Community in Action: A Comprehensive Educational Toolkit on Air Quality Sensors

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Background - The AQ-SPEC Program

- Availability, interest, and use of air quality sensors continues to increase
- **AQ-SPEC** (Air Quality Sensor Performance Evaluation Center), established in 2014
- Main Goals:
  - Evaluate the performance of commercially available "low-cost" air quality sensors in both field and laboratory settings
  - Catalyze the successful evolution, development, and use of sensor technology
  - Provide guidance and clarity for ever-evolving sensor technology and data interpretation

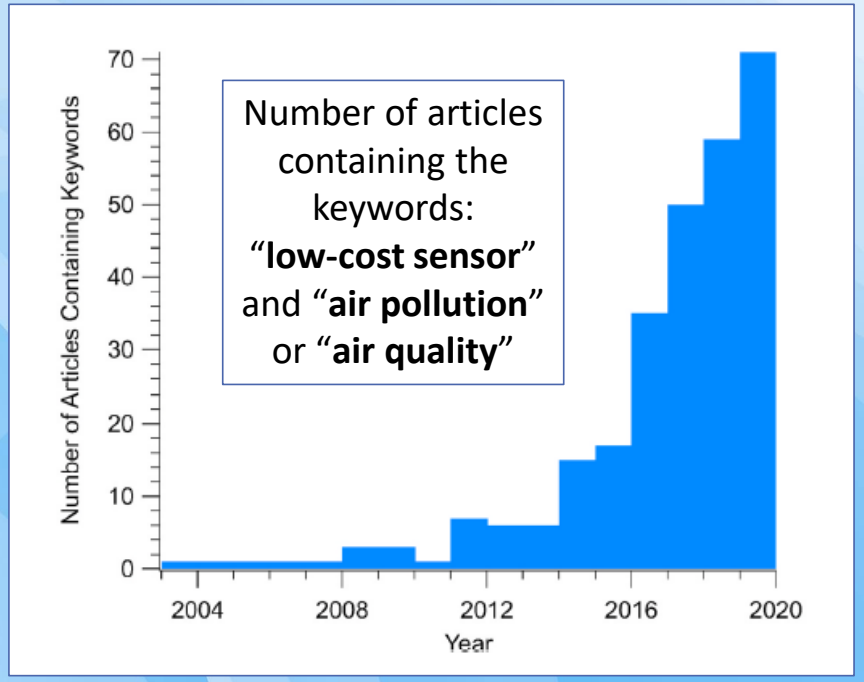
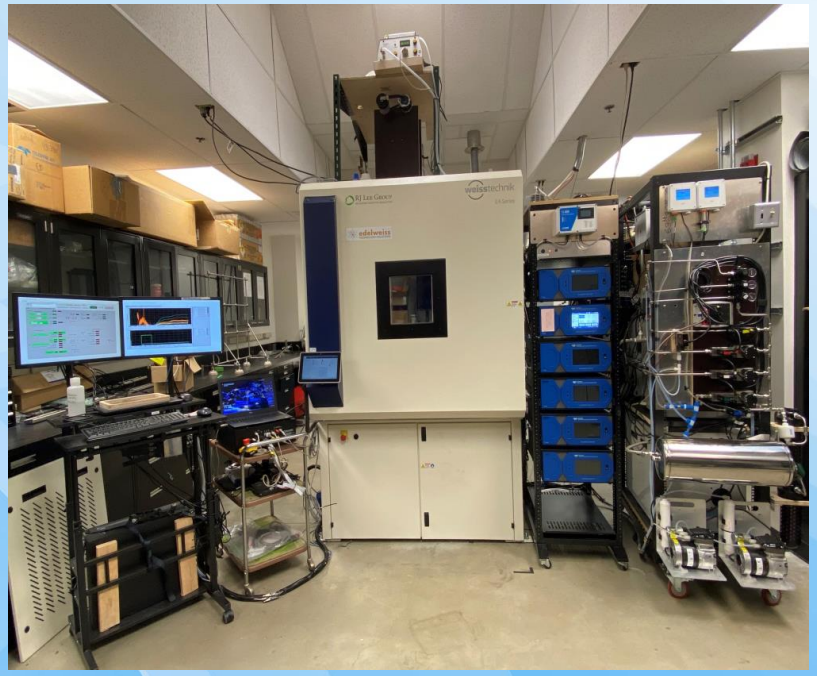


Figure from Giordano et al., 2021

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

South Coast AQMD



- ✓ **ASTM D8405-21 standard test method for IAQ $PM_{2.5}$ sensors**
- ✓ Home Ventilating Institute (HVI) Certification
- ✓ ASTM DXXXX-XX standard test method for IAQ CO_2 sensors
- ✓ VOC sensor evaluations: 4-VOC blend/Benzene/CO/O_3
- ✓ 20+ Sensors testing
- ✓ Specialty Tests (wind, vibration, altitude)
- ✓ Simultaneous Pollutant testing
- ✓ U.S. EPA sensor testing protocols

