Community in Action

A COMPREHENSIVE GUIDEBOOK ON AIR QUALITY SENSORS

South Coast AQMD

STi Sonoma Technology

This document contains blank pages to facilitate two-sided printing.

Community in Action
A Comprehensive Guidebook on Air Quality Sensors
April 2021

Published by South Coast Air Quality Management District
21865 Copley Drive
Diamond Bar, CA 91765

Authors

South Coast AQMD
Andrea Polidori, Contact Principal Investigator
Vasileios Papapostolou, Project Lead
Ashley Collier-Oxandale, Project Coordinator

Sonoma Technology
Hilary Hafner, Principal Investigator
Timothy Blakey, Design Lead

Citation

Polidori A., Papapostolou V., Collier-Oxandale A., Hafner H., and Blakey T. (2021) Community in Action: A Comprehensive Guidebook on Air Quality Sensors. April.
Available on the South Coast AQMD's AQ-SPEC website:
http://www.aqmd.gov/aq-spec/special-projects/star-grant

Acknowledgments

The Authors (Dr. Andrea Polidori, Contact Principal Investigator; Dr. Vasileios Papapostolou, Project Lead; and, Dr. Ashley Collier-Oxandale, Project Coordinator) would like to thank the following Individuals, Agency partners, and Community Groups and Organizations for their valuable contributions to the project and the development of the Guidebook.

Collaborating Principal Investigators

- Dr. Philip Fine, Dr. Jason Low, Dr. Laki Tisopulos, South Coast AQMD, Diamond Bar, CA
- Hilary Hafner, Tim Blakey, Jennifer DeWinter, Bryant West, Lauren Tannenbaum, Jana Schwartz, Sonoma Technology, Petaluma, CA
- Dr. Yifang Zhu and students; Fielding School of Public Health, University of California, Los Angeles (UCLA)

Project Support

- AQ-SPEC staff (Berj Der Boghossian, Dr. Brandon Feenstra, Dr. Michelle Kuang, Randy Lam, Dr. Wilton Mui), South Coast AQMD

Internal and External Agency Partners

- Information Management, South Coast AQMD
- Bay Area AQMD
- San Luis Obispo County APCD
- Santa Barbara County APCD

Communities and Other Partners

- Asian Health Services, Oakland, CA
- Asian Pacific Environmental Network, Richmond, CA
- Comite Civico del Valle, Inc, Imperial County, CA
- Leisure World Club, Seal Beach, CA
- Mazama Science, Seattle, WA
- Pioneer Valley High School, Santa Maria, CA
- Roberts Environmental Center at Claremont McKenna College, Claremont, CA
- Special Service for Groups/Asian Pacific Islander Forward Movement, San Gabriel Valley, CA
- Sycamore Heights Community Action Group, Riverside, CA
- South Gate Community Environmental Health Assessment Team, Los Angeles, CA
- Temescal Valley, Riverside, CA
- University Village Apartments, UCLA, CA

Appendices

Appendix A. Air Quality Index – A Guide to Air Quality and Your Health	A-1
Appendix B. STAR Grant Community Meetings – Frequently Asked Questions	B-1
Appendix C. Information About the PurpleAir Sensor	C-1
Appendix D. Data Analysis Guide	D-1
Appendix E. Sample Infographic	E-1
Appendix F. Installation Guide Template (For Other Sensors)	F-1
Appendix G. Project One-Pager Template	G-1
Appendix H. Blank Log Notes Form	H-1
Appendix I. Release of Liability Sample	I-1
Appendix J. Local Regulatory Agency Contacts (Sample List)	J-1
Appendix K. Examples of Sensor Performance	K-1
Appendix L. User Guide for AirSensor DataViewer	L-1
Appendix M. Sample Community Reports and Resources	M-1

Appendix A. Air Quality Index – A Guide to Air Quality and your Health

Introduction

The Air Quality Index (AQI) is an index for reporting daily air quality. It tells you how clean or polluted your air is and what associated health effects might be a concern for you. The AQI focuses on health effects one may experience within a few hours or days after breathing polluted air. The U.S. Environmental Protection Agency (EPA) calculates the AQI for five major air pollutants (also known as criteria pollutants) regulated by the Clean Air Act:

1. Ground-level Ozone (O_3)
2. Particle Pollution, also known as particulate matter (PM_{10} and $PM_{2.5}$)
3. Carbon Monoxide (CO)
4. Sulfur Dioxide (SO_2)
5. Nitrogen Dioxide (NO_2)

For each of these pollutants, the EPA has established national ambient air quality standards (NAAQS) to protect public health. Ground-level ozone and airborne particles are the two criteria pollutants that pose the greatest threat to human health in this country.

As an area with severe challenges to meet federal Clean Air Act standards by their mandated deadlines, the State of California has established standards that are more stringent than federal standards for certain pollutants, including O_3 and NO_2.

How Does AQI Work?

Think of the AQI as a yardstick that runs from 0 to 500 m. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little potential to affect public health, while an AQI value over 300 represents hazardous air quality. An AQI value of 100 generally corresponds to the NAAQS for the pollutant, which is the level EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values reach above 100, air quality is considered to be unhealthy for certain sensitive groups of people. As the AQI values climb above 100, increasingly more people may become susceptible to the effects of the unhealthy air.

Understanding the AQI Range

The purpose of the AQI is to clarify what local air quality means to your health. To make it easier to understand, the AQI is divided into six categories. Each category corresponds to a different level of health concern. There are six levels of health concern.

Good: The AQI value for your community is between 0 and 50. Air quality is considered satisfactory and air pollution poses little or no health risks.

Moderate: The AQI for your community is between 51 and 100. Air quality is acceptable; however, for some pollutants, there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.

Unhealthy for Sensitive Groups: When AQI values are between 101 and 150, members of sensitive groups may experience health effects. This means they are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.

Unhealthy: Everyone may begin to experience health effects when AQI values are between 151 and 200. Members of sensitive groups may experience more serious health effects.

Very Unhealthy: Values between 201 and 300 trigger a health alert, meaning everyone may experience serious health effects.

Hazardous: Values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

Understanding the AQI Color Code

The EPA has assigned a specific color to each AQI category to make it easier for people to quickly understand if air pollution is reaching unhealthy levels in their communities.

Air Quality Index	
Numerical Value	Level of Health Concern
0 - 50	Good
51 - 100	Moderate
101 - 150	Unhealthy for Sensitive Groups
151 - 200	Unhealthy
201 - 300	Very Unhealthy
> 300	Hazardous

Criteria Pollutants Explained

Carbon Monoxide (CO) is a colorless, odorless gas that is formed when carbon in fuel is not burned completely. Sources include motor vehicle exhaust, industrial processes such as metals processing and chemical manufacturing, residential wood burning, and natural sources such as forest fires.

Nitrogen Oxides (NO_x) is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the oxides of nitrogen are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO_2), along with particles in the air, can often be seen as a reddish-brown layer over many urban areas.

Ozone (O_3) is a gas created by a chemical reaction between oxides of nitrogen and volatile organic compounds (VOCs) in the presence of sunlight. Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents, as well as natural sources, emit NO_x and VOCs that help form ozone. Ground-level ozone is the primary constituent of smog.

Sulfur Dioxide (SO_2) belongs to the family of sulfur oxide gases (SO_x). SO_x gases are formed when fuel containing sulfur, such as coal and oil, is burned, when gasoline is extracted from oil, or when metals are extracted from ore. SO_2 dissolves in water vapor to form acid and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and their environments.

Particulate Matter 10 (PM_{10}) or "inhalable coarse particles" or "particle pollution" are smaller than 10 micrometers in diameter and typically found near roadways and dusty industries. PM_{10} is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

Particulate Matter 2.5 ($PM_{2.5}$) or "fine particles" are 2.5 micrometers in diameter and smaller. Often found in smoke and haze, these particles can be directly emitted from sources such as forest fires or can form when gases emitted from power plants, industries, and automobiles react in the air. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

Mapping of Current Air Quality Data

Many air quality management districts in the US provide air quality forecasts for their areas (see https://www.airnow.gov/). In the South Coast Air Quality Management District (South Coast AQMD), air quality forecasts are prepared for nearly 40 source/receptor areas, or forecast areas. These forecast areas are displayed on the current air quality map (see link on http://www.aqmd.gov/home/air-quality/air-quality-forecasts). Most of these areas have one or more air monitoring stations that measure air pollutants and meteorological data. The real-time measurement of five criteria pollutants factor into the current AQI reading. This monitoring equipment is distributed among the permanent air monitoring stations, as follows:

- 30 stations measure O_3

- 26 stations measure CO
- 25 stations measure NO_2
- 11 stations measure PM_{10}
- 9 stations measure $PM_{2.5}$

The sites selected for the equipment are chosen based on how well the locations represent local air quality, local emission sources and transport issues, the relative severity of the problem from the predominant pollutant in the area, and financial factors such as the cost of equipment, maintenance, and support staff. For areas where a particular criteria pollutant is not monitored, the closest station or a combination of surrounding stations are mapped to that area. These substitute stations are known as proxy stations. The use of proxies allows the closest available monitoring data to be applied to forecast areas that otherwise do not have monitoring equipment for a specific criteria pollutant.

