



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

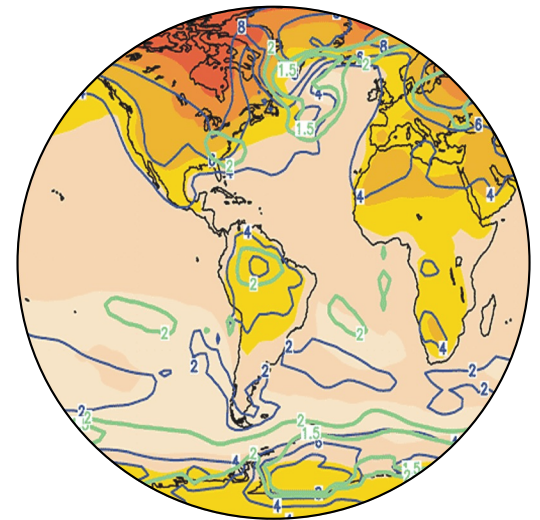




Air Quality

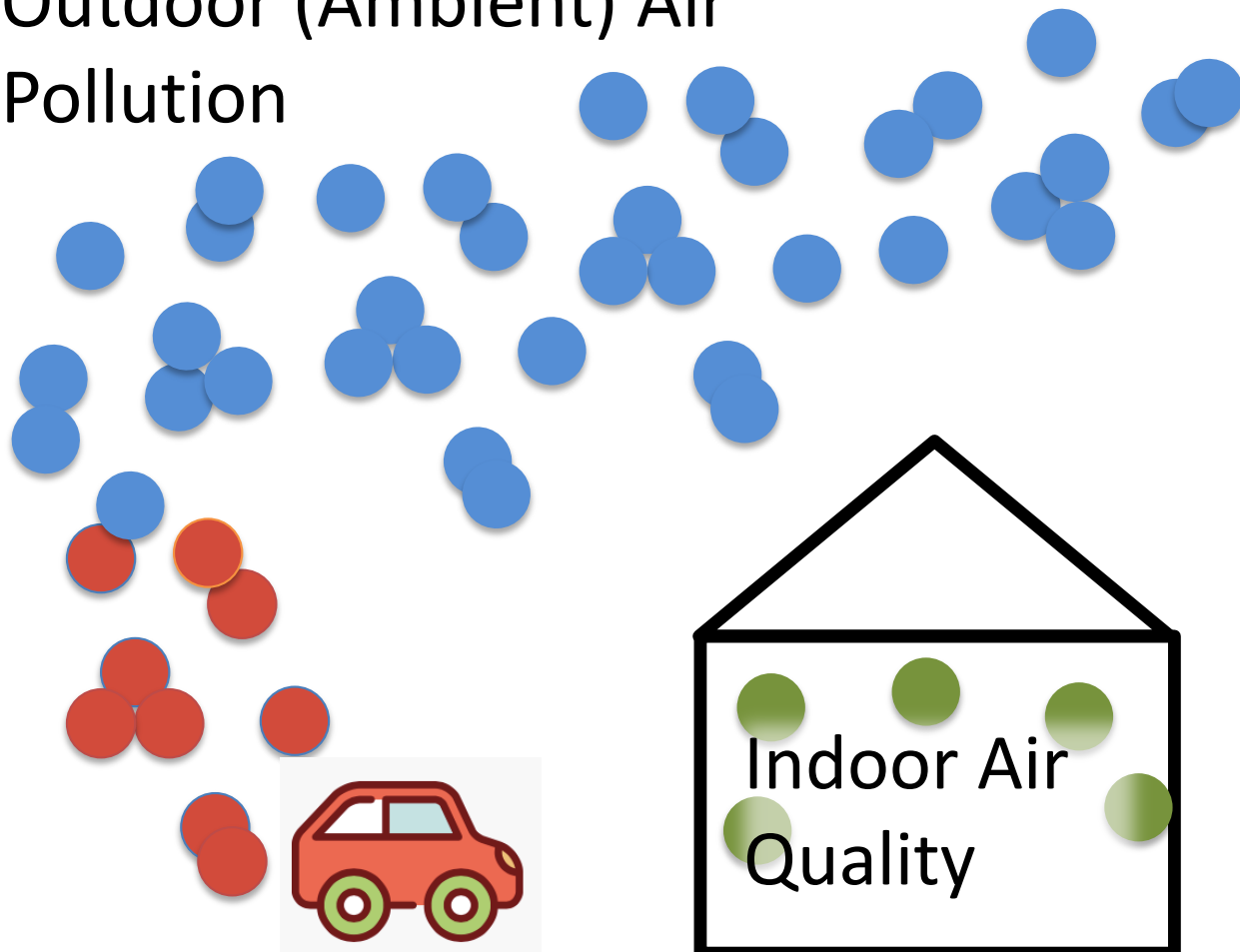


Ozone Depletion

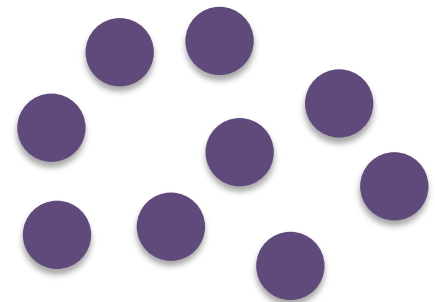


Climate Change

Outdoor (Ambient) Air
Pollution



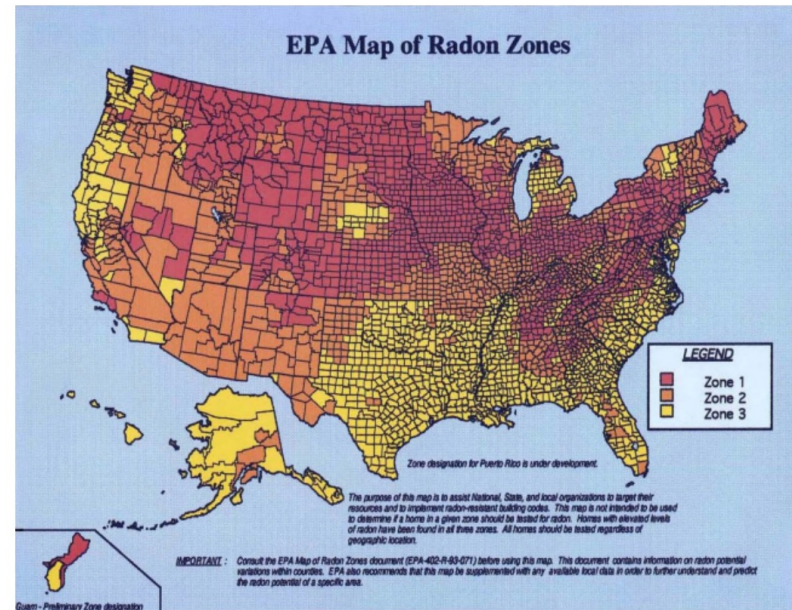
Occupational
Air Pollution



Shout-out to



Map of Radon Zones

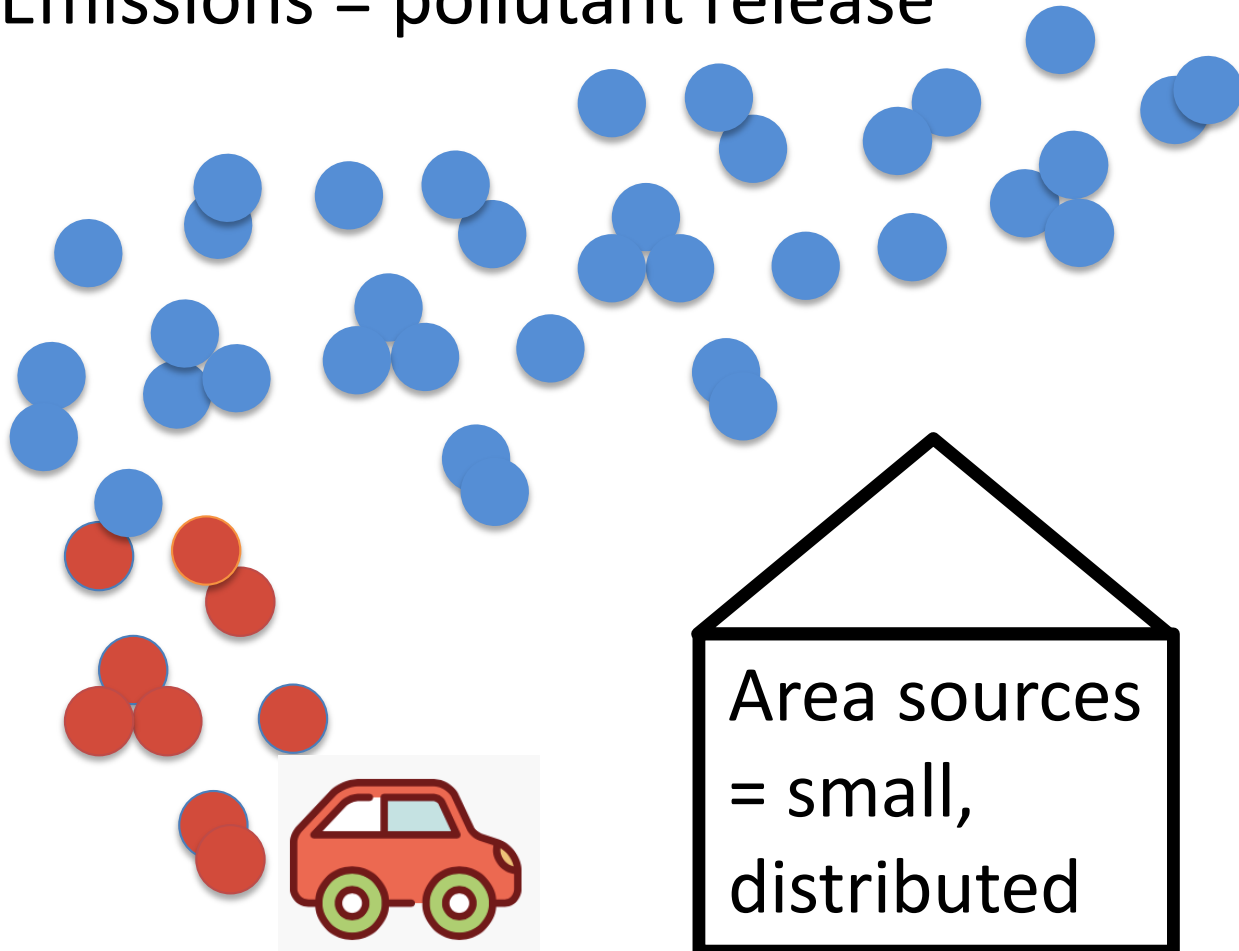


What do the colors mean?

Color	Zone	Potential
Red	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))
Orange	Zone 2 (orange zones)	Moderate potential; average indoor radon levels may be between 2 and 4 pCi/L (75 -150 Bq/m ³)
Yellow	Zone 3 (yellow zones)	Low potential; average indoor radon levels may be less than 2 pCi/L (75 Bq/m ³)