www.aqmd.gov/aq-spec/evaluations/laboratory

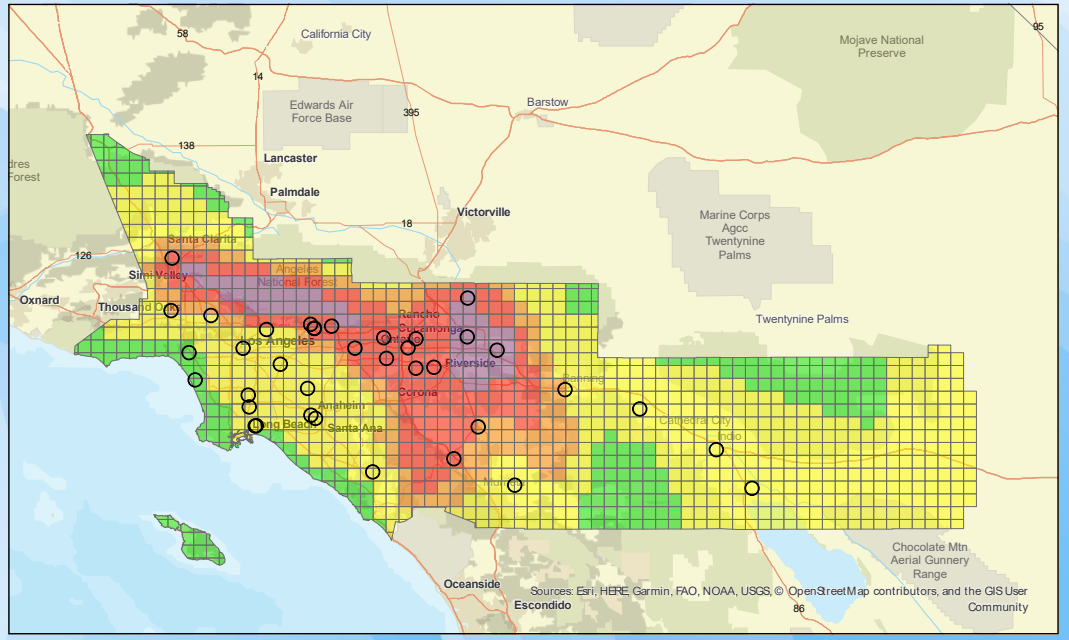
500 sensors and…deploying

Community Monitoring
- 350+ PurpleAir PA-II
- 60+ Aeroqual AQY

AB 617 Monitoring
- San Bernardino
- Eastern Coachella Valley
- East LA

Wildfire Response
- fire.airnow.gov/

5 x 5 AQI Map
- www.aqmd.gov/aqimap



www.aqmd.gov/aq-spec/special-projects/aeroqual-aqy-deployments

www.aqmd.gov/aq-spec/special-projects/airsensor

14 Data Sources <-> Single-point of Access

Internal Databases (data produced by South Coast AQMD)

- Sensor networks (non-regulatory)
- Air monitoring stations (regulatory)
- Laboratory samples
- AB 617 Community Air Monitoring
- Rule 1180 Refinery Emissions Monitoring
- Air Quality Assessment (AQI data with associated health messaging)
- Special projects (e.g., MATES V)
- Air quality advisories
- Facilities information

(note, includes continuous/time integrated data as well as stationary/mobile data)

External Databases

- Traffic count data
- NOAA meteorological data
- Fence line data collected by refineries
- NASA satellite data (OMI, TROPOMI)

(note, ability to add more in the future)

- *Analytics tools: High Charts and RStudio Team (Work Bench, Shiny apps, and Python)*
- *Compatible with: MatLab, JMP, Tableau, Power BI, and MS Excel*

Azure Cloud Infrastructure
(database for storage, organization, and processing)

Data Export

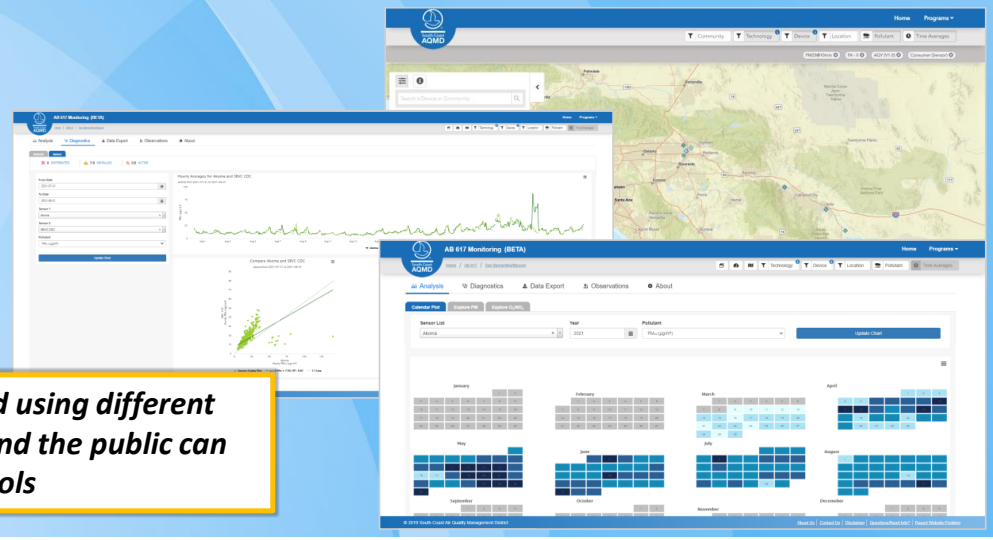
- Easier access to data
- Ability to customize downloaded data

External Dashboards (for the public and staff)

- Designed for intuitive use and engaging interaction with the data for all types of users
- Web-based
- For the public to better understand their local air quality AND explore special projects
- Wide range of visualization types
- Dashboards ranging from the "All Programs" or global/district level to the program-, project-, and even community-specific levels

Internal Dashboards (for district staff)

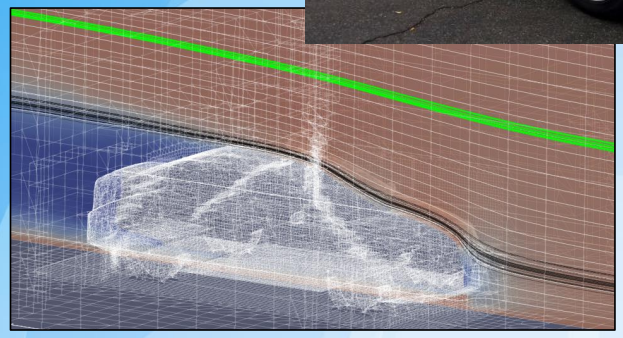
- For diagnostics and more complex analysis