The South Coast AQMD also offers a mobile phone app that provides access to real-time air quality information and forecasts. This app can be used to find out air quality conditions for your current location, and the information is presented using the AQI scale described above. The flyer below provides more information about the mobile app and where to download it in both English and Spanish.

California State and National Ambient Air Quality Standards (NAAQS)

Air quality standards define the amount of a pollutant (averaged over a specified time period) that can be present in outdoor air without harmful effects on people or the environment. National ambient air quality standards apply to all states. Many states have also set their own air quality standards and in some cases, such as California, some state standards may be more stringent than national standards. There are two types of air quality standards, primary and secondary. ***Primary standards*** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. ***Secondary standards*** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings (Source: EPA). The table below summarizes California and Federal standards for criteria pollutants.

Pollutant	Primary/Secondary	Averaging Period	CA State Standard (2016)	Federal Standard (Year)
CO	Primary	1-Hour	20 ppm	35 ppm (2011)
		8-Hour	9 ppm	9 ppm (2011
O_3	Primary & Secondary	1-Hour	0.090 ppm	—
	Primary & Secondary	8-Hour	0.070 ppm	0.070 ppm (2015)
NO_2	Primary	1-Hour	0.180 ppm	0.100 ppm (2010)
	Primary & Secondary	1-Year	0.030 ppm	0.053 ppm (2012)
SO_2	Primary	1-Hour	0.25 ppm	0.075 ppm (2010)
	Secondary	3-Hour	—	0.500 ppm (2012)
PM_{10}	Primary & Secondary	24-Hour	50 µg/m^3	150 µg/m^3 (2012)
$PM_{2.5}$	Primary & Secondary	24-Hour	—	35 µg/m^3 (2012)
	Primary	1-Year	12 µg/m^3	12 µg/m^3 (2012)
	Secondary	1-Year	—	15 µg/m^3 (2012)

Calculating AQI Using the NowCast Method

The NowCast method is a way of approximating the AQI information to any given hour in a day, resulting in more "real-time" information about air quality. The form of the standard for ozone is an 8-hr average and a 24-hr standard for $PM_{2.5}$. NowCast produces AQI information that is likely to be more reflective of current conditions occurring for the hour the user is curious about.

Essentially, the calculations involve calculating a weight factor, based on the range of the data, then summing each hourly concentration multiplied by the weight factor, which is raised to the power of how many hours ago the concentration was measured. This sum is then divided by the summed weight factors also raised to the power of when the concentration was last measured.

Step 1: calculate the weight factor as one minus the concentration range divided by the maximum concentration (note, if the weight factor is less than 0.5, then use 0.5)

$$weight\ factor = \ 1 - ((concentration\ range)/(maximum\ concentration))$$

Step 2: sum each concentration multiplied by the weight factor raised to the power of how many hours ago it was measured (i.e., the data from the current hour will be raised to a power of 0) and divide this sum by the weight factors summed and also raised to the number of hours ago the corresponding value was measured. In the example equation, c1 – indicates the most recent concentration measured, c2 – indicates the second most recent hourly concentration measured, etc.

$$NowCast\ Value = \frac{c1 * wf^0 + cf2 * wf^1 + cf3 * wf^2 + cf4 * wf^3 + cf5 * wf^4 + \cdots}{wf^0 + wf^1 + wf^2 + wf^3 + wf^4 + \cdots}$$

As an example, below is the calculation with some sample data:

Sample O_3 data (in ppb):

Time	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00
O_3 (ppb)	55	70	80	75	65	60	50	45

Weight factor = 1- (80-45)/80 = 0.5625

NowCast average =
$(55*0.5625^7+70*0.5625^6+80*0.5625^5+75*0.5625^4+65*0.5625^3+60*0.5625^2+50*0.5625^1+45*0.5625^0)/$
$(0.5625^7+0.5625^6+0.5625^5+0.5625^4+0.5625^3+0.5625^2+0.5625^1+0.5625^0)$ = 52.54 ppb

Appendix B. STAR Grant Community Meetings – Frequently Asked Questions

About the Project

Q: What is my role in this project?
A: Community Scientist. As a Community Scientist you will host a sensor, track sensor performance, view sensor data, and provide feedback on the sensor, the sensor's usefulness, and the data application. This feedback will enhance the development of the sensor educational toolkit.

Q: What do I have to do?
A: Active participation in the project includes hosting a sensor, tracking its performance, recording interesting data and associated observations, and participating in the community meetings.

Q: How much time will I invest into this project?
A: The project is centered on a 12 to 15 month sensor deployment period. Within this time frame, three to four meetings/workshops will be scheduled that last a couple of hours. Throughout the deployment period, the level of active participation and time spent with recording log notes and tracking sensor performance and data is entirely up to you.

Q: Is this project a first for you. or are you experienced with this?
A: The EPA Science To Achieve Results (STAR) program has traditionally involved only research groups in academic institutions. For the first time, such a grant was awarded to a government agency (i.e., South Coast AQMD) along with another five research groups in academic institutions (i.e., MIT, Carnegie Mellon, Kansas State University, University of Washington, DRI-RTI).

Q: Where else are you doing this?
A: Several communities in the State of California from North to South.

Q: What actions were taken since the earlier studies?
A: This is an educational – Community science – exercise with the ultimate product being the development of a sensor educational toolkit consisting of a sensor guidebook, training videos, and data collection checklists.

Q: What is the benefit of community member involvement?
A: The benefit would be the participation in a Community science project to gain experience operating a low-cost sensor as well as collecting and understanding sensor data.

Q: Do we have to be part of the study to get a sensor or do we have to purchase them?
A: The sensor is provided by South Coast AQMD free of cost to those who are willing to engage in the project.

Q: How long will we have the sensors for?
A: The sensor is yours to keep indefinitely, starting from the beginning of the deployment.

Q: What if I cannot commit to the full 12-15 month timeframe for this project?
A: In the case that a sensor host can no longer participate in the project, the community group is encouraged to find a close neighbor to host the sensor and actively participate in the outreach activities.

Q: Do I install the sensors myself? Will I be supervised?
A: Sensors will be installed by the participants. During a technical workshop on the sensor, installation guides will be provided to aid in the proper deployment of each sensor.

Q: Is the sensor data for my own personal information?
A: The sensor data will be publicly accessible via an online website.

Q: Are the results going to help us with respect to policy making?
A: Results may lead to action/policy-making/rule-making moving forward; however, this is outside the scope and objectives of the STAR research grant.

Q: Once the official deployment of 12 to 15 months is completed, what happens if the sensor breaks down and I would still like to measure air quality at my home?
A: If the sensor host would like to continue collecting data and providing feedback to the STAR Grant program, please contact the AQ-SPEC program at South Coast AQMD [e-mail: info.aq-spec@aqmd.gov or tel: +1 (909) 396 – 2173], and the sensor may be replaced at no cost.

Q: Should I be more concerned about gas-phase pollutants than particulate matter?
A: Both gas-phase and particulate matter are criteria air pollutants and regulated by the National Ambient Air Quality Standards (NAAQS). The selection on what pollutants to measure depends on community needs, currently available sensor technology, and application-specific requirements and limitations.

Q: Will the toolkit include the next steps and future actions?
A: Yes, there will be a section on "Taking Action" that will include information and guidelines on communicating results effectively with regards to developing mitigation strategies, planning outreach activities, and assessing resources for mitigation strategies.

About Sensors

Q: What is the lifespan of a sensor?
A: Sensor lifespans vary depending on the manufacturer. For example, PurpleAir claims that the PA-II sensor lifetime is 40,000 hours (or about 4.5 years).

Q: Can the sensors malfunction or be damaged?
A: High drops or strong impacts can possibly damage the raw sensors or loosen internal wiring, causing the sensor to power off. Heavy particle loading, floating plant debris, or insects that enter the unit's internal measurement chamber can cause sensor malfunction.

Q: What happens to a sensor in very high heat?
A: Prior to deployment, sensors are challenged at temperatures as high as 105-110°F. They have showed no indication of failure or malfunctioning.

Q: Can the sensor be installed in direct sunlight?
A: Manufactures recommend avoiding direct sunlight and mounting the unit on the shady side of your home.

Q: Will close-proximity to light sources affect my measurements?
A: No, the raw sensors inside units are designed to operate regardless of external light sources.

Q: Are there any extra precautions we should take if plugging sensors into outdoor power outlets?
A: Install a weatherproof, in-use outdoor receptacle cover to ensure a safe, waterproof seal around the electrical outlet and power cord.

Q: What are the health risks involved with hosting a sensor at my home?
A: Sensors are safe and do not pose any health risks.

Q: Are there any calibrations required with sensors?
A: Sensor calibration requirements vary depending on the manufacturer. For example, no calibrations are required for the PurpleAir sensors.

Q: What is an ideal height to install a sensor?
A: An ideal height to install a sensor would be between about 6 feet (1.80 meters) up to a rooftop edge.

Q: Are there privacy concerns with a sensor connected to my Wi-Fi?
A: No, the Wi-Fi system and associated data-cloud services are secure.

Q: How are the data collected?
A: Sensor data are uploaded via Wi-Fi to a cloud server, and users can download the data from a dedicated website.