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

Emissions = pollutant release



Area sources
= small,
distributed

Point
sources =
power
plants &
industry

NAAQS Table

6 Criteria Pollutants:
CO, Pb, NO₂, O₃, PM, SO₂

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 (NO₂)		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 (O₃)		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 (SO₂)		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.

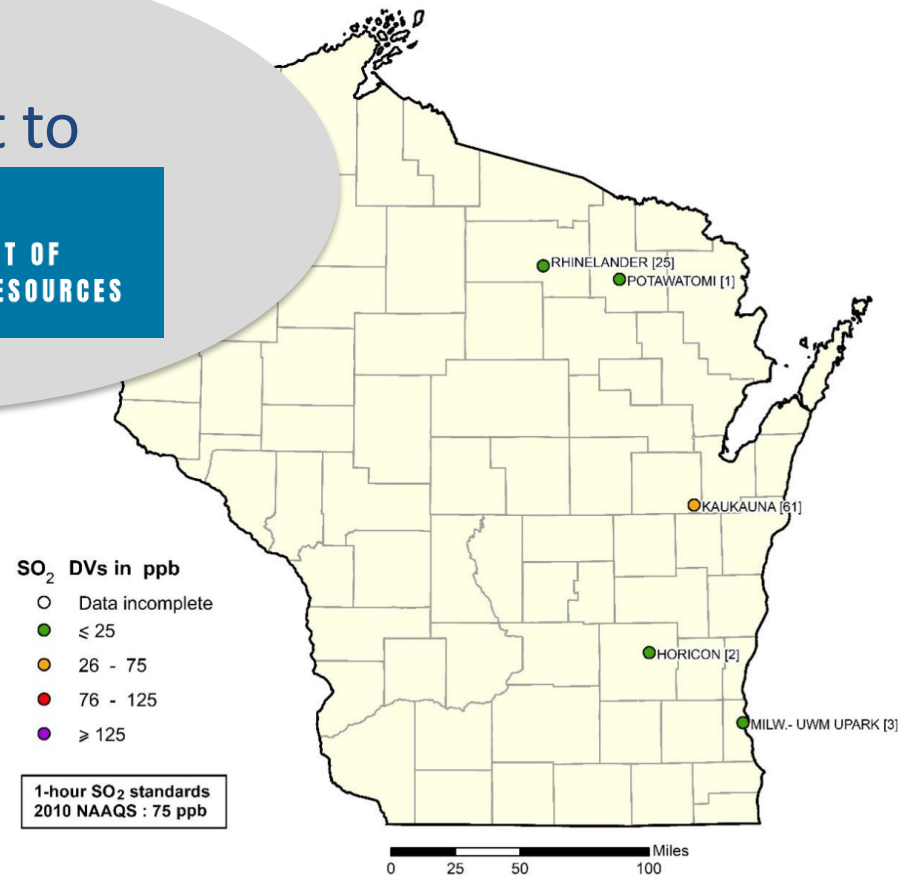
http://www.houstontx.gov/health/Environmental/bpcp/images/air_monitoring_trailer.jpg

Shout-out to



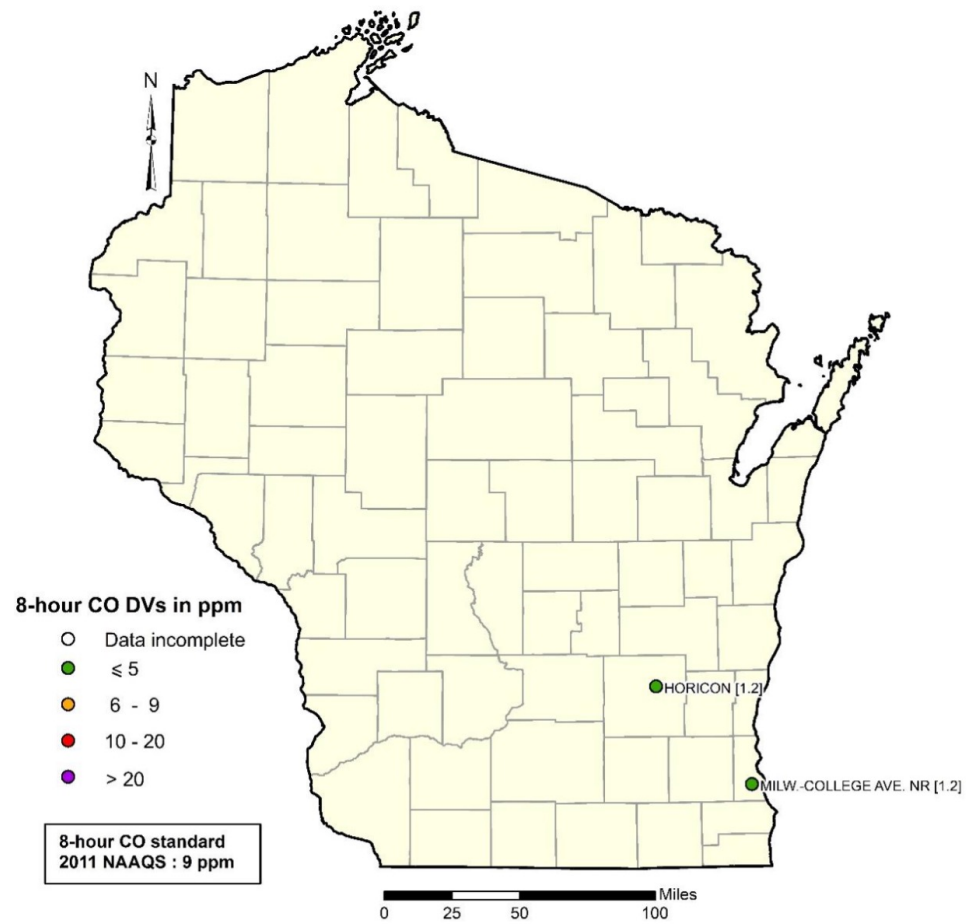
WISCONSIN
DEPARTMENT OF
NATURAL RESOURCES