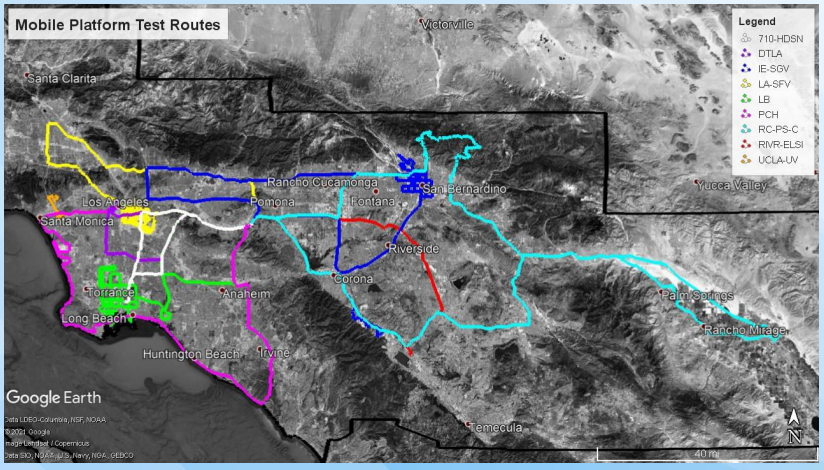


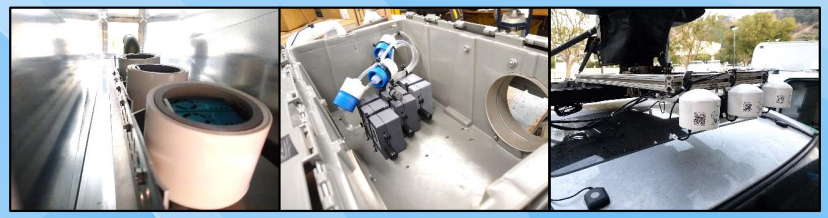
Air Quality Management District-level Solution

This solution harmonizes different types of air monitoring data, collected using different types of instrumentation, offering a single platform where district staff and the public can more easily access and analyze the data using advanced tools

South Coast AQMD







- ✓ Chevy Volt mobile sensor testing platform
- ✓ Fully-equipped with FRM/FEM/BAT reference monitors
- ✓ Computational fluid dynamics and particle trajectory simulation inform design of sampling components
- ✓ Evaluate sensors that measure $PM_{2.5}$, PM_{10}, O_3, NO_2, or CO

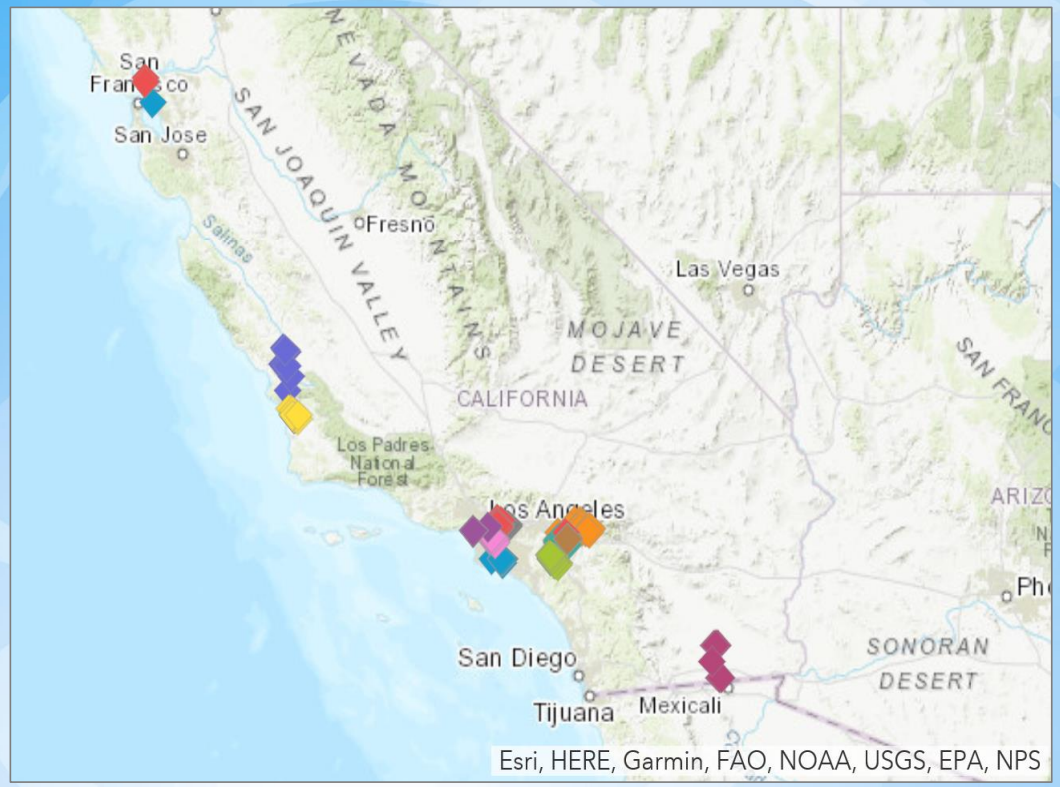
- ✓ Three sensor testing scenarios: Controlled-flow duct; Rooftop box; Rooftop exposed
- ✓ Evaluation protocol published this year in *ES&T*
- ✓ Produce reports that help set user expectations of data quality from sensors used in mobile applications

www.aqmd.gov/aq-spec/special-projects/mobile-sensors

"Engage, Educate, and Empower California Communities on the Use and Applications of Low-Cost Air Monitoring Sensors"

- *Main Objective:* Provide communities across California with the knowledge necessary to appropriately select, use, and maintain "low-cost" sensors and to correctly interpret the collected data
- In 2015 the South Coast AQMD was awarded funding from the U.S. EPA under their "Science to Achieve Results" (STAR) Program ("Air Pollution Monitoring for Communities")
- Collaboration:

