Air Quality in Madison

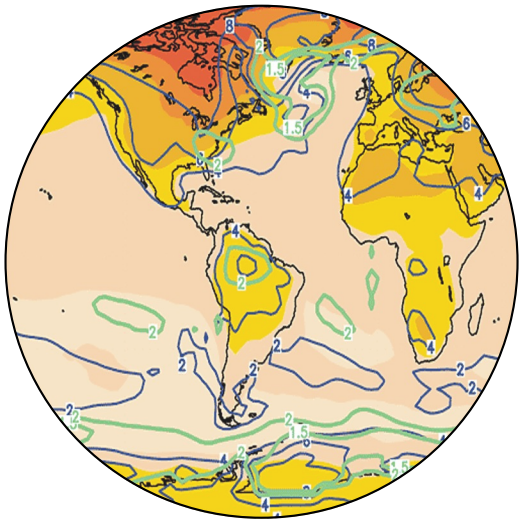
Tracey Holloway
University of Wisconsin-Madison

Sustainable Madison Committee Meeting, August 2025

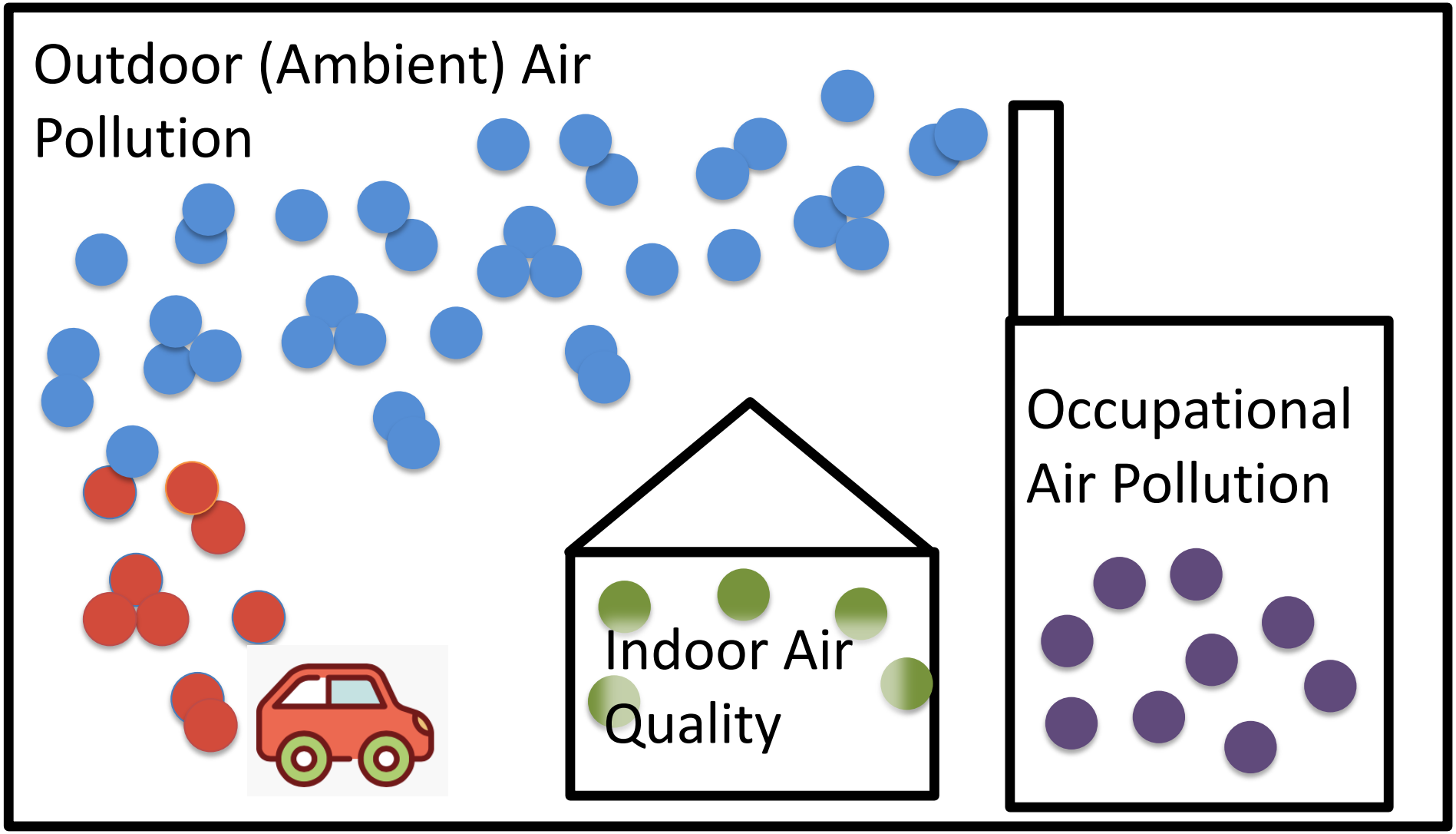
Nelson Institute for Environmental Studies/SAGE &
Department of Atmospheric and Oceanic Sciences

Air Quality

Ozone Depletion



Climate Change

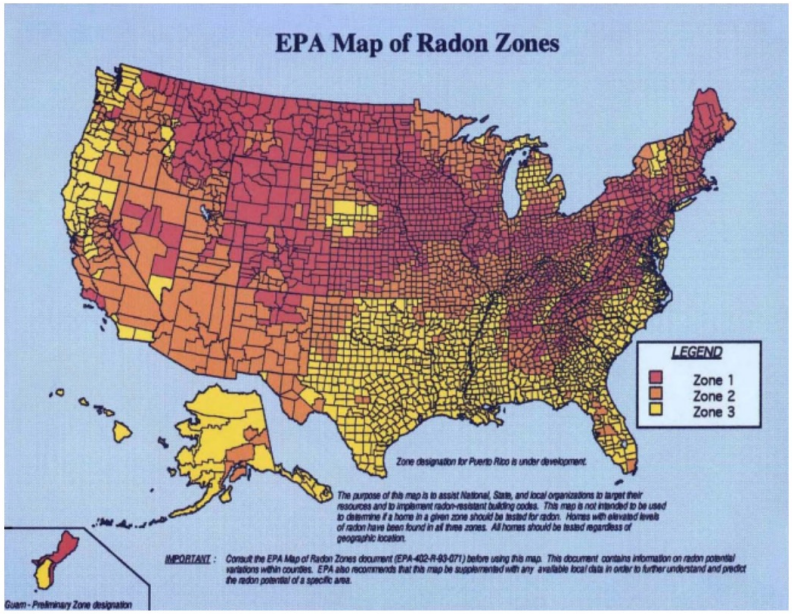

Outdoor (Ambient) Air Pollution
Indoor Air Quality
Occupational Air Pollution

Shout-out to

slipstream

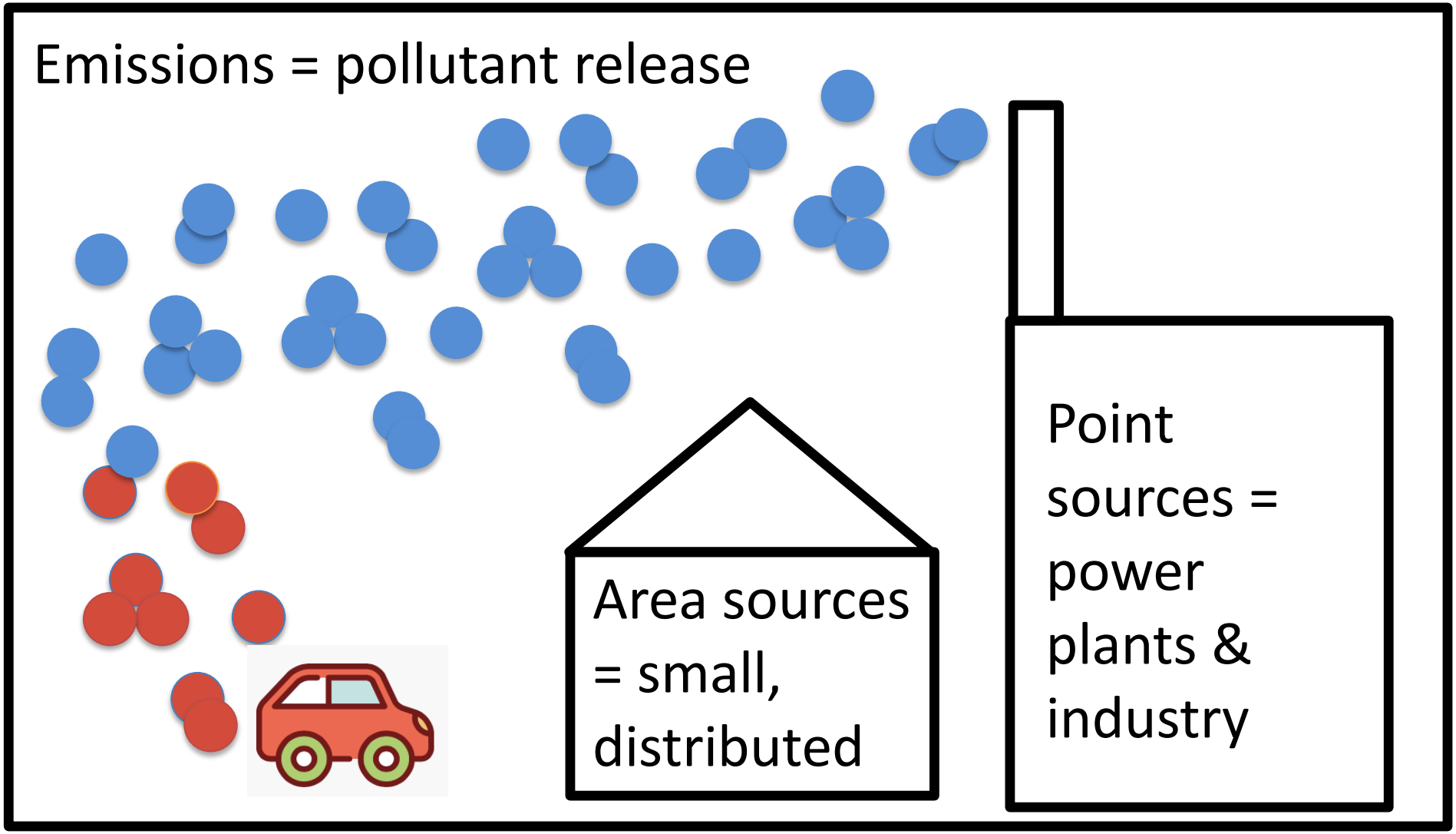
https://www.epa.gov/radon/epa-map-radon-zones-0

Map of Radon Zones



What do the colors mean?