1-Hour SO₂ Design Values: 2021-2023



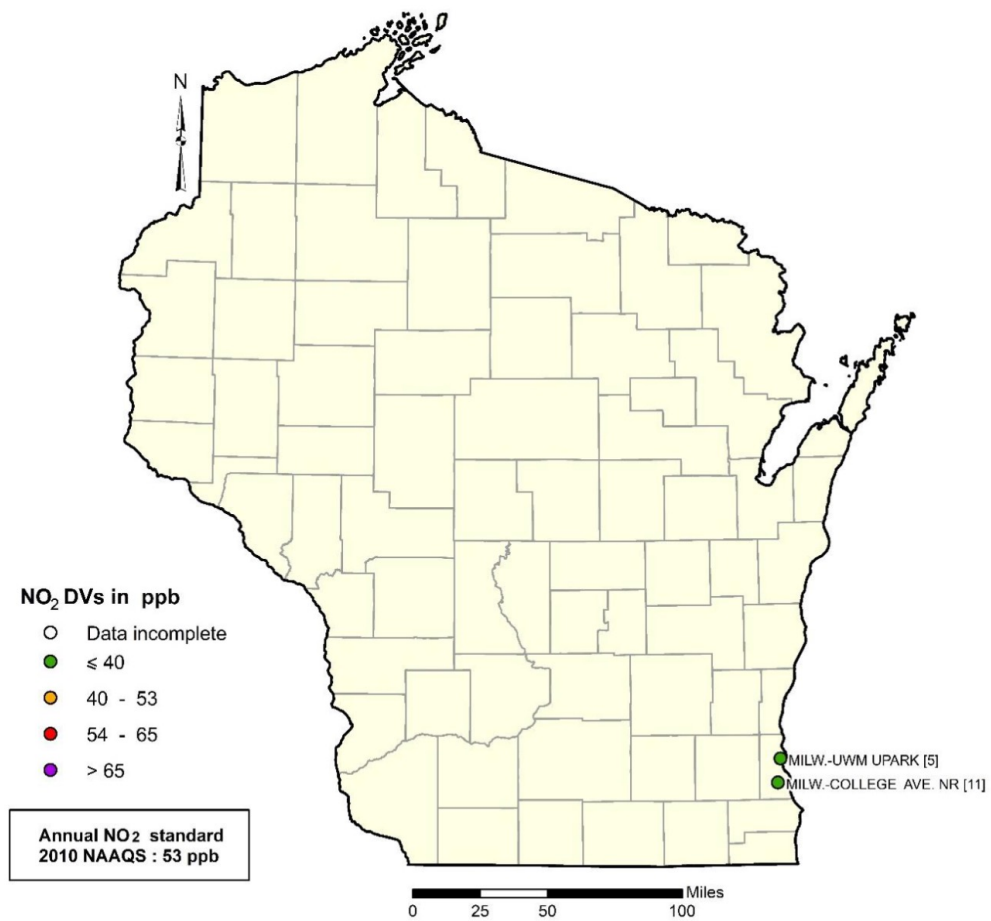
From Wisconsin DNR <https://widnr.widen.net/s/vfm6lrxbc7/am643>

8-Hour CO Design Values: 2021-2023



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

Annual NO₂ Design Values: 2021-2023



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

Satellite NO₂ Column Density Over Wisconsin

TROPOMI Satellite Images

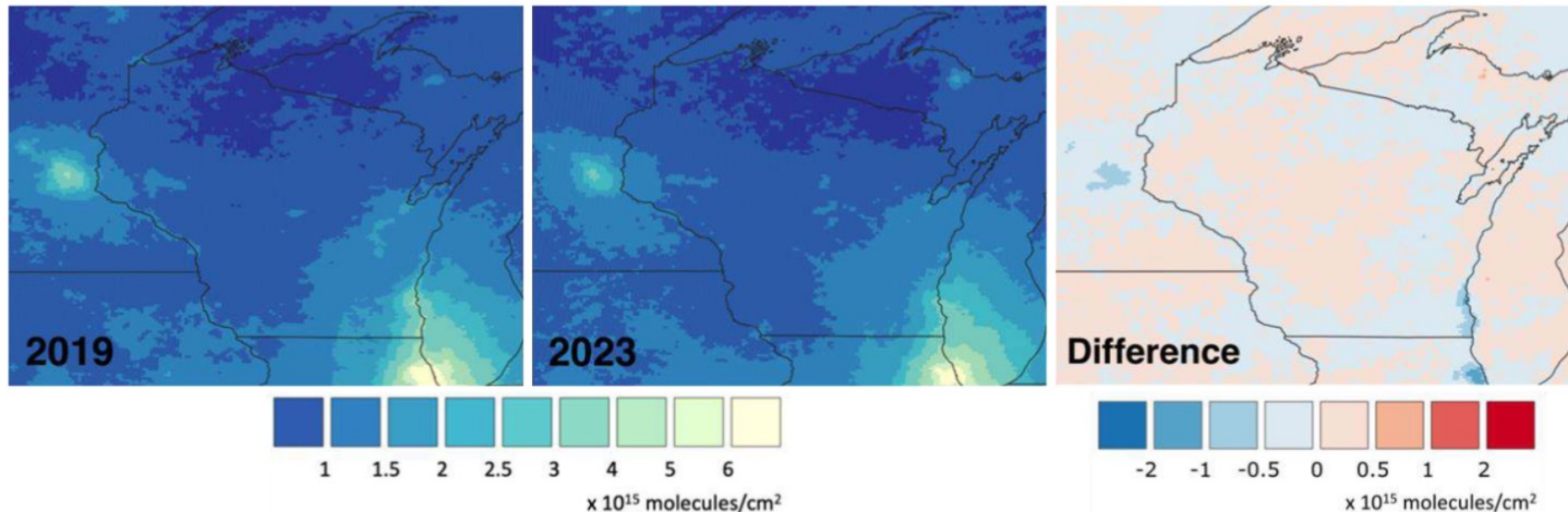


Figure 33. Maps of average annual NO₂ column density from the Tropospheric Monitoring Instrument (TROPOMI) satellite. The difference in NO₂ column density between 2019 and 2023 is also provided. Maps courtesy of Dr. Monica Harkey, Dr. Tracey Holloway and Colleen Heck of the University of Wisconsin-Madison. The methodology is available upon request.

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

NAAQS Table

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

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NAAQS Table

Particulate Matter (PM) is any solid or liquid suspended in air. Regulated in 2 size classes: < 2.5 microns ("fine") and < 10 microns ("coarse")

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
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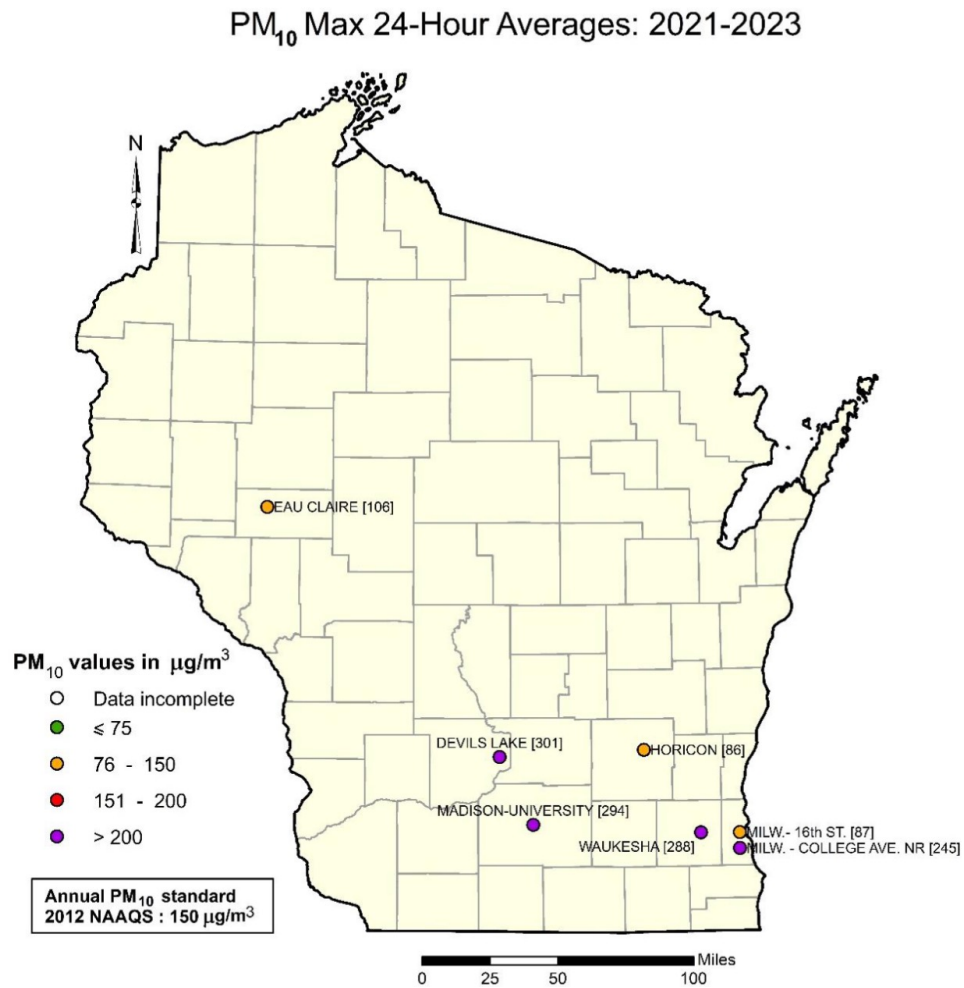


Figure 25. The maximum 24-hour averages of PM₁₀ for 2021-2023.