Other Sensor Information

Q: What is sensor response time?
A: Response time refers to how quickly the sensor measures the pollutant in the air. Quick response time (on the order of seconds) is needed for mobile monitoring or to see rapid changes in pollutant concentrations. Slower response (such as 10 minutes to 1-hr) may be useful for stationary (non-moving) monitoring.

Q: What is meant by sensor interferences?
A: Some sensors may be affected by pollutants other than the one you are monitoring for or by sampling conditions (temperature, humidity, dust, etc. See Zheng et al., 2018, Jayaratne et al., 2018). Interference would cause the pollutant of interest to have a higher (or lower) concentration than the true values, or the sensor could be rendered useless because of excessive noise in the sensor output. In other words, the true signal could be obscured by wild fluctuations in the readings. Some sensor manufacturers will disclose pollutants and weather conditions that may impact their sensor performance. In that case, it is best to minimize those interferences if possible. A way to correct for these interferences is to measure them as well, for example, by using a multi-sensor platform. Having these signals for multiple sensors can facilitate the development and implementation of correction algorithms.

Q: What is the difference between the types of particulate matter?
A: The range of particle sizes from emissions sources is several orders of magnitude (0.05 to >100 micrometers). Particulate matter (PM) measurements are classified by three size fractions, $PM_{1.0}$, $PM_{2.5}$, and PM_{10}:

- $PM_{1.0}$: Particles 1 micrometer (1×10^{-6} meters) in aerodynamic diameter or smaller; classified as fine particles
- $PM_{2.5}$: Particles 2.5 micrometers (2.5×10^{-6} meters) in aerodynamic diameter or smaller; classified as fine particles
- PM_{10} : Particles 10 micrometers (10×10^{-6} meters) in aerodynamic diameter or smaller; classified as a mix of coarse and fine particles

The particle size range detectable by low-cost sensors using optical particle counter (OPC) technology covers a relatively small portion of this size range and thus will not detect emission from some important sources.

For gas-phase sensors, interferents are more complicated as they can vary based on the sensor type; see the following table for a few known interferents.

Table B-1. Gas-phase sensors and interferents.

Type of Sensor	Interferents	Reference(s)
Electrochemical and metal oxide semi-conductor sensors (common gas-phase sensors)	Changes in temperature and humidity can affect the sensitivity of the sensor	Wang et al., 2010 Mead et al.., 2013 Masson et al., 2015
Electrochemical O_3 sensors	Can respond to NO_2	Lewis et al. 2016 Spinelle et al., 2015 Afshar-Mohajer et al., 2018
Metal oxide O_3 sensors	Do not appear to demonstrate a cross-sensitivity to NO_2	Collier-Oxandale et al., 2020
Electrochemical NO sensors	Observed to respond to NO_2 in addition to NO	Lewis et al. 2016
Electrochemical NO_2 sensors	Seen to respond to both NO and O3, in addition to NO_2	Bigi et al., 2018 Spinelle et al., 2015
Electrochemical SO_2 sensors	May respond to NO_2	Lewis et al., 2016
Metal oxide volatile organic compound (VOC) sensors	These exhibit varying levels of responsiveness to a wide variety of VOCs as well as other confounding gases (e.g., some are cross-sensitive to CO)	Spinelle et al., 2017 Mirzaei et al., 2016 Collier-Oxandale et al., 2019 Spinelle et al., 2017
Photoionization detector (PID)	Lacks sensitivity for individual VOCs Detection limits may be too high for ambient use	Williams et al., 2015 Spinelle et al, 2017 Spinelle et al., 2017

References

Kelly, K.E., Whitaker, J., Petty, A., Widmer, C., Dybwad, A., Sleeth, D., Martin, R. and Butterfield, A., 2017. Ambient and laboratory evaluation of a low-cost particulate matter sensor. *Environmental pollution*, *221*, pp.491-500.

Wang, C., Yin, L., Zhang, L., Xiang, D. and Gao, R., 2010. Metal oxide gas sensors: sensitivity and influencing factors. *sensors*, *10*(3), pp.2088-2106.

Mead, M.I., Popoola, O.A.M., Stewart, G.B., Landshoff, P., Calleja, M., Hayes, M., Baldovi, J.J., McLeod, M.W., Hodgson, T.F., Dicks, J. and Lewis, A., 2013. The use of electrochemical sensors for monitoring urban air quality in low-cost, high-density networks. *Atmospheric Environment*, *70*, pp.186-203.

Masson, N., Piedrahita, R. and Hannigan, M., 2015. Quantification method for electrolytic sensors in long-term monitoring of ambient air quality. *Sensors*, *15*(10), pp.27283-27302.

Lewis, A.C., Lee, J.D., Edwards, P.M., Shaw, M.D., Evans, M.J., Moller, S.J., Smith, K.R., Buckley, J.W., Ellis, M., Gillot, S.R. and White, A., 2016. Evaluating the performance of low cost chemical sensors for air pollution research. *Faraday discussions*, *189*, pp.85-103.

Spinelle, L., Gerboles, M. and Aleixandre, M., 2015. Performance evaluation of amperometric sensors for the monitoring of O3 and NO2 in ambient air at ppb level. *Procedia engineering*, *120*, pp.480-483.

Afshar-Mohajer, N., Zuidema, C., Sousan, S., Hallett, L., Tatum, M., Rule, A.M., Thomas, G., Peters, T.M. and Koehler, K., 2018. Evaluation of low-cost electro-chemical sensors for environmental monitoring of ozone, nitrogen dioxide, and carbon monoxide. *Journal of occupational and environmental hygiene*, *15*(2), pp.87-98.

Collier-Oxandale, A., Feenstra, B., Papapostolou, V., Zhang, H., Kuang, M., Der Boghossian, B. and Polidori, A., 2020. Field and laboratory performance evaluations of 28 gas-phase air quality sensors by the AQ-SPEC program. *Atmospheric Environment*, *220*, p.117092.

Bigi, A., Mueller, M., Grange, S.K., Ghermandi, G. and Hueglin, C., 2018. Performance of NO, NO 2 low cost sensors and three calibration approaches within a real world application. *Atmospheric Measurement Techniques*, *11*(6), pp.3717-3735.

Spinelle, L., Gerboles, M., Kok, G., Persijn, S. and Sauerwald, T., 2017. Performance evaluation of low-cost BTEX sensors and devices within the EURAMET key-VOCs project. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 1, No. 4, p. 425).

Spinelle, L., Gerboles, M., Kok, G., Persijn, S. and Sauerwald, T., 2017. Review of portable and low-cost sensors for the ambient air monitoring of benzene and other volatile organic compounds. *Sensors*, *17*(7), p.1520.

Mirzaei, A., Leonardi, S.G. and Neri, G., 2016. Detection of hazardous volatile organic compounds (VOCs) by metal oxide nanostructures-based gas sensors: A review. *Ceramics international*, *42*(14), pp.15119-15141.

Collier-Oxandale, A.M., Thorson, J., Halliday, H., Milford, J. and Hannigan, M., 2019. Understanding the ability of low-cost MOx sensors to quantify ambient VOCs. *Atmospheric Measurement Techniques*, *12*(3), pp.1441-1460.

Williams, R., Kaufman, A. and Garvey, S., 2015. Next generation air monitoring (NGAM) VOC sensor evaluation report. *EPA: Washington, DC, USA*.

Appendix C. Information About the PurpleAir Sensor

Rationale for Selecting the PurpleAir Sensor and Associated Resources Developed for the STAR Grant Project

PurpleAir sensors were selected for use in the STAR grant project. South Coast AQMD selected this low-cost sensor because it fulfilled the project's needs for open and accessible data, relative ease of deployment/installation, cost (especially given the number of participating communities), and sensor performance as compared to other sensors available at the time (2016-2017).

We note that the use of PurpleAir sensors for activities associated with this grant does not constitute an endorsement.

Contents of this Appendix

This appendix provides

- PurpleAir sensor installation guide – English (pg. C-2) and Spanish (pg. C-8) versions
- PurpleAir PA-II Sensor Data Download and Processing Guide (pg. C-10)
- Frequently Asked Questions About the PurpleAir PA-II Sensor (pg. C-20)

Please note that the links provided in this appendix are not clickable.

PurpleAir PA-II Sensor Installation Guide - English Version

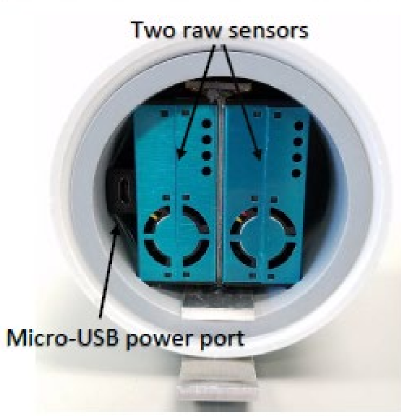
Measuring AIR QUALITY in Your Community

The South Coast AQMD, in collaboration with Sonoma Technology and the UCLA Fielding School of Public Health, will be forming partnerships with local communities to engage, educate, and empower California communities on the use and applications of "low-cost" air monitoring sensors.