Color	Zone	Potential
	Zone 1 (red zones)	Highest potential; average indoor radon levels may be greater than 4 pCi/L (picocuries per liter)(150 becquerels per cubic meter (Bq/m^3))
	Zone 2 (orange zones)	Moderate potential; average indoor radon levels may be between 2 and 4 pCi/L (75 -150 Bq/m^3)
	Zone 3 (yellow zones)	Low potential; average indoor radon levels may be less than 2 pCi/L (75 Bq/m^3)


Emissions = pollutant release
Area sources = small, distributed
Point sources = power plants & industry

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Related Topics: Criteria Air Pollutants

NAAQS Table

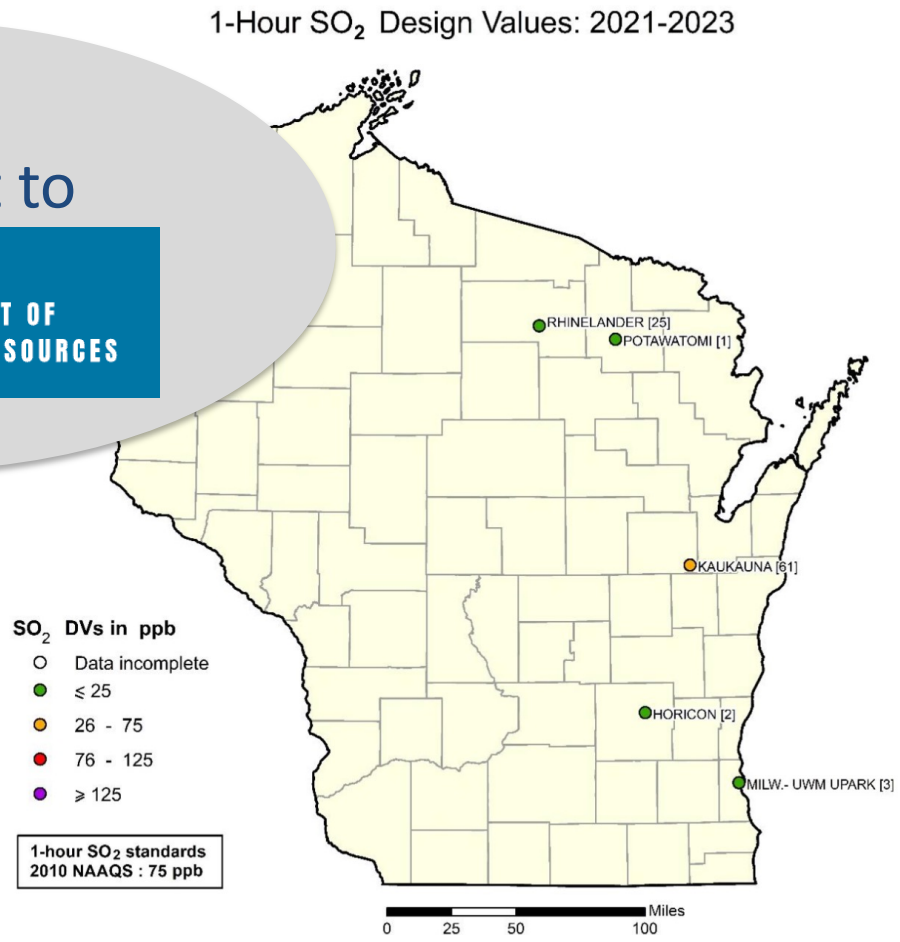
6 Criteria Pollutants:
CO, Pb, NO_2, O_3, PM, SO_2

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 µg/m^3 (1)	maximum arithmetic mean of 3 consecutive monthly means in a 3-year period
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb	Annual 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	9.0 µg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb (4)	Annual 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	1 year	10 ppb	annual mean, averaged over 3 years

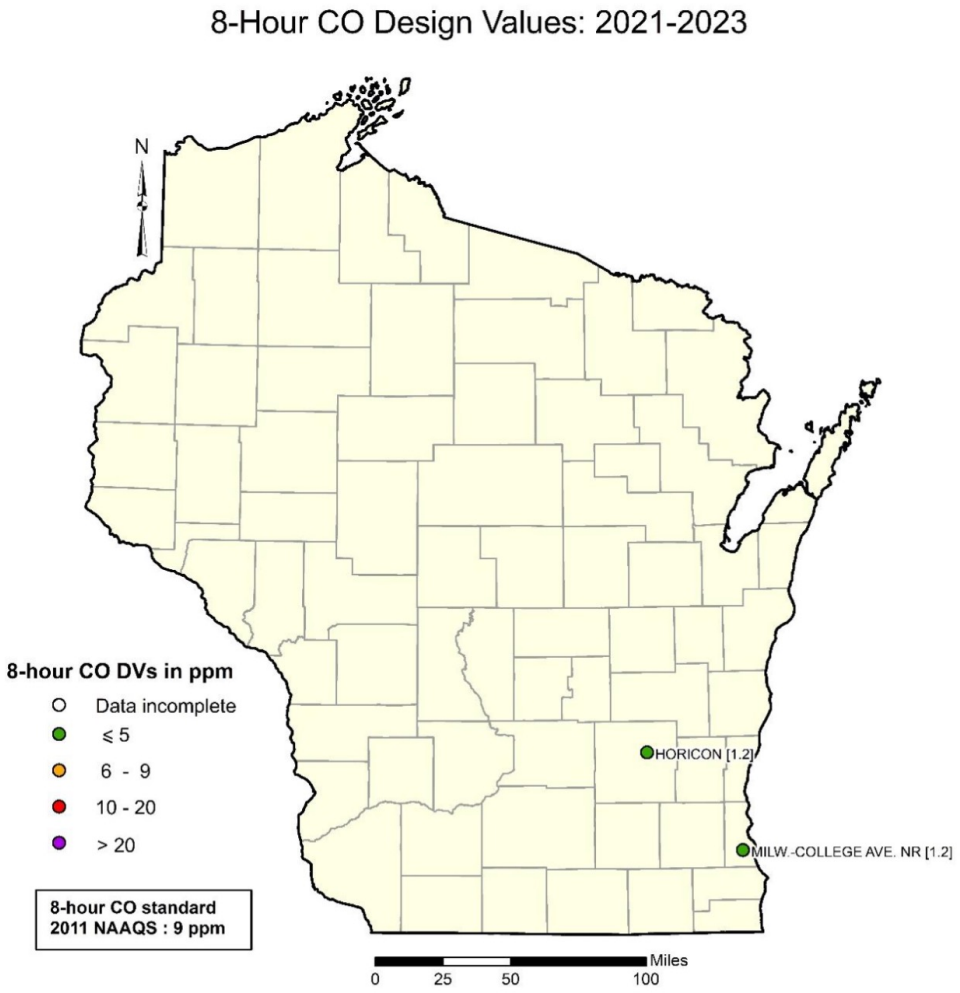
Regulatory air monitoring sites typically look like this: trailers hold air pollution monitoring equipment. This photo is from Houston, Texas.
http://www.houstontx.gov/health/Environmental/bpcp/images/air_monitoring_trailer.jpg

Shout-out to

WISCONSIN DEPARTMENT OF NATURAL RESOURCES



From Wisconsin DNR https://widnr.widen.net/s/vfm6lrxbc7/am643



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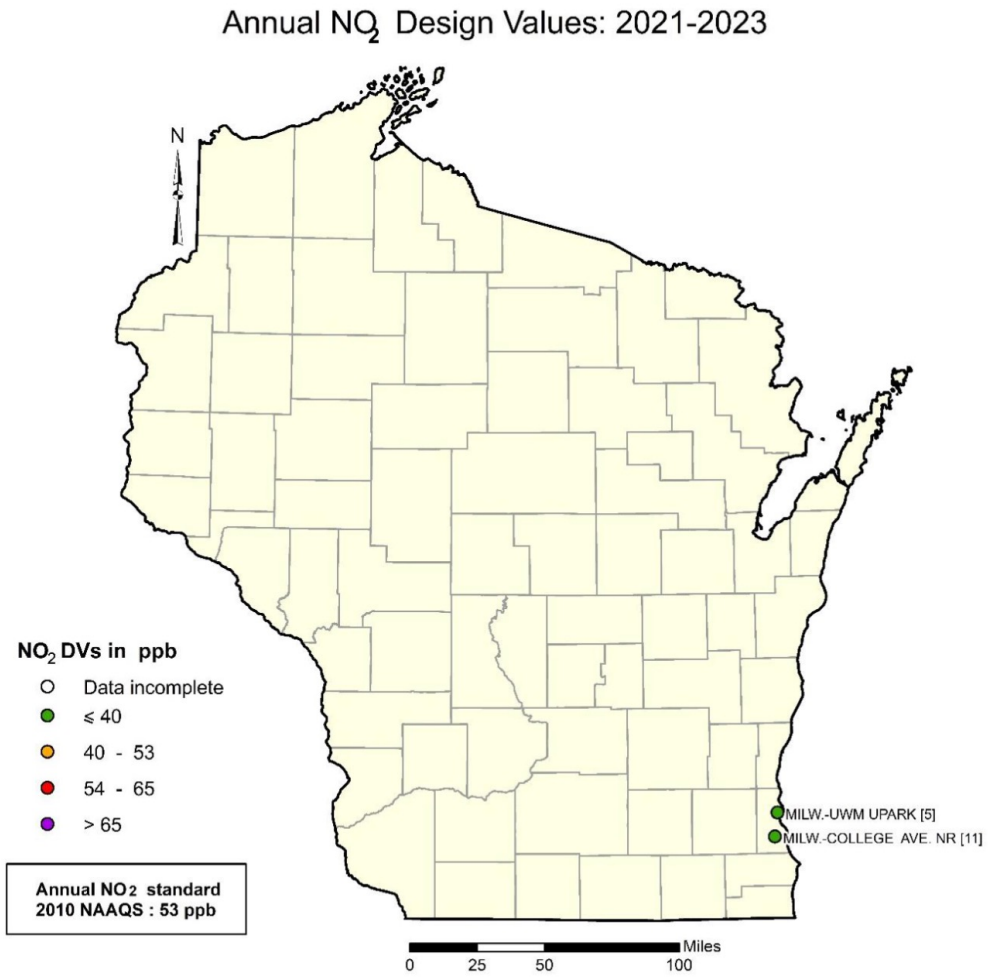

From Wisconsin DNR https://widnr.widen.net/s/vfm6lrxbc7/am643

Satellite NO_2 Column Density Over Wisconsin

TROPOMI Satellite Images

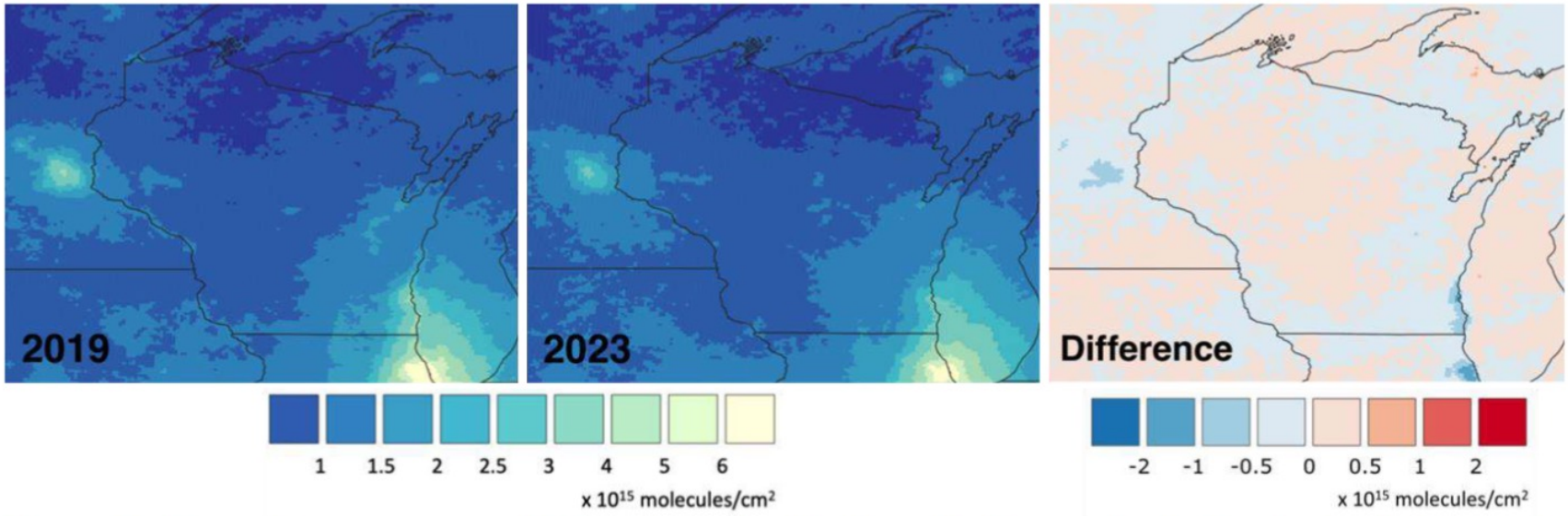

Figure 33. Maps of average annual NO_2 column density from the Tropospheric Monitoring Instrument (TROPOMI) satellite. The difference in NO_2 column density between 2019 and 2023 is also provided. Maps courtesy of Dr. Monica Harkey, Dr. Tracey Holloway and Colleen Heck of the University of Wisconsin-Madison. The methodology is available upon request.