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

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



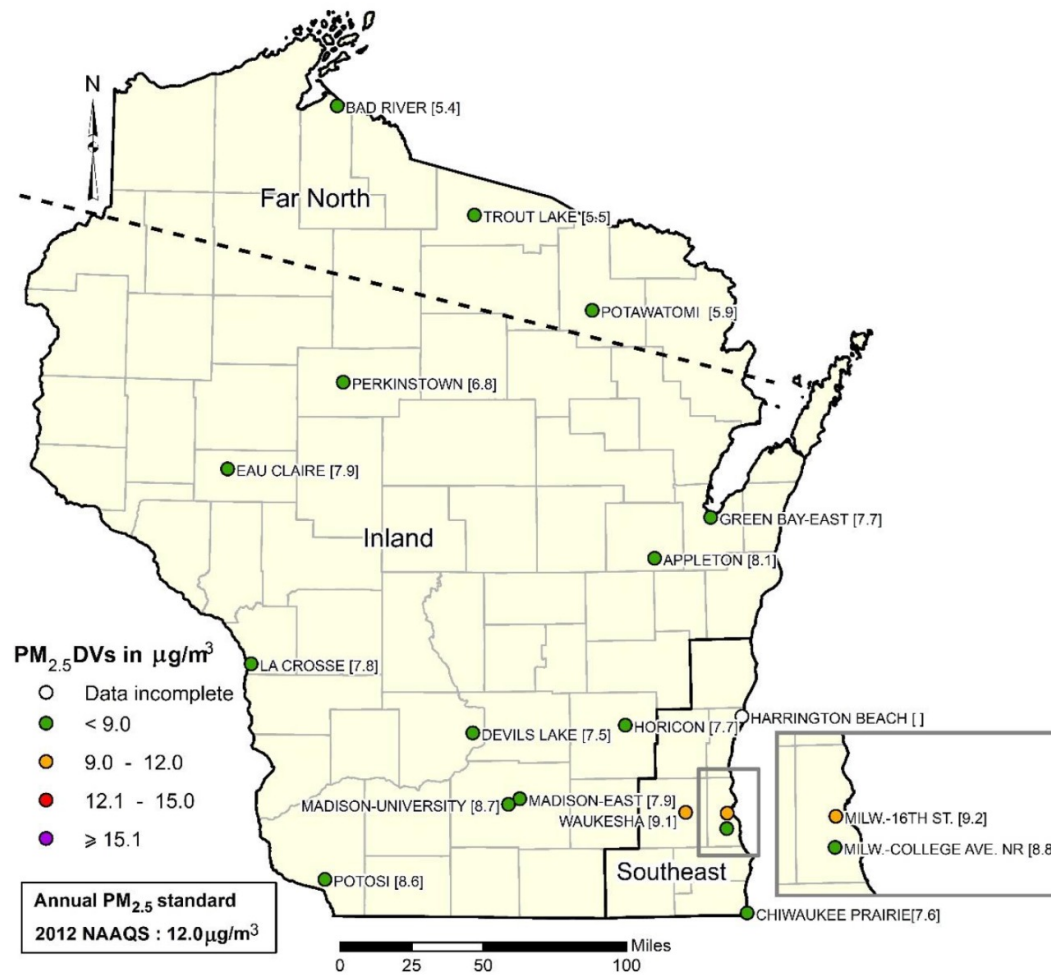
A haze from Canadian wildfires is seen over Milwaukee, Tuesday, June 27, 2023. The haze from Canadian wildfires, which, along with higher ozone levels is continuing to create low-visibility conditions and lead to air quality alerts throughout the area. Mary Cook/AP Photo

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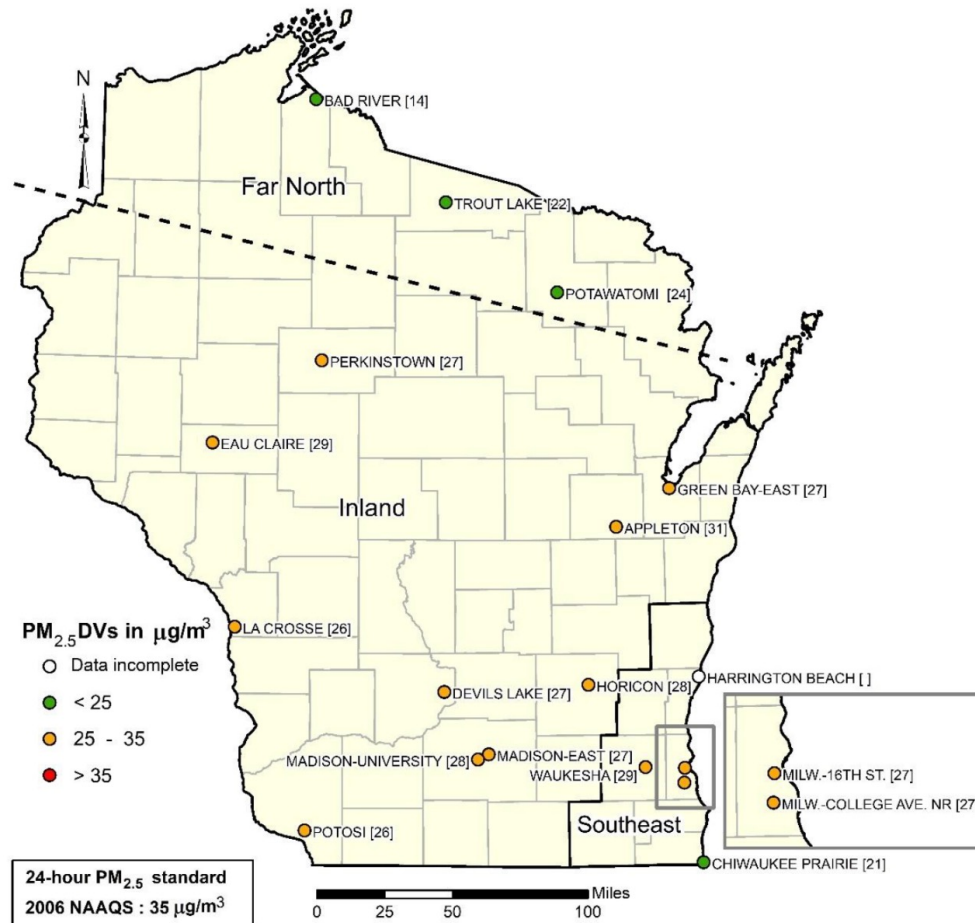
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Annual PM_{2.5} Design Values: 2021-2023



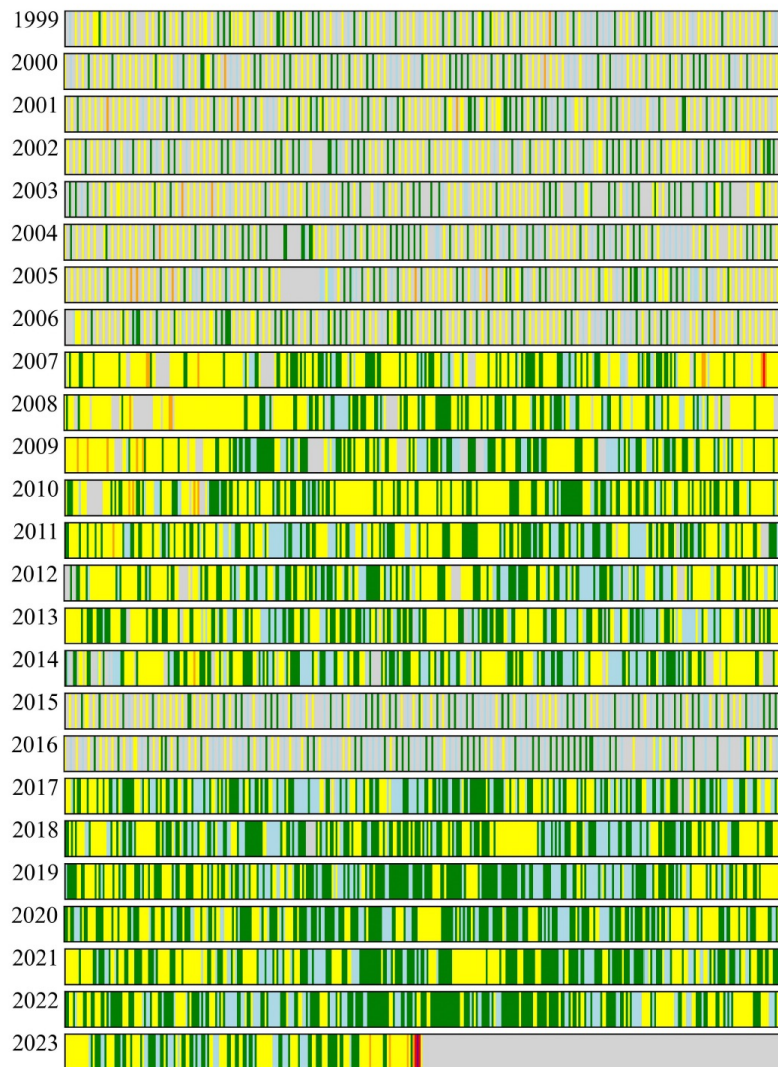
From Wisconsin DNR <https://widnr.widen.net/s/vfm6lrxbc7/am643>

24-Hour PM_{2.5} Design Values: 2021-2023



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

Fine Particulate Matter in Madison, WI



Air Quality Index Categories

	Index Value
Below WHO Air quality level is below standard of World Health Organization of 5 $\mu\text{g}/\text{m}^3$.	
Good Air quality is satisfactory, and air pollution poses little or no risk.	0-50 ($\leq 12.0 \mu\text{g}/\text{m}^3$)
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 $\mu\text{g}/\text{m}^3$)
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 $\mu\text{g}/\text{m}^3$)
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 $\mu\text{g}/\text{m}^3$)
Very Unhealthy Health alert: The risk of health effects is increased for everyone.	201-300 (150.5-250.4 $\mu\text{g}/\text{m}^3$)
Hazardous Health warning of emergency conditions: everyone is more likely to be affected.	301+ ($\geq 250.5 \mu\text{g}/\text{m}^3$)

EPA data from Lizzy Kysela, 2023

Air Data - Multiyear Tile Plot

Plot daily AQI values for a specific location and time period. Each "tile" represents one day of the year and is color-coded based on the highest daily AQI value at the selected monitor - or among all monitors in the geographic area if "All Sites (Highest Daily AQI)" is selected.