Project Outcomes

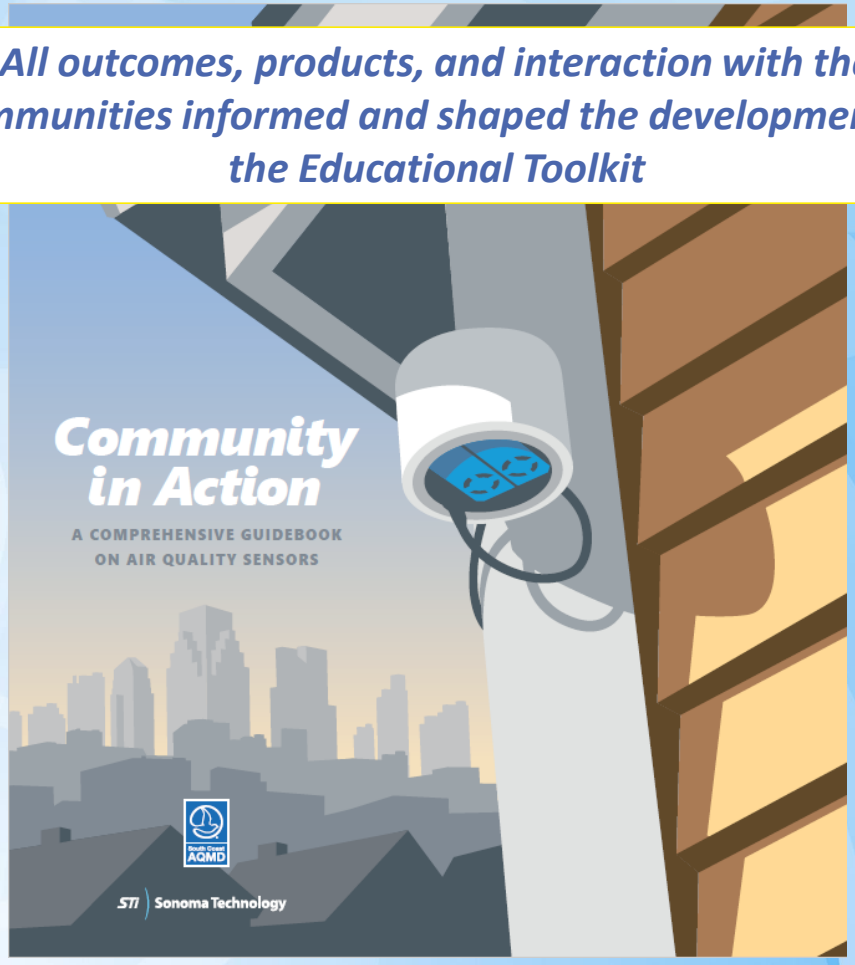


- **14** California communities
- **300** PurpleAir PA-II sensors
- **100** Aeroqual AQY sensors
- **3** years of data
- **33** community workshops
- **86** installation surveys
- **113** surveys collected
- **3** Reports for/by STAR Grant communities
- **7** peer-reviewed publications
- **1** Master's Thesis
- **2** Conference Training Workshops
- **16** Conference Presentations

Educational Toolkit

All outcomes, products, and interaction with the communities informed and shaped the development of the Educational Toolkit

- Guidebook on Air Quality Sensors
- Training videos (3)
- Installation guides
- Surveys and project forms
- Data analysis/visualization tools
- Infographic examples
- Community reports & analysis



- ✓Accessible to public
- ✓Visually engaging
- ✓One or more languages
- ✓Decision-making to reduce exposure
- ✓Data collection practices
- ✓Resources for additional info

Chapter 1, "Introduction"

Versatile Product

- Guidebook and other resources are designed to meet the needs of a broad range of users and projects
- For example, users could include:
  - An academic researcher new to community-based work
  - A community leader new to air quality and concerned about local sources
  - Staff from a government agency experienced in working with the public, but new to sensors
  - An individual interested in using sensors to better understand their own air quality