From Wisconsin DNR https://widnr.widen.net/s/vfm6lrxbc7/am643

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Related Topics: Criteria Air Pollutants

NAAQS Table

"Primary" here mean NAAQS for health (confusing: also means directly emitted)

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Related Topics: Criteria Air Pollutants

NAAQS Table

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Regulated in 2 size classes:
< 2.5 microns ("fine") and
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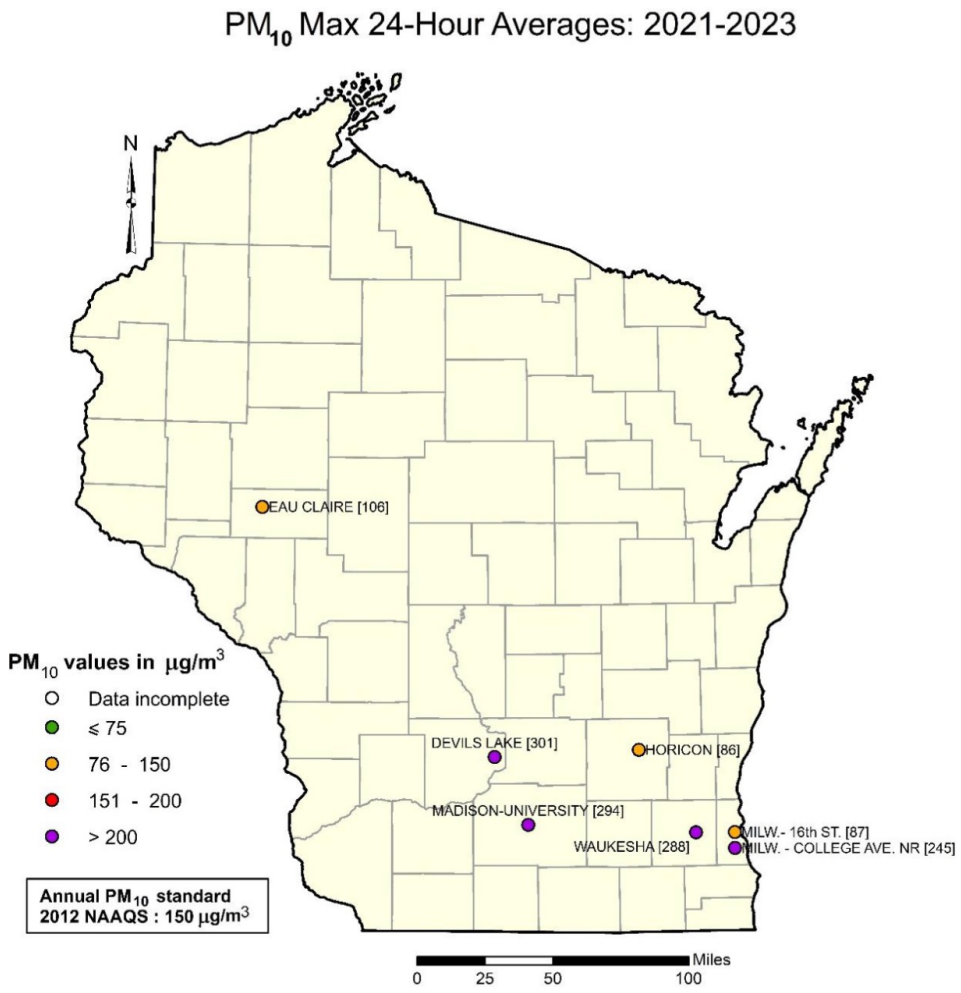

Figure 25. The maximum 24-hour averages of PM_{10} for 2021-2023.

From Wisconsin DNR https://widnr.widen.net/s/vfm6lrxbc7/am643

WISCONSIN PUBLIC RADIO

ENVIRONMENT, HEALTH, POLLUTION

Wildfire smoke caused highest spike of air quality warnings in Wisconsin in more than a decade

2023 was first year DNR issued 'very unhealthy' warning due to smoke

BY RICH KREMER • AUGUST 25, 2023

Listen

A haze from Canadian wildfires is seen over Milwaukee, Tuesday, June 27, 2023. The haze from Canadian wildfires, which, along with higher ozone levels is continuing to create low visibility conditions and lead to air quality alerts throughout the area. *Morry Gash/AP Photo*

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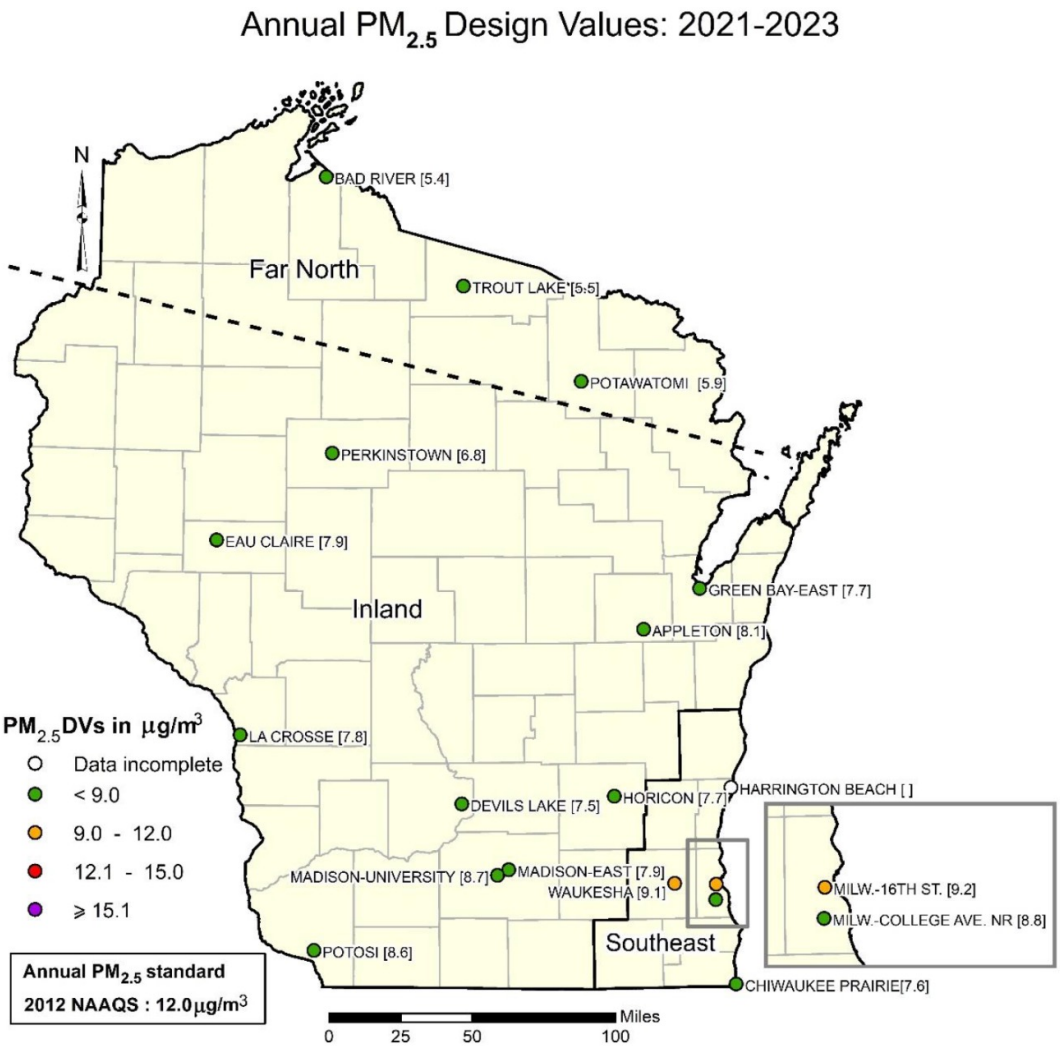

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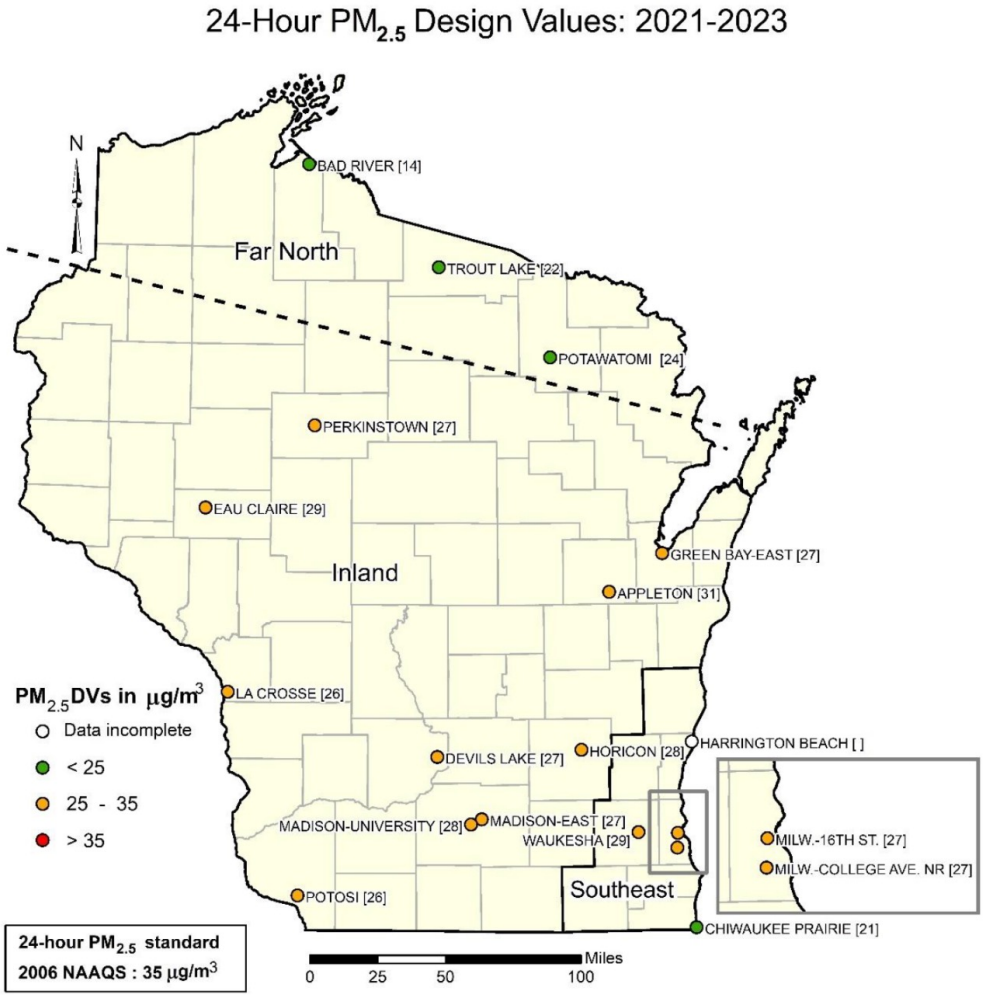