Technology for Measuring Particulate Matter (PM)

PurpleAir PA-II Dual Laser Air Quality Sensor

1. PurpleAir PA-II Dual Laser Sensor
2. Outdoor-rated Power Supply
3. 17 Feet of Cable



- Dual PM sensors
- Measures $PM_{1.0}$, $PM_{2.5}$, and PM_{10} along with Temperature, Relative Humidity, and Pressure
- Host Requirements:
  1. Available power outlet
  2. Available Wi-Fi to log data to PurpleAir map
- Easy to install with a single screw or zip ties
- Wi-Fi data logging with open data access at www.purpleair.com/map

PurpleAir PA-II Air Quality Sensor Quick Start Guide

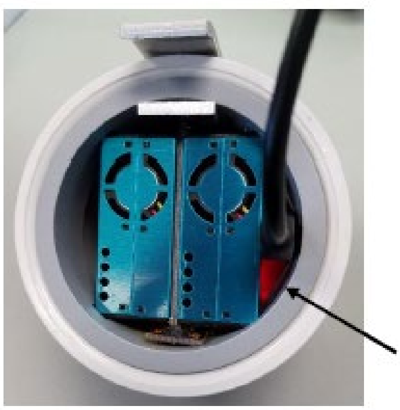
(Note: helpful information is available on page 6 of this guide)

STEP 1 — Finding a Location and Installation

1. Before mounting your sensor, take a photo of the label (you will need the Device-ID and Location Name, see Step 3)
2. Look for a shady place, usually a north-facing part of the house, away from tall trees.
   Note: Location will need a nearby power outlet and Wi-Fi signal.
3. Mount sensor away from local sources of pollution (A/C units, vents, BBQs).
4. Mount the sensor using either cable ties (railing) or a screw (beneath the roof edge).
   Note: The power supply should be mounted so it will not be submersed in water and ensure that the cord is secured safely to avoid a tripping hazard.
5. Take a photo of the installed sensor and area around the sensor (it may help with data analysis later on)

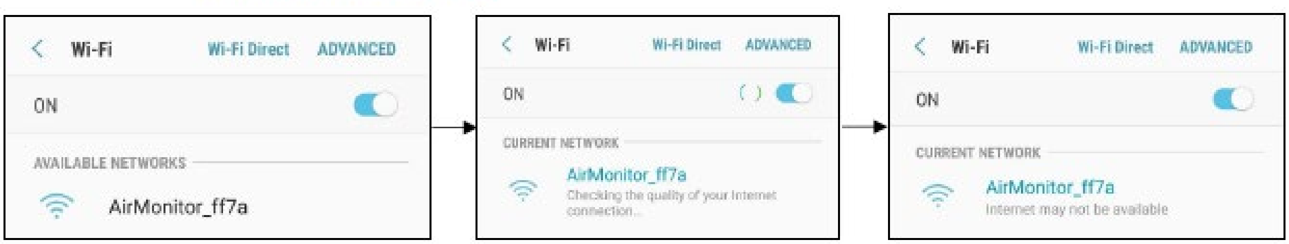
STEP 2 — Configuring the Wi-Fi

1. Ensure that the sensor is connected to power. When powered, you will see a red LED on inside the sensor.



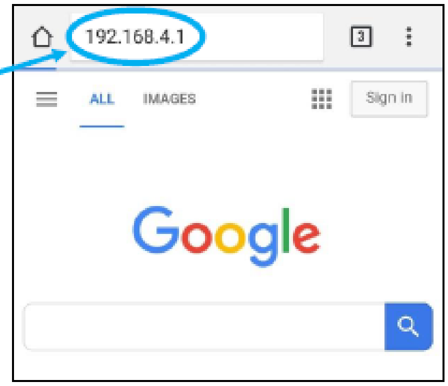
A red LED will be on when the sensor is powered.

2. Using a Wi-Fi-enabled device (cell phone, tablet, or laptop), connect to the Wi-Fi network called "AirMonitor_xxxx" where xxxx is specific to the sensor. Your device may display an error like "Internet may not be available." This is normal and you can proceed to the next step.

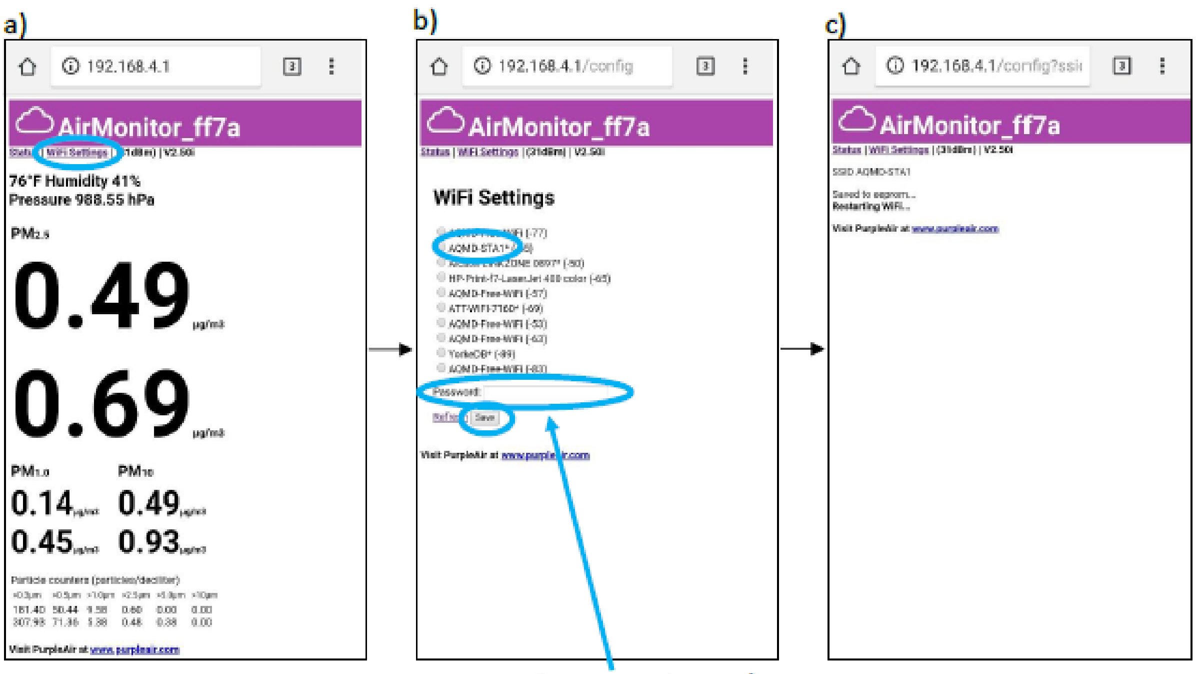


Configuring the Wi-Fi (continued)

3. Once you have connected your device to the "AirMonitor_xxxx" network, open an internet browser, type "192.168.4.1" in the search bar, and search.



4. a) Press/click on the "Wi-Fi Settings" link.
   b) Select your personal Wi-Fi access name from the list, enter your password, and save.
   c) Your sensor will reboot to configure the settings.

