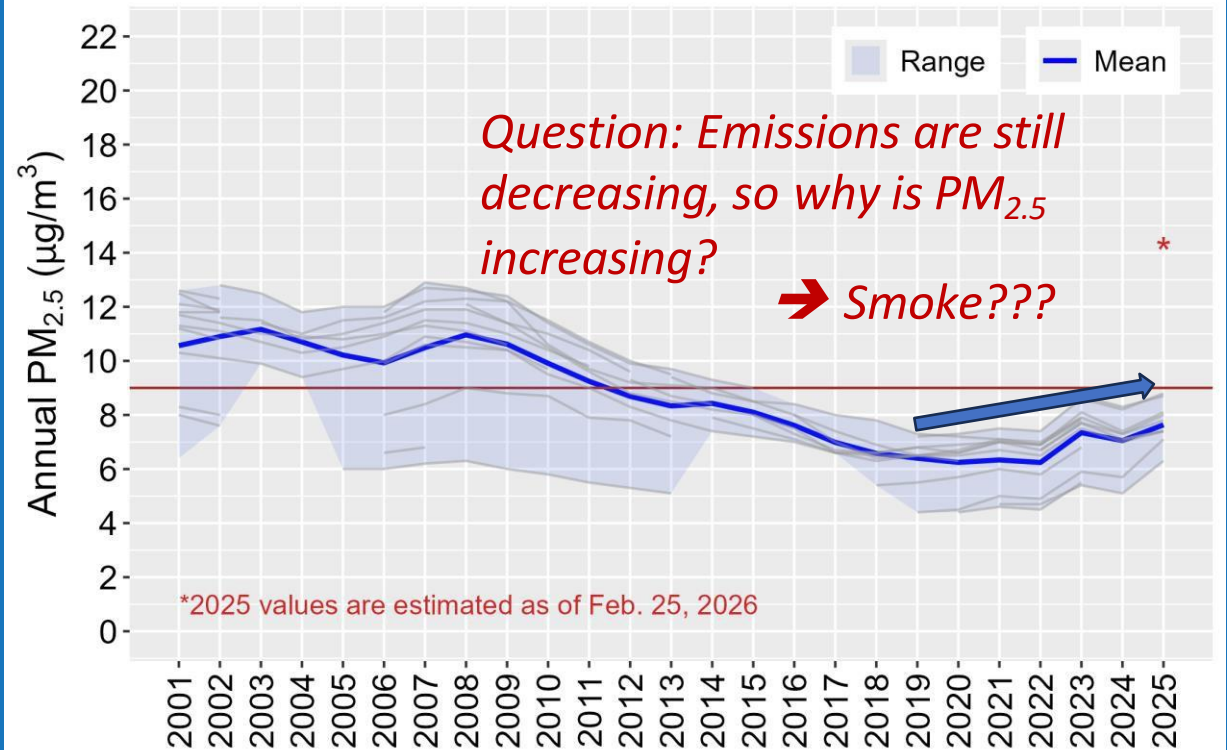
Generally way below the standard → focus on annual NAAQS

PM_{2.5} Annual Design Values Over Time

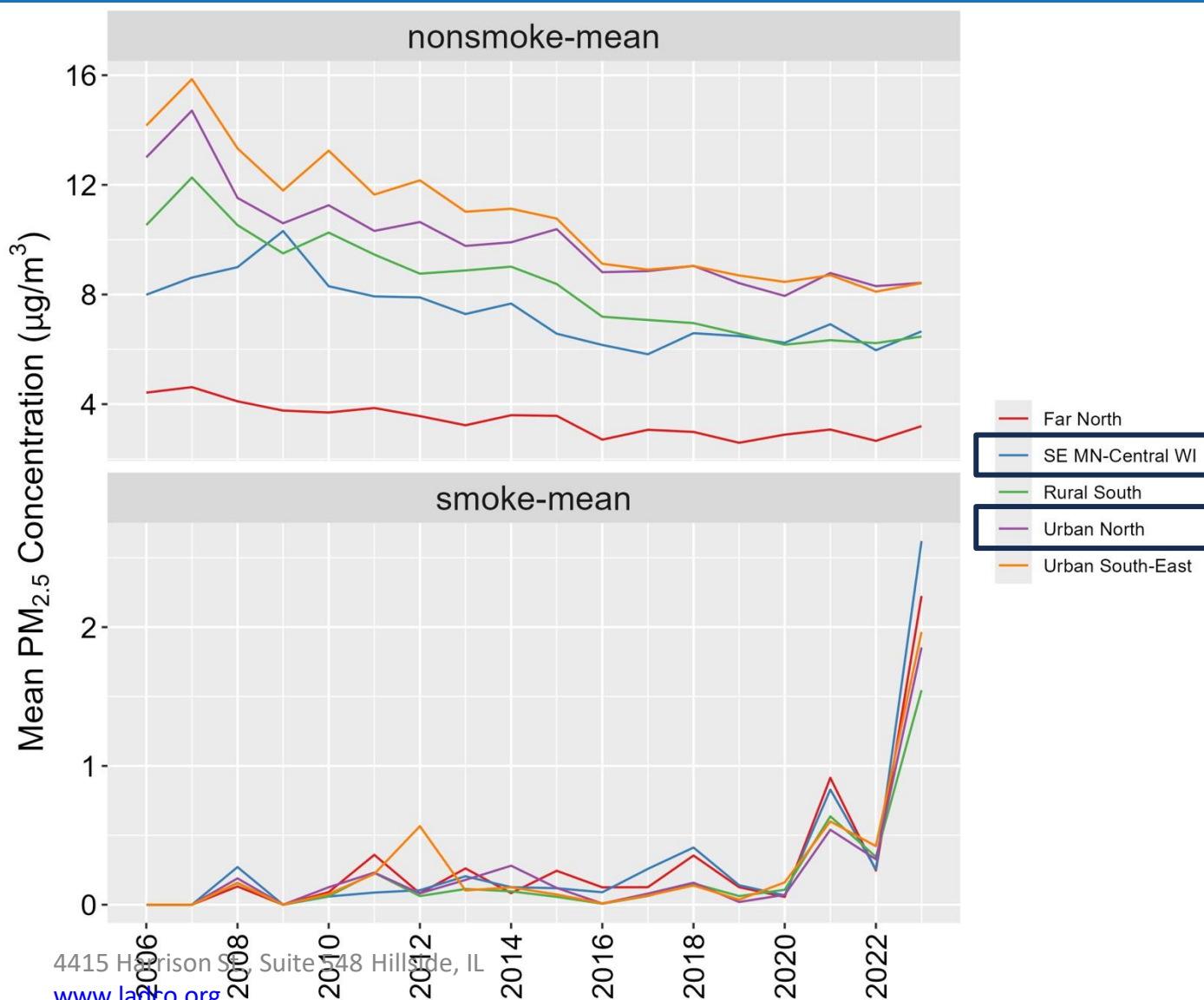
Annual DVs Trends - Milwaukee-Waukesha, WI



Annual DVs Trends - Wisconsin-other



Estimating Smoke Impacts on PM_{2.5}



- Grouped monitors based on similarity in trends
- Large increase in smoke PM_{2.5} in 2021 & 2023
- Smoke accounts for observed increase in PM_{2.5}
- Non-smoke PM_{2.5} trends have been roughly flat in recent years
 - Apparent flatness of non-smoke mean trend may be influenced by switch to continuous monitors (with relative high bias)

Air Quality and Emissions Trends Summary

- Emissions reductions have stagnated
 - There is a need for local, regional, and national emissions control programs to make further progress on NAAQS and public health goals
- Meteorologically adjusted ozone is decreasing in all areas other than Chicago
 - Continued emissions reductions should reduce ozone
 - Chicago would benefit from VOC reductions along with NOx reductions
- Ongoing emissions reductions are needed for nonattainment areas to attain the NAAQS
- Wildfire smoke is playing an increasing role in air quality in WI
 - Directly adding PM_{2.5} and contributing to enhanced formation of ozone

A wide-angle photograph of the Chicago skyline at dusk, viewed from across Lake Michigan. The sky is filled with dramatic, dark clouds with some light breaking through. The city lights are beginning to glow, and the water in the foreground is a deep blue-green. The Willis Tower is the most prominent building on the right side of the skyline.

Regional Air Pollution Planning

Two Truths about Air Pollution

Air pollution in a region comes from hard to control remote and natural sources

Air pollution in a region comes from controllable local and in-region sources

Transported vs Local Pollution

Transported & Background Pollution

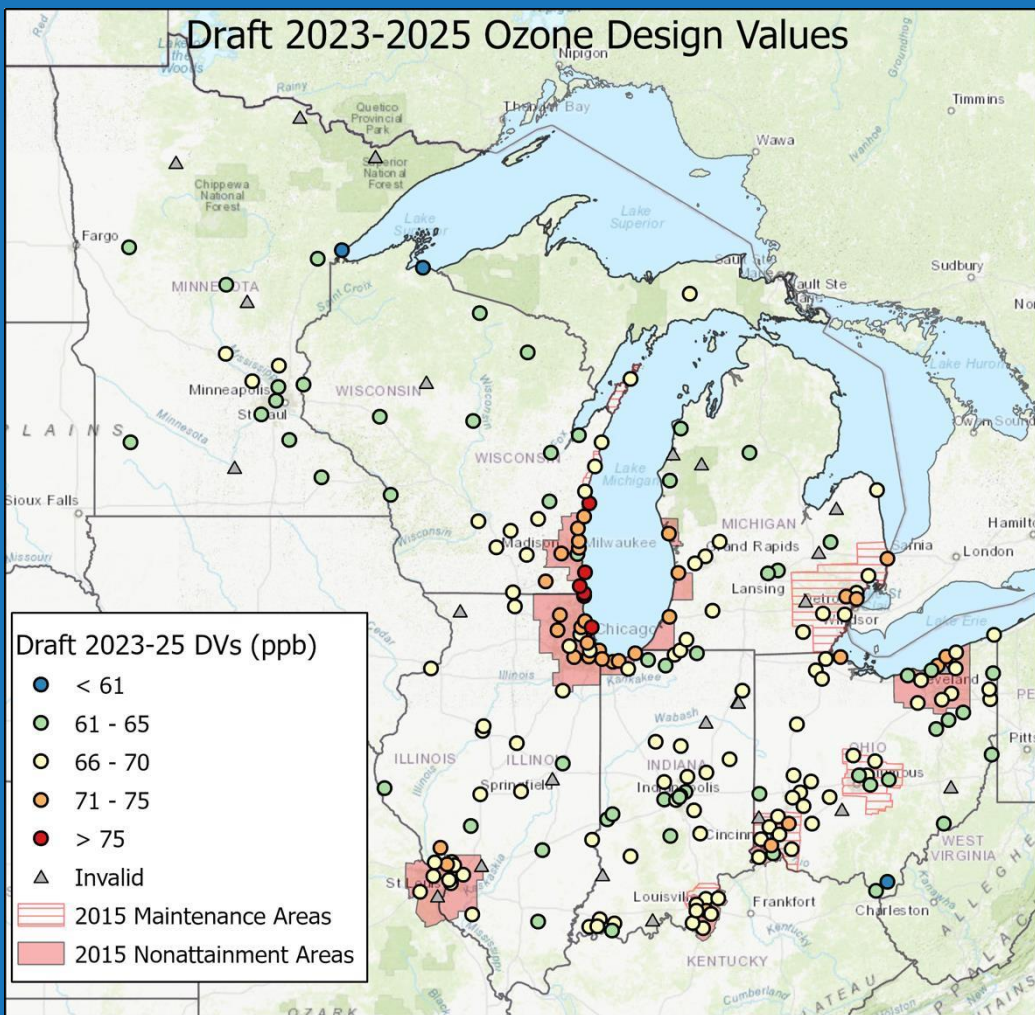
- Present everywhere across the region
- Arrives from outside the state/region
- Increasingly driven by wildfire smoke
- Dominates peak events, not long-term averages
- Harder to control with local policies

Local & Persistent Pollution

- Comes from local and in-region sources
- Traffic, industry, population density, agriculture
- Related to persistent elevated pollution and peak events
- Drives long-term average air quality
- Most effective target for regional strategies

Transported smoke and local emissions both matter...but they require different solutions.

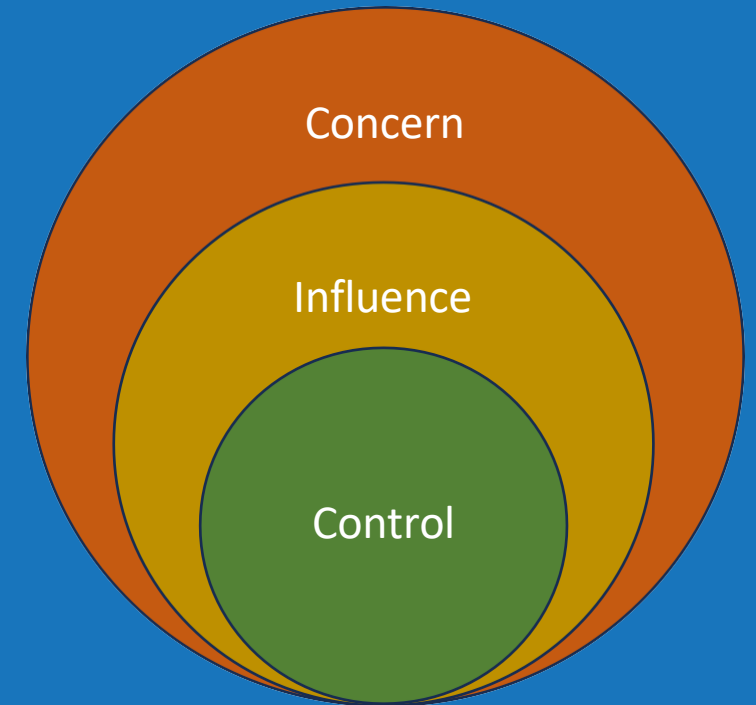
Which Policy Tools Matter?