Pollutant

Period

from

to

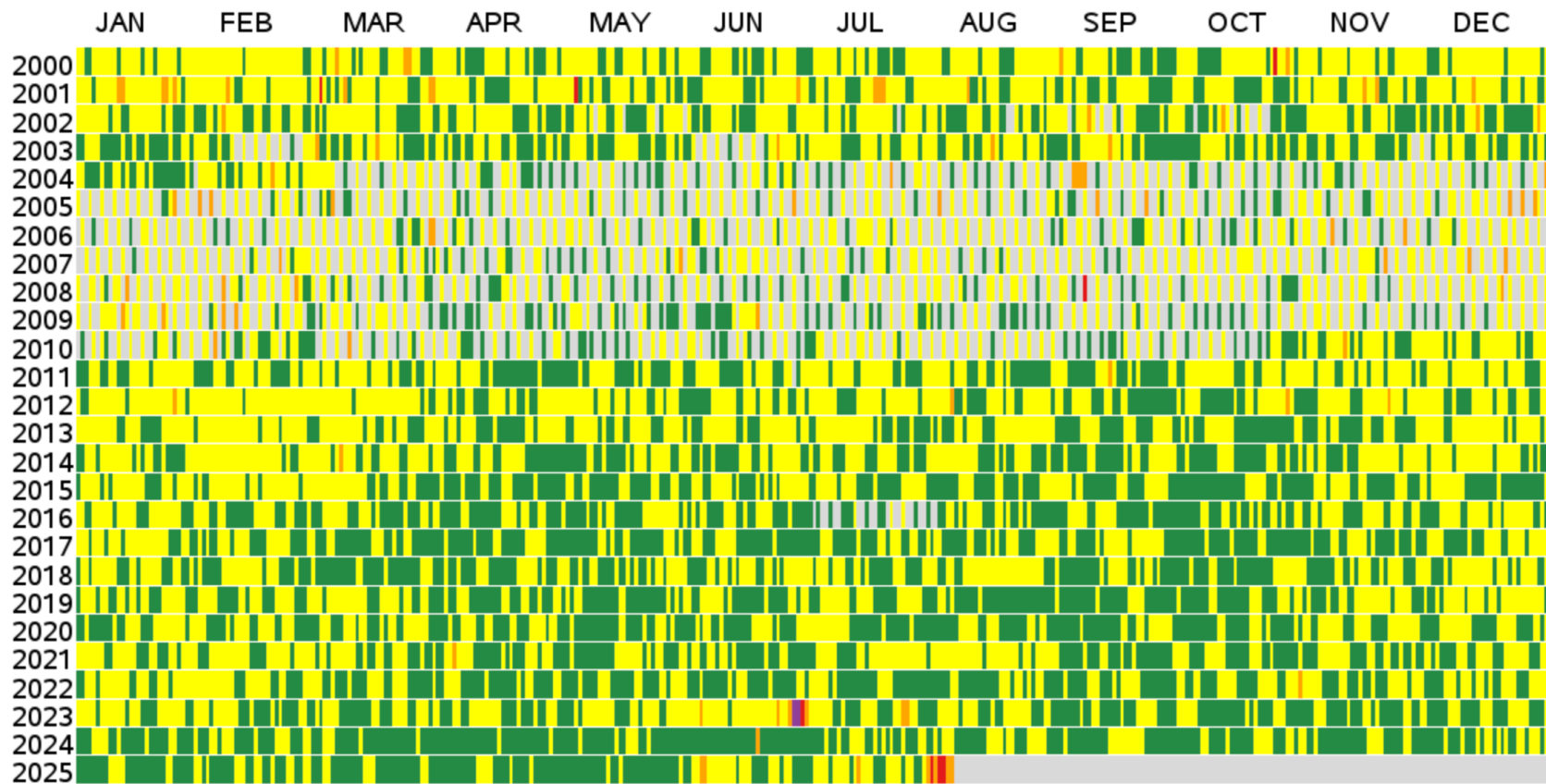
(Maximum 25 years / Query time: 15 years ~ 30 sec, 25 years ~ 1 min)

Geographic Area

-- or --

Monitor Site

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

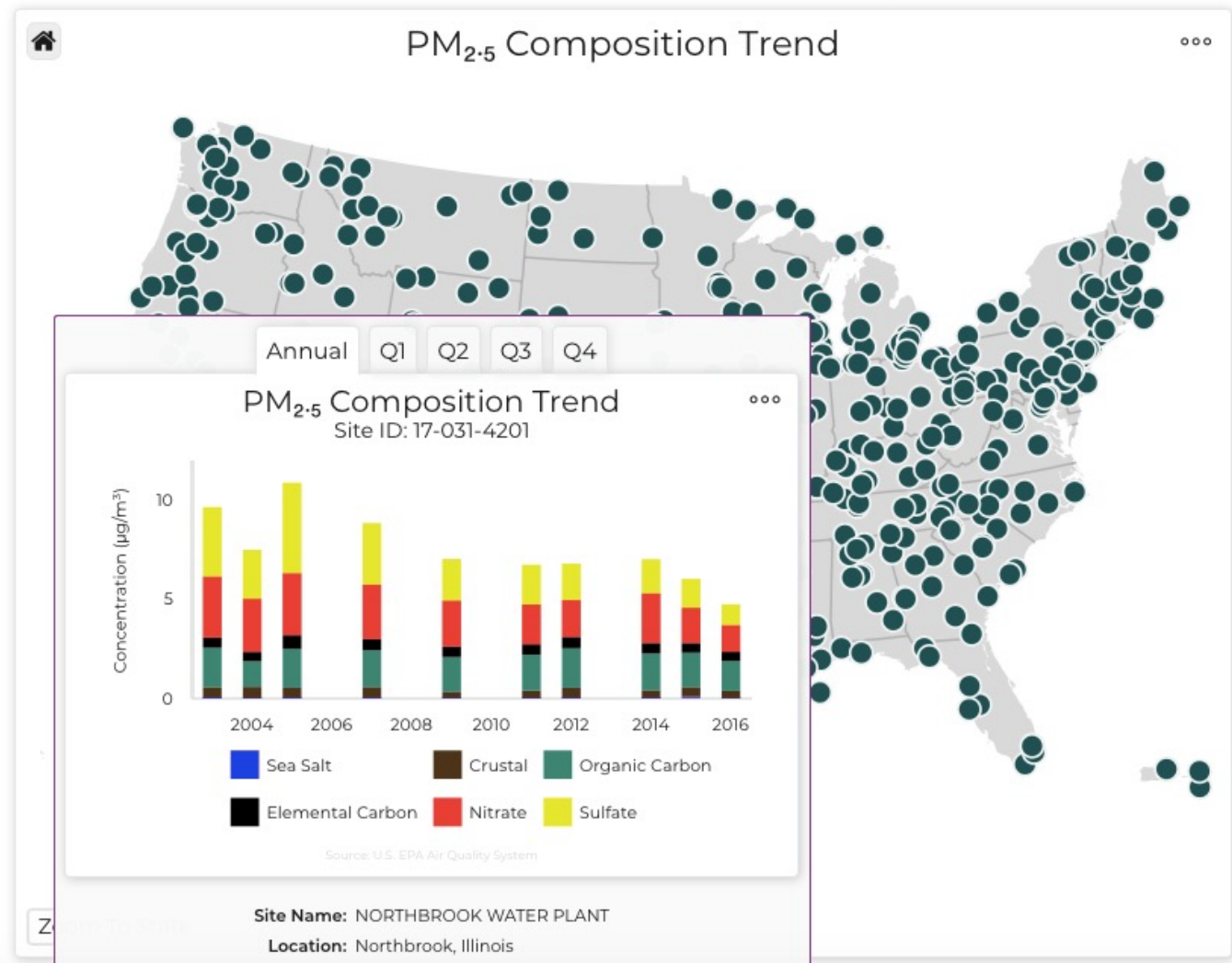


Understanding PM_{2.5} Composition Helps Reduce Fine Particle Pollution

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.