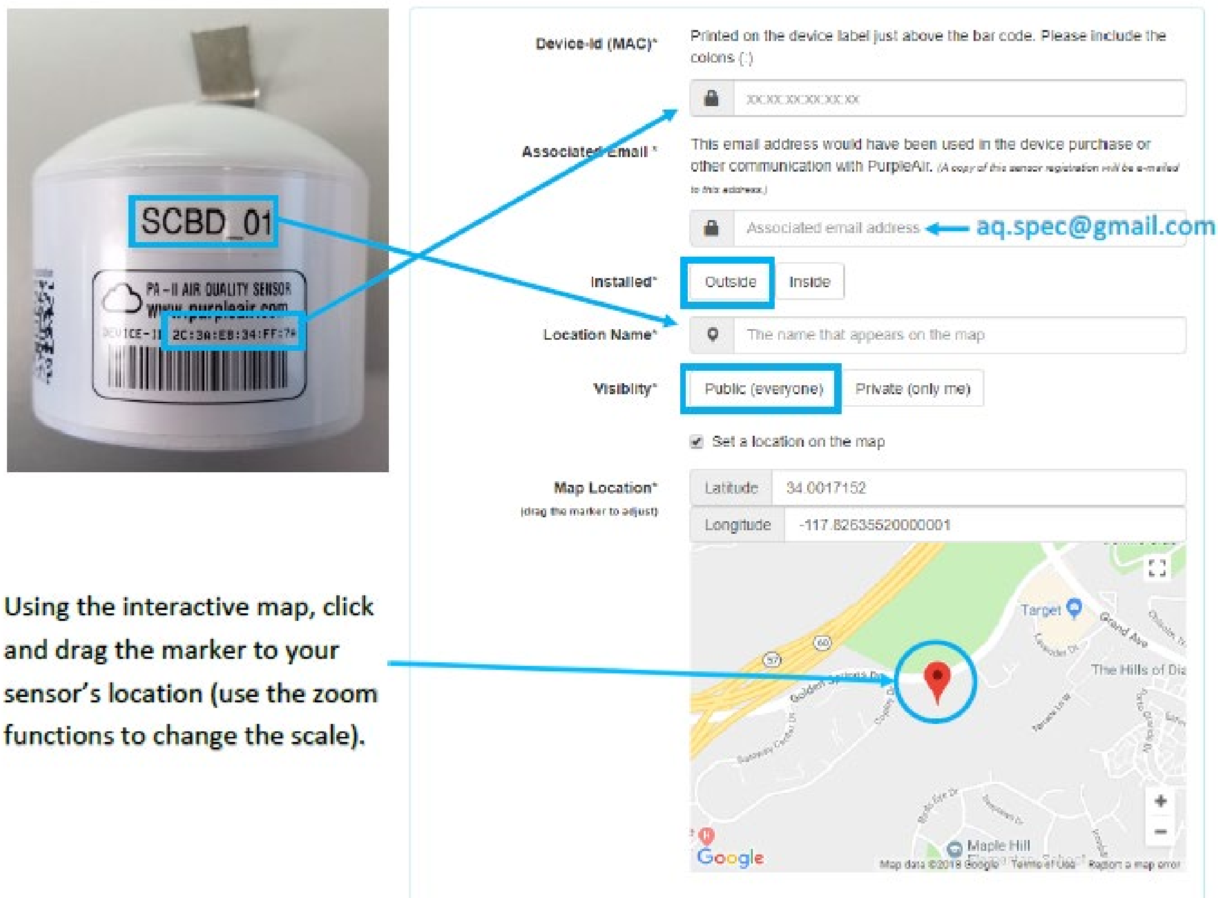


Be sure to input the correct Wi-Fi password! Passwords are case-sensitive.

5. Once the monitor successfully connects to your Wi-Fi, it will start uploading data and the "AirMonitor_xxxx" network will no longer be available to connect to via Wi-Fi.

STEP 3 — Registering Your PurpleAir Device

Enter www.purpleair.com/register on an internet-enabled device and input the following information. Note, marking your sensor "Public (everyone) will only share the sensor location and data, but will not result in any of your personal information being shared.



Registering Your PurpleAir Device (continued)

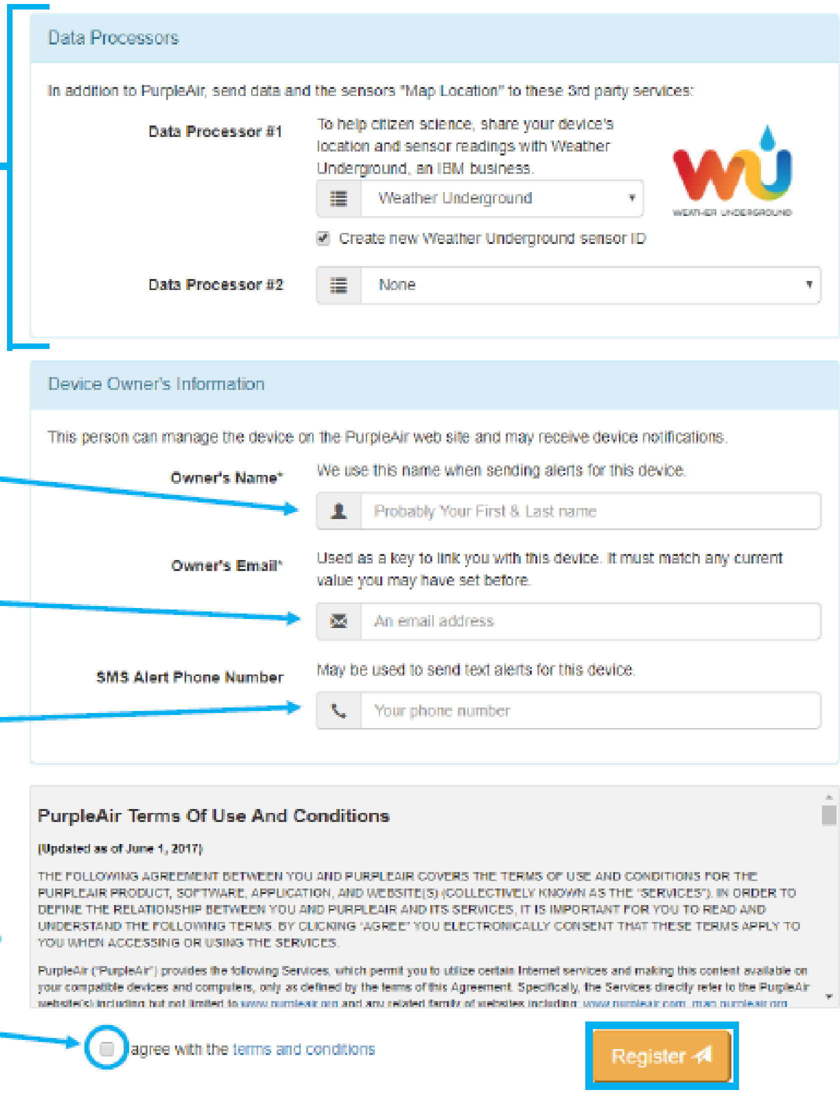
Leave the information in this section as-is, no edits needed.

Your first and last name (required)

Your email address (required)

Your phone number (optional)

After reading and agreeing to the Terms of Use and Conditions, click this box then click "Register" to complete the registration.



The installation is now complete and your sensor is now visible on the PurpleAir Map! (www.purpleair.com/map)

(Note: helpful information is available on page 6 of this guide)

Helpful Information:

- If your sensor loses power, it will remain configured with the Wi-Fi information and automatically reconnect once the power comes back on as long as the SSID name and password remained the same.
- If your sensor loses Wi-Fi connection, the data previously collected and uploaded to PurpleAir will still be available. However, the sensor will not collect data while the Wi-Fi connection is down, resulting in data loss.
- The "AirMonitor_xxxx" network is only available to connect to while the sensor isn't configured to a Wi-Fi.
- To change the information the sensor was registered with, simply repeat the registration process with the current/updated information and the original information will be replaced.
- The sensor can be relocated and registered again provided the new location is within 1 mile of the focused area of the study. Registering the sensor with the updated information will replace the previously-registered information. Contact the AQ-SPEC program at SCAQMD before a relocation is completed.
- If you can't find your sensor on the PurpleAir Map, it is possible that your sensor may have become inactive for an extended amount of time. On the PurpleAir Map, find the panel on the top left side of the page. Go to "Last Active" and select "All Time". Your sensor should now appear on the map as a gray oval icon, , indicating it is currently Offline and not reporting data. Your sensor's Wi-Fi may need to be reconfigured and/or power may need to be supplied to your sensor. If you still cannot see your sensor on the map, it is possible that your sensor has not been registered or it was registered incorrectly. Register your sensor again by simply repeating the PurpleAir registration process with the corrected information.
- If your sensor stops reporting data on the PurpleAir Map, perform a power cycle by unplugging the unit, waiting 10 seconds, and plugging it back in.

Technical Support

e-mail: info.aq-spec@aqmd.gov

Tel: +1 (909) 396-2713

PurpleAir PA-II Sensor Installation Guide - Spanish Version

Midiendo la Calidad de Aire en su Comunidad

El Distrito de Administración de la Calidad del Aire de la Costa Sur (SCAQMD por sus siglas en ingles), en colaboración con Sonoma Technology y UCLA Fielding School of Public Health formara una colaboración con comunidades locales para involucrar, educar y motivar a las comunidades de California en el uso y aplicaciones de sensores de monitoreo de aire de "bajo costo."

Tecnología para Medir Particulas (PM)

Sensor de Calidad de Aire Laser PurpleAir PA-II Dual

1) PA-II Dual sensor laser
2) Conector USB termo contraíble
3) Cargador de electricidad
4) 17 pies de cable
5) Tornillos o ataduras de plástico

- Sensores duales de PM
- Medidas de $PM_{1.0}$, $PM_{2.5}$, y PM_{10} junto con temperatura, humedad relativa y presión
- Requisitos de Anfitrión :
    1. Tomacorriente disponible
    2. Wi-Fi disponible para registrar datos en el mapa de PurpleAir
- Fácil de instalar con un solo tornillo o abrazador
- Registro de datos Wi-Fi con acceso a datos abierto en www.purpleair.com/map

Guía de Inicio Rápido del Sensor de Calidad del Aire PurpleAir PA-II

Encontrar una localizacion e instalacion

1. Busque un lugar sombreado, generalmente una parte orientada al norte de la casa
2. La ubicación necesitara una toma de corriente y una señal de Wi-Fi.
3. Monte el sensor lejos de las fuentes de contaminación cercanas (unidades de aire acondicionado, respiraderos, parrillas de barbacoa).
4. Monte el sensor usando ataduras de cables (barandas) o un tornillo (debajo del borde del techo).
5. El aparato debe montarse de modo que no se sumerja en el agua y confirme que el cable este asegurado en una forma para evitar un peligro de tropiezo.