- **Nonattainment area and urban emissions control programs continue to be relevant**
 - Remain the most effective tools where sources and people are concentrated
- **International transport (179b) is *not* relevant in this region**
 - Not a meaningful pathway for addressing regional air quality
- **Exceptional event demonstrations can be useful for areas that are nearing attainment**
 - Useful near meeting attainment, but not as a long-term strategy

Engagement on Regional Air Pollution Planning

- The Great Lakes region states have made significant progress in reducing air pollution
- For the first time, attainment of all NAAQS for most of the region looks plausible
- We can get to attainment with local and regional strategies through a collective effort between state, municipal, industry, and transportation partners
- LADCO would like to convene stakeholders to envision in-region solutions
 - LADCO will facilitate discussions and share technical and policy scenario ideas



Call for a Regional Coalition

- The Great Lakes region is a success story of air pollution mitigation
- Likely entering a period with very few NAAQS attainment issues
 - Standards can change in the future
- Air pollution will continue to be problem
- Federal rules will change with administration swings
- LADCO proposes engagement on a consensus regional strategy to make continued improvements on emissions and air quality
 - Focus on public health and solutions that are within the control of regional stakeholders





Questions?

Zac Adelman
adelman@ladco.org

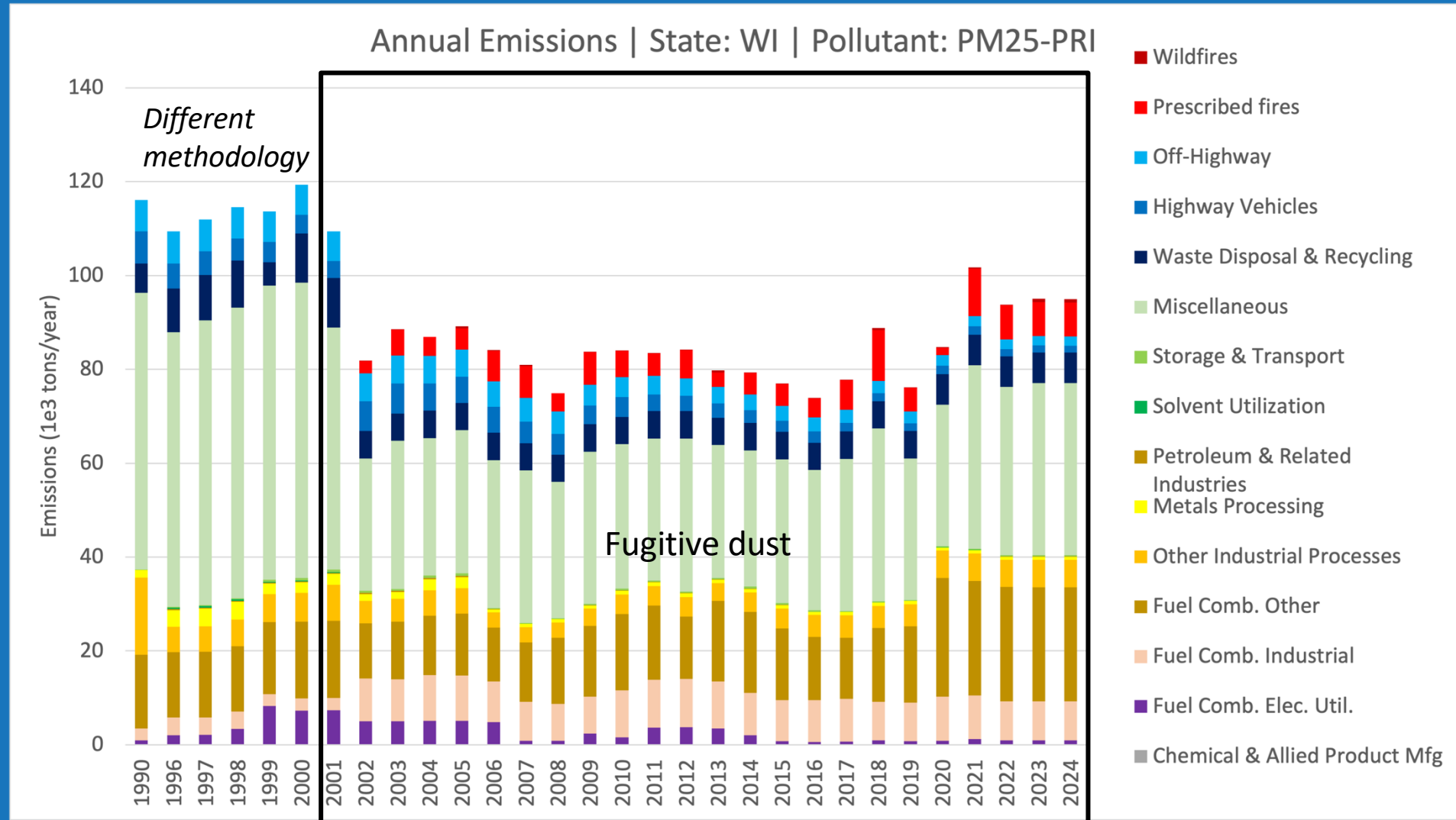
Angie Dickens
dickens@ladco.org

APPENDIX

Emissions: Primary Fine Particulate Matter (PM_{2.5})

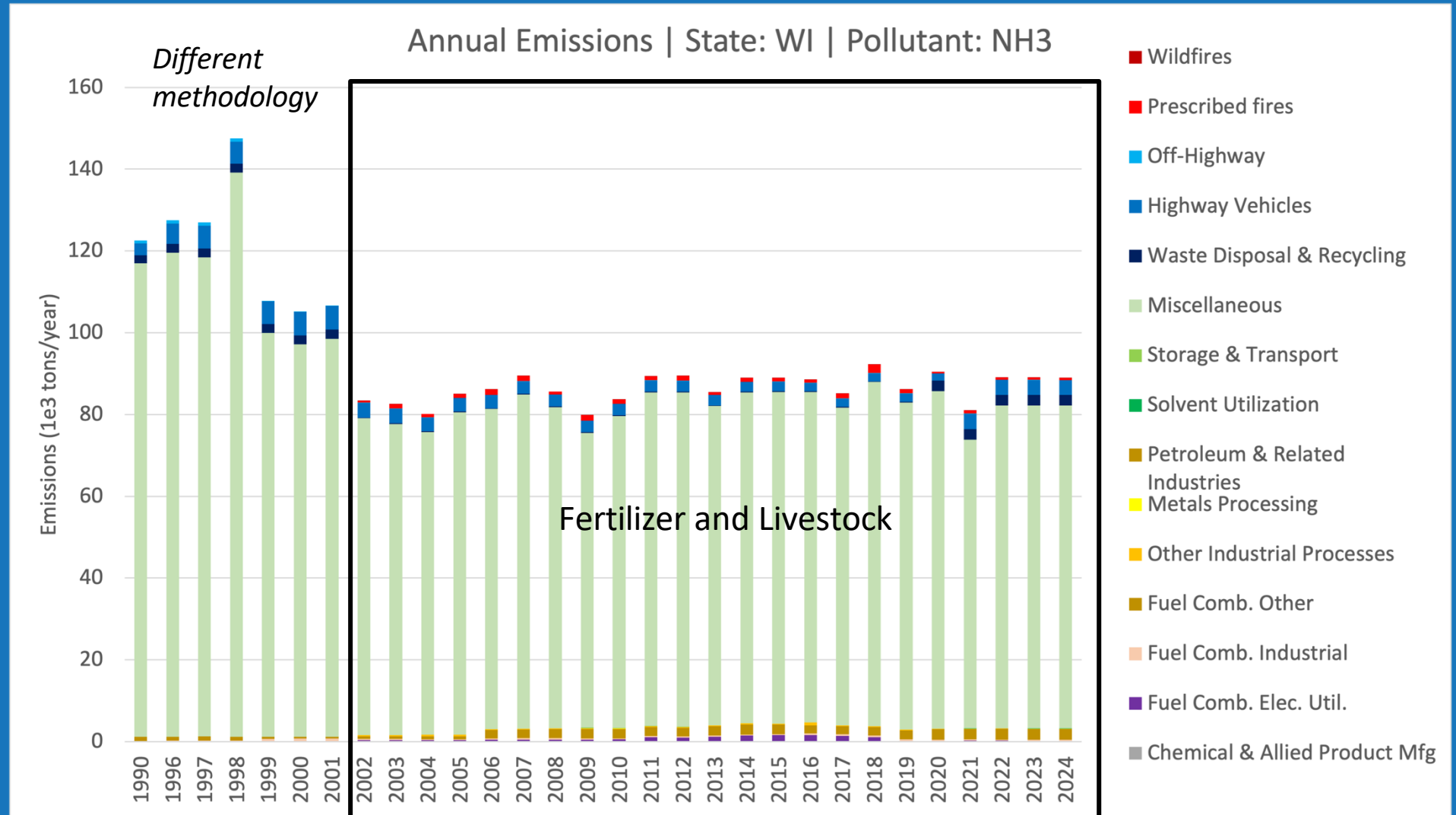
Directly emitted PM_{2.5}

PM_{2.5} is a NAAQS pollutant



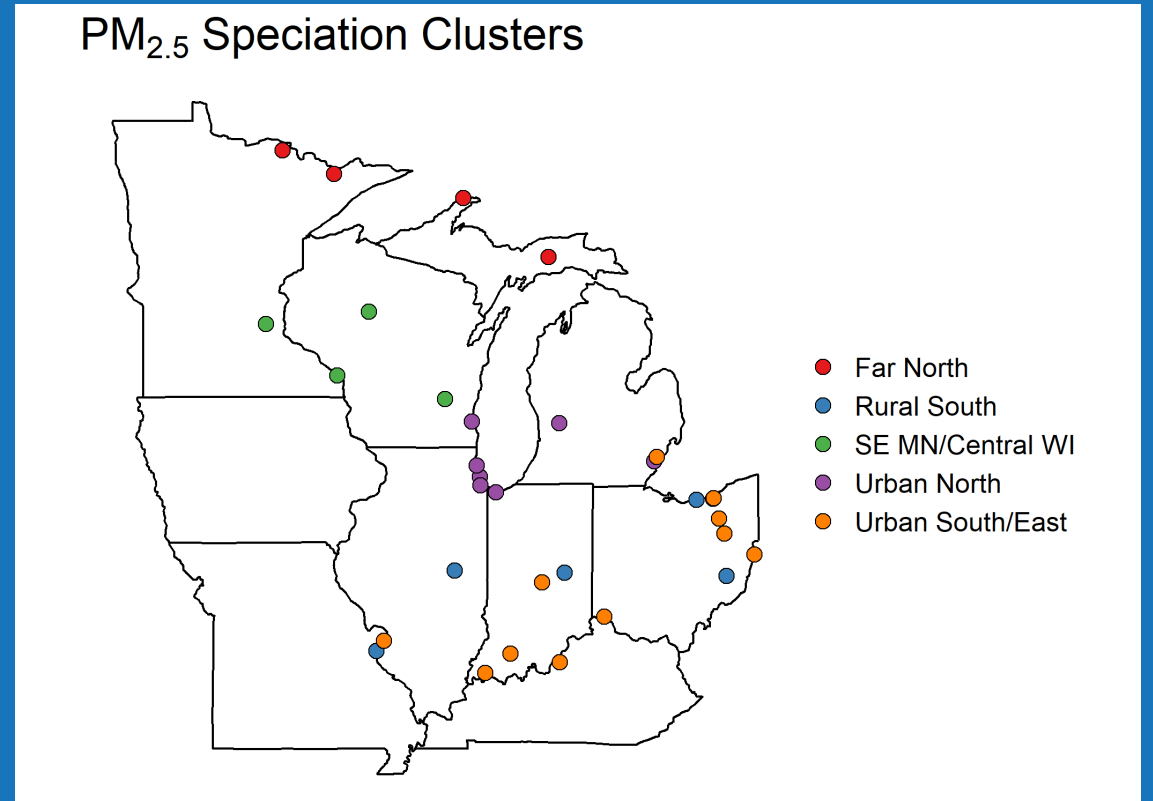
Emissions: Ammonia (NH₃)

Precursor to PM_{2.5}

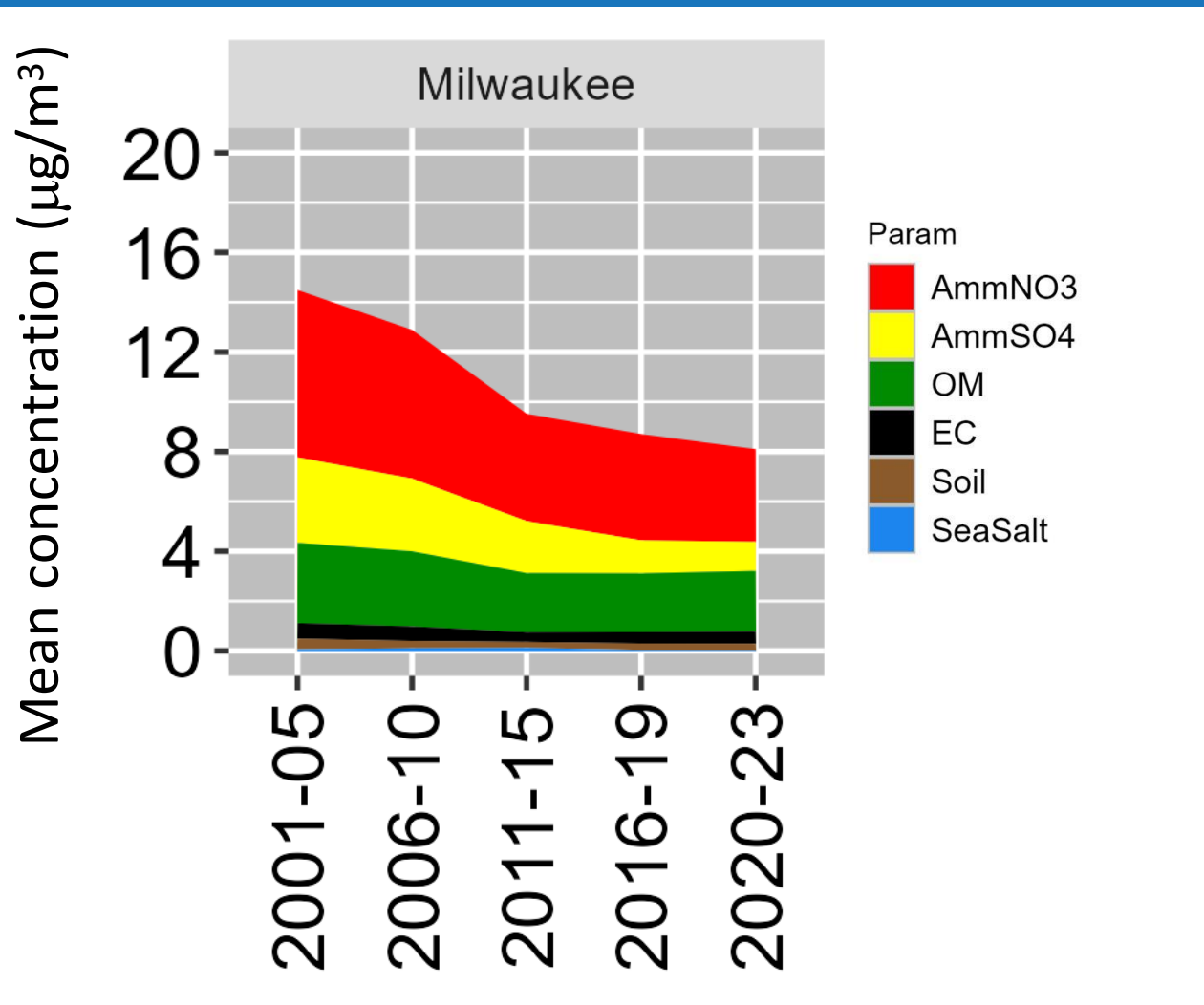


Estimating Smoke Impacts on PM_{2.5}

- Grouped monitors based on similarity in trends
- Determined amount of smoke on a given day
 - Based on the difference from the average concentration
 - = $PM_{2.5\text{-daily}} - (\text{Mean } PM_{2.5} + 1 \text{ stdev})_{\text{nonsmoke-days-month}}$
 - When smoke in satellite column (HMS smoke)
 - Method adapted from Childs et al. (2022) *ES&T* and Burke et al. (2023) *Nature*
- Analyzed through 2023 (so far)