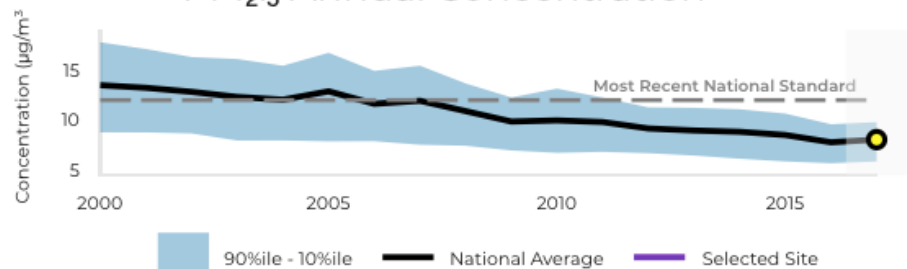


Criteria Pollutant Trends Show Clean Air Progress

Select a [NAAQS](#) to view concentration and emission trends

Particulate Matter 2.5 microns (Seasonally-weighted Annual Average)

PM_{2.5} Annual Concentration



Source: U.S. EPA Air Quality System

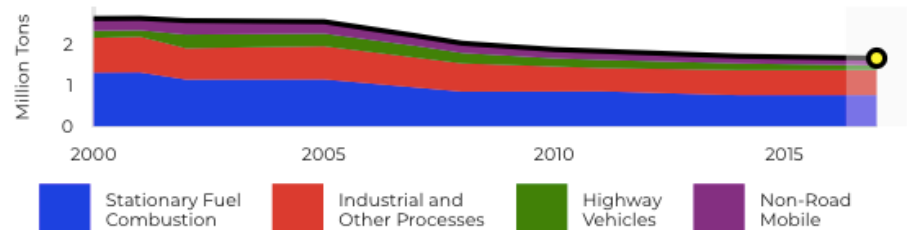
Direct PM_{2.5} Emissions

SO₂ Emissions

NO_x Emissions

VOC Emissions

Direct PM_{2.5} Emissions



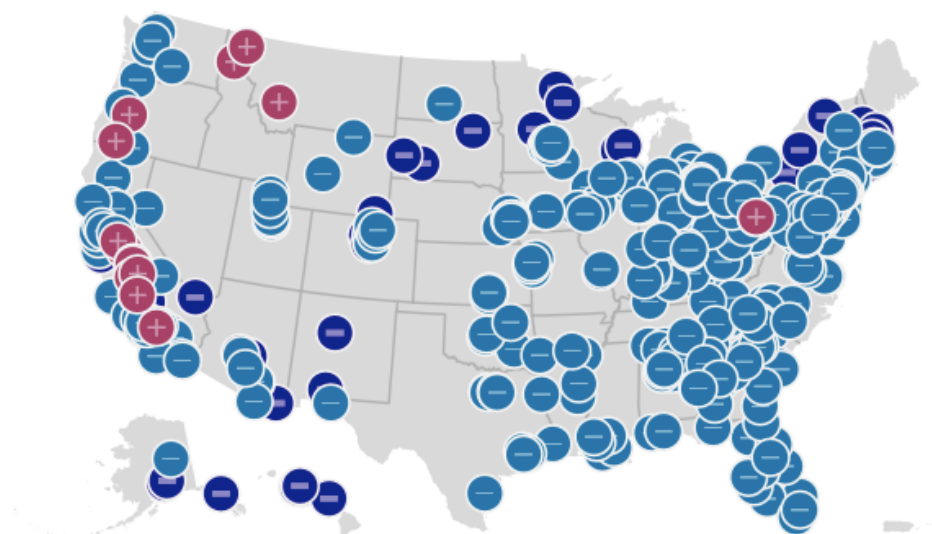
Source: U.S. EPA National Emissions Inventory 2014 ver. 2

Year: 2017

2000 2005 2010 2015



PM_{2.5} Annual Concentration



<= 6



6.1 - 12



12.1 - 35.4



>= 35.5

Zoom To State

Source: U.S. EPA Air Quality System

Direct PM_{2.5} Emissions

SO₂ Emissions

NO_x Emissions

VOC Emissions

SO₂ Emissions



Direct PM_{2.5} Emissions

SO₂ Emissions

NO_x Emissions

VOC Emissions

NO_x Emissions



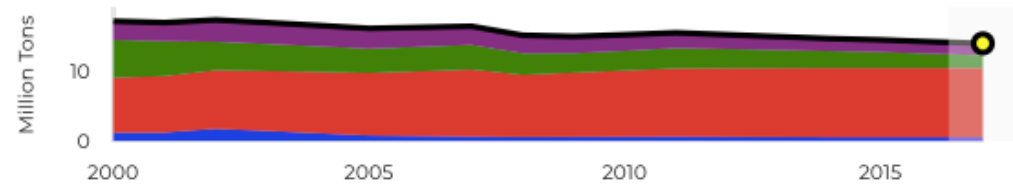
Direct PM_{2.5} Emissions

SO₂ Emissions

NO_x Emissions

VOC Emissions

VOC Emissions



Stationary Fuel Combustion



Industrial and Other Processes



Highway Vehicles



Non-Road Mobile



graded for at least one measure of air quality.

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Related Metropolitan Areas

Metro Area ▾

High Ozone Days

Particle Pollution

Populations at Risk

Wisconsin reports data on **18** out of **72** counties. Counties with no particle pollution data are not shown.

Sorted by County

County	Grade	Wgt. Avg.	Orange Days	Red Days	Purple Days	Maroon Days	Grade (Annual)	Design Value
Ashland	D	2.5	6	1	0	0	Pass	5.4
Brown	F	4.8	7	5	0	0	Pass	7.7
Dane	F	4.5	6	1	3	0	Pass	8.7
Dodge	F	3.7	4	2	2	0	Pass	7.7
Eau Claire	F	5.8	10	5	0	0	Pass	7.9
Forest	F	4.7	8	4	0	0	Pass	5.9
Grant	D	3.0	4	2	1	0	Pass	8.6
Jackson	D	2.7	5	2	0	0	INC	INC

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

NAAQS Table

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

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Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
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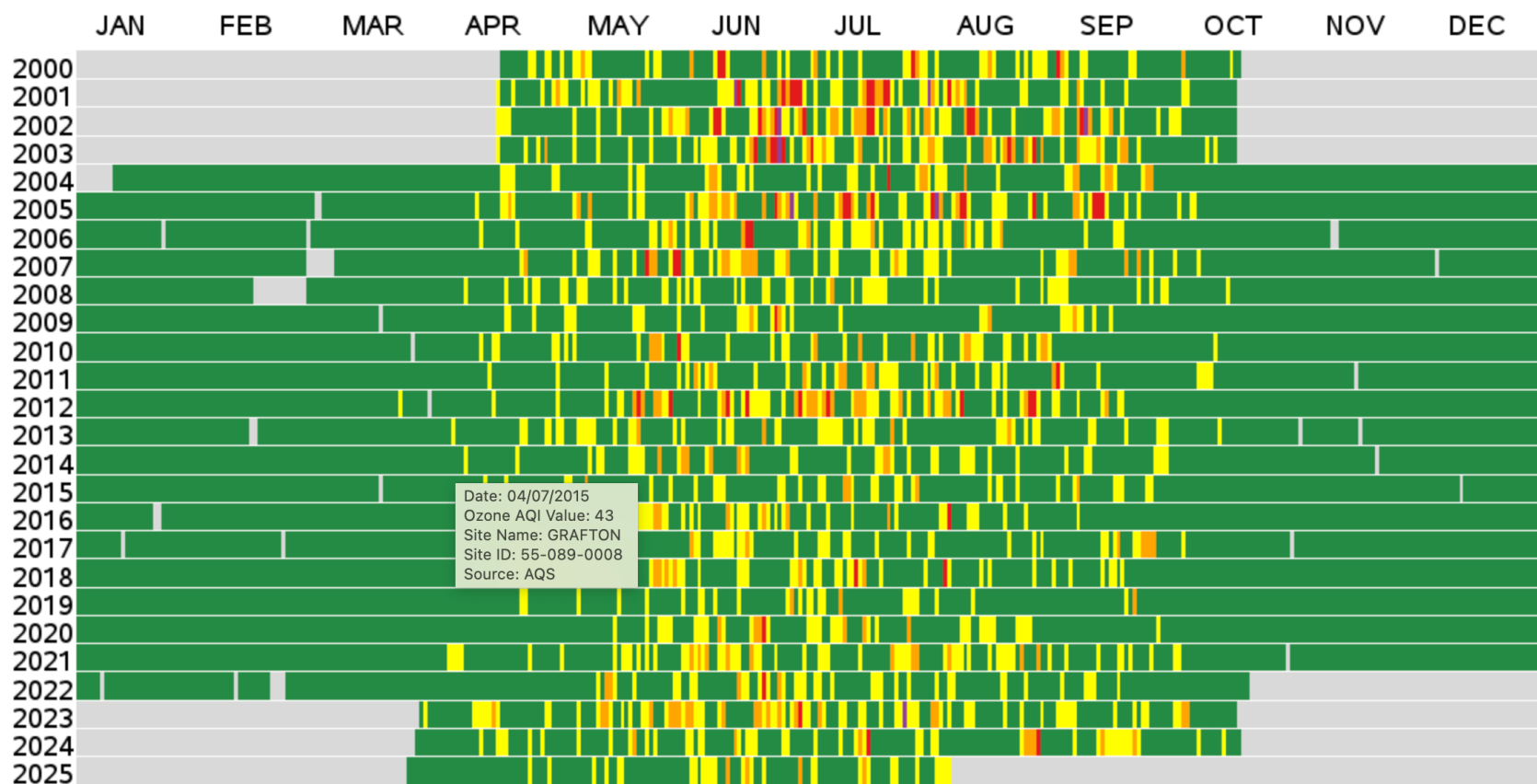
8-Hour Ozone Design Values: 2021-2023