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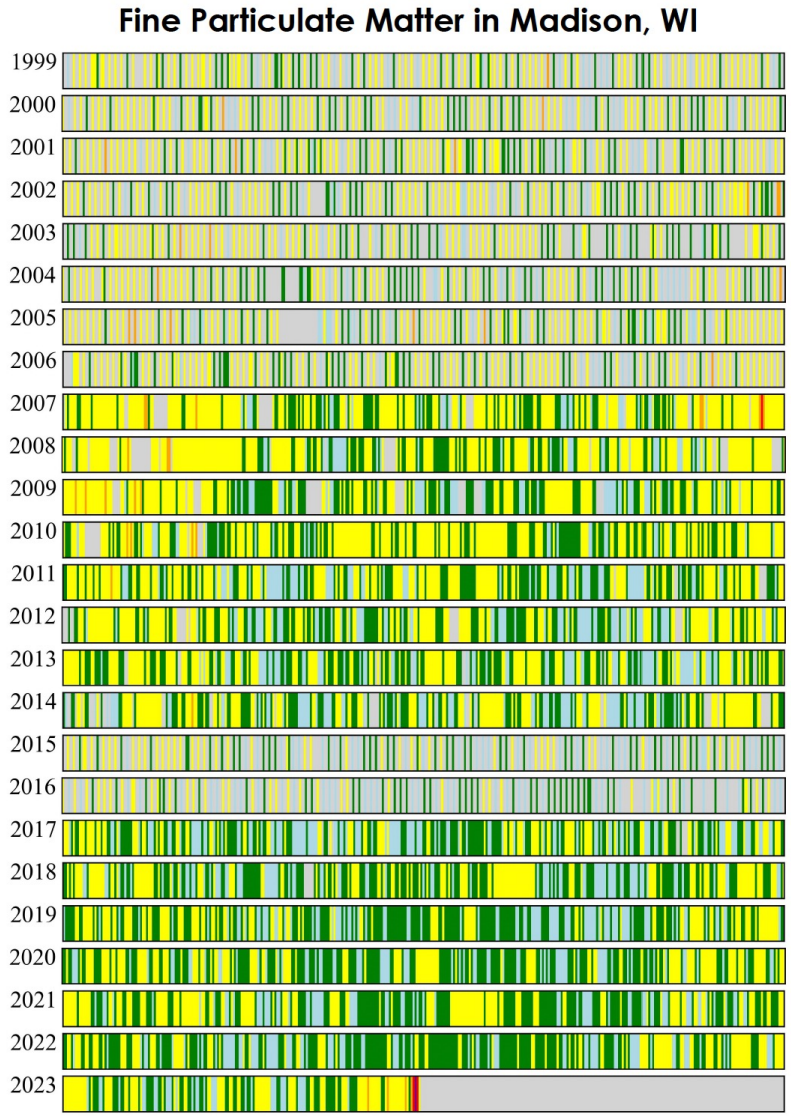
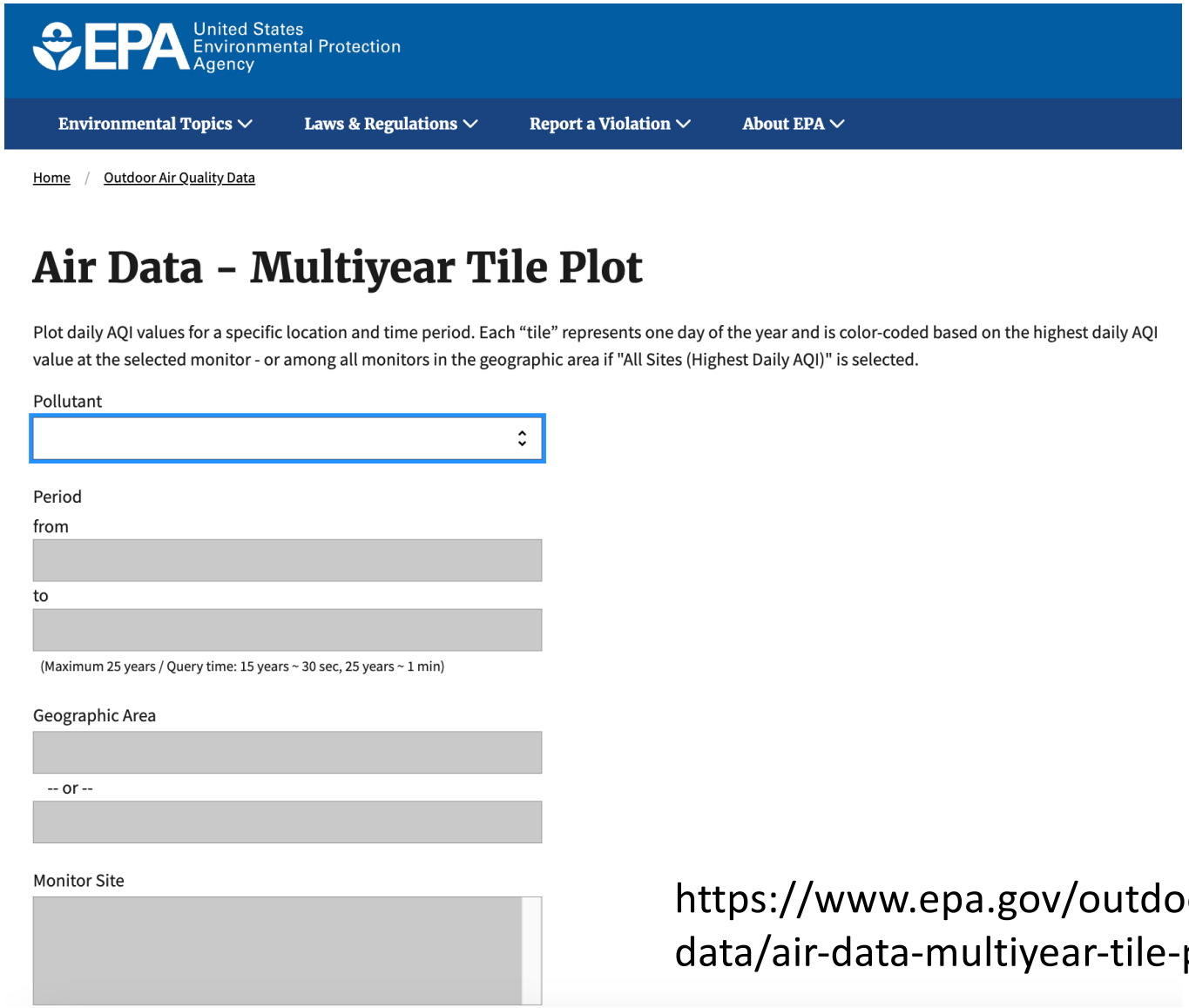


Air Quality Index Categories

	Index Value
Below WHO Air quality level is below standard of World Health Organization of 5 µg/m³.	
Good Air quality is satisfactory, and air pollution poses little or no risk.	0-50 (≤12.0 µg/m³)
Moderate Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.	51-100 (12.1-35.4 µg/m³)
Unhealthy for Sensitive Groups Members of sensitive groups may experience health effects. The general public is less likely to be affected.	101-150 (35.5-55.4 µg/m³)
Unhealthy Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.	151-200 (55.5-150.4 µg/m³)
Very Unhealthy Health alert: The risk of health effects in increased for everyone.	201-300 (150.5-250.4 µg/m³)
Hazardous Health warning of emergency conditions: everyone is more likely to be affected.	301+ (≥250.5 µg/m³)