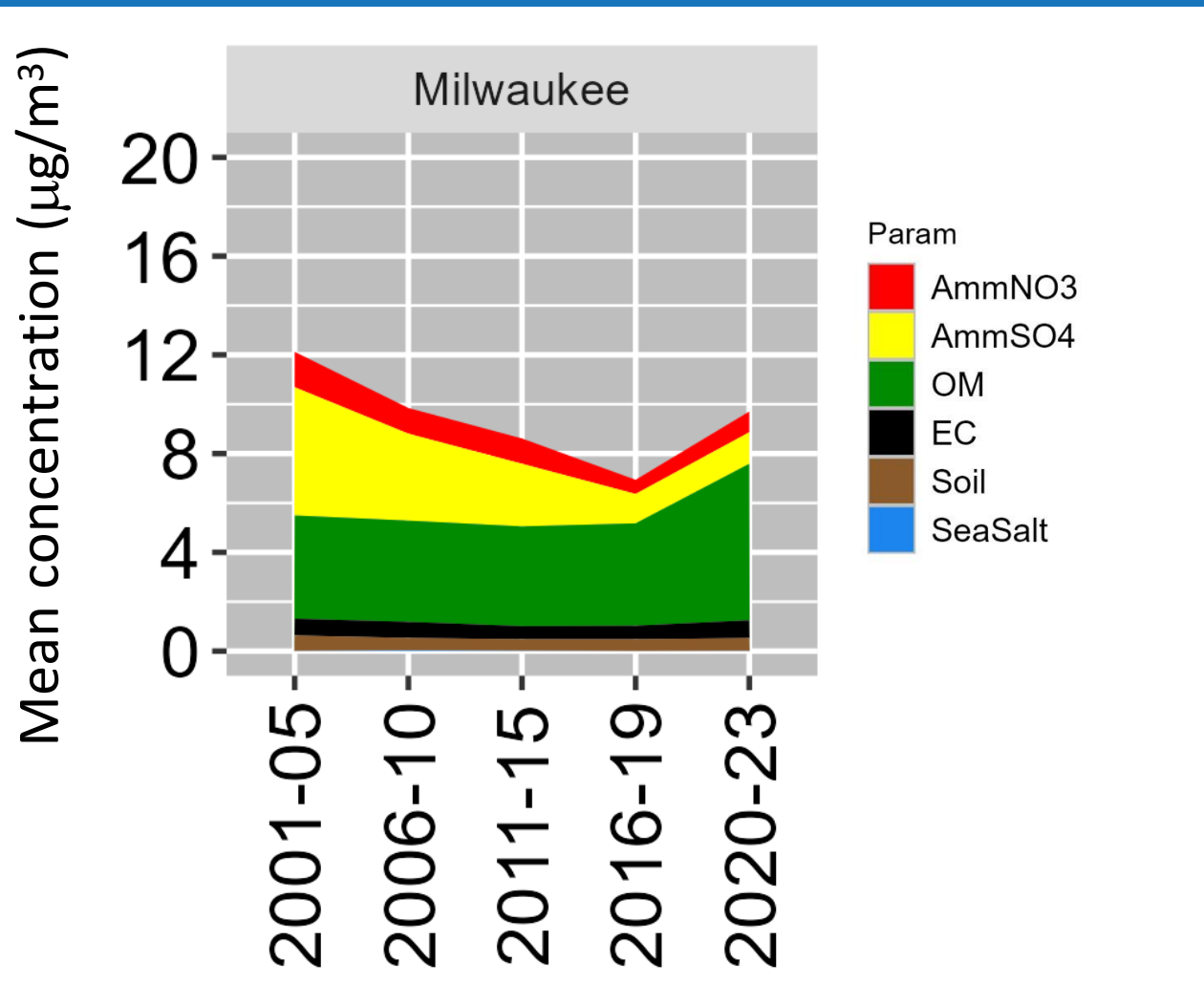
Trends over time: Winter Speciated PM_{2.5}



- Main wintertime component: Ammonium Nitrate
 - Forms from NO_x and ammonia
- All 3 major components have decreased over time in the winter
- AmmNO₃ follows similar trends to NO_x emissions
 - Smaller decrease
 - Doesn't track flat NH₃ emissions

Winter AmmNO₃ likely controlled primarily by NO_x emissions so would need to reduce NO_x to reduce winter PM_{2.5}

Trends over time: Summer Speciated PM_{2.5}



- Main summertime component: Organic Matter (OM)
 - Forms from VOCs (including smoke)
- OM has increased a lot recently
 - Doesn't track decreases in anthropogenic VOC emissions
 - Due to increased smoke
- Large reductions in ammonium sulfate
 - Due to large reductions in SO₂ emissions
 - (Doesn't track flat ammonia emissions)

Summer OM is increasing due to increased smoke → Difficult to control



NASA Satellite Data for Air Quality Assessment & Planning

Tracey Holloway

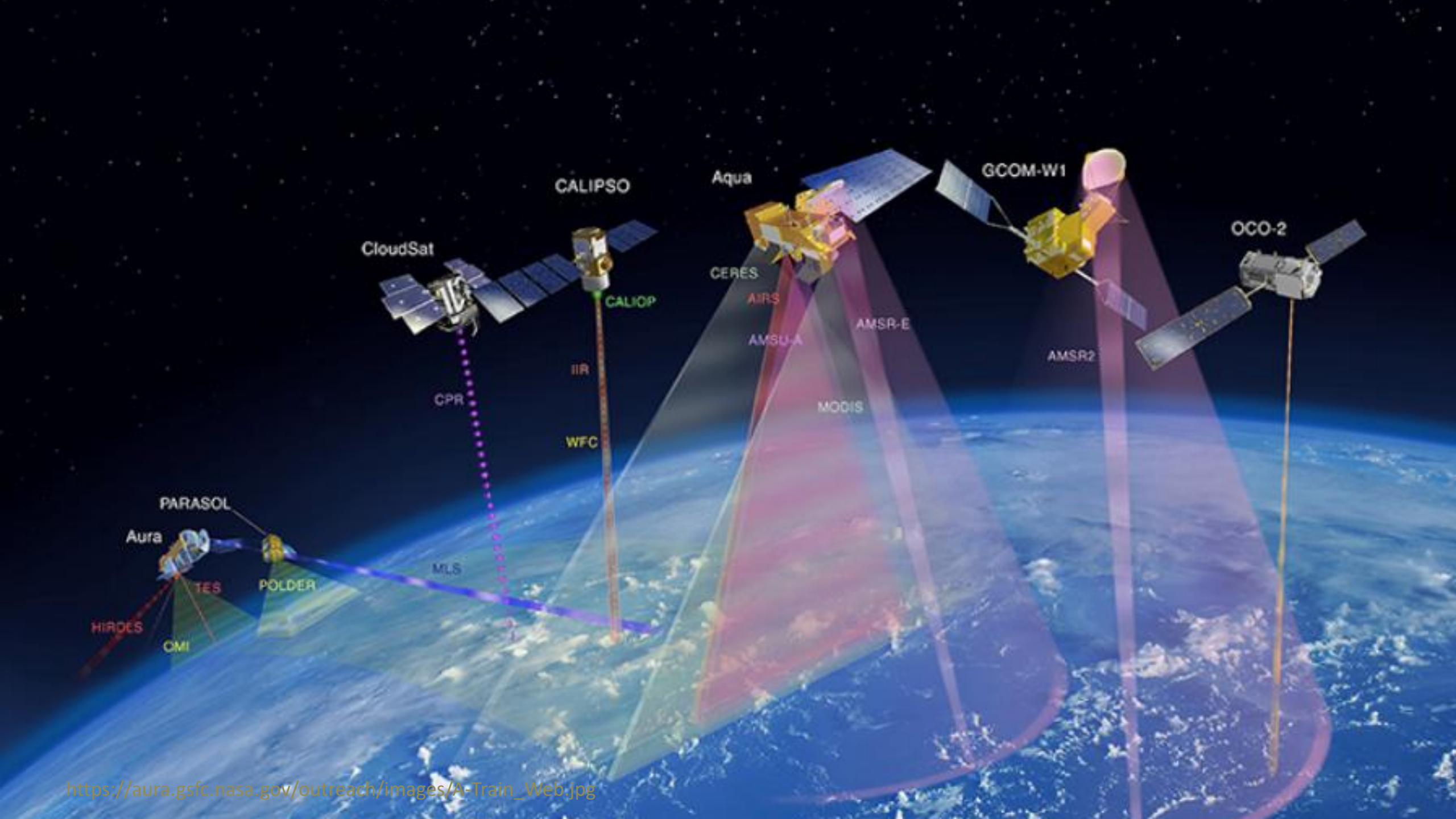
University of Wisconsin—Madison



Thanks to

- NASA funding
- 2025 AWMA Critical Review Committee & Co-authors Jenny Bratburd, Gaige Kerr, Arlene Fiore, and Jingqiu Mao
- HAQAST Members & Co-Is, Ambassadors & Collaborators
- Student Interns Olivia Goins, Summer Acker







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Satellite data to support air quality assessment and management

Tracey Holloway, Jennifer R. Bratburd, Arlene M. Fiore, Gaige H. Kerr & Jingqiu Mao

To cite this article: Tracey Holloway, Jennifer R. Bratburd, Arlene M. Fiore, Gaige H. Kerr & Jingqiu Mao (2025) Satellite data to support air quality assessment and management, Journal of the Air & Waste Management Association, 75:6, 429-463, DOI: [10.1080/10962247.2025.2484153](https://doi.org/10.1080/10962247.2025.2484153)

To link to this article: <https://doi.org/10.1080/10962247.2025.2484153>



R.M. Hoff



S.A. Christopher

Remote Sensing of Particulate Pollution from Space: Have We Reached the Promised Land?

Raymond M. Hoff

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Sundar A. Christopher

Department of Atmospheric Sciences and Earth System Science Center, University of Alabama–Huntsville, Huntsville, AL

Scientists / Researchers

Group A

Academia/University

Research institute

Private enterprise

Government advisory group

Stakeholders / Data Users

Group B

Government regulatory body

Local authority

Air quality consultancy

Research institute/Government lab

Public health

Investigating the barriers and pathways to implementing satellite data into air quality monitoring, regulation and policy design in the United Kingdom

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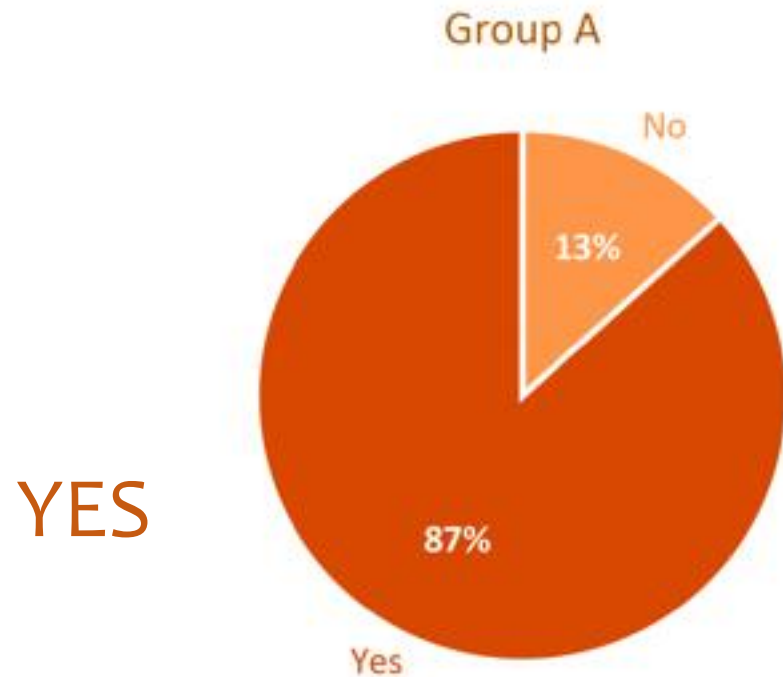
^c Centre for Environmental Health and Sustainability, University of Leicester, Leicester LE1 7RH, UK



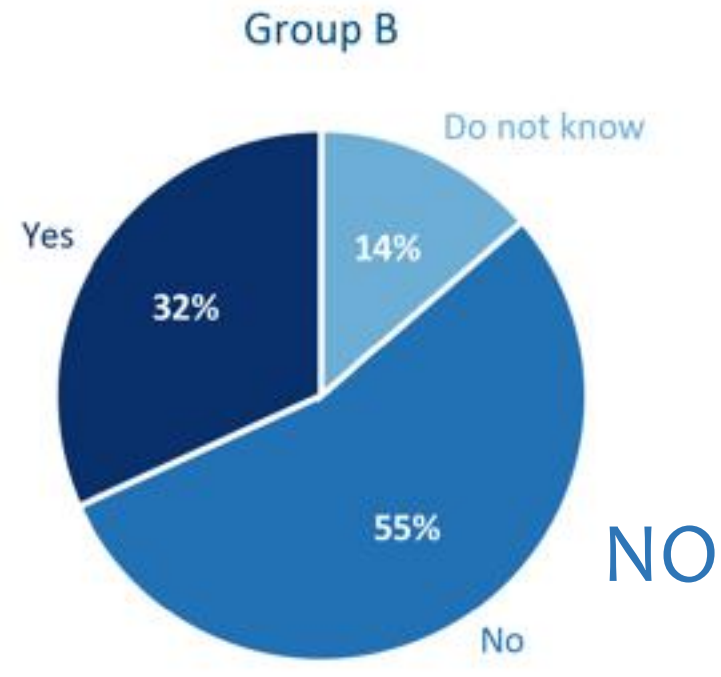
Do you consider satellite air quality data, in their current state,
to be useful to potential end users?