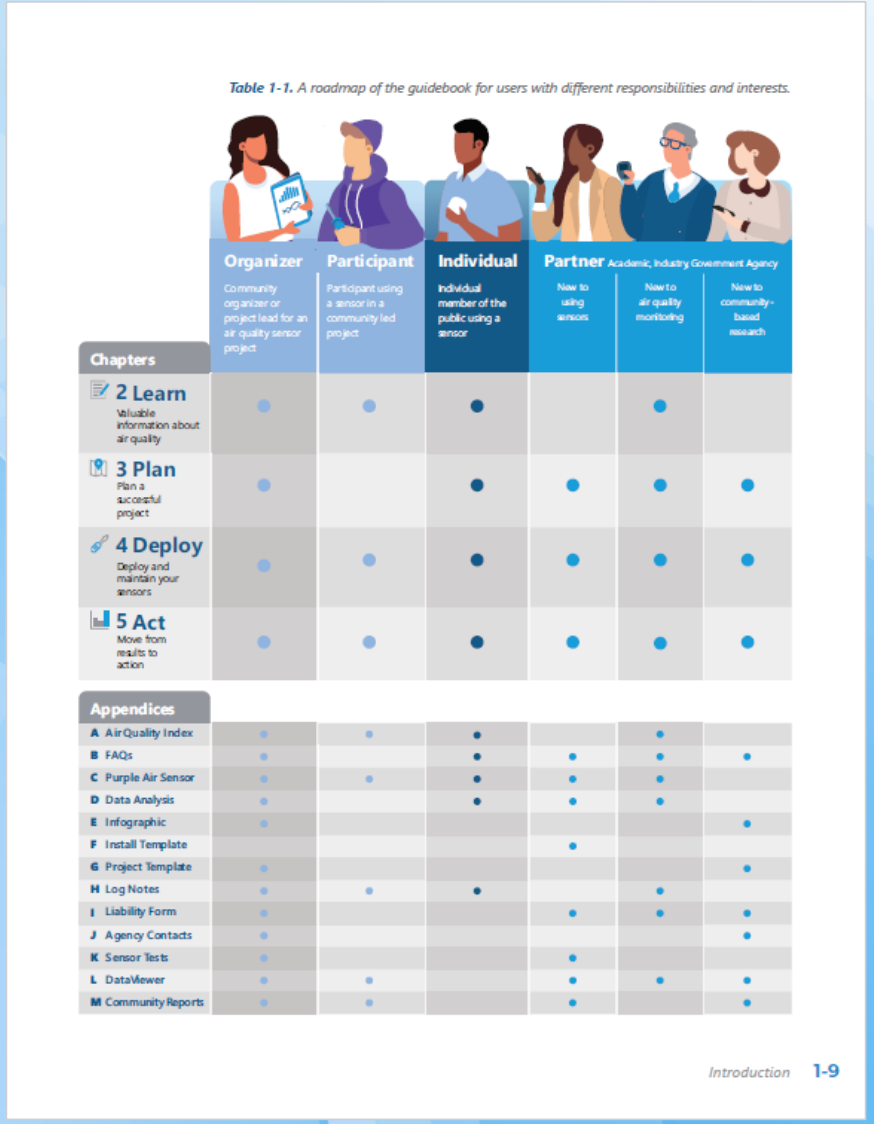
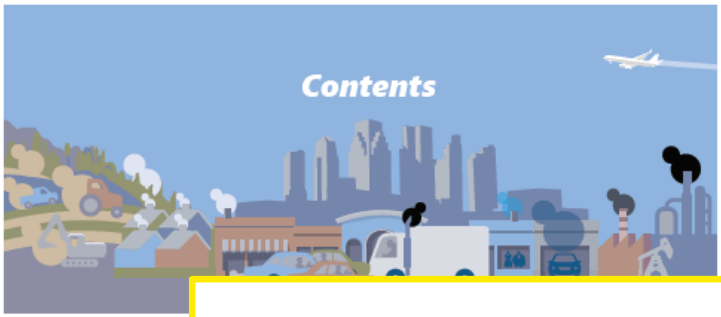
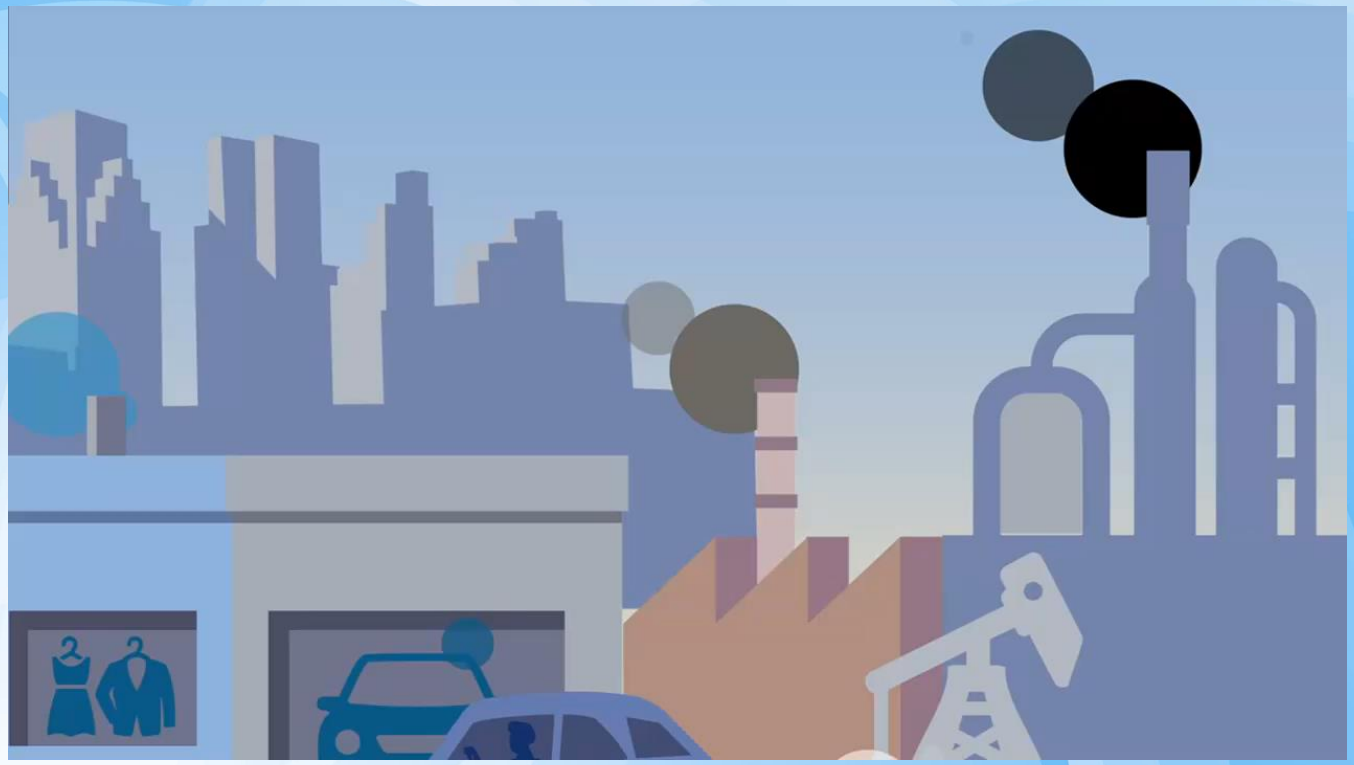


Table 1-1. A roadmap of the guidebook for users with different responsibilities and interests.