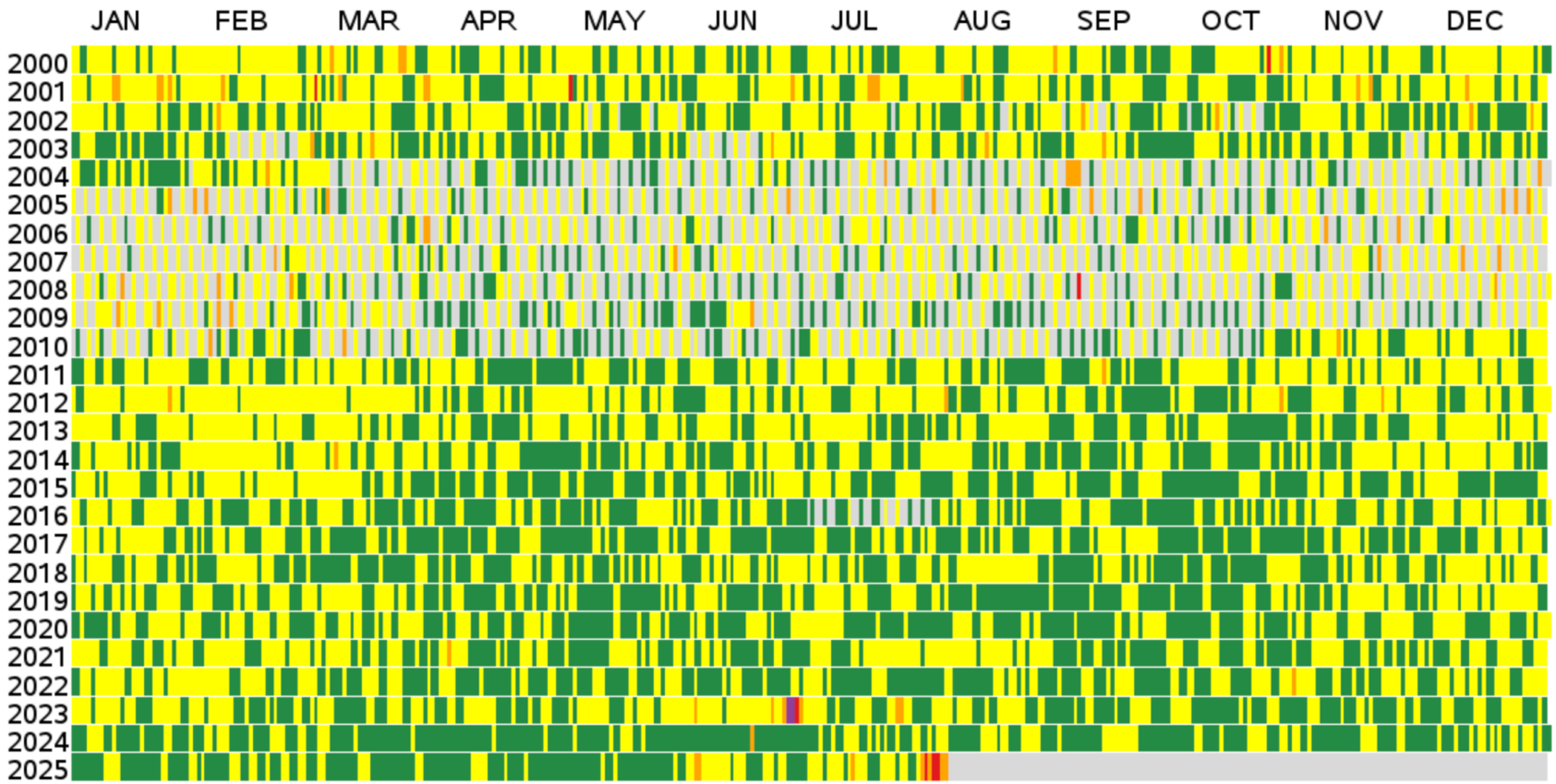
EPA data from Lizzy Kysela, 2023



https://www.epa.gov/outdoor-air-quality-data/air-data-multiyear-tile-plot

PM2.5 Daily AQI Values, 2000 to 2025

Milwaukee-Waukesha-West Allis, WI

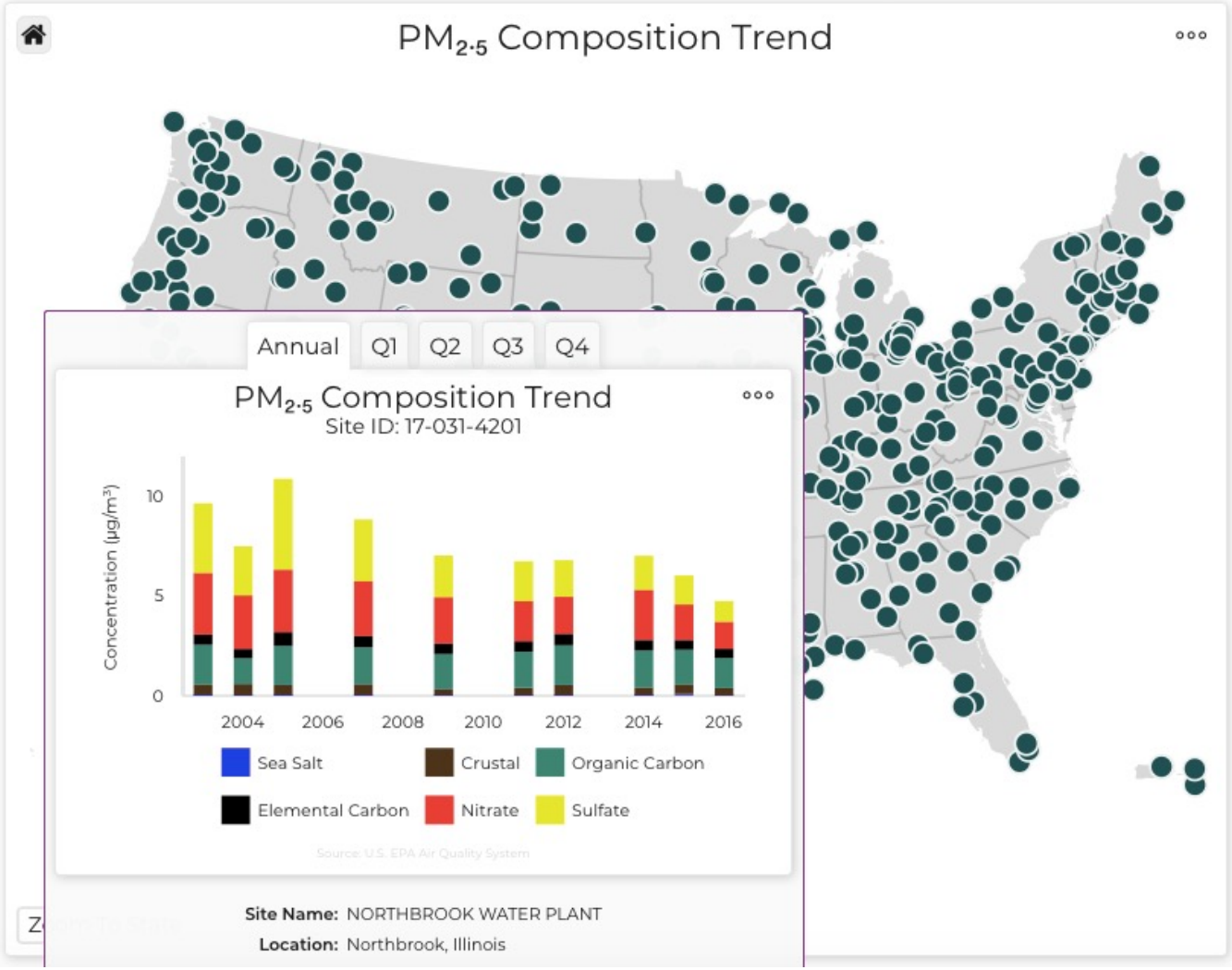


Understanding $PM_{2.5}$ Composition Helps Reduce Fine Particle Pollution

The different components that make up particle pollution come from specific sources and are often formed in the atmosphere. The major components, or species, are elemental carbon (EC), organic carbon (OC), sulfate and nitrate compounds, and crustal materials such as soil and ash.

As previously shown, $PM_{2.5}$ concentrations are declining. Assessing particle pollution concentrations along with composition data aids in understanding the effectiveness of pollution controls and in quantifying the impacts to public health, regional visibility, ecology and climate.

Click any point to display 2000-2016 annual and quarterly $PM_{2.5}$ speciation trends, and select maximize to enlarge the chart. Double click the map to zoom in and click the home button to reset.



Criteria Pollutant Trends Show Clean Air Progress

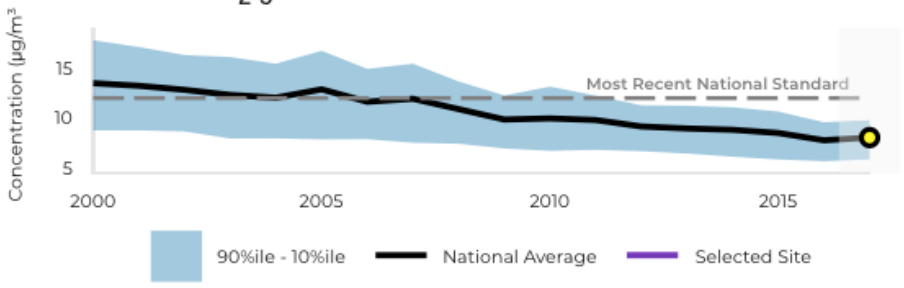
Select a NAAQS to view concentration and emission trends

Particulate Matter 2.5 microns (Seasonally-weighted Annual Average)