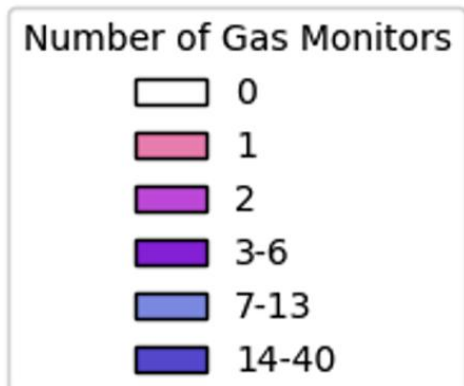
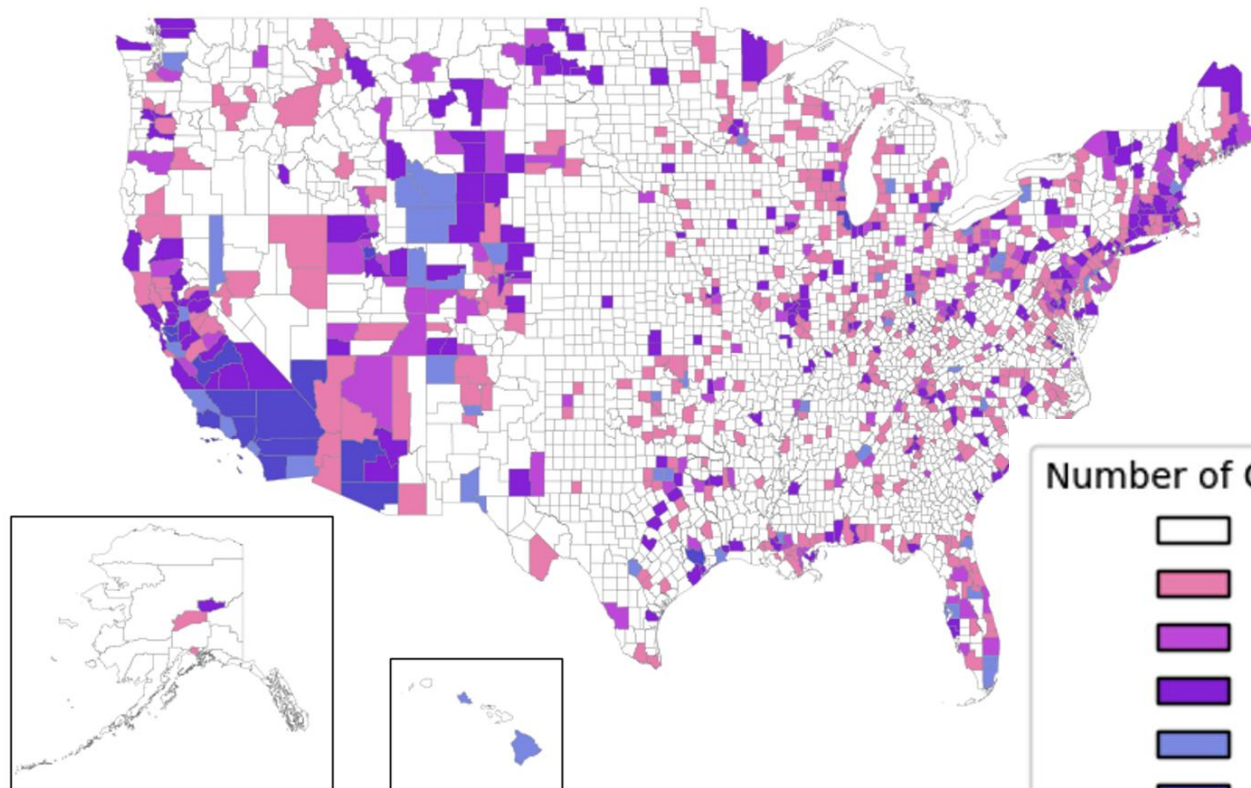
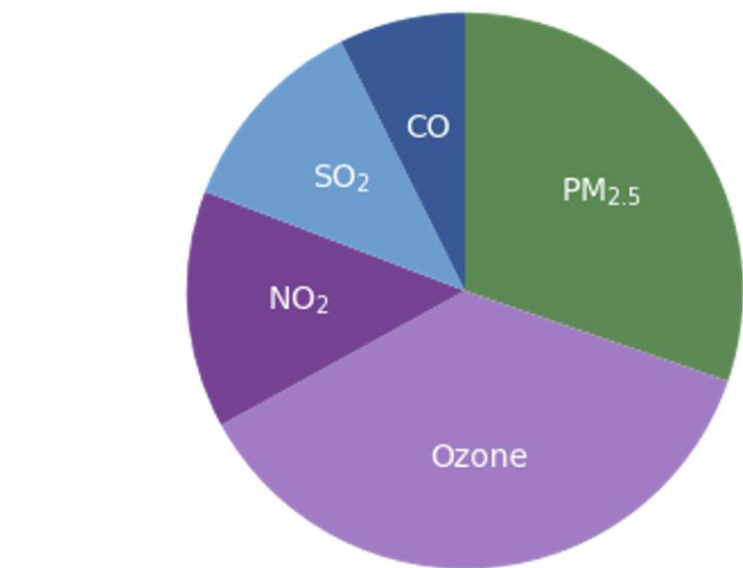
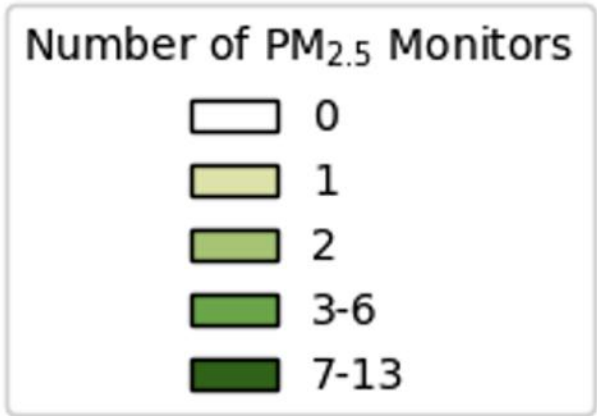
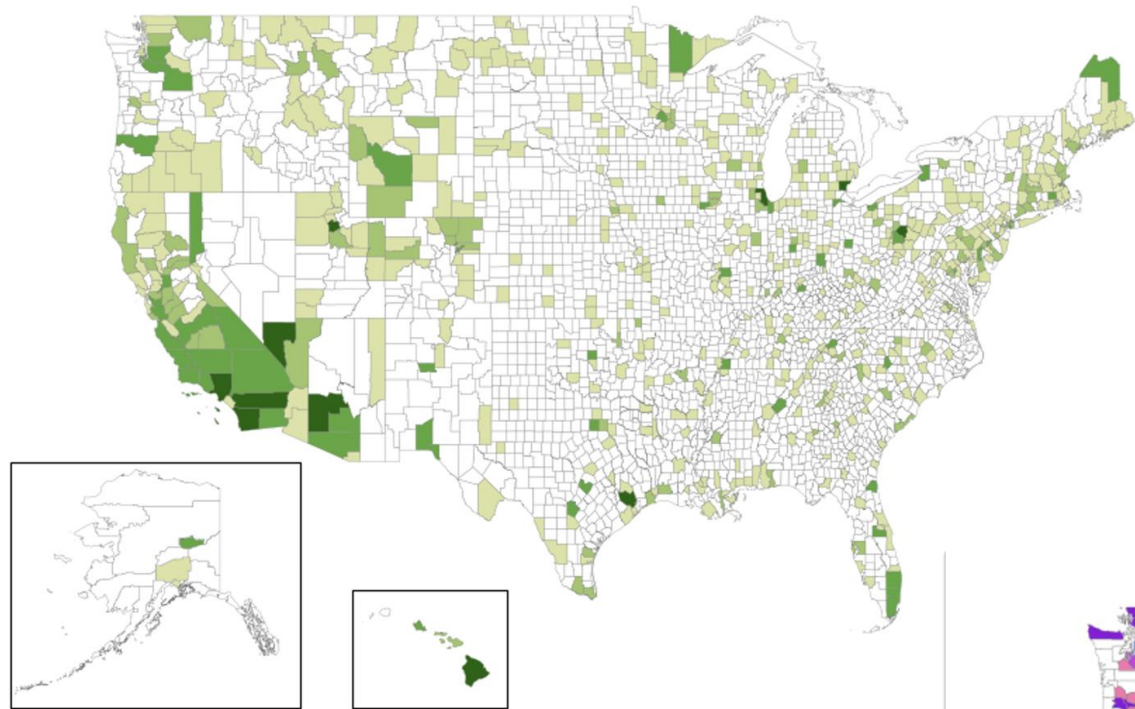
Do you consider satellite air quality data, in their current state, to be useful to potential end users?

Scientists / Researchers



Stakeholders / Data Users





Satellite Data Capabilities

Satellites CANNOT

- Monitor surface-level air quality
- Directly measure emissions
- Detect all pollutants of interest
- Replace ground monitors, CEMS or other standard AQ data

Satellites CAN

- Detect the column – sometimes layers – of some chemicals in the atmosphere (NO₂, aerosols, HCHO, SO₂, NH₃, CO ...)
- Track patterns, trends and events
- Combine with other data to calculate surface-level air quality, especially PM_{2.5}, or emissions

One region, hourly or better
(e.g. TEMPO)



Global, 1 x day snapshots
e.g. TROPOMI



Figure 1. Example of the combined utilization of data data products to understand air quality through the set of field campaigns known as AGES+. In this schematic, satellite data from TEMPO (purple) provides a top-down estimate of NO₂, to complement ground-based monitors, model data, and research-focused aircraft and balloon measurements (NOAA 2023).

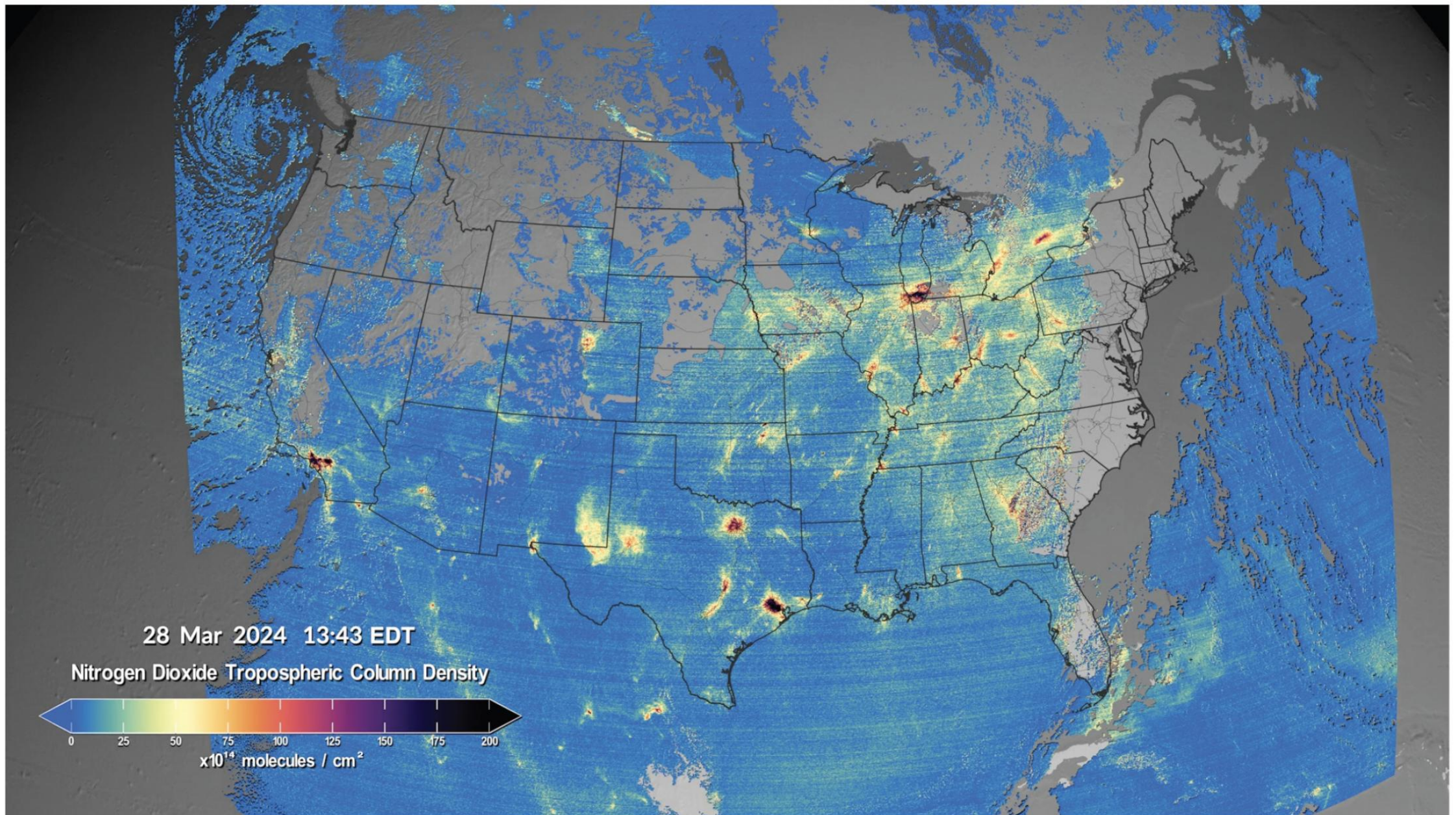
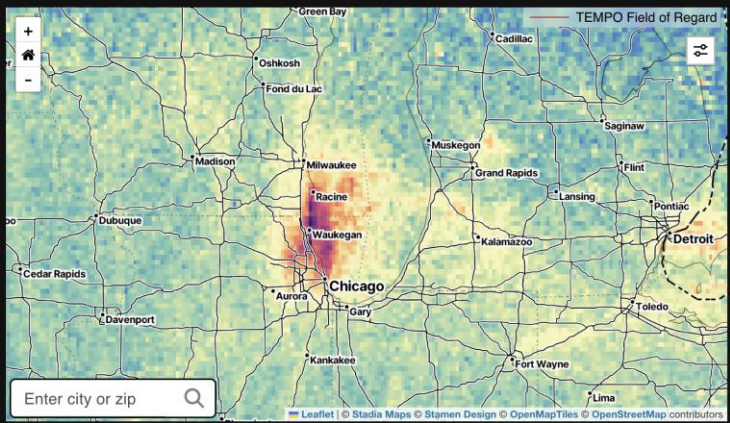
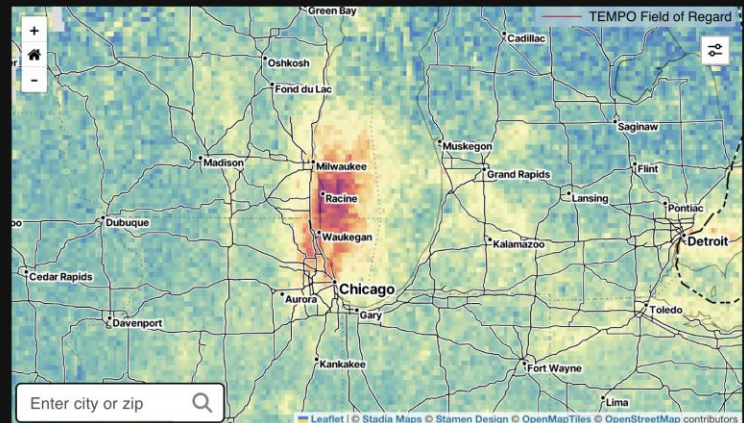