	Organizer Community organizer or project lead for an air quality sensor project	Participant Participant using a sensor in a community led project	Individual Individual member of the public using a sensor	Partner Academic, Industry, Government Agency New to using sensors	 New to air quality monitoring	 New to community-based research
Chapters						
2 Learn Valuable information about air quality	●	●	●		●	
3 Plan Plan a successful project	●		●	●	●	●
4 Deploy Deploy and maintain your sensors	●	●	●	●	●	●
5 Act Move from results to action	●	●	●	●	●	●
Appendices						
A Air Quality Index	●	●	●		●	
B FAQs	●		●	●	●	●
C Purple Air Sensor	●	●	●	●	●	
D Data Analysis	●		●	●	●	
E Infographic	●					●
F Install Template				●		
G Project Template	●					●
H Log Notes	●	●	●		●	
I Liability Form	●			●	●	●
J Agency Contacts	●					●
K Sensor Tests	●			●		
L DataViewer	●	●		●	●	●
M Community Reports	●	●		●		●



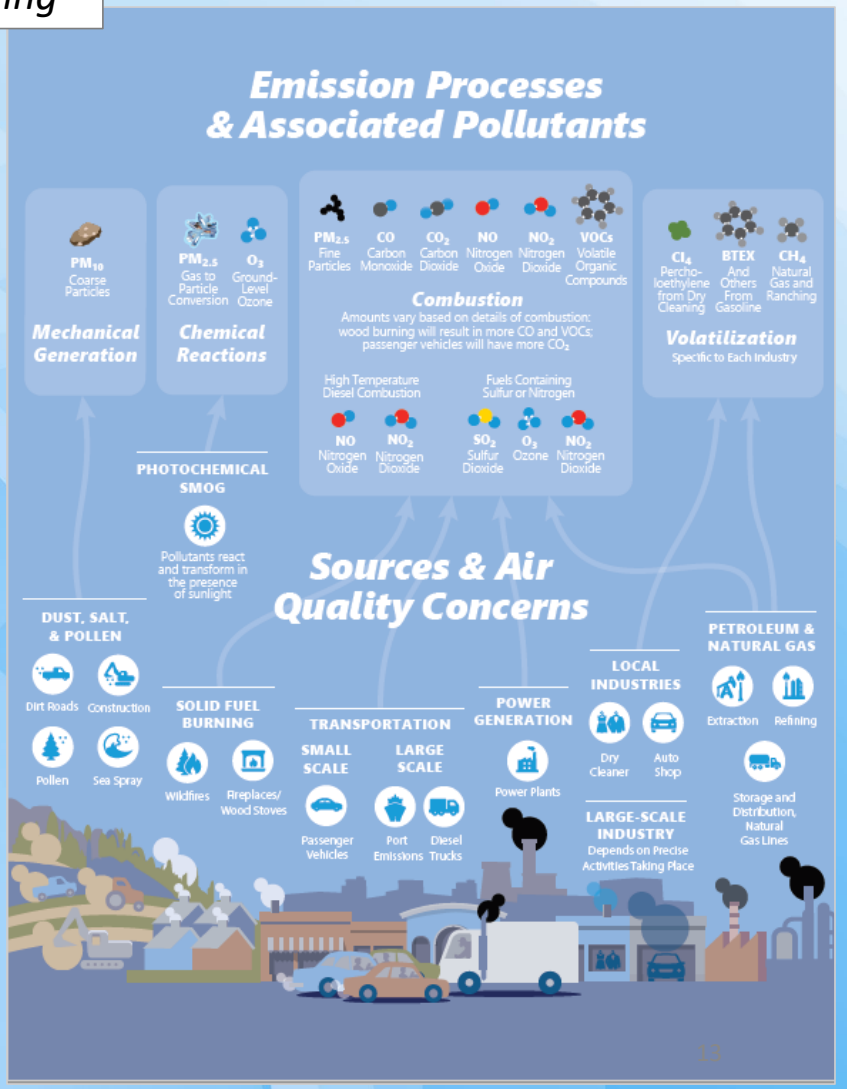
Understanding Air Quality and Monitoring:

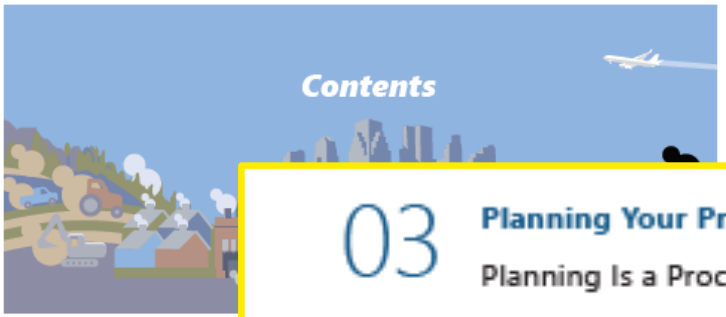


Chapter 2, "Understanding Air Quality and Monitoring"

Table 2-2. Summary of characteristics of fine and coarse particulate matter (adapted from Seinfeld and Pandis, 1998).[11]

	$PM_{2.5}$ Fine Particles	PM_{10} Coarse Particles
Chemical Process *How the particles are formed*	Reaction, nucleation, condensation, coagulation, cloud/fog processing	Suspension of dust or sea salt, mechanical process
Sources *Where the particles come from*	Coal Combustion, Gasoline Combustion, Diesel Combustion, Wood Combustion, Motor Vehicles, Industry, Fires, Gas to Particle Conversion	Industrial Dust, Farming Dust, Mining Dust, Unpaved Roads, Biological Sources, Construction/ Demolition, Ocean Spray, Road Salt
Composition *What the particles are made of*	Sulfates and Nitrates, Elemental Carbon, Other Organics, Water, Metals	Crustal Elements, Salt, Pollen, Mold, Plant and Animal Debris
Formation *When the particles are formed*	Primary (directly emitted) and Secondary (formed in the atmosphere)	Primary (directly emitted)
Atmospheric Lifetime *How long the particles stay in the air*	Days to Weeks	Minutes to Days
Travel Distance *How far the particles travel*	100 to 1000+ km (about 60 to over 600 miles)	Generally < 100 km (< about 60 miles)