Year: 2017

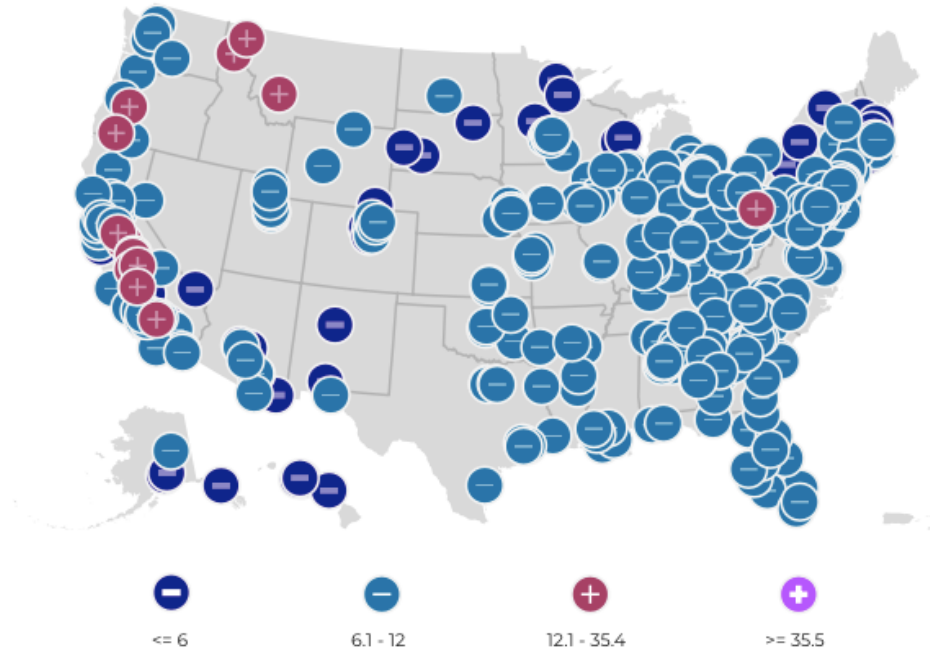
2000 2005 2010 2015

$PM_{2.5}$ Annual Concentration



Source: U.S. EPA Air Quality System

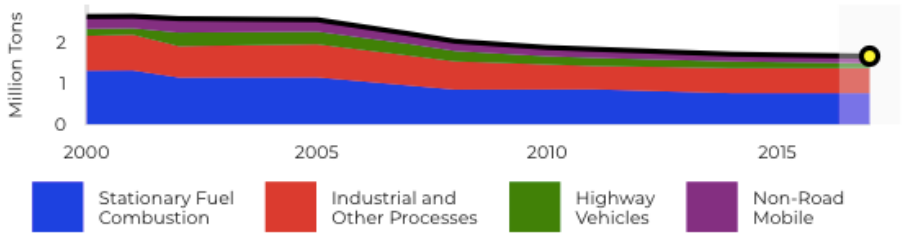
$PM_{2.5}$ Annual Concentration



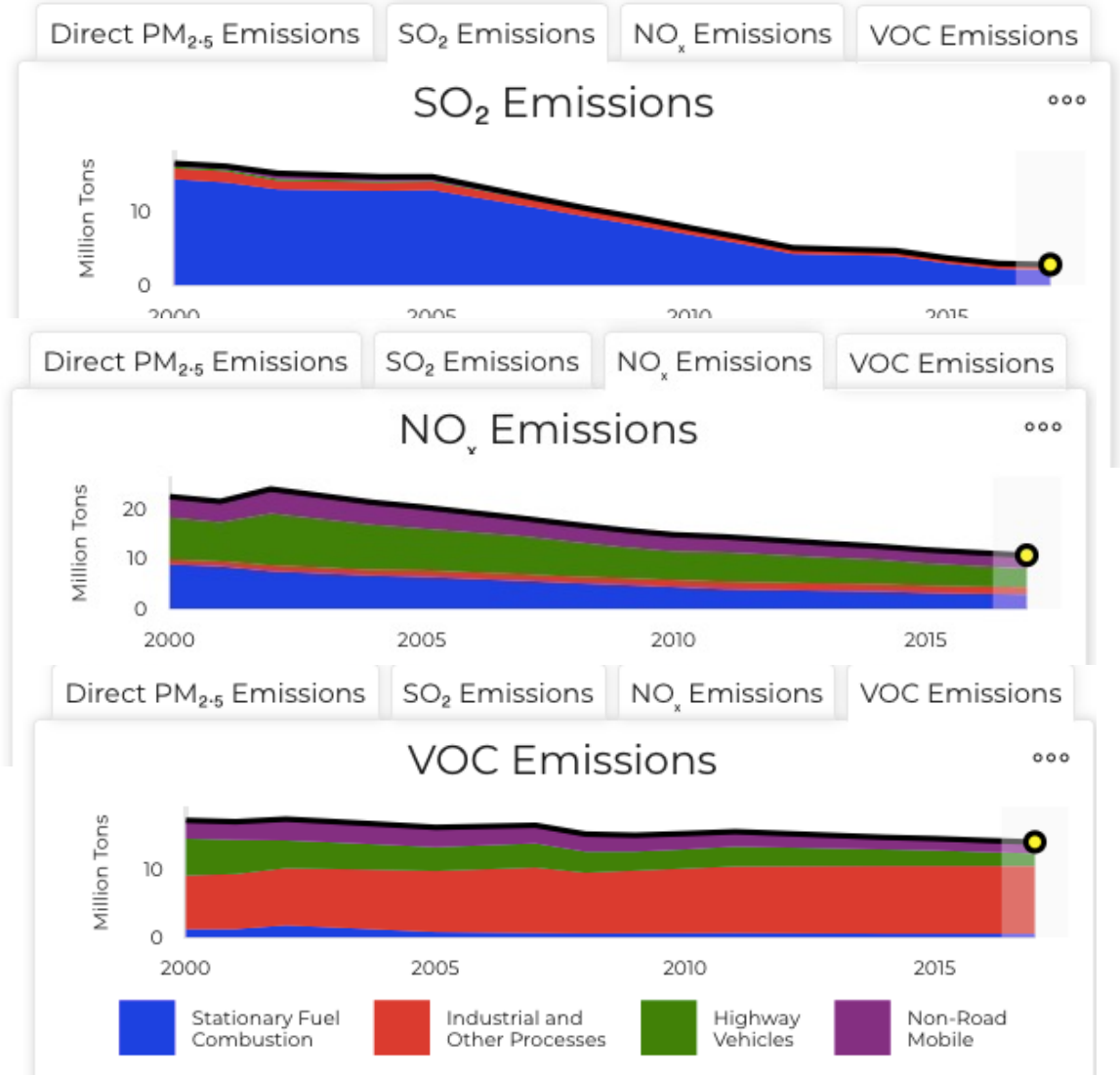
Source: U.S. EPA Air Quality System

Direct $PM_{2.5}$ Emissions | SO_2 Emissions | NO_x Emissions | VOC Emissions

Direct $PM_{2.5}$ Emissions



Source: U.S. EPA National Emissions Inventory 2014 ver. 2


Direct $PM_{2.5}$ Emissions
SO_2 Emissions
NO_x Emissions
VOC Emissions
SO_2 Emissions
Million Tons
10
0
2000
2005
2010
2015
Direct $PM_{2.5}$ Emissions
SO_2 Emissions
NO_x Emissions
VOC Emissions
NO_x Emissions
Million Tons
20
10
0
2000
2005
2010
2015
Direct $PM_{2.5}$ Emissions
SO_2 Emissions
NO_x Emissions
VOC Emissions
VOC Emissions
Million Tons
10
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2000
2005
2010
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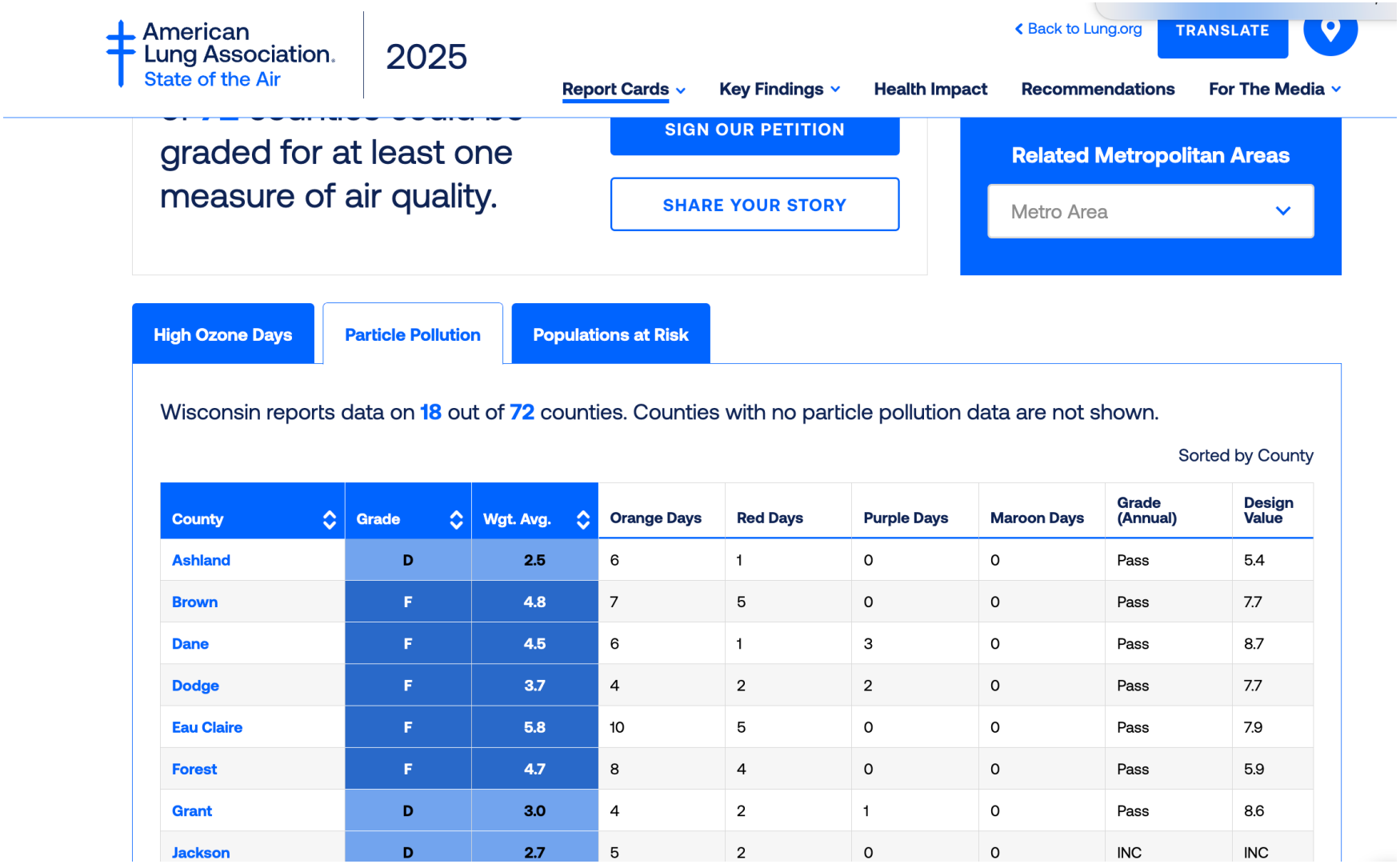
Stationary Fuel Combustion
Industrial and Other Processes
Highway Vehicles
Non-Road Mobile



https://www.lung.org/research/sota/city-rankings/states/wisconsin

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NAAQS Table

Ozone is a daytime pollutant, so it is regulated only based on the daytime (8 highest hours) values

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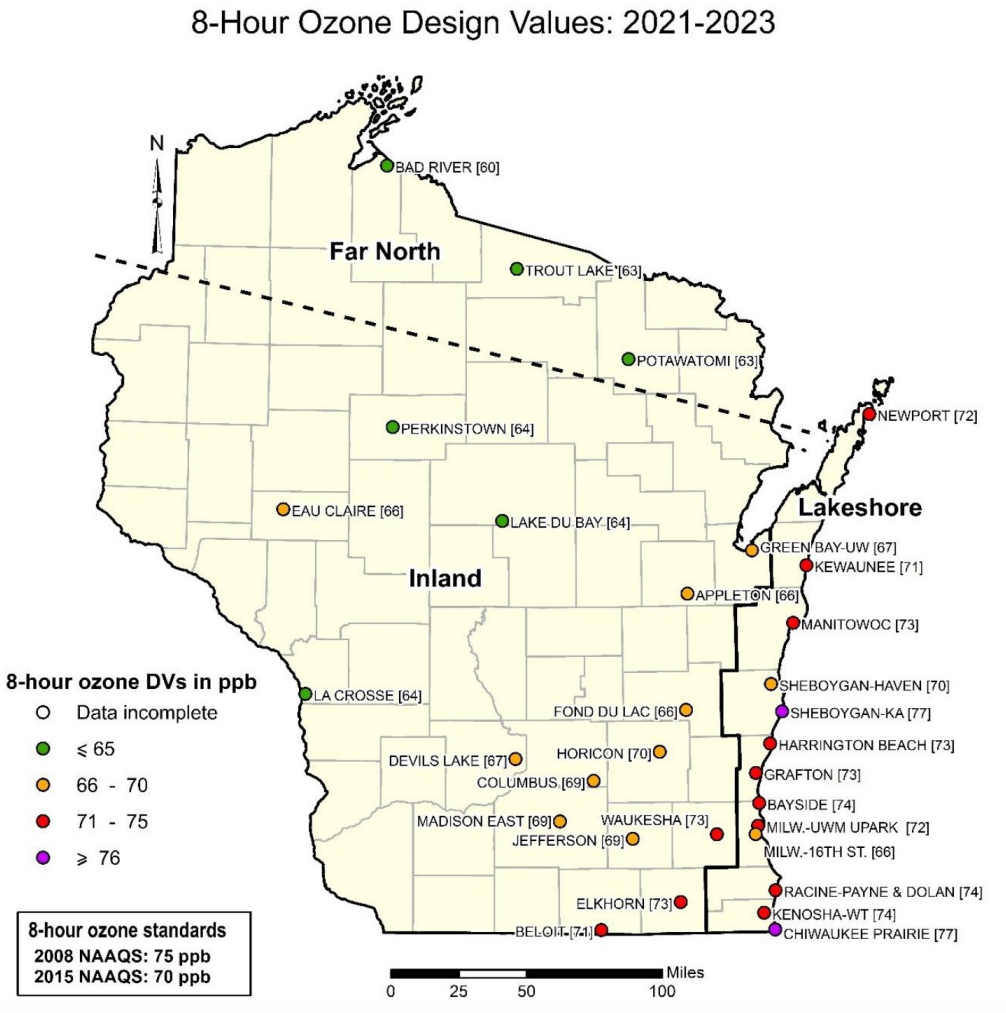

From Wisconsin DNR https://widnr.widen.net/s/vfm6lrxbc7/am643

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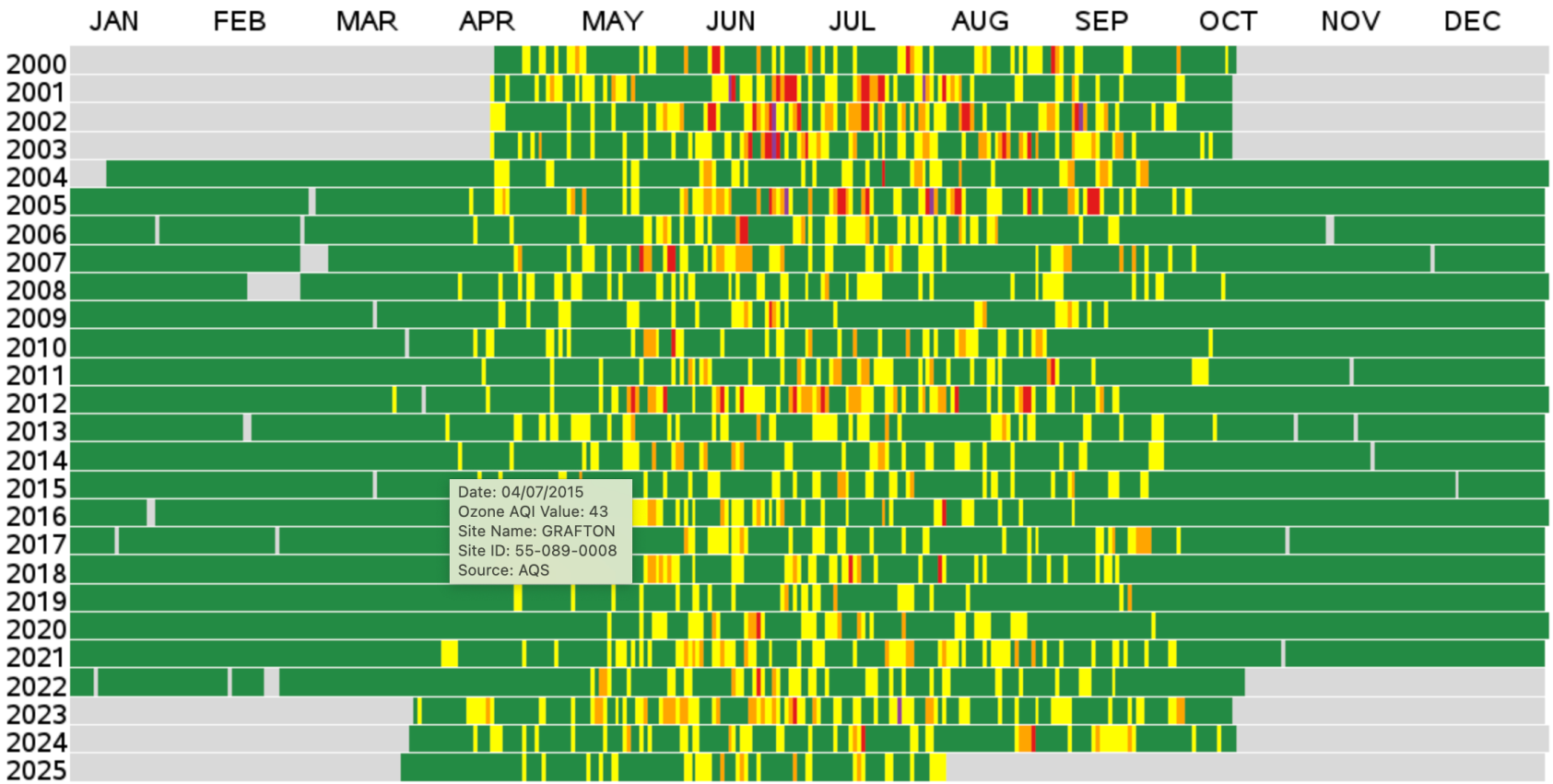


Within Wisconsin, **29** out of **72** counties could be graded for at least one measure of air quality.

You can make a difference in the air that you breathe.