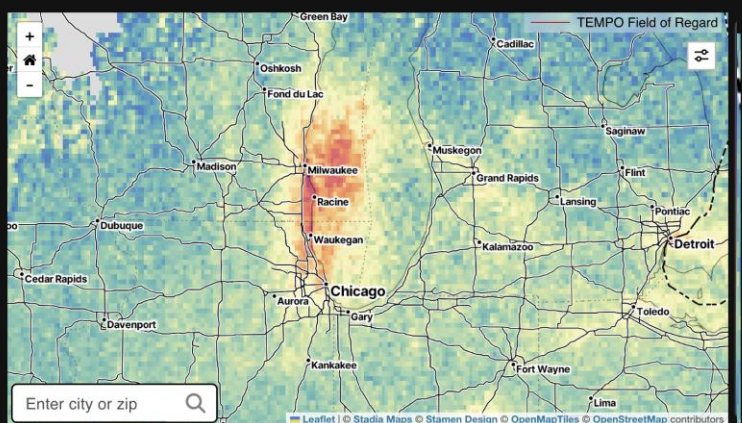
Figure 4. Example of nitrogen dioxide (NO_2) from the TEMPO instrument, here for March 28, 2024, mid-day conditions. (schindler, NASA scientific visualization Studio, 2024).



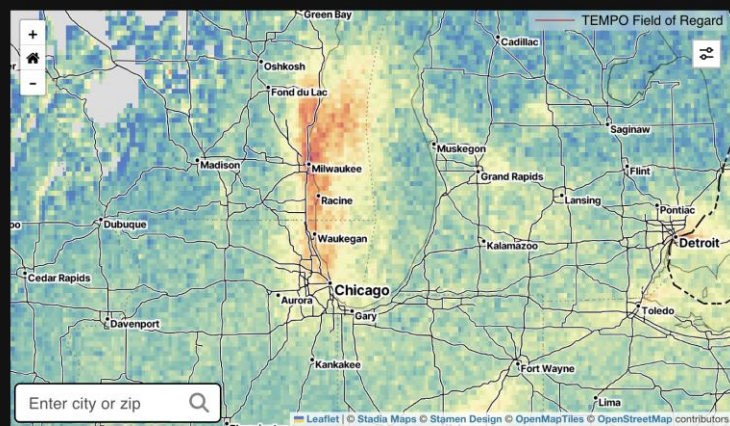
10/20/2025 12:23 PM



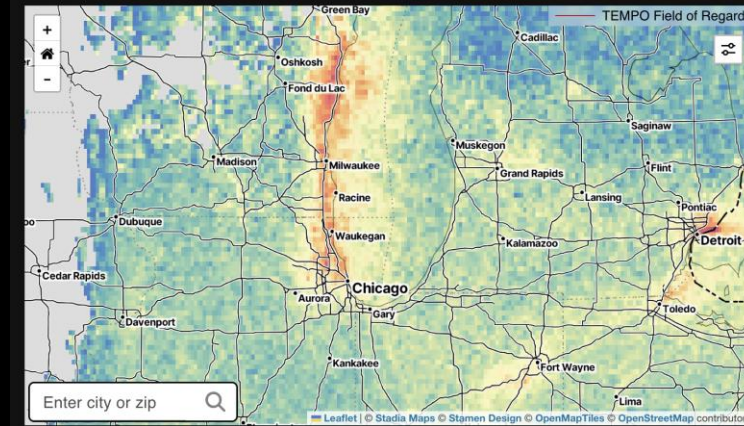
10/20/2025 1:23 PM



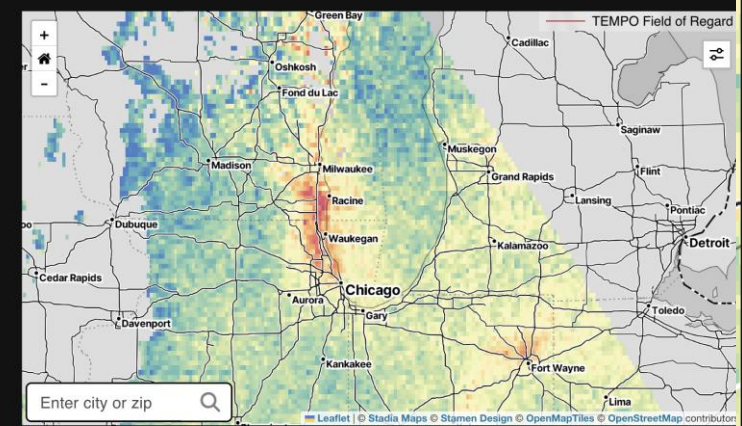
10/20/2025 2:23 PM



10/20/2025 3:23 PM



10/20/2025 4:23 PM

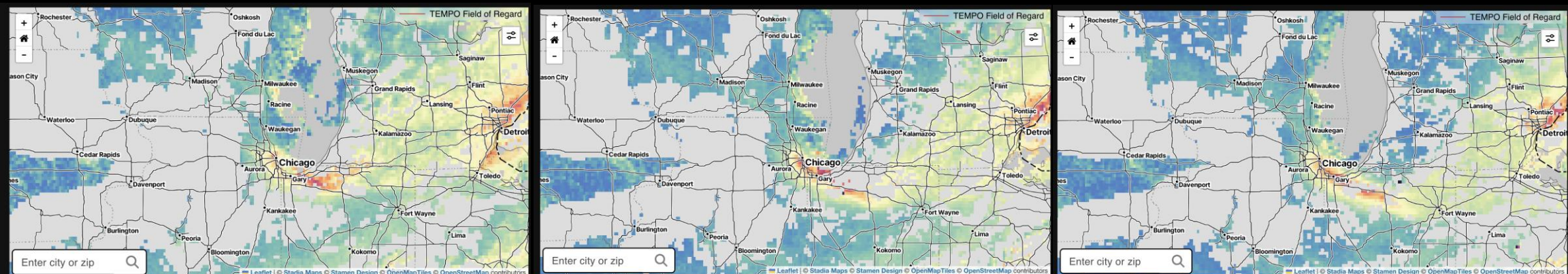


10/20/2025 5:23 PM



NO₂ 10/20/25: 11:30 am to 6:30 pm

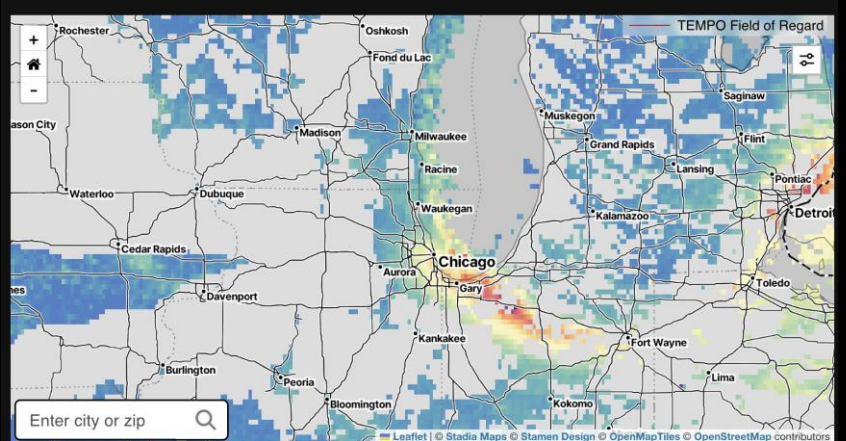
https://tempo.si.edu/data_for_public.html



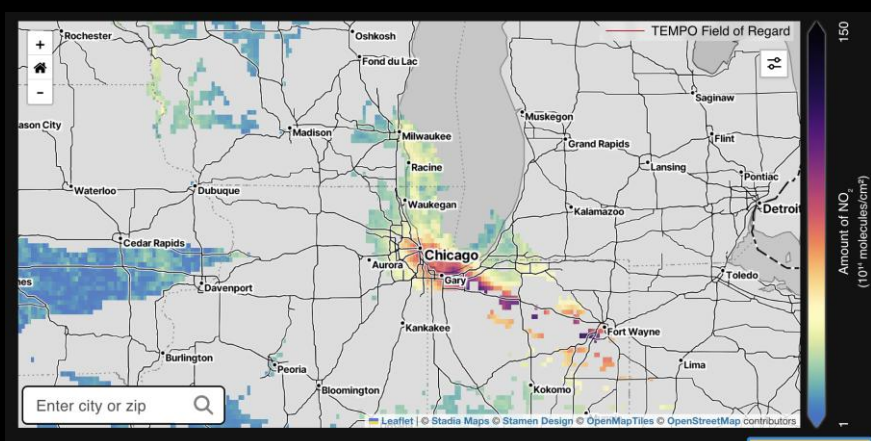
1/27/2026 9:21 AM

1/27/2026 10:21 AM

1/27/2026 11:21 AM



1/27/2026 1:21 PM



1/27/2026 4:21 PM

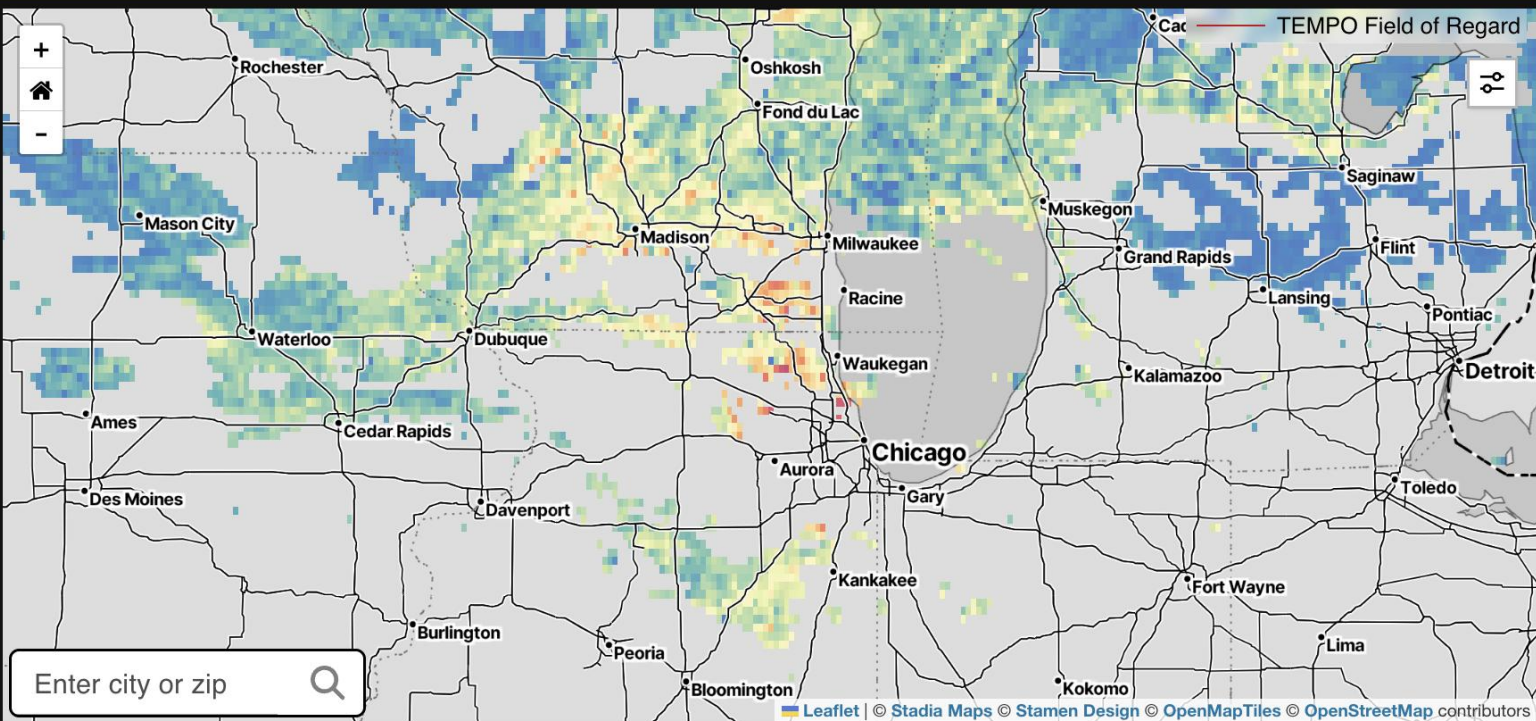


NO₂ 1/27/26: 8:20 am CT to 3:30 pm

https://tempo.si.edu/data_for_public.html



Search



Select a Date

Tue Mar 03 2026

<< LATEST DATA >>

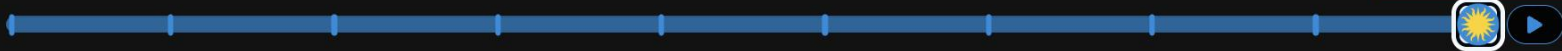
Data Loaded

- ### Notable Dates
- LA Wildfires (Jan 8-31, 2025) [i](#)
 - March 28, 2024 [i](#)
 - November 3, 2023 [i](#)
 - November 1, 2023 [i](#)

Timezone

Eastern Standard

3/3/2026 3:51 PM



TEMPO NO₂ Data

TEMPO, a collaboration between the Smithsonian and NASA, is the first space-based probe to measure air pollution hourly over North America at neighborhood scales. NO₂ (nitrogen dioxide) is one of the pollutants detected by TEMPO. It is produced by wildfires and the burning of fossil fuels. NO₂ contributes to the formation of harmful ground-level ozone and toxic particulates in the air we breathe.