Configurar Wi-Fi

1. Asegúrese que el sensor esté conectado.
2. Utilizando un aparato que le permite Wi-Fi (teléfono, tableta o computadora), conéctese a una red de Wi-Fi llamado "AirMonitor_xxxx" donde xxxx es especifico al sensor.
   a. NOTA: La red de "AirMonitor_xxxx" solamente es disponible cuando el sensor no está conectado al Wi-Fi.
3. Una vez que el Wi-Fi esté conectado a la red "AirMonitor_xxxx", abre un navegador de internet y escriba http://192.168.4.1 para conectarse directamente al PA-II y visualizar el estado y la página de configuración del monitor.
4. Presione "Wi-Fi Settings" y seleccione su nombre de acceso de Wi-Fi personal de la lista, ingrese la contraseña y presione "Save" (guardar).
5. Una vez que el monitor se conecte con su Wi-Fi, comenzara a cargar datos y la red de AirMonitor_xxxx ya no estará disponible para conectarse a través de Wi-Fi.

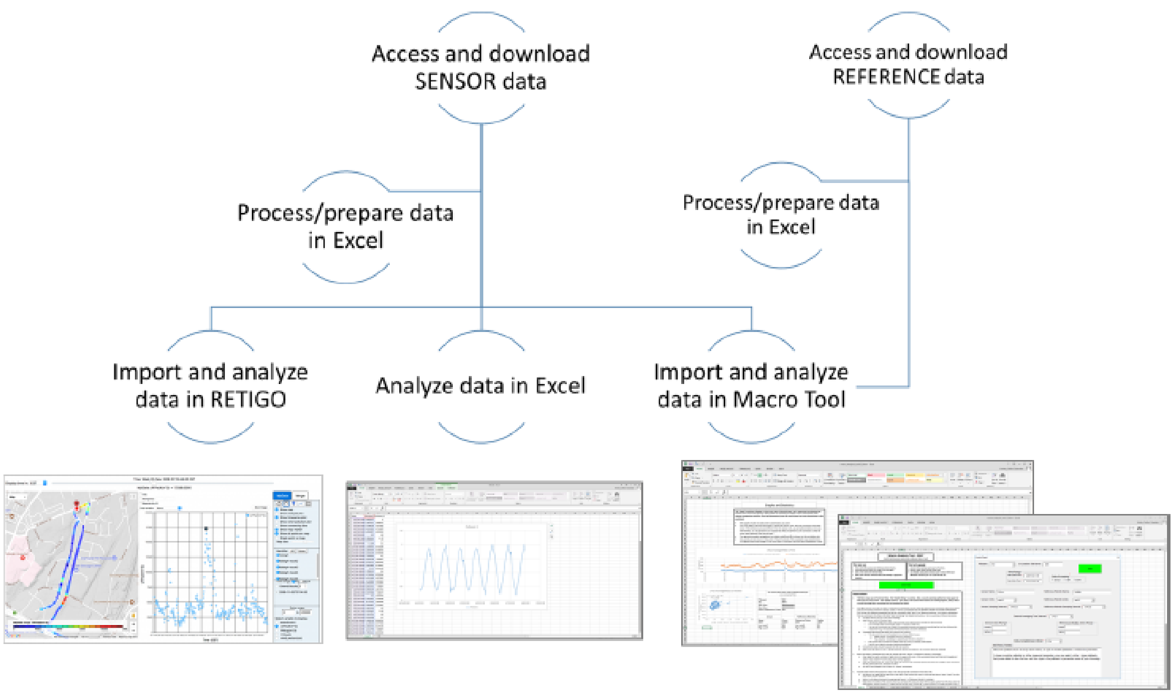
Registre su Aparato PurpleAir

1. Entre www.purpleair.com/register en un aparato que permita internet.
2. El "ID" del aparato (MAC) esta imprimido en el sensor PA-II arriba del código de barras.
3. Correo electrónico asociado: Debe usar aq.spec@gmail.com para registrarse
4. Installed: Choose "outside" --Instalado: Elije "Outside"
5. Location name- Nombre de la ubicacion: Utilice el nombre etiquetado en el PA-II
6. Visibility- Visibilidad: Elije "Public (everyone)"- publico (todos)
7. Ubicación del mapa: Ingrese la lectura de latitud y longitud mueva su marcador a su ubicación
8. Procesador de datos #1: deje el "settings" a Weather Underground
9. Procesador de datos #2: dejar en blanco
10. Nombre del dueño del aparato:

PurpleAir PA-II Sensor Data Download and Processing Guide

Accessing & Analyzing PurpleAir Sensor Data

The diagram below illustrates the steps necessary to prepare data for analysis using the various tools available. In order to understand what steps are necessary given your objectives, begin at the end of the diagram with your preferred analysis tool and follow the diagram backward to get an idea of the overall process you will need to follow. The pages that follow provide specific instructions for carrying out each of these steps.



Downloading Data

This section includes instructions for accessing and downloading air quality data.

PurpleAir Sensor Data

1. Sensor data from any sensor designated as public is available here: https://map.purpleair.org/sensorlist
2. Check the box next to your desired sensor(s) (hint: using "ctrl – f" can help you to find your sensor more quickly)
3. Enter your date range (it is OK to over-estimate the range, the program will automatically download any and all available data within your date range)
4. Click "Download Selected", steps visible in FIG 1

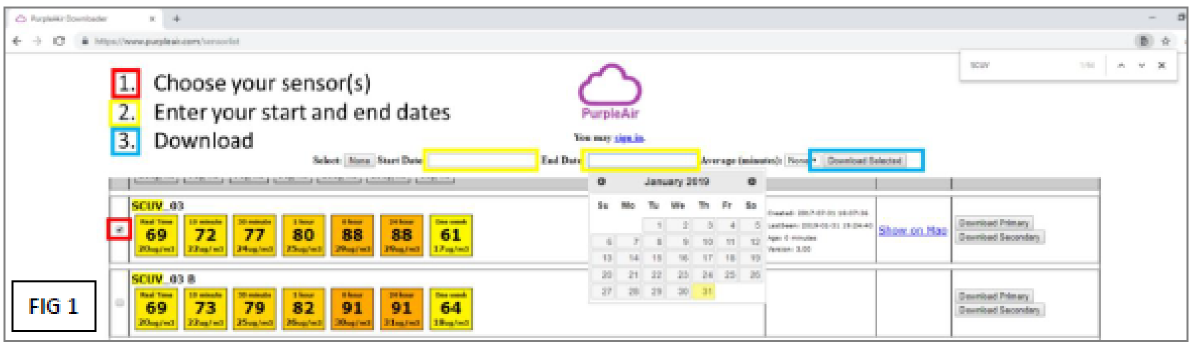


FIG 1

Important Notes:

- There are actually two sensors in each PurpleAir, the second sensor has the same name with a "_B" added to the end, the purpose of the second sensor is to help identify when there is a problem with one of the sensors (e.g., when they do not match). For simplicity, we recommend downloading only the files for the first sensor in each device. Though you are welcome to look at the data from secondary sensor, especially if you have concerns about how well the primary sensor is functioning, or would like to learn more about how well the two sensors typically match.
- When you download the files from an individual sensor, two files will automatically be downloaded, these are designated as either "primary" or "secondary". We recommend using the "primary" file for your analysis, as it contains the $PM_{2.5}$ data you are most likely interested in (converted into mass concentrations). The "secondary" file includes the raw PM count data, or number of particles detected at a given time for a given size.

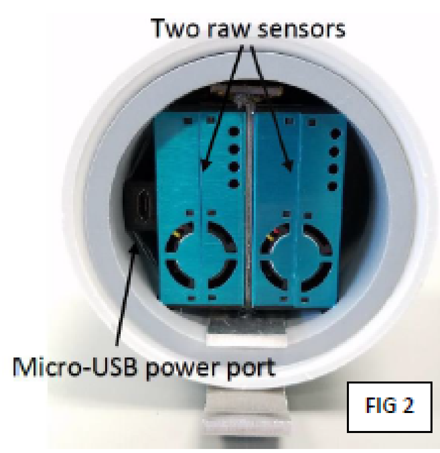
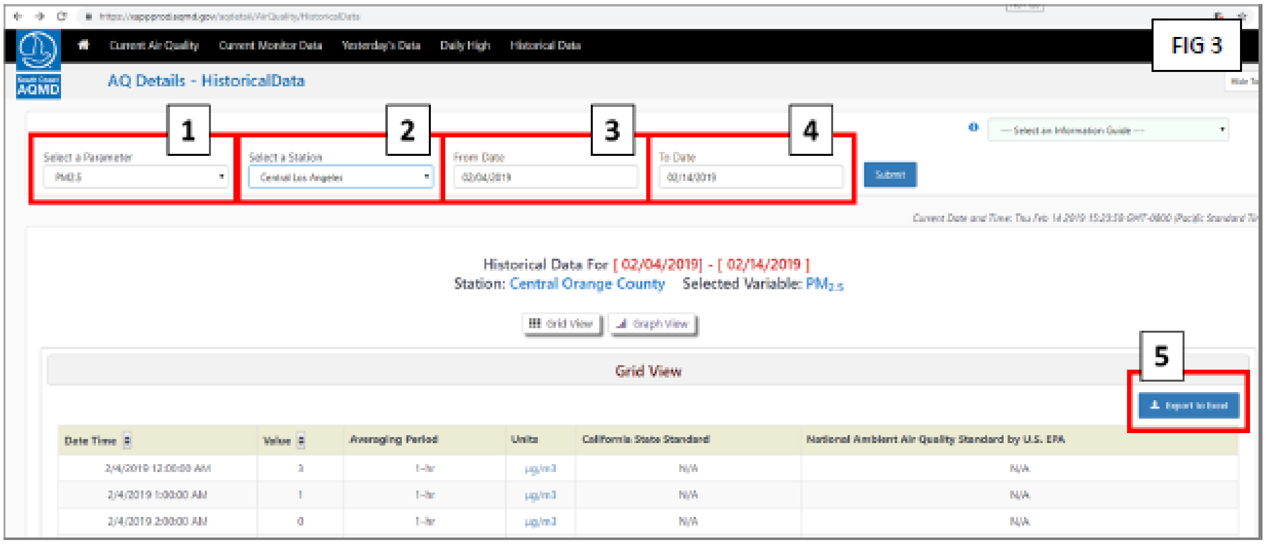