SIGN OUR PETITION

SHARE YOUR STORY

Related Metropolitan Areas

Metro Area

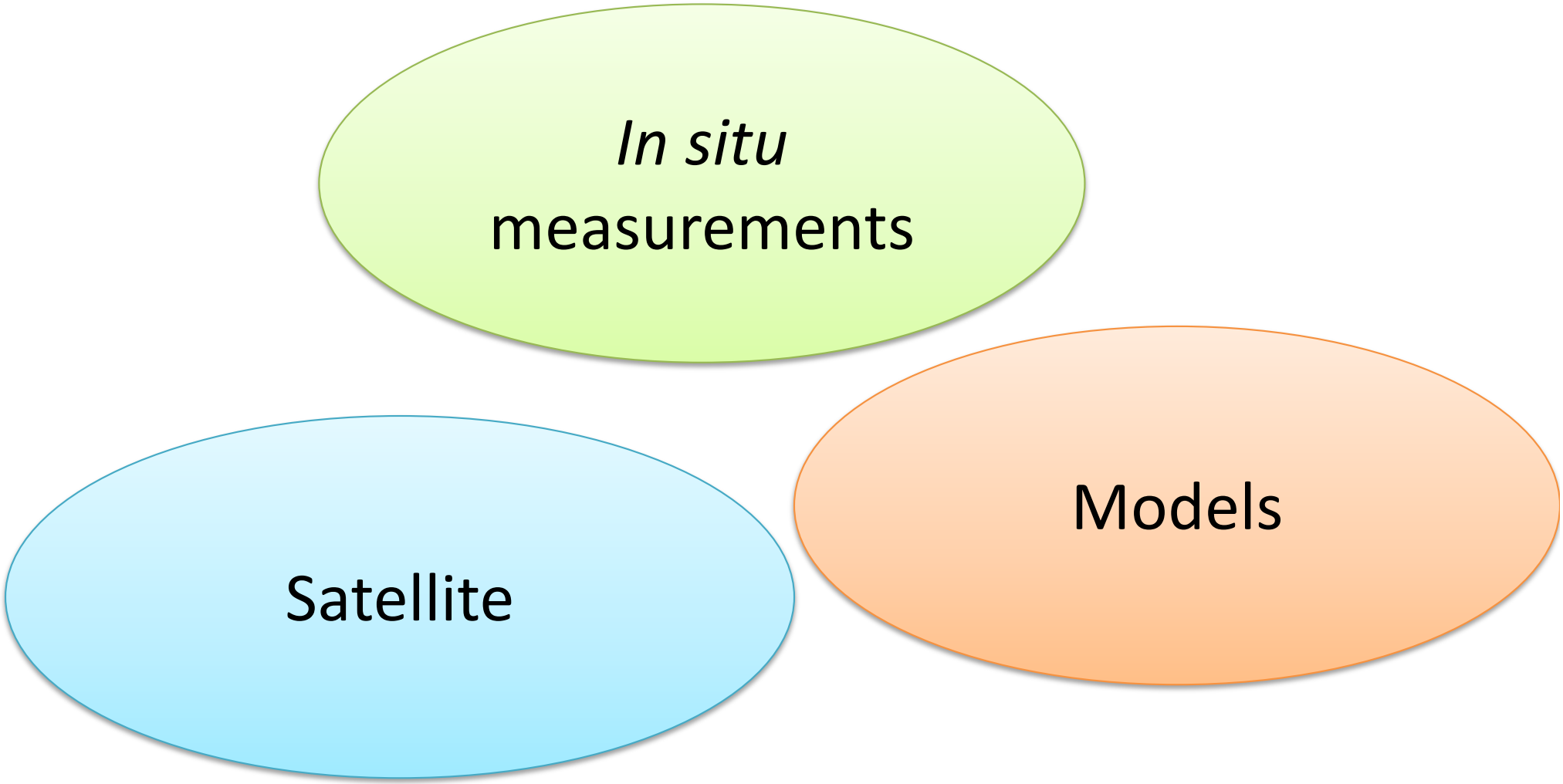
High Ozone Days | Particle Pollution | Populations at Risk

Wisconsin reports data on **26** out of **72** counties. Counties with no ozone data are not shown.

Sorted by County

County	Grade	Wgt. Avg.	Orange Days	Red Days	Purple Days
Ashland	B	0.3	1	0	0
Brown	D	2.7	8	0	0
Columbia	F	6.3	16	2	0
Dane	F	6.5	18	1	0
Dodge	F	5.0	15	0	0
Door	F	5.2	14	1	0
Eau Claire	D	2.7	8	0	0
Fond du Lac	C	1.7	5	0	0

https://www.lung.org/research/sota/city-rankings/states/wisconsin


In situ
measurements
Models
Satellite

In Situ: On the ground measurements

Shout-out to

WISCONSIN PUBLIC RADIO

ENVIRONMENT, NEWS, POLLUTION, SCIENCE AND TECHNOLOGY

Madison installing air quality sensors to bring 'hyper-local' pollution data to neighborhoods

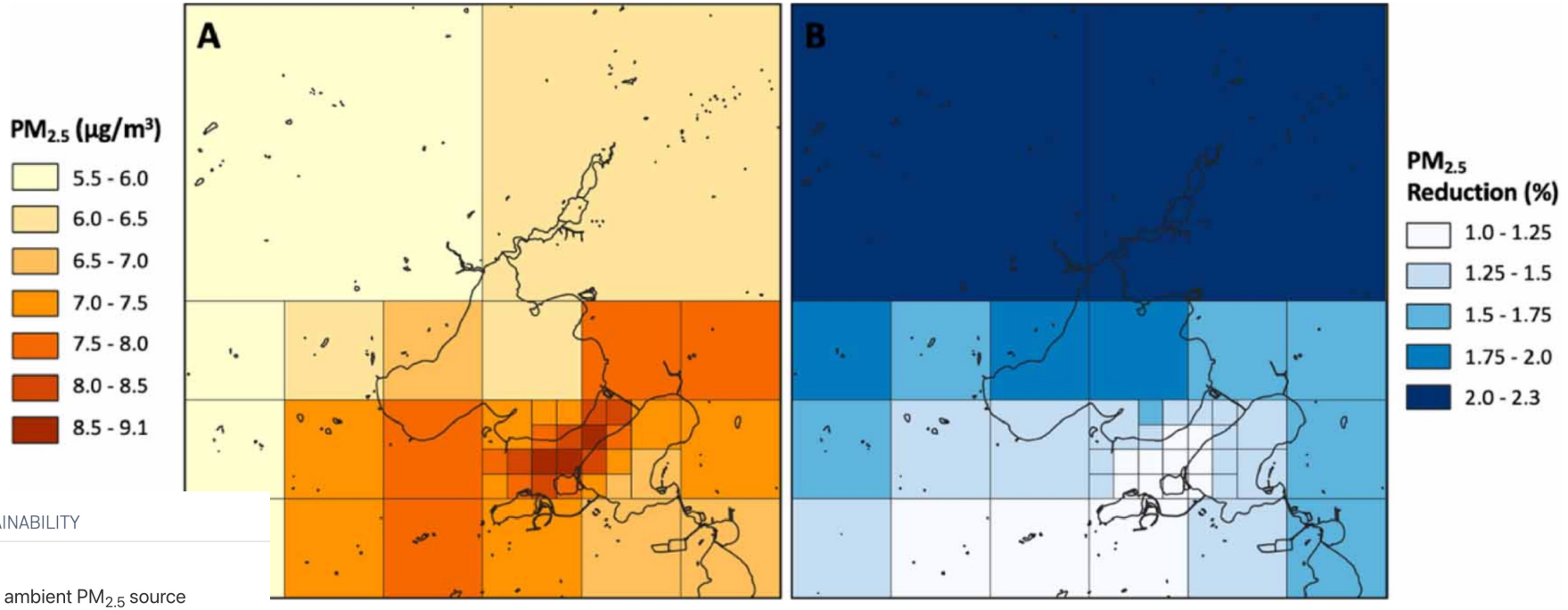
City will share public-facing data as part of federally-funded project

BY SARAH LEHR • JULY 26, 2024 • UPDATED JULY 31, 2024 at 12:36 PM

Listen

Madison officials installed this solar-powered air quality sensor on the city's west side, near an-already existing sensor overseen by the DNR. The aim is to compare the new sensor to the DNR's data to check for accuracy. (Photo courtesy of the City of Madison)

Models: What if no Columbia PP?



ENVIRONMENTAL RESEARCH
INFRASTRUCTURE AND SUSTAINABILITY

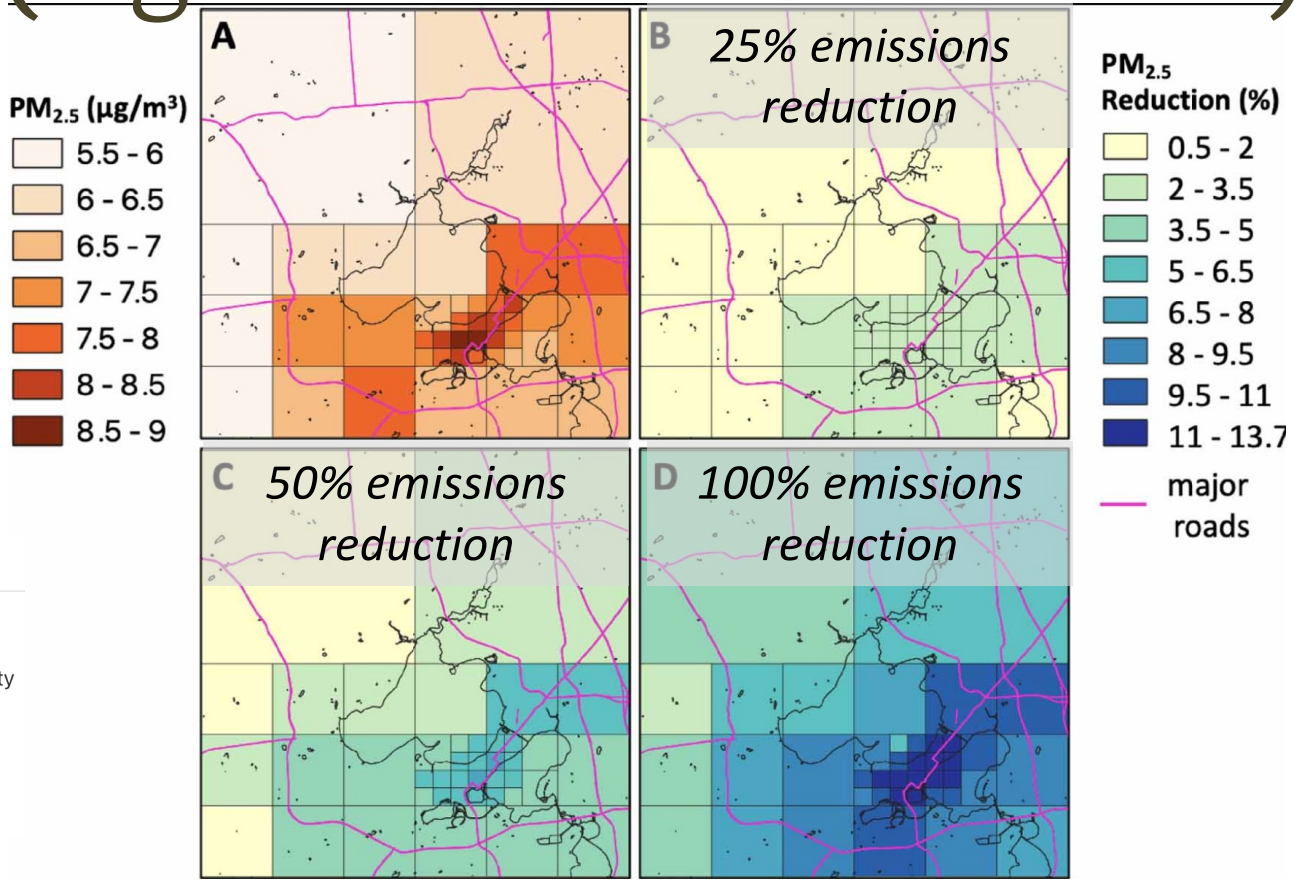
PAPER • OPEN ACCESS

City-scale analysis of annual ambient $PM_{2.5}$ source contributions with the InMAP reduced-complexity air quality model: a case study of Madison, Wisconsin

Clara M Jackson, Tracey Holloway and Christopher W Tessum

Published 1 February 2023 • © 2023 The Author(s). Published by IOP Publishing Ltd
Environmental Research: Infrastructure and Sustainability, Volume 3, Number 1
Citation Clara M Jackson *et al* 2023 *Environ. Res.: Infrastruct. Sustain.* **3** 015002
DOI 10.1088/2634-4505/acb0fa

Models: Reductions in light-duty vehicles (e.g. vehicle electrification)



