Air Sensors Potential for Regulatory Applications: US National Ambient Air Quality Standards and Other Uses

MODULAIRM-PN

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Karoline Barkjohn¹, Andrea Clements¹, Amara Holder¹, Corey Mocka² ¹US Environmental Protection Agency (EPA) Office of Research and Development

²US EPA Office of Air Quality Planning and Standards

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National Ambient Air Quality Standards (NAAQS)

- Clean Air Act requires EPA to set for 6 pollutants
- Primary standards
 - Protect public health and sensitive populations
- Secondary standards

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- Public welfare protection from
 - Decreased visibility
 - Damage to animals, crops, vegetation, and buildings
- Federal Reference & Equivalent Methods (FEM & FRM) monitor compliance

https://www.epa.gov/amtic/air-monitoringmethods-criteria-pollutants

Pollutant		Primary/ Secondary	Averaging Time	Level	Form	
<u>Carbon</u> Monoxide (CO)		primany	8 hours	9 ppm	Not to be exceeded more than once per year	
		primary	1 hour	35 ppm		
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 μg/m ^{3 <u>(1)</u>}	Not to be exceeded	
<u>Nitrogen</u> Dioxide (NO ₂)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years	
		primary and secondary	1 year	53 ppb (2)	Annual Mean	
<u>Ozone (O₃)</u>		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/m³	annual mean, averaged over 3 years	
		secondary	1 year	15.0 μg/m³	annual mean, averaged over 3 years	
		primary and secondary	24 hours	35 μg/m³	98th percentile, averaged over 3 years	
	PM ₁₀	primary and secondary	24 hours	150 μg/m³	Not to be exceeded more than once per year on average over 3 years	
Sulfur Dioxide		primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years	
<u>(30₂)</u>		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year	

Source: https://www.epa.gov/criteria-air-pollutants/naaqs-table

If an Area is Out of Attainment

State submits a statewide implementation plan (SIP)

- Describes how the nonattainment area(s) will improve their air quality to meet the standards
 - Reviewed and approved by EPA
 - Includes emissions inventory
 - Identifies applicable rules and regulations
 - Evaluate feasibility of new pollution controls
 - Uses modeling to determine if actions are sufficient to meet standard



https://www3.epa.gov/airquality/greenbook/mapnpoll.html

Exceptional Events

- Agencies can exclude air quality data influenced by exceptional events from regulatory action
 - Example exceptional events: wildfires, high wind dust events, fireworks, prescribed fires, stratospheric ozone intrusion, and volcanic and seismic activities
- Requirements include:
 - A narrative describing the event
 - Demonstration that
 - There is a causal relationship between the event and exceedance/violation
 - The event was not reasonably controllable and not reasonably preventable
 - The event was caused by human activity that is unlikely to recur at a particular location or was a natural event
- Some air agencies have used sensor data to support their exceptional events demonstrations

More information: <u>https://www.epa.gov/system/files/documents/2023-09/Wildfire%20Resource%20Document_Final_Revised.pdf</u> Example: <u>https://ww2.arb.ca.gov/sites/default/files/2021-09/2018_Southern_California_EE_Full_Demo_2.pdf</u> Determining Attainment Is Not the Only Way to Use Air Quality Data to Protect Human Health

Air Monitoring Equipment is a Spectrum

Examples of PM sensors and monitors



Image sources: ikea.com, amazon.com, purpleair.com, iqair.com, quant-aq.com, NOAA.gov, Teledyne-api.com, metone.com

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Data acknowledgement: Thank you to PurpleAir!

Sensor Uses

- Not used for NAAQS compliance monitoring
- Offer better understanding of spatial and temporal variations in local air quality
 - Publicly displayed sensor data provides personalized air quality information to impact communities
 - Raising awareness
 - Encouraging actions to reduce exposure
- Identify highly localized air pollution sources
 - Hot spot or leak detection in some cases warrants further rigorous investigation
- Supporting the regulatory process
 - Can use for determining the placement of regulatory monitoring
 - May be used in weight-of-evidence analyses (e.g., exceptional events demonstration)
- Scientific research supporting the regulatory process
 - Estimate exposure for population health studies
 - Assess and enhance air quality model performance

Requirements for Regulatory Monitors: Operation

- Must adhere to stringent
 - Siting
 - Quality assurance requirements

An FEM instrument is not an FEM unless it is operated with the required QA methods.



Add significant costs to monitoring

Requirements for Regulatory Monitors: Equipment

EPA's Office of Research and Development evaluate and designate instruments as FEM or FRM based on

- Accuracy
- Precision
- Range
- Detection Limit
- Pollutant Specificity
- Freedom from co-pollutant interferences
- Noise
- Drift (short-term and long-term)
- Lag/Rise/Fall (gas analyzers)
- Multi-Site Measurement Performance
- Must pass ALL tests to be approved by EPA



Evaluations more costly than what is specified in EPA's Air Sensor Performance Targets

If air sensors cost more, would they still be as useful?