FIG 2

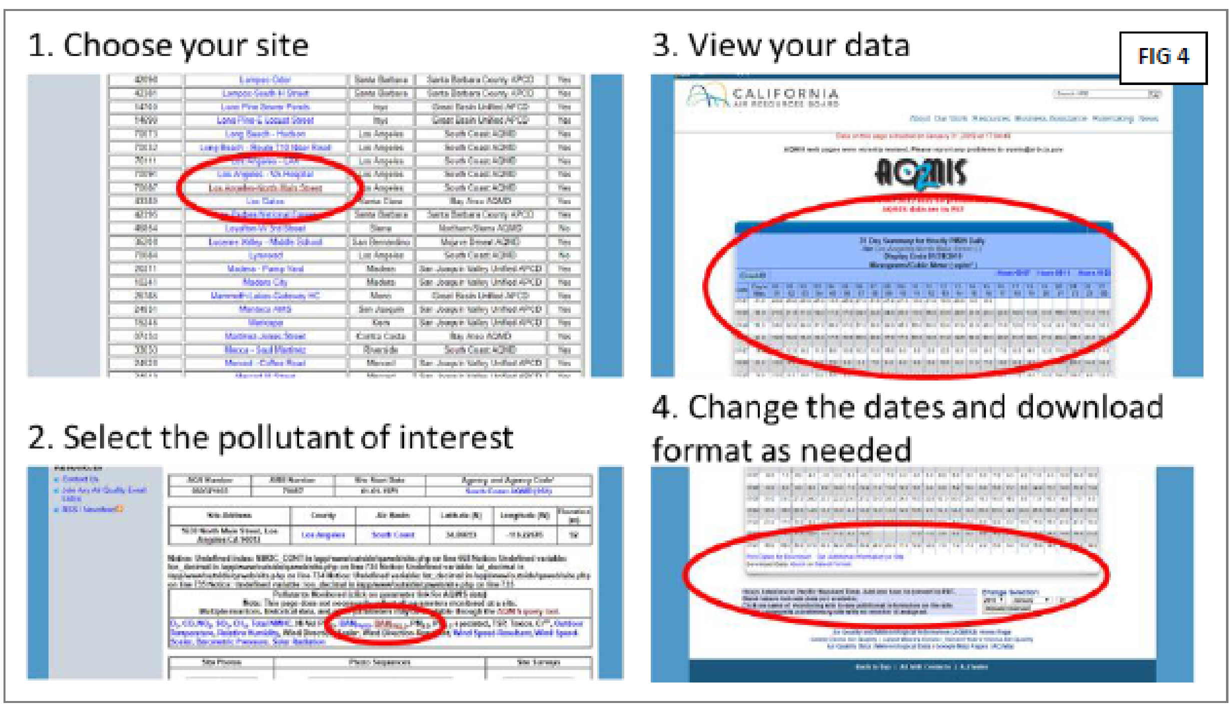
Reference Data

1. Reference data from regulatory monitoring sites is generally available for download; two places where this data may be found are databases maintained by the South Coast Air Quality Management District and by the Air Resources Board

2. SCAQMD: https://xappprod.aqmd.gov/aqdetail/AirQuality/HistoricalData



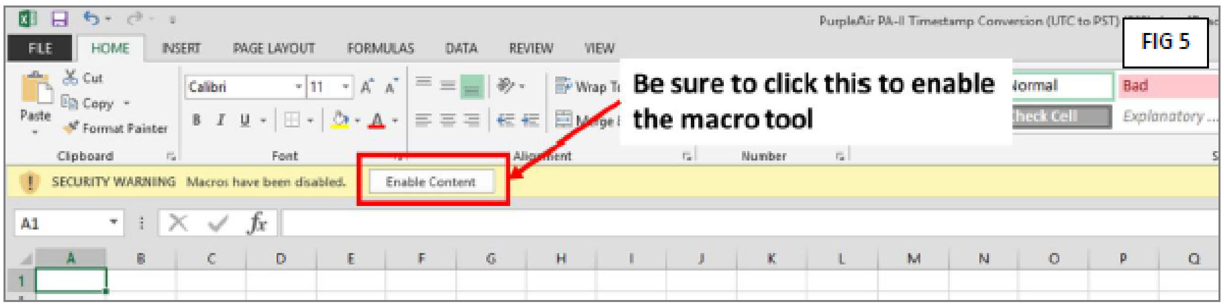
3. ARB: https://www.arb.ca.gov/qaweb/site.php



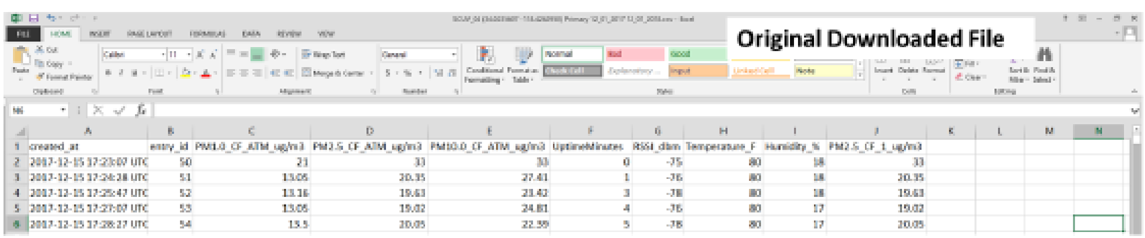
Analyzing PurpleAir Sensor Data in Excel

This section includes tips for analyzing PurpleAir sensor data in Excel; including a way to adjust the timestamp using a macro tool (for example, from Universal Time Coordinated or UTC to Pacific Standard Time or PST), a guide to which columns are recommended for use in the analysis, and a few links to Excel tutorials.

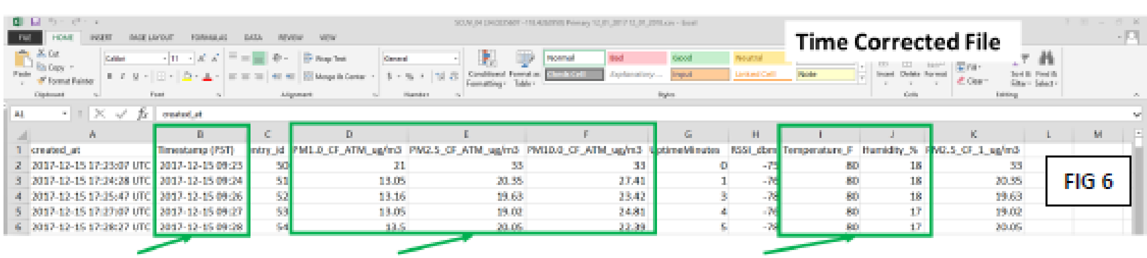
1. Download the PurpleAir PA-II Timestamp Conversion Macro Tool (it should be attached to the same email as this guide and the file is entitled: "PurpleAir PA-II Timestamp Conversion (UTC to PST).xlsm"
2. Open it on your computer and click "Enable Content", if the security warning comes up (FIG 5)



1. Leaving the Macro file open in the background, open your sensor data file (i.e., two Excel files will be open) – it should look like the "Original Downloaded File" in the figure below (FIG 6)
2. Press "ctrl-t", and you should see a new column added with the timestamp in PST, this new column is visible in the second Excel screenshot below
3. The figure below also highlights which columns of data that the manufacturer recommends you use for your analysis (a correction factor has been applied to the data in columns D, E, and F by the sensor manufacturer to help minimize the impacts of environmental factors, such as temperature and humidity, on the sensor – this is referred to as "adjusted" data in FIG 6)
4. Using this data, you can now use Excel to create plots or calculate statistics



With the PA Timestamp Conversion Macro Tool open, and with "Content Enabled",
Press "ctrl-t"
You should now see results (or columns) matching those below…



Date and Time in PST   Adjusted PM Data   Sensor Temperature and Humidity Data

Important Notes:

- The timestamps have all been converted to PST or Pacific Standard Time (UTC/GMT minus 8 hours); this will make comparisons to reference instruments straightforward as reference instruments at regulatory monitoring sites always record data in the local standard time. Additionally, having your data in local time will make it easier to look for patterns with respect to activities such as morning rush hour or notes you may have made. However, this does not take into account daylight savings. In CA, PST (UTC minus 8 hours) is observed from early-November to mid-March, while PDT or Pacific Daylight Time (UTC minus 7 hours) is observed throughout the rest of the year. Thus you should be aware that you may need to add an hour to the new timestamp if you are analyzing data collected during PDT.
- To add an hour to your timestamp you can, in a new column, simply enter the formula shown below. (FIG 7)
- *If you are analyzing data from an indoor sensor*, the manufacturer recommends that you use the data from column K, "PM2.5_CF_1_ug/m3", this dataset uses a different correction factor, applied by the manufacturer, that is indeed to mitigate the effects of typical indoor temperature and humidity values.