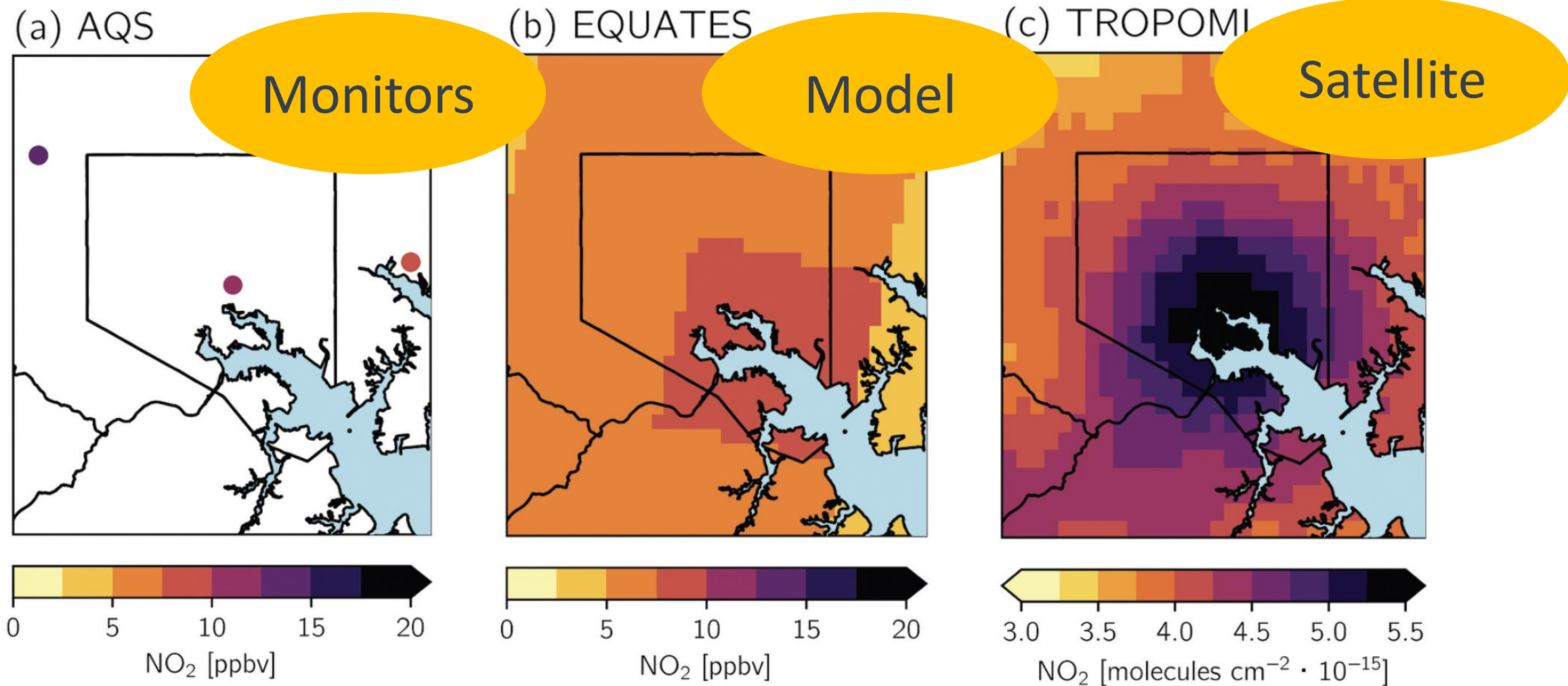


Figure 2. 2019 annual average NO₂ levels for different observational or modeled datasets with different spatial coverage and resolution over the Baltimore, MD metropolitan area: (a) NO₂ surface measurements; (b) estimated surface-level concentrations from the 12 km x 12 km EQUATES photochemical model, (c) tropospheric column measurements from an oversampled 1 km x 1 km TROPOMI product.

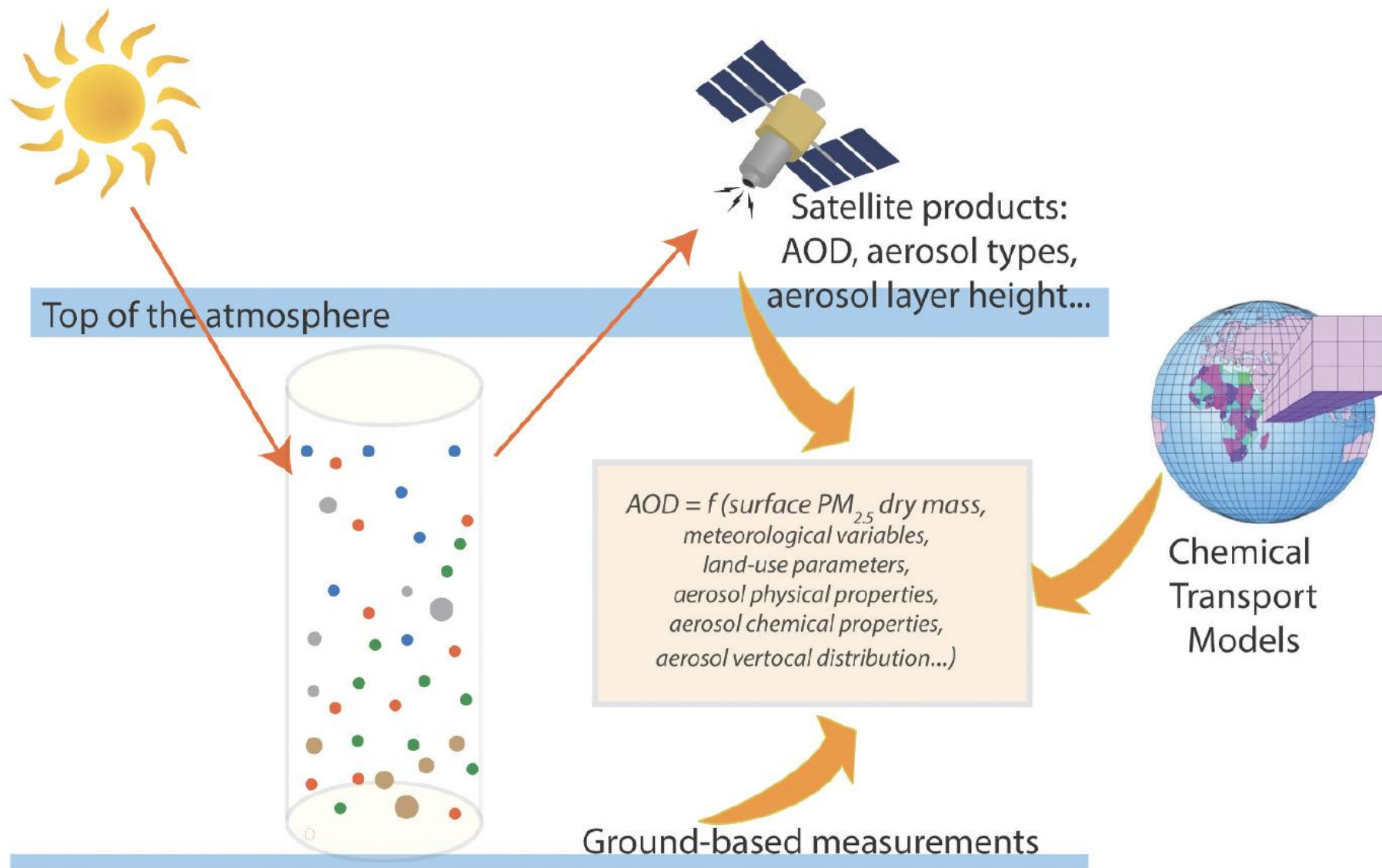


Figure 6. Schematic representation of satellite AOD, ground-based PM_{2.5} measurements, and the role of chemical transport models in calculating AOD-PM_{2.5} relationships.

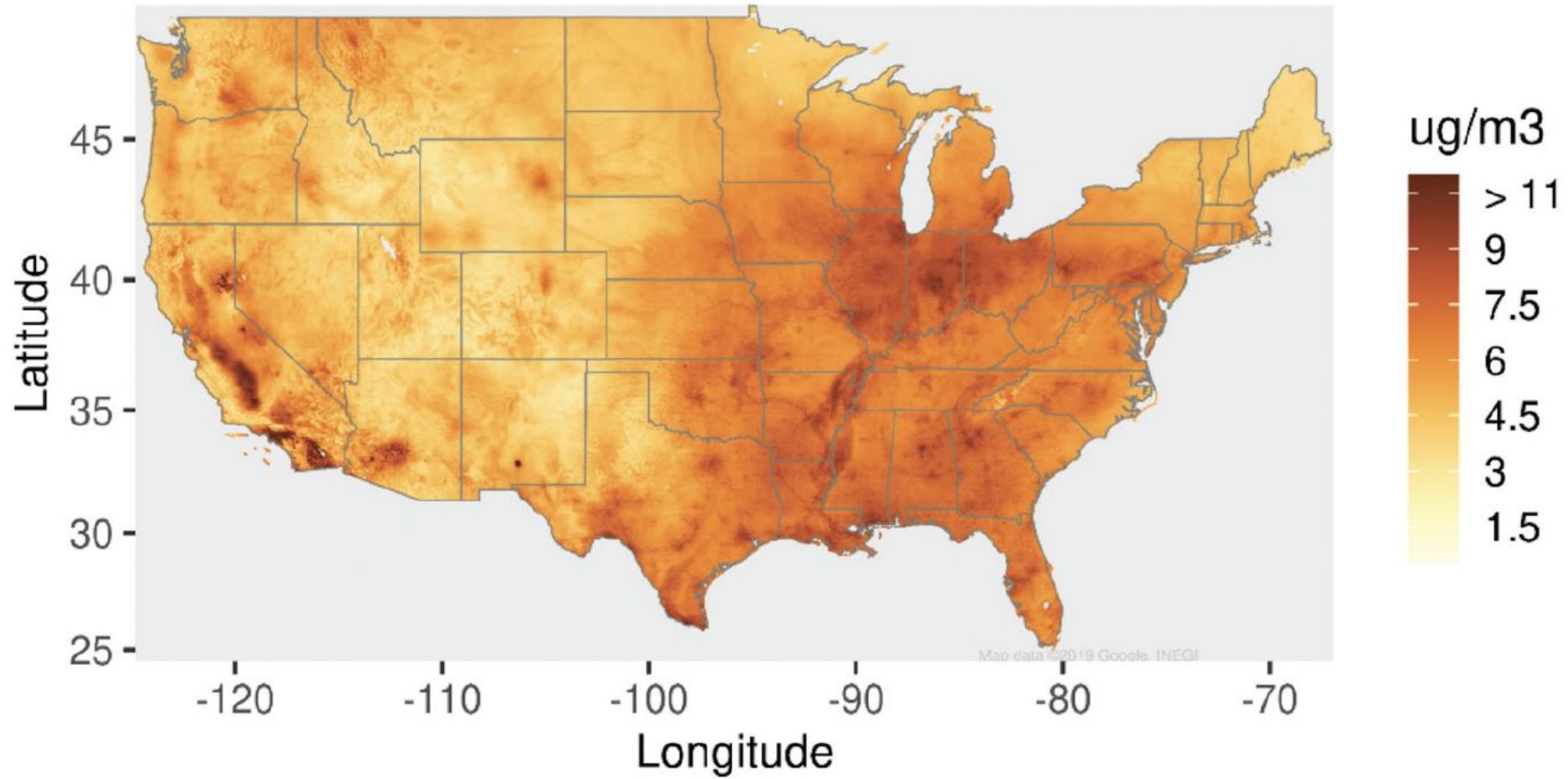


Figure 7. 2019 average PM_{2.5} concentrations from Van Donkelaar et al. (2021), as presented by the EPA in the 2022 PM_{2.5} Regulatory Impact Analysis (Figure 2–1, EPA 2022).

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*
Low-Earth Orbiting		
AOD (+ related aerosol characteristics) modis.gsfc.nasa.gov	Instrument: Moderate Resolution Imaging Spectroradiometer (MODIS) Satellites: NASA Terra and Aqua Terra: 1999 - Present [†] Aqua: 2002 - Present [†]	Global, daily at Terra: 10:30 AM [†] Aqua: 1:30 PM [†] 10 km x 10 km*
AOD (+ NO ₂ , SO ₂ , HCHO, NH ₃) www.nesdis.noaa.gov/our-satellites/currently-flying/joint-polar-satellite-system .	Instrument: Ozone Mapping and Profiler Suite - Nadir Mapper Spectrometer (OMPS-NM)/Visible Infrared Imaging Radiometer Suite (VIIRS)/Cross-track Infrared Sounder (CrIS) Satellite(s): NASA/NOAA Suomi National Polar-orbiting Partnership (S-NPP): 2011 - Present NOAA-20: 2017 - Present NOAA-21: 2022 - Present	All: Global, daily S-NPP: 1:30 AM, 1:30 PM NOAA-20 ~25 min behind S-NPP; NOAA-21 ~25 min ahead of S-NPP S-NPP: 7.5 km x 3 km NOAA-20: 17 km x 12 km NOAA-21: 10 km x 10 km
AOD (+ composition and vertical structure) misr.jpl.nasa.gov	Instrument: The Multi-angle Imaging SpectroRadiometer (MISR) Satellites: NASA Terra and Aqua Terra: 1999 - Present [†]	Global, Every 9 days, with repeat coverage between 2 and 9 days depending on latitude, at Terra: 10:30 AM [†] 17.6 km x 17.6*
AOD (+ composition and vertical structure) www-calipso.larc.nasa.gov	Instrument: Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) Satellite: Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), collaboration between NASA and the French Space Agency, CNES 2006 – 2023	Every 16 days/Global 5 km x 5 km

... + 3 more for AOD..