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

Ozone Daily AQI Values, 2000 to 2025

Milwaukee-Waukesha-West Allis, WI



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

A diagram consisting of three overlapping ovals. The top oval is light green and contains the text 'In situ measurements'. The bottom-left oval is light blue and contains the text 'Satellite'. The bottom-right oval is light orange and contains the text 'Models'. The ovals overlap in a triangular arrangement.

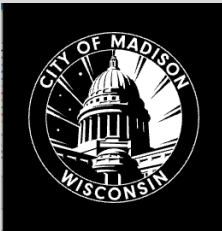
Satellite

Models

In Situ: On the ground measurements



Shout-out to



ENVIRONMENT, NEWS, POLLUTION, SCIENCE AND TECHNOLOGY

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

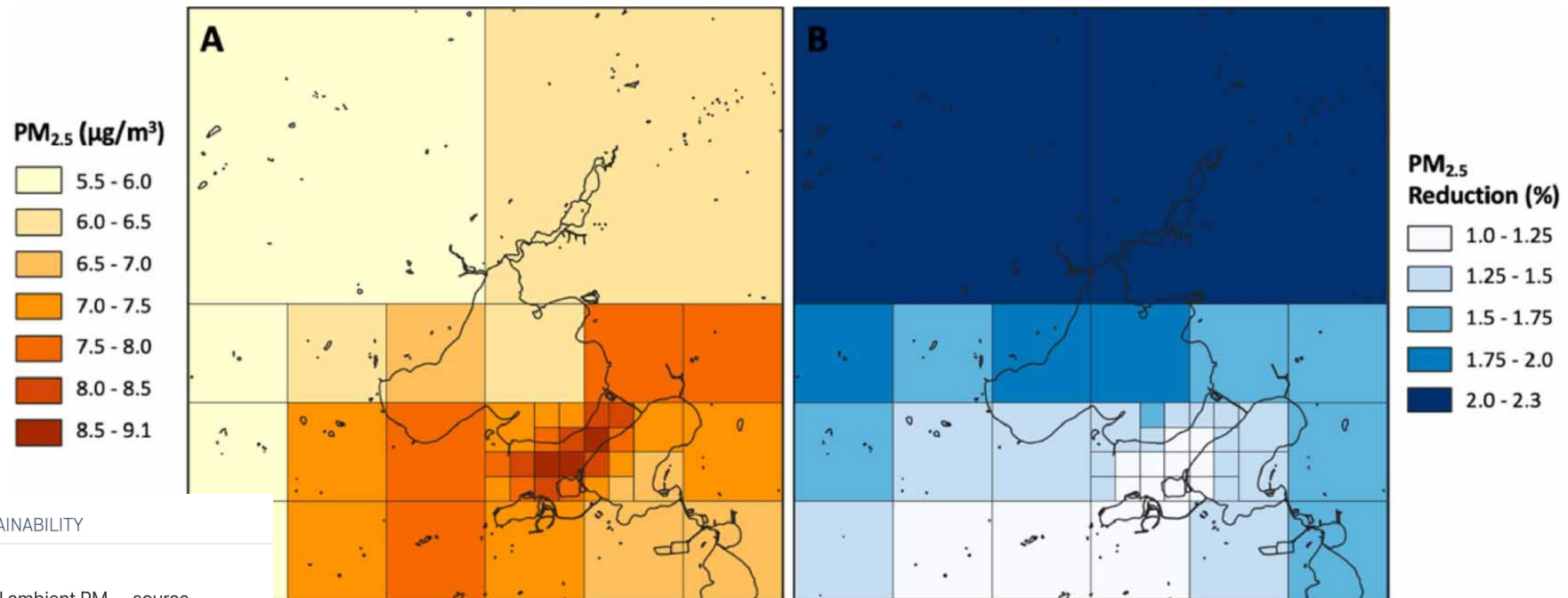
City will share public-facing data as part of federally-funded project

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



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

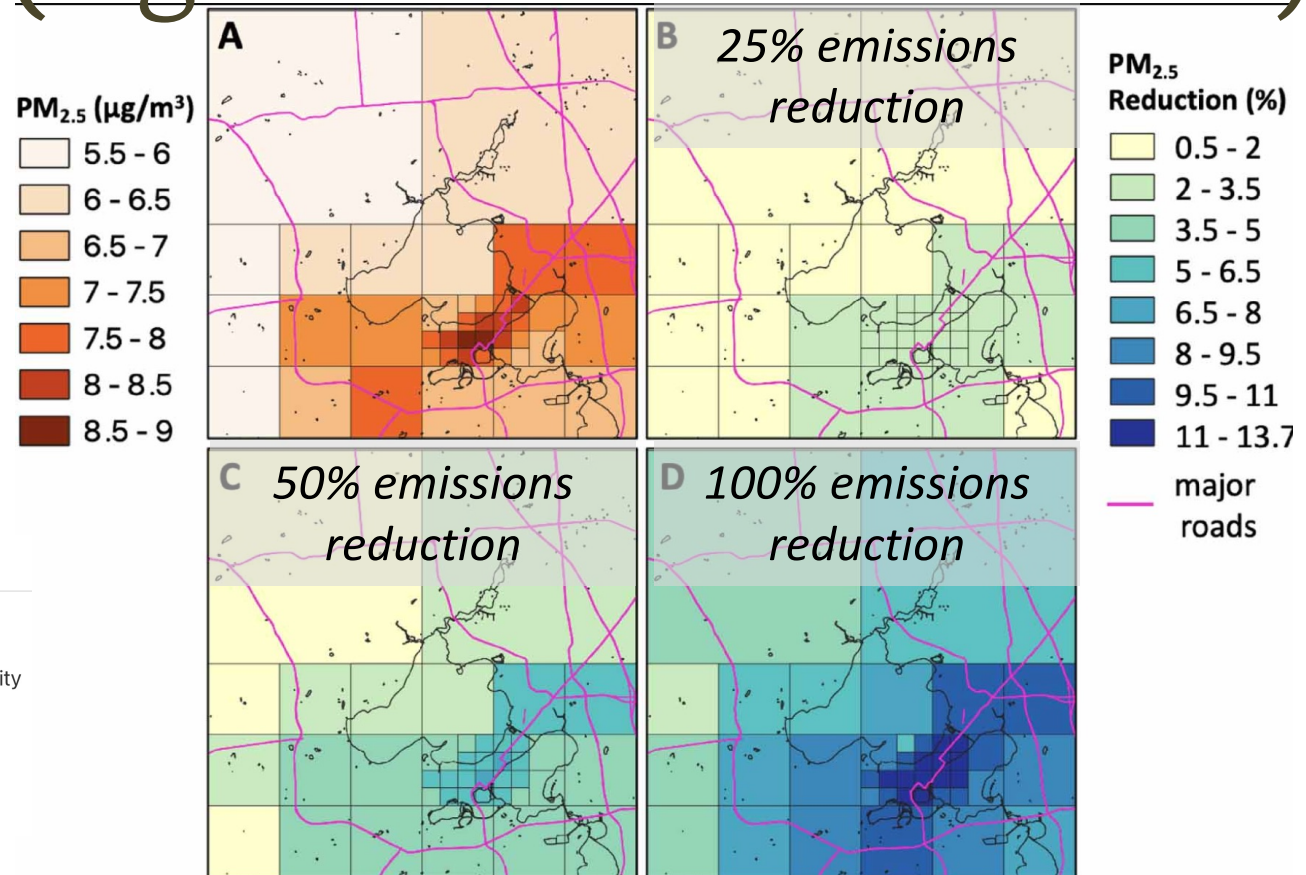
Published 1 February 2023 • © 2023 The Author(s). Published by IOP Publishing Ltd

[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)