Currently, both gas and PM sensors have limitations that prevent them passing the rigorous FEM/FRM review process

FEM=Federal Equivalent Method, FRM=Federal Reference Method, PM=Particulate Matter

Sensor Limitations

- Accuracy
- Precision
- Range
- Detection Limit
- Pollutant Specificity
- Freedom from co-pollutant interferences
- Noise
- Drift (short-term and long-term)
- Lag/Rise/Fall
- Multi-Site Measurement Performance



Hear more on this topic in my talk tomorrow during Session 6A: Effectively converting air quality data to actionable air quality information: Data science tools to scale QA/QC (11:15 am)

My talk: "Air Sensor Quality Assurance Workshop Summary"

Paper summary coming soon!

EPA/600/R-22/028| May 2022 | www.epa.gov/isa

Weight of Evidence

- Sensors can support the weight of evidence analysis of air pollution health effects
- Used in the integrated science assessment
 - Scientific basis of the NAAQS limits



https://assessments.epa.gov/risk/document/&deid=354490

Sensors in the Integrated Science Assessment (ISA)

Table A-11 (Continued): Study-specific details for epidemiologic studies examining socioeconomic status and PM_{2.5} exposure.

Study/Location Years	Exposure Assessment	Mean Concentration (µg/m ³)	Copollutant Examination
Tanzer et al. (2019) Pittsburgh, PA Apr 2017-May 2018	PM _{2.5} measured using Met-One Neighborhood PM Monitors (NPMs) and small subset measured using PurpleAir PA-II, as part of a Real-time Affordable Multi-Pollutant (RAMP) package	Annual average range: 7.5 to 25.8 EJ Communities: 10.6 (1.0) Non-EJ Communities: 10.3 (1.5)	Correlation (<i>r</i>): 0.32 (0.16–0.56) SO ₂ Copollutant models with: NA

- At least 1 sensor study was cited in the 2022 PM ISA
- Potentially ISA relevant sensor papers have increased exponentially in recent years



International Journal of Environmental Research and Public Health

Article

Demonstration of a Low-Cost Multi-Pollutant Network to Quantify Intra-Urban Spatial Variations in Air Pollutant Source Impacts and to Evaluate Environmental Justice

Rebecca Tanzer^{1,2}, Carl Malings^{2,3}, Aliaksei Hauryliuk^{1,2}, R. Subramanian^{2,3} and Albert A. Presto^{1,2,*}

- Department of Mechanical Engineering, Carnegie Mellon University, Pittsburgh, PA 15213, USA
- ² Center for Atmospheric and Particle Studies, Carnegie Mellon University, Pittsburgh, PA 15213, USA
- ³ OSU-EFLUVE, CNRS, Université Paris-Est Créteil, 61 Avenue du Général de Gaulle, 94000 Créteil, France
- * Correspondence: apresto@andrew.cmu.edu; Tel.: +1-412-721-5203



MDP

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ISA Example: Summary of Evidence



Note: *U.S. and Canadian studies published since the literature cutoff date (~January 2018) for the 2019 PM ISA. Circles represent ratio of each SES group to the reference group; red text and circles represent evidence included in the 2019 PM ISA; blue text and circles represent evidence not included in the 2019 PM ISA. Reference concentrations in µg/m³. This figure builds on Figure 12-1 in the 2019 PM ISA.

Summary

- Air monitoring is a spectrum of typically increasing cost and increasing accuracy
 - There is value in having a variety of tools for a variety of tasks
 - Lower cost enables wider usage and extensive air sensor dataset
 - Extensive dataset valuable for scientific research supporting the regulatory process
- Air sensors would be more expensive if they met regulatory requirements
 - Currently, both gas and PM sensors have limitations that prevent them passing the rigorous FEM/FRM review process
- Air sensors can be used in weight of evidence when determining new National Ambient Air Quality Standards



https://www.epa.gov/air-sensor-toolbox

Want to know more about EPA's work with air sensors? Check out the air sensor toolbox for a variety of resources

Resources: Air Sensor Toolbox

Research Projects



- Overview of Current Research
- <u>Collaborative Agreements</u>
- Grants
- <u>Reports and Publications</u>
- Past Projects

Additional Resources



- Frequently Asked Questions
- <u>Air Sensor Loan Programs</u>
- <u>Newsletter Articles, Fact Sheets and</u>
 <u>Infographics</u>
- Educational Resources
- <u>Conferences, Workshops, and</u>
 <u>Webinars</u>
- <u>Sensor Evaluations by Other</u>
 <u>Organizations</u>
- <u>Quality Assurance for Air Sensors</u>

Questions?

Contact:

Barkjohn.Karoline@epa.gov

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