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 NO_2 , HCHO and SO_2 . 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*
NO_2, HCHO & SO_2 (+ 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
NO_2, HCHO & SO_2 (+ 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 [‡]
NO_2, HCHO & SO_2 (+ 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 <i>NOVA 21, 2022 - Present</i>	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

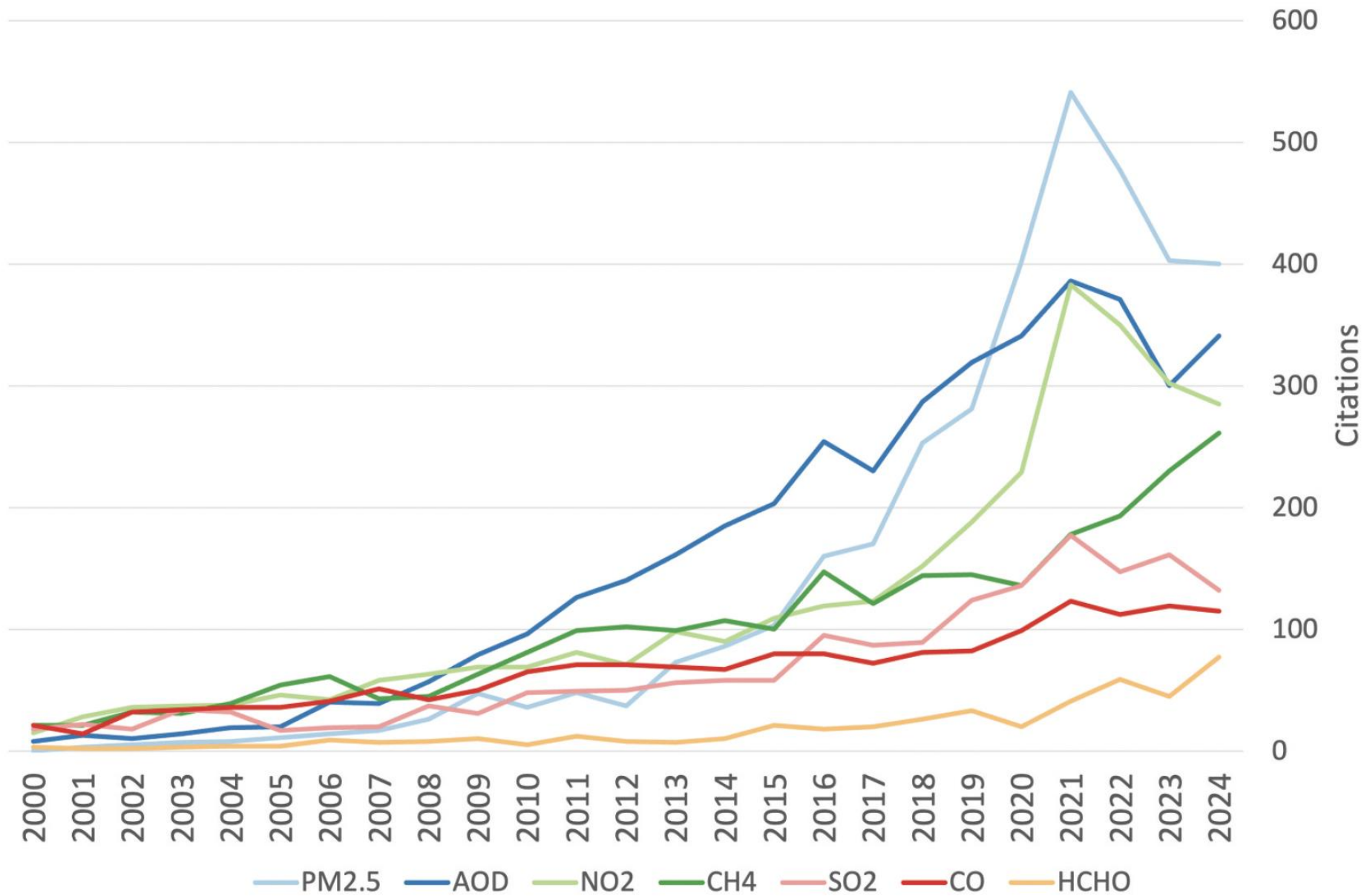


Figure 3. Comparison of citations from Web of Science, based on queries with keywords “PM2.5,” “AOD,” “NO2,” “CH4,” “SO2,” “CO,” “HCHO,” and “satellite” over time. All terms searched in web of science (March 6, 2025) as the pollutant term itself with “AND satellite.”



NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM

Connecting NASA Data and Tools with Health and Air Quality Stakeholders

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HAQAST1:
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HAQAST2: 2016-2020
HAQAST3: 2021-2025

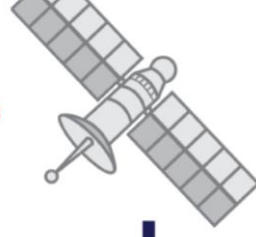


The team structure fundamentally changes outcomes.

- Increased visibility of work and resources to end-users
- Culture to support and promote collaborations
- Growth of two-way dialogue
- Increased collaborations to meet stakeholder needs
- Rapid spin-up of high-value activities



HAQAST Ambassadors



Zac Adelman
Lake Michigan Air Directors Consortium
(LADCO)



Temilayo Adeyeye
New York State Department of Health



Doug Boyer
Texas Commission on Environmental Air
Quality



Eric Choi
Mission Control



Kelly Crawford
Bay Area Air District



Barron H. Henderson
United States Environmental Protection
Agency



Tabassum Z Insaf
New York State Department of Health



Alex Karambelas
NESCAUM



Byeong-Uk Kim
Georgia Environmental Protection Division



Maeve MacMurdo
Cleveland Clinic



Libby Mohr
Environmental Defense Fund



Amirhosein Mousavi
Google / University of Southern California



Leticia Nogueira, PhD MPH
American Cancer Society



Pallavi Pant
Health Effects Institute



Allison Patton
Health Effects Institute



Nathan Pavlovic
Sonoma Technology



Pat Reddy
University of Wisconsin-Madison



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University of Chicago - EPIC Air Quality
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WESTAR

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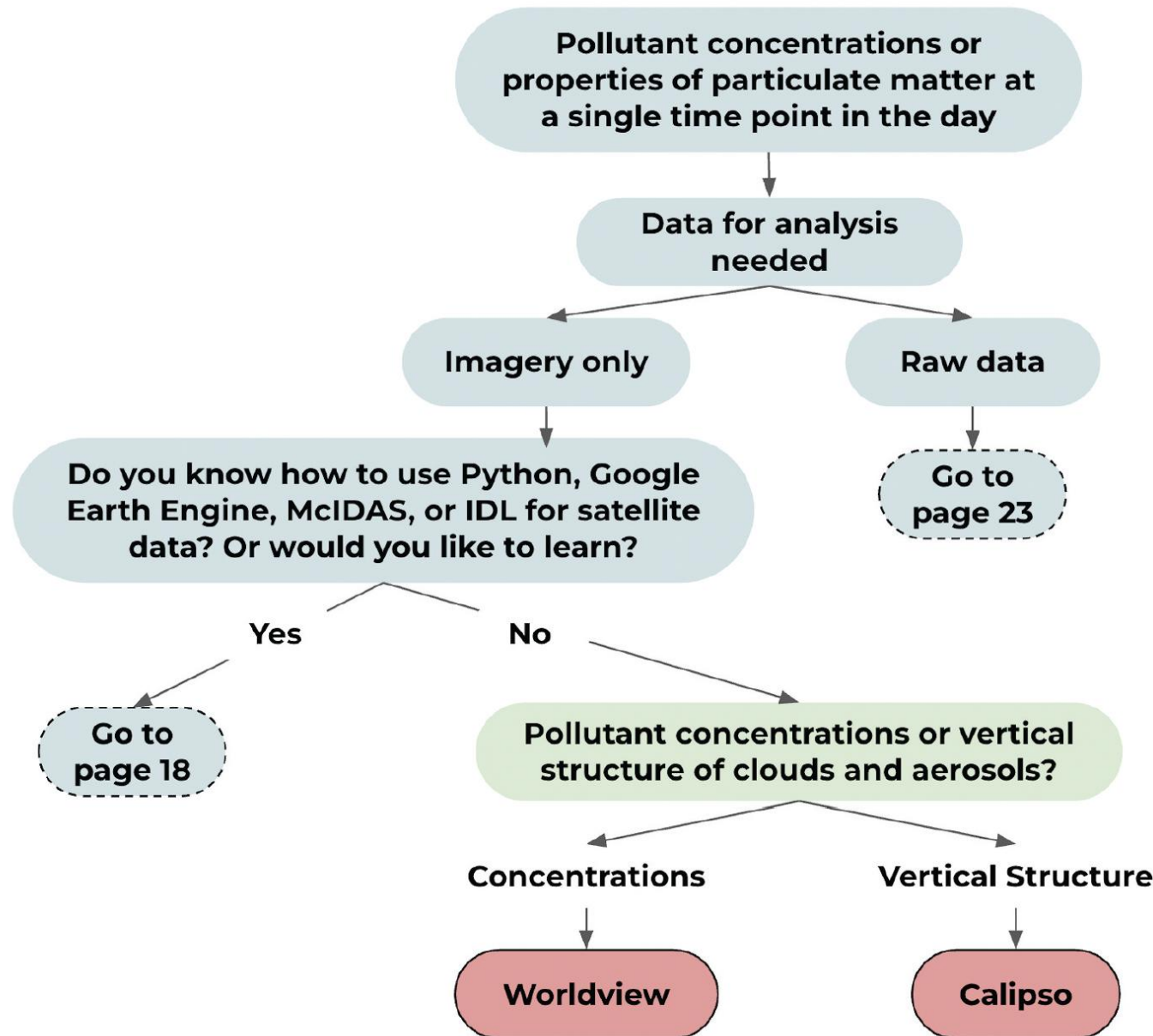


Figure 5. Excerpt from the McGinnis, Holloway, and Bratburd (2023) flowchart, where blue represents steps along the path connecting need to outcome, green represents final criteria in the matching process, and red represents data, tutorial, or research paper end-points.

3) Assessing Status and Measuring Progress

- Emissions trends
- Air quality trends
- Health effects trends
- Ecosystem trends
- Institutional accountability

1) Setting Standards and Objectives

- Emissions standards
- Ambient air quality standards
- Reducing acid deposition
- Reducing regional pollution
- Protecting visibility

Scientific and Technical Foundation

Monitoring:

- Emissions
- Ambient air quality
- Health and exposure
- Ecosystems
- Meteorology

Analysis:

- Models (e.g., air quality, emissions)
- Economics
- Health and ecological risk assessment

Research:

- Public health and ecosystems studies
- Laboratory studies (e.g., air chemistry, toxicology)

Development:

- Source control technology
- Monitoring technology

2) Designing and Implementing Control Strategies

- Source control technology requirements
- Emissions caps and trading
- Voluntary or incentive-based programs
- Energy efficiency
- Pollution prevention (e.g., product substitution and process alteration)
- Compliance assurance

National Research Council, 2004

Setting standards and objectives to protect public health

Satellite data application: Epidemiological studies and health impact assessments

Satellite data application: Community health and environmental justice

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.

Assessing status and monitoring progress

Satellite data application: Air quality forecasting

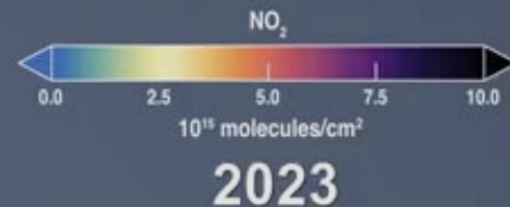
Satellite data application: Trend analysis

***Potential satellite data application: Support for
NAAQS evaluation***

National Ambient Air Quality Standards (NAAQS)

The Clean Air Act directs EPA to periodically review the National Ambient Air Quality Standards. Together with our Tribal, state, and local air agency partners, we have successfully implemented those standards to bring Americans cleaner air and lower risks of adverse health effects.

[Play background video](#) of [NASA](#) 2005 - 2023 NO₂ satellite imagery



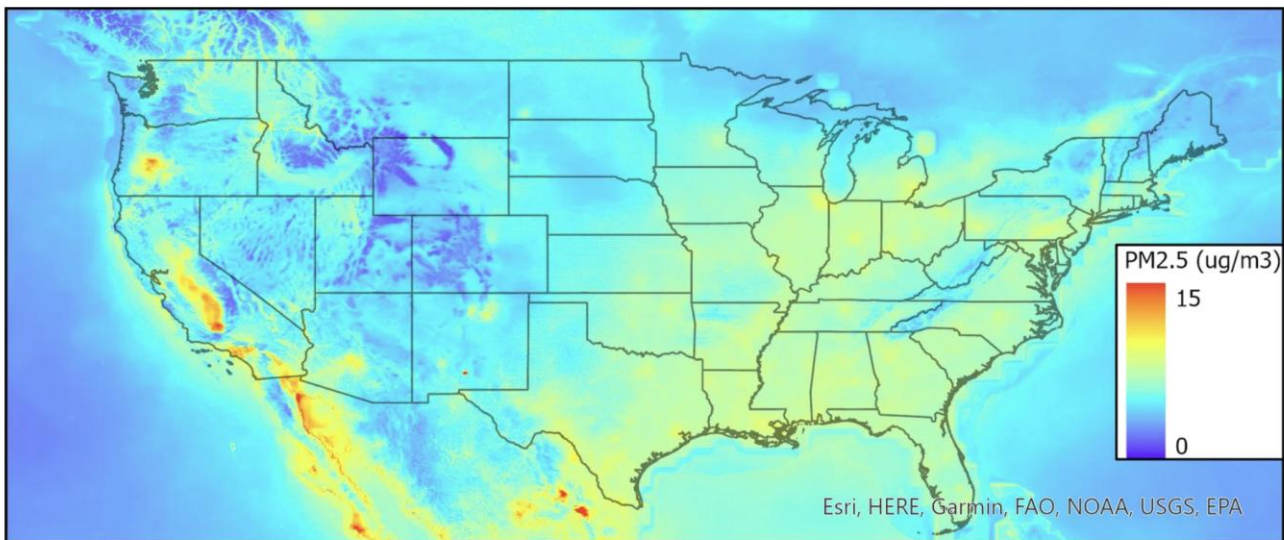


Figure 1. Washington University 0.01 degree 2022 average PM_{2.5}.