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INFRASTRUCTURE AND SUSTAINABILITY

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City-scale analysis of annual ambient $PM_{2.5}$ source contributions with the InMAP reduced-complexity air quality model: a case study of Madison, Wisconsin

Clara M Jackson, Tracey Holloway and Christopher W Tessum

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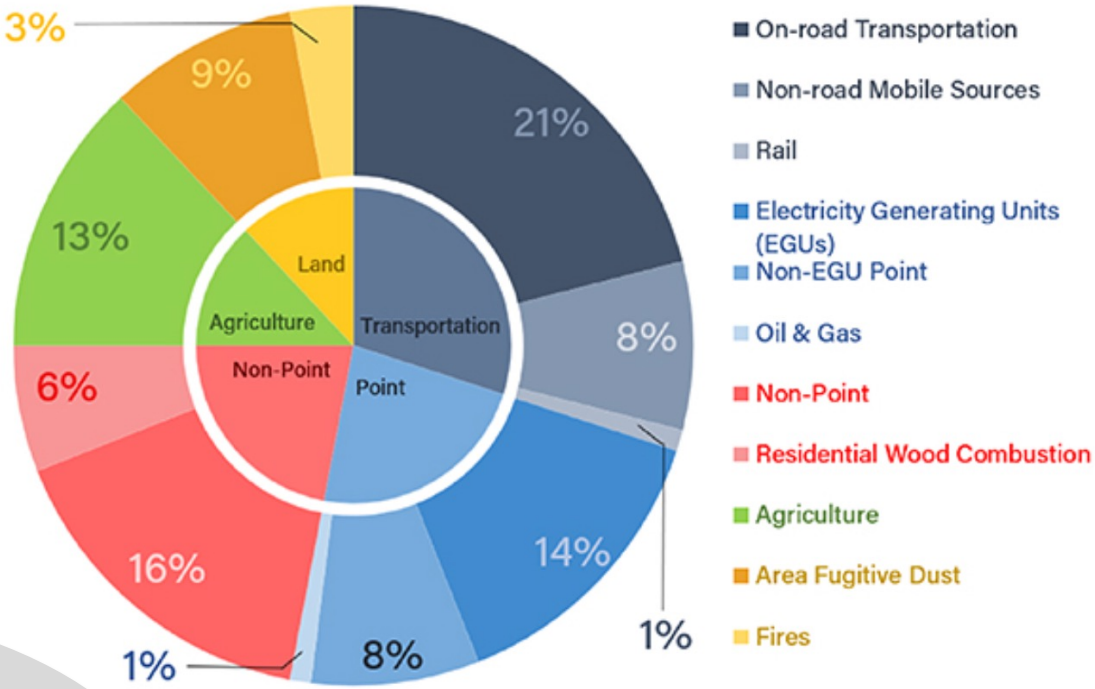
Models: Source Attribution



Zoom In Zoom Out Reset image size

Shout-out to

Madison Gas and Electric

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City-scale
contributio
model: a case
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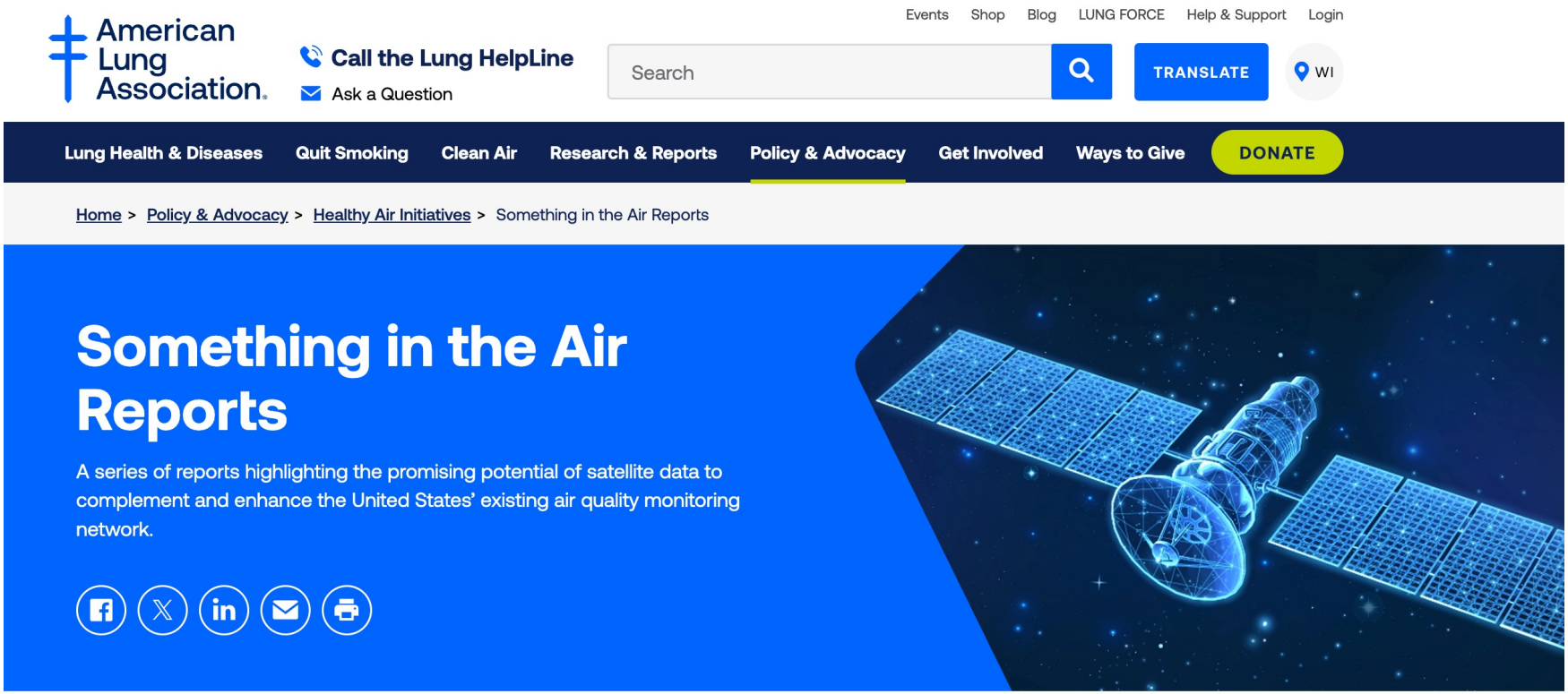
ribution of $PM_{2.5}$ in Madison-area in 2014. 'Non-EGU Point Sources' is
y of industrial sources. 'Non-point' encompasses all non-point sources not
ified (e.g. residential heating, commercial combustion). 'Fires' refers to
ural and prescribed burns; wildfires are omitted.

Satellite Data: Filling in the Gaps

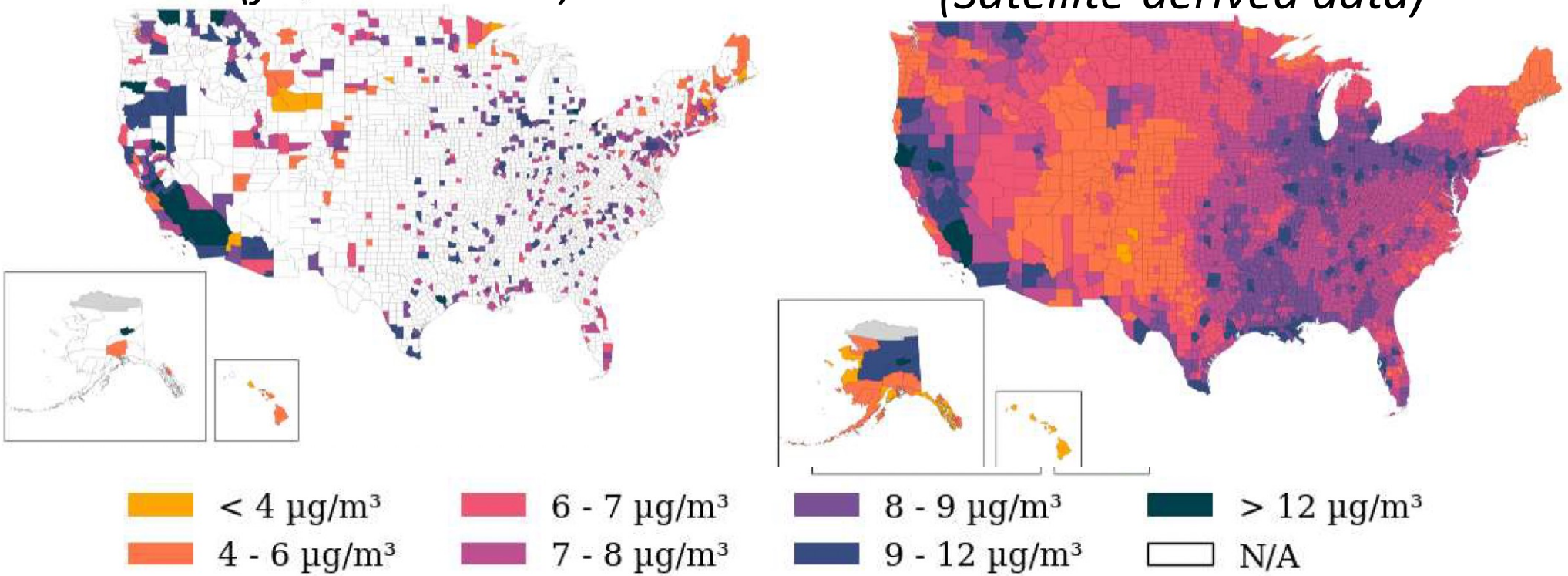


As a nation, we make great strides cleaning up air pollution—but not all communities benefit equally.

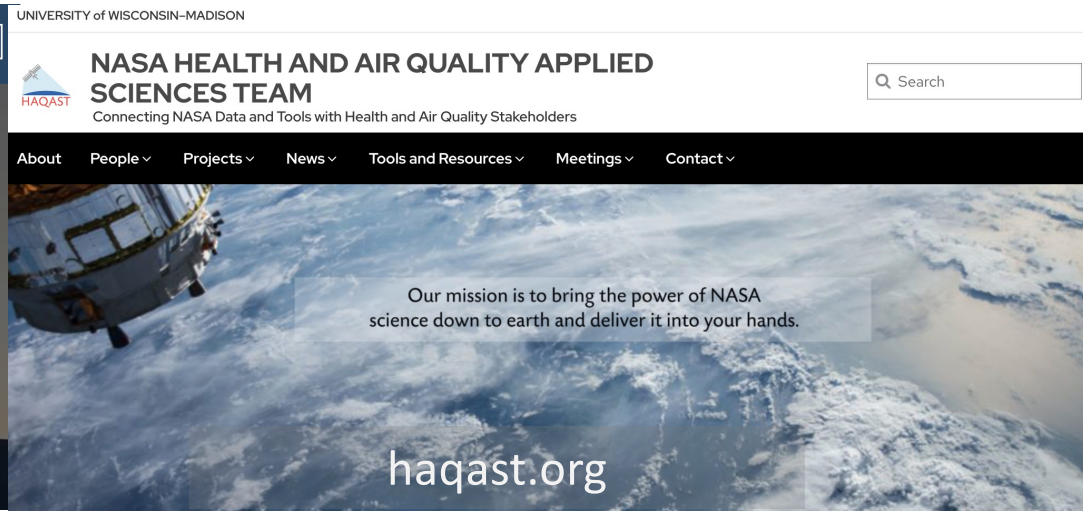
Satellite Data: Filling in the Gaps

County Design Values (from monitors)

County Design Value Equivalents (Satellite-derived data)



Holloway et al., in review *GeoHealth*



- Madison's air quality had been getting better… but wildfires change the story
- AQ is affected by shifting federal priorities for energy, EVs, environmental data, etc.
- Madison is the most densely monitored city (in the world?) ... but the narrative is complex given sources of PM, day-to-day variability, and impact of sources outside of our control
- New opportunities from satellite data could benefit Madison
- UW-Madison is a national and international leader on AQ research – how can this strength best align with city priorities?

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