ENVIRONMENTAL RESEARCH
INFRASTRUCTURE AND SUSTAINABILITY

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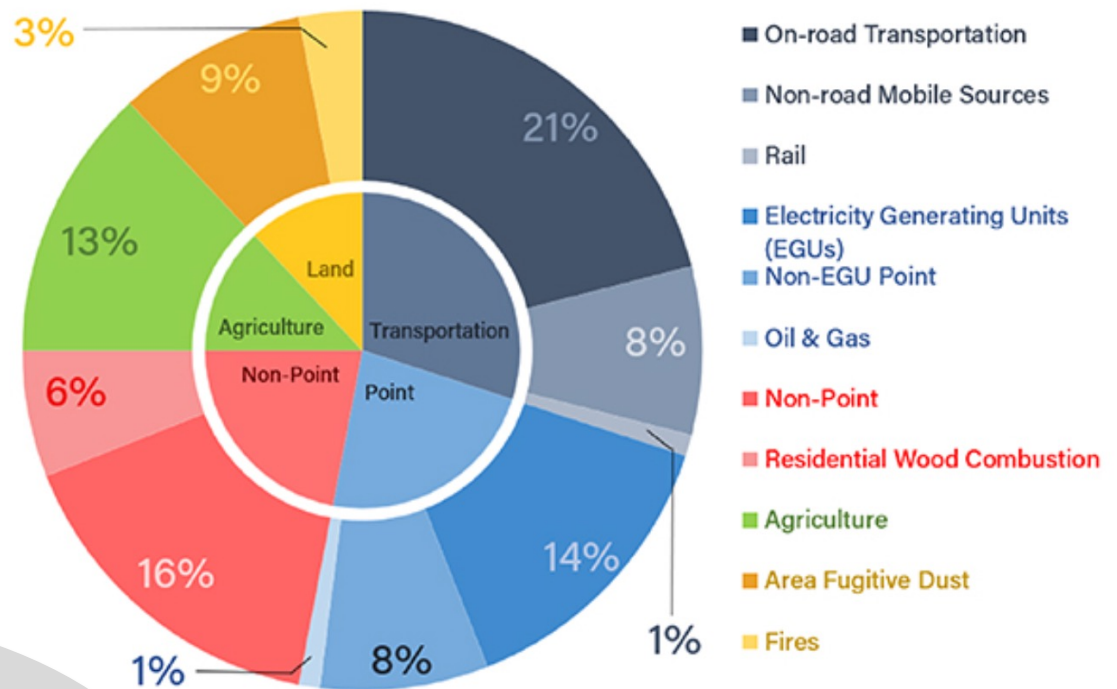
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Citation Clara M Jackson et al 2023 *Environ. Res.: Infrastruct. Sustain.* 3 015002

DOI 10.1088/2634-4505/acb0fa

Models: Source Attribution



[Zoom In](#) [Zoom Out](#) [Reset image size](#)

ENVIRONMENTAL
INFRASTRUCTURE

PAPER • OPEN ACCESS
City-scale
contribution
model: a case

Clara M Jackson, Tracey J
Published 1 February 2023 • © 2023
[Environmental Research: Infrastructure](#)
Citation Clara M Jackson et al 2023 Environ. Res.
DOI 10.1088/2634-4505/acb0fa

Shout-out to



tribution 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
atural and prescribed burns; wildfires are omitted.

Satellite Data: Filling in the Gaps



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Something in the Air Reports

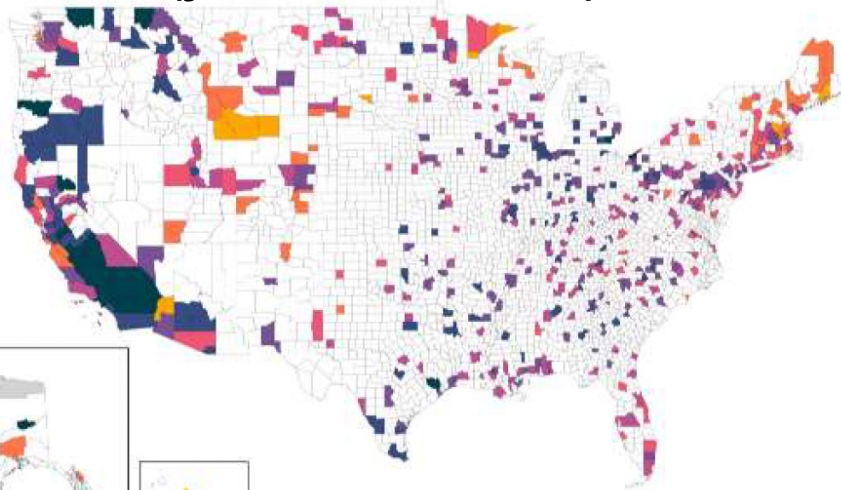
A series of reports highlighting the promising potential of satellite data to complement and enhance the United States' existing air quality monitoring network.



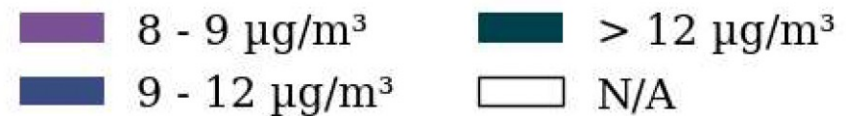
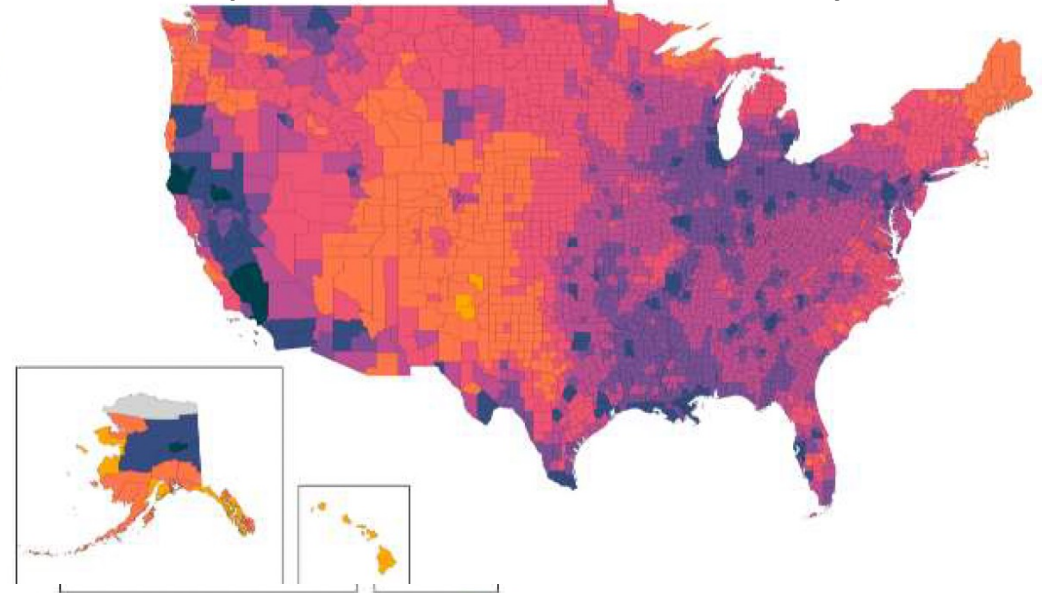
As a nation, we make great strides cleaning up air pollution—but not all communities benefit equally.

Satellite Data: Filling in the Gaps

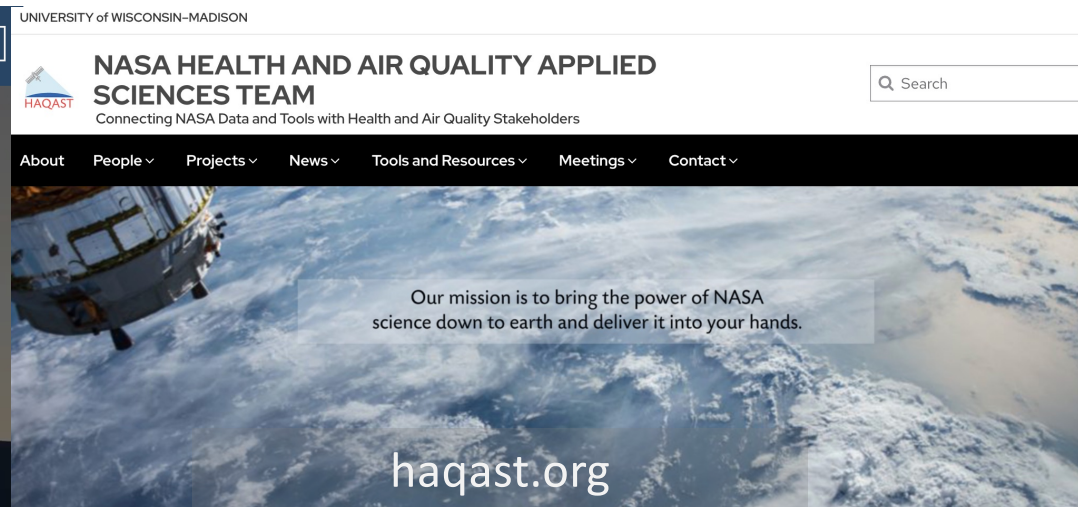
*County Design Values
(from monitors)*



*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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