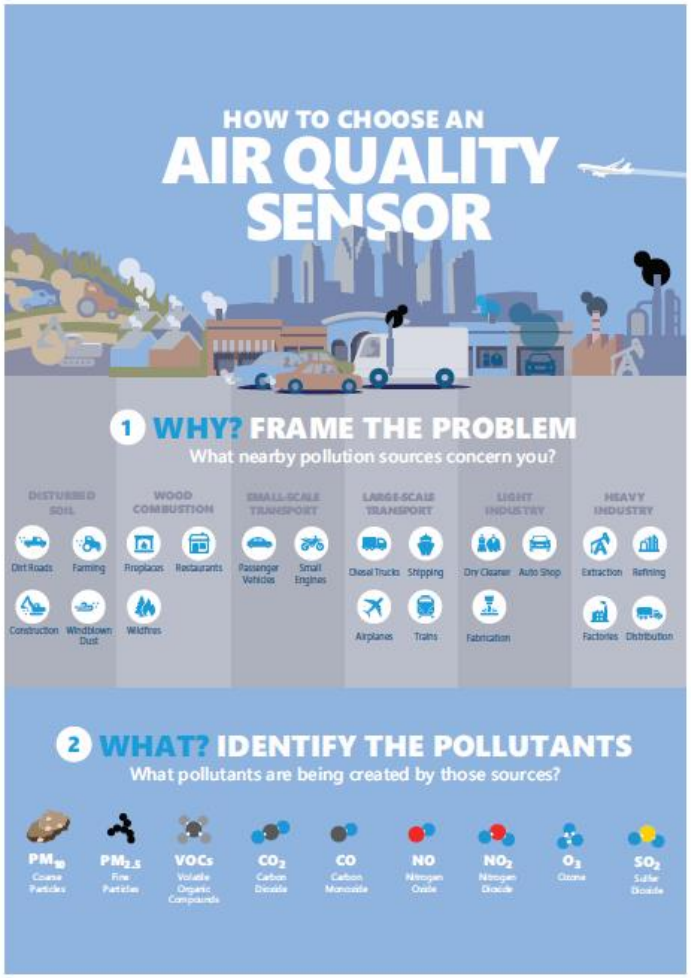


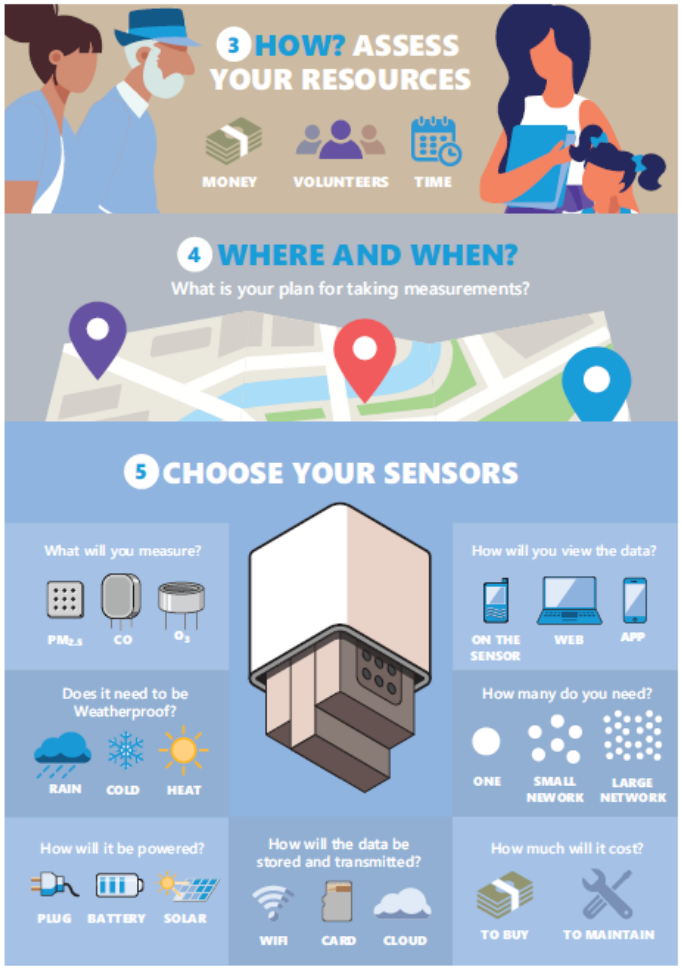
and Resources

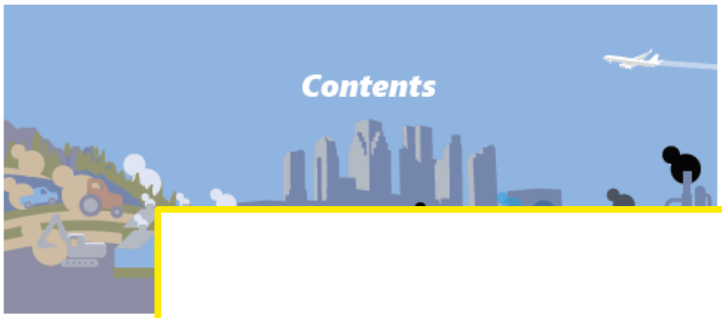
Thorough Planning Guidance

Figure 3-1. *Project planning is a process that may need to be repeated to adjust for realities such as budget limitations.*

Chapter 3, "How to Select a Sensor System"