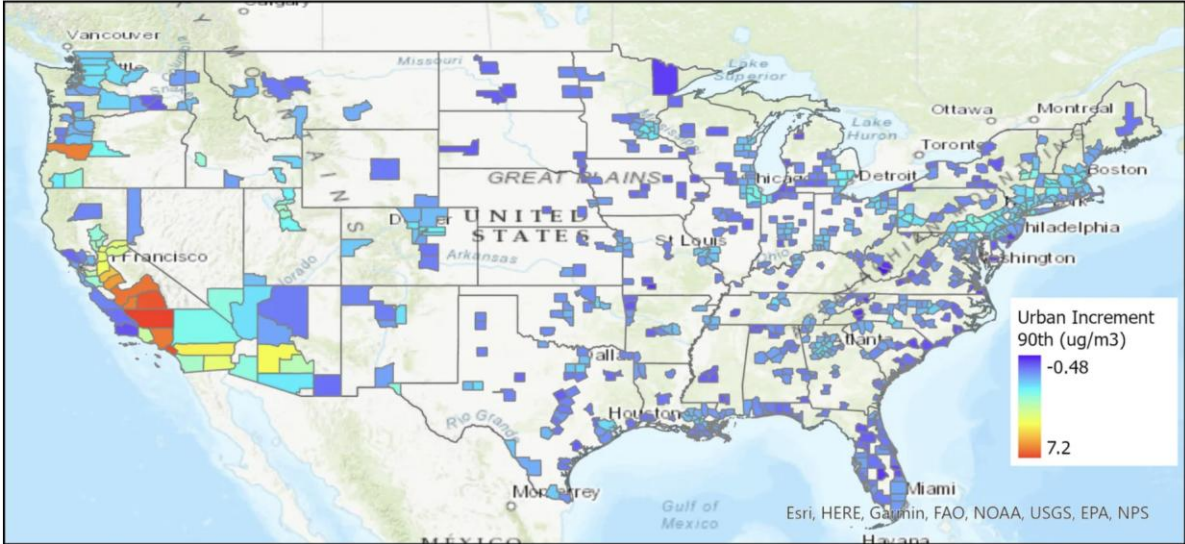


Figure 7. Urban increment based on the 90th percentile concentration for urban counties, determined as the difference between the 90th percentile urban and mean rural PM_{2.5} concentrations.

Designing and implementing control strategies

Satellite data application: Model evaluation

Satellite data application: Improved emission inventories

Satellite data application: Exceptional event demonstrations

Satellite data application: Ozone sensitivity to precursors

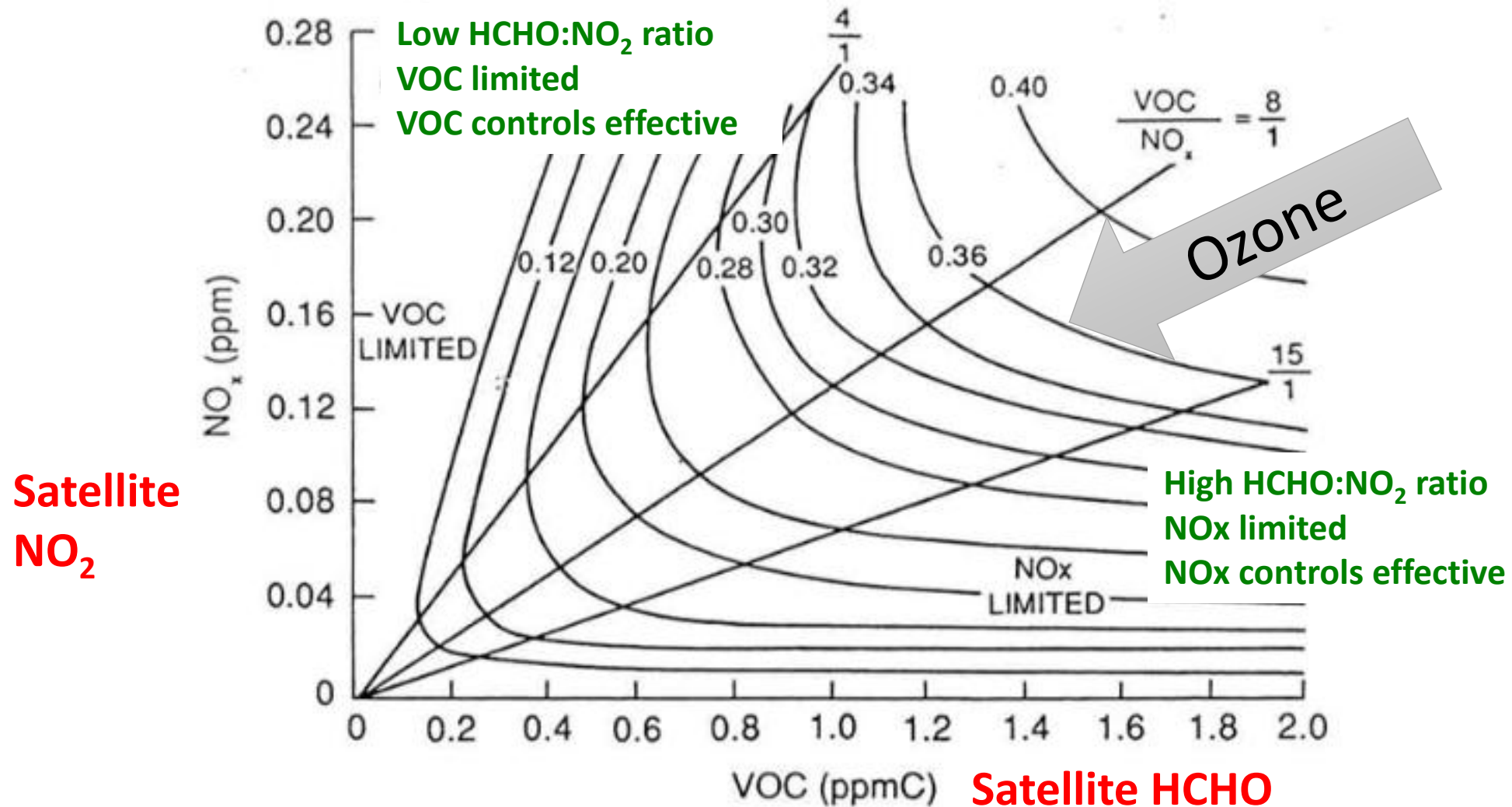


FIGURE 6-1 Typical ozone isopleths used in EPA's EKMA. The NO_x-limited region is typical of locations downwind of urban and suburban areas, whereas the VOC-limited region is typical of highly polluted urban areas. Source: Adapted from Dodge, 1977.

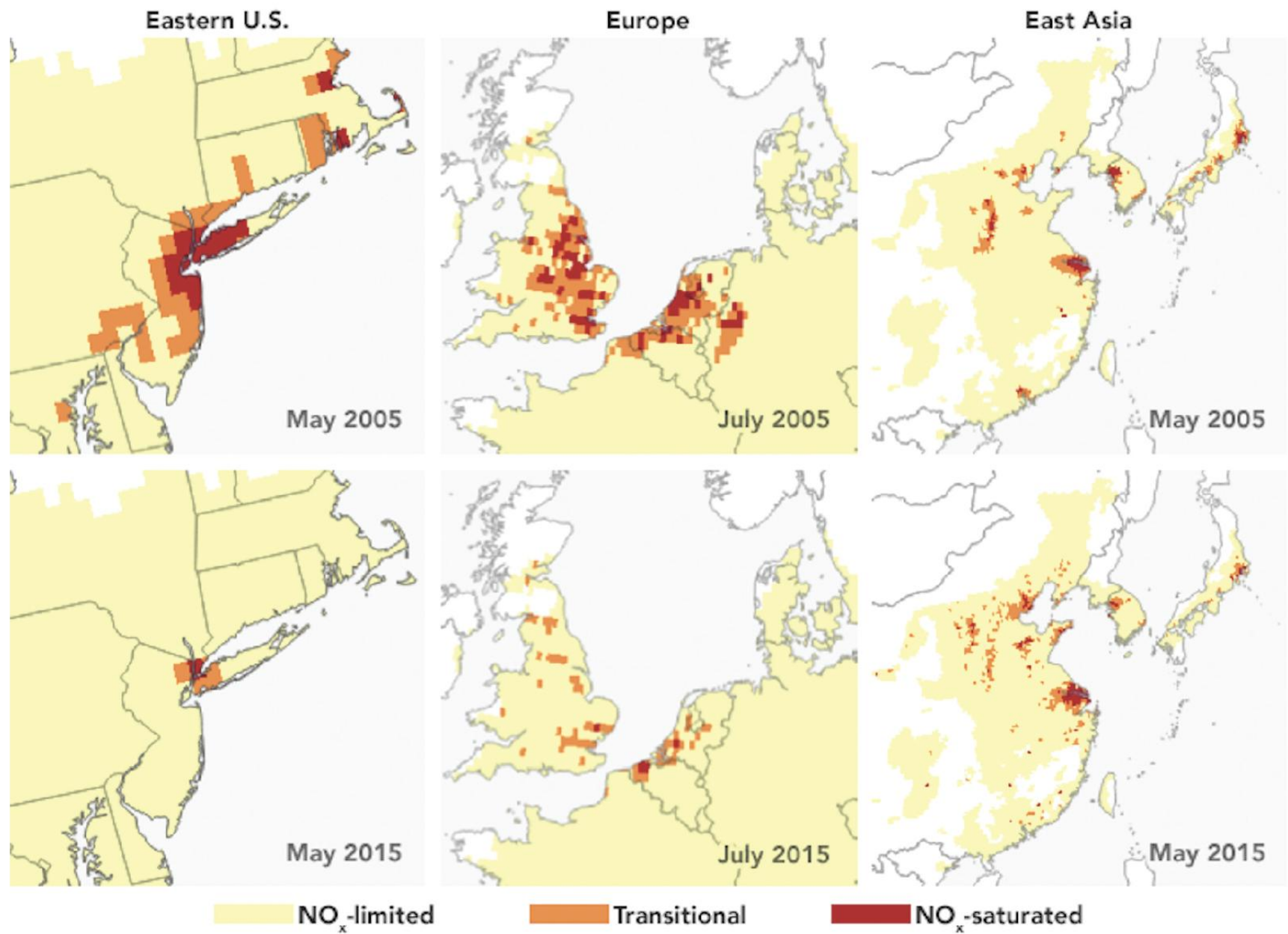
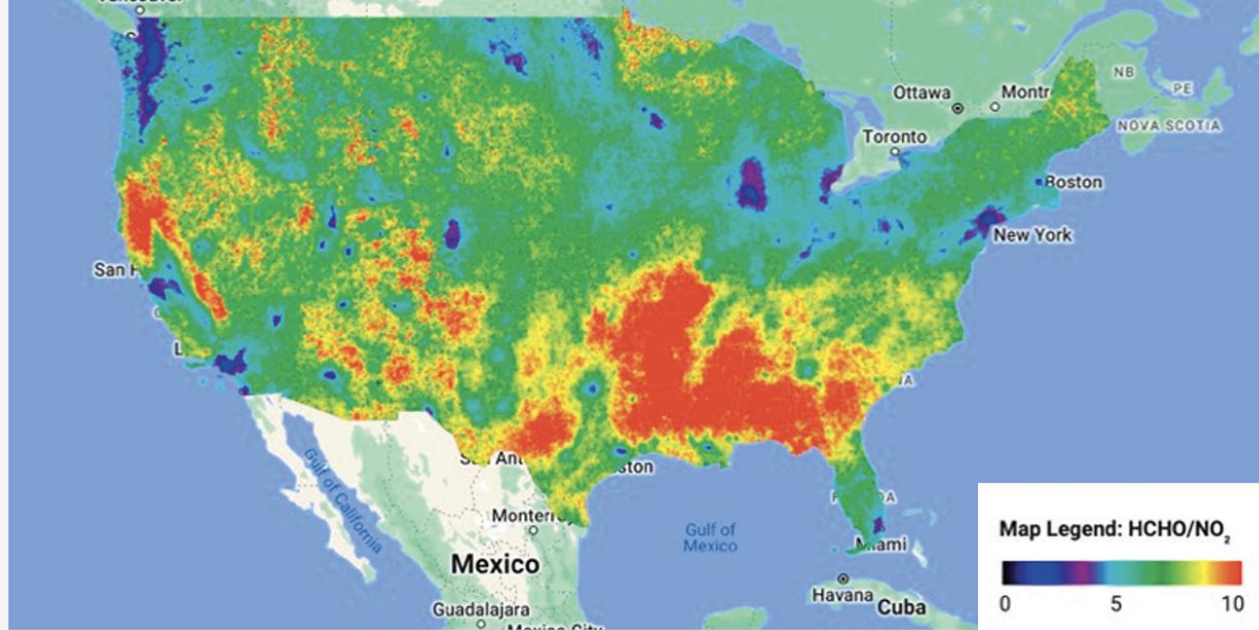


Figure 9. The ratio of column HCHO to column NO₂ from the ozone monitoring instrument shows widespread transition away from VOC-limited ozone production. Image from Jin, Fiore, and Geigert (2018) via NASA Earth Observatory (2017).



hollowaygroup.org/tutorials

Satellite Data to Inform Ozone Sensitivity: **A Practical Methodology Using Google Earth Engine**

by Jennifer McGinnis, Tracey Holloway, Jenny Bratburd, Madankui Tao,
and Arlene Fiore

Evaluating ozone sensitivity to emissions of its precursor gases with satellite data has evolved into a cutting-edge and increasingly popular application of remote sensing for health and air quality. Google Earth Engine offers a practical, user-friendly platform to support this analysis anywhere in the world using data from the TROPOMI instrument.



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Connecting NASA Data and Tools with Health and Air Quality Stakeholders

- Satellite data are **already** part of the data portfolio for air quality ... and rapidly advancing
- You can stay on top of this area through NASA's investment in the Health and Air Quality Applied Sciences Team - haqast.org
- Join us in Madison May 13-14! <https://haqast.org/haqast-madison/>
- Access data & how-to's: haqast.org/data-and-tools
- Please reach out – Tracey Holloway taholloway@wisc.edu



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**The Holloway Group Advances Air Quality Research To Inform
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- Thu. Sept. 17, 2026

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