04 Deploying Your Sensors 4-1

Using and Troubleshooting Sensors 4-2

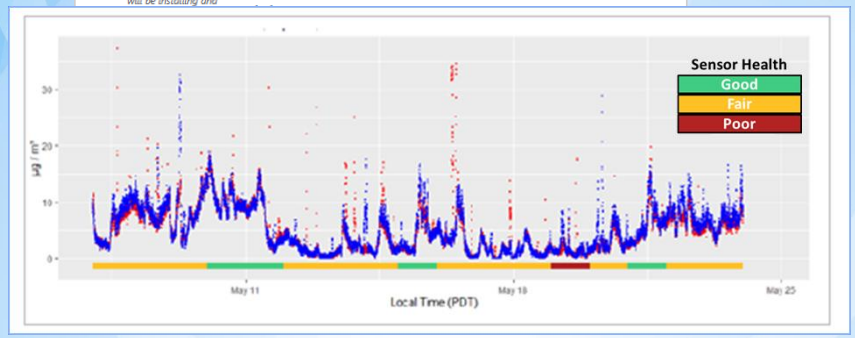
Collecting Useful Data 4-5

Understanding Your Data 4-12

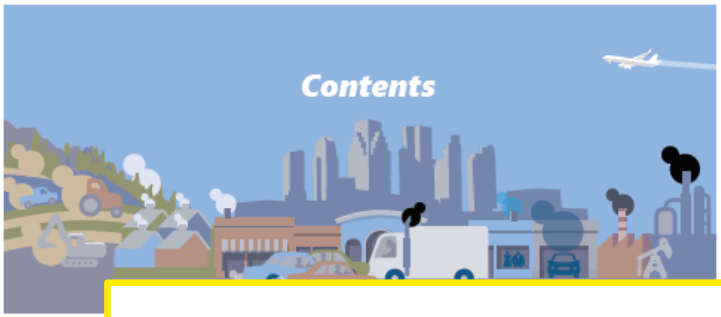
Maintaining Momentum on a Project 4-26

References 4-29

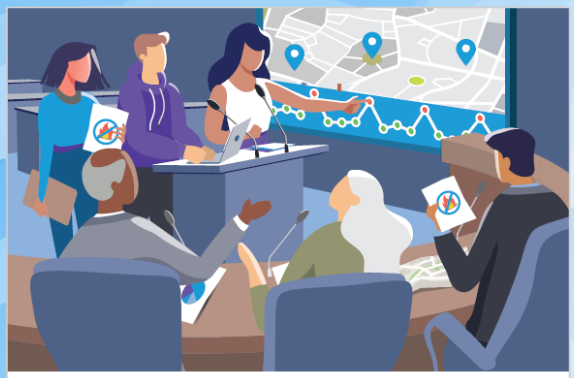
Chapter 4, "Deploying Your Sensors"



- Practical advice for siting, installing, and maintaining sensors
- Sensor co-location, correction, and calibration
- Introduction to different plot types, assessing accuracy, and useful quality control (QC) metrics/algorithms
- Ways to monitor the "State-of-Health" of deployed sensors
- Description of tools and resources available for data analysis
- Step-by-step example analysis of an air quality event (using the AirSensor DataViewer)



Chapter 5, "Taking Action"



05 Taking Action

Now that you have data, what do you do with the results? Options include taking action locally

(Above) Create an anti-idling program to protect students from harmful vehicle emissions near schools.

(Left) Work with your local air quality agency to develop a no-burning policy for days with poor air quality.

Create a community awareness program that will help reduce emissions.

a flag that corresponds to the AQI: green, yellow, orange, red, and purple. EPA offers guidance on school flag programs.[15]

Other Mitigation Strategies

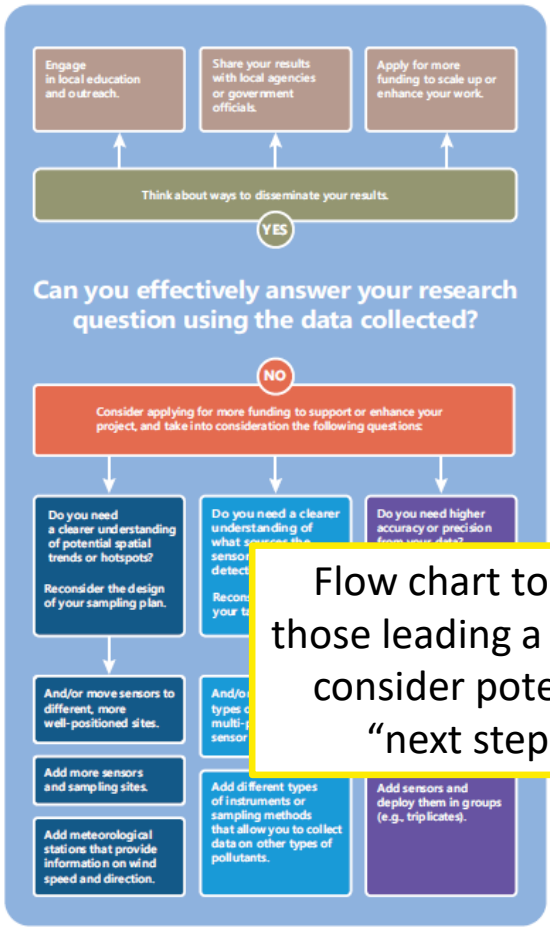


Figure 5-1. Use this decision tree to determine whether more measurements are needed to meet project objectives.

Taking Action 5-9

- Ideas for and examples of "local action"
- Advice to help determine whether additional data should be collected
- Strategies for communicating with local government agencies and/or the broader community (e.g., sharing results)

Flow chart to help those leading a project consider potential "next steps"

http://www.aqmd.gov/aq-spec/special-projects/star-grant

Conclusions & Future Work

- Next Steps -> ***Dissemination***
  - Disseminate to communities and via conferences
  - Publish products on the AQ-SPEC website

- Future Work -> ***Sustainability***
  - Share with STAR Grant communities to help sustain and strengthen these partnerships
  - Conduct outreach to new communities and to support sensor projects locally and beyond

➢ ***Dissemination will bring more feedback and the opportunity to enhance and improve the Educational Toolkit***

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- Leisure World Club, Seal Beach, CA
- Sycamore Heights Community Action Group, Riverside, CA
- California Environmental Health Action Team, South Gate, CA
- Temescal Valley Community, CA
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