FIG 7

=B4+(1/24)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	[illegible]	Timestamp (PST)	entry_id	PM1.0_CF_ATM_ug/m3	PM2.5_CF_ATM_ug/m3	PM10.0_CF_ATM_ug/m3	UptimeMinutes	RSSI_dbm	Temperature_F	Humidity_%	PM2.5_CF_1_ug/m3		Timestamp (PDT)	
2	2017-12-15 17:23:07 UTC	2017-12-15 09:23	50	21	33	33	0	-75	80	18	33		2017-12-15 10:23	
3	2017-12-15 17:24:28 UTC	2017-12-15 09:24	51	13.05	20.35	27.41	1	-78	80	18	20.35		2017-12-15 10:24	
4	2017-12-15 17:25:47 UTC	2017-12-15 09:26	52	13.16	19.63	23.42	3	-78	80	18	19.63		=B4+(1/24)	
5	2017-12-15 17:27:07 UTC	2017-12-15 09:27	53	13.05	19.02	24.81	4	-78	80	17	19.02			

- **Excel Tutorials**
  - Intro to Excel: https://support.office.com/en-us/article/introduction-to-excel-starter-601794a9-b73d-4d04-b2d4-eed4c40f98be
  - Create a chart in Excel: https://support.office.com/en-us/article/create-a-chart-from-start-to-finish-0baf399e-dd61-4e18-8a73-b3fd5d5680c2
  - Chart Types in Excel: https://support.office.com/en-us/article/available-chart-types-in-office-a6187218-807e-4103-9e0a-27cdb19afb90
  - Calculating statistics: https://support.office.com/en-us/article/calculate-the-median-of-a-group-of-numbers-2e3ec1aa-5046-4b4b-bfc4-4266ecf39bf9

Analyzing PurpleAir Sensor Data using the US EPA's RETIGO Tool

This section includes instructions for formatting and uploading PurpleAir sensor data to the US EPA's RETIGO (Real Time Geospatial Data Viewer) tool. This is a free, web-based tool intended to assist with data visualization and analysis. This tool allows users to plot data on a map, compare different data sets, and analyze data temporally and spatially. From the main page there is access to the tool itself as well as a number of valuable tutorials.

RETIGO Main Page: https://www.epa.gov/hesc/real-time-geospatial-data-viewer-retigo

1. Open the original PurpleAir sensor data file
2. Download and open the PurpleAir PA-II to RETIGO Template (it should be attached to the same email as this guide and the file is entitled: "PurpleAir PA-II to RETIGO Template.csv")
3. Delete the UTC identifier on the timestamp using "ctrl-f", then choosing the "Replace" tab (FIG 8)
    a. Type: " UTC" in the "Find What" box, then leave the "Replace with" box empty, click "Replace All"
    b. The UTC identifier should be gone and excel should recognize this column as date and time values

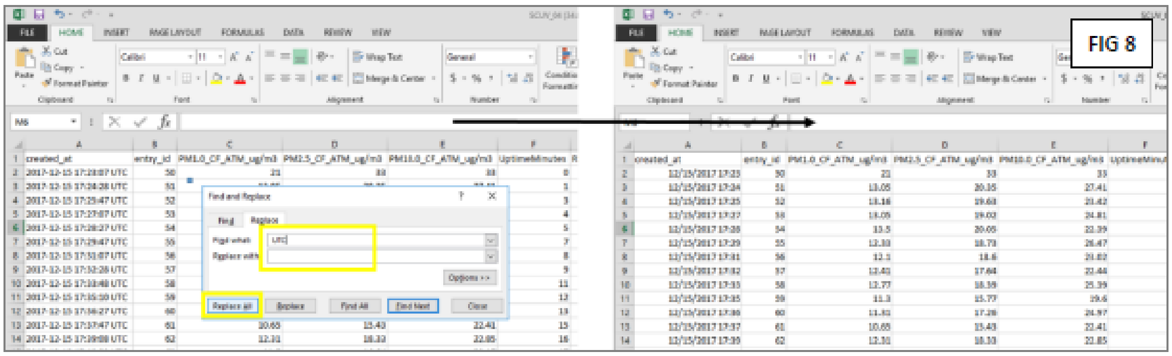


FIG 8

4. Highlight the timestamp column and adjust the format to: "m/d/yyyy-mm:hh:ss" (FIG 9)

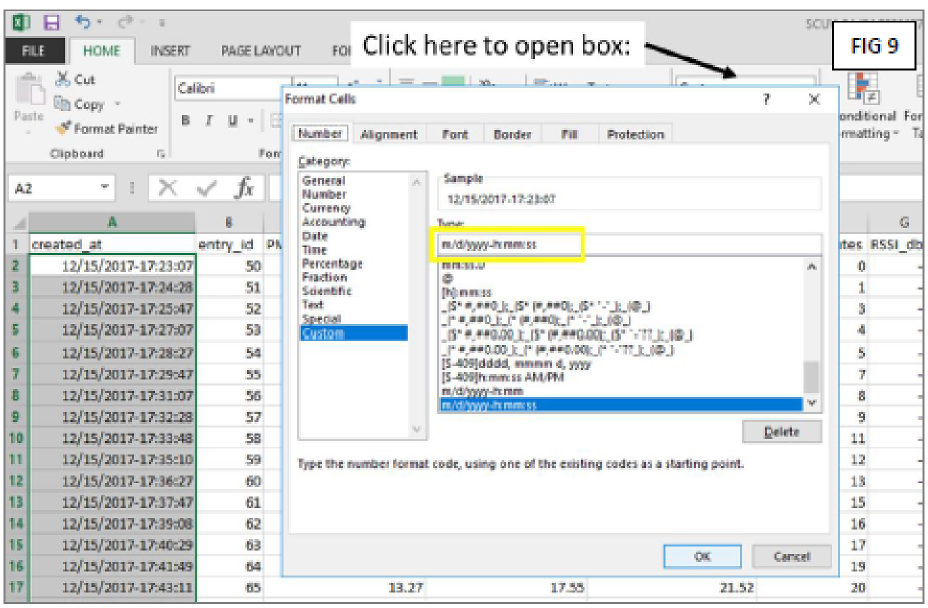


FIG 9

5. Copy the date and time column, and paste it into the RETIGO online timestamp converter (this will convert the timestamp into the format that the RETIGO tool is looking for) (FIG 10)
6. Paste the data into the box on the left, select the appropriate original format and time zone, which should be GMT (the same as UTC); for the output timestamp you can keep UTC/GMT or select a local time (e.g., PST)
7. Click “convert”

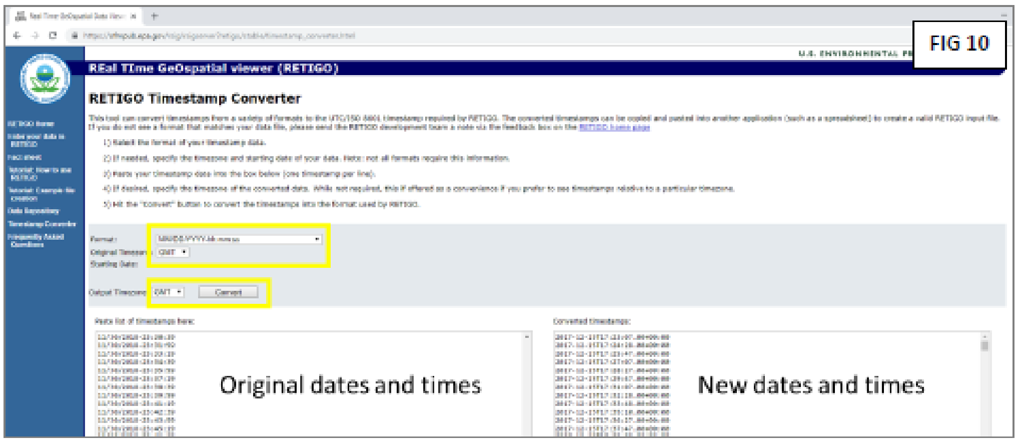


FIG 10

8. Copy and paste the new dates and times into the “Timestamp” column in the Purple Air PA-II RETIGO Template
9. Copy and paste the data columns you wish to analyze from the original data file
10. Enter the longitude, latitude, and sensor ID into the template (these can all be found in the file name from the original downloaded file); copy and paste these values into the top three rows – you can then autofill the remainder of the values by highlighting the section and double clicking the small black plus sign that appears when you hover over the bottom right corner
11. Save the file as a .CSV, and it can now be uploaded to the RETIGO tool, here: https://ofmpub.epa.gov/rsig/rsigserver?retigo/stable/retigo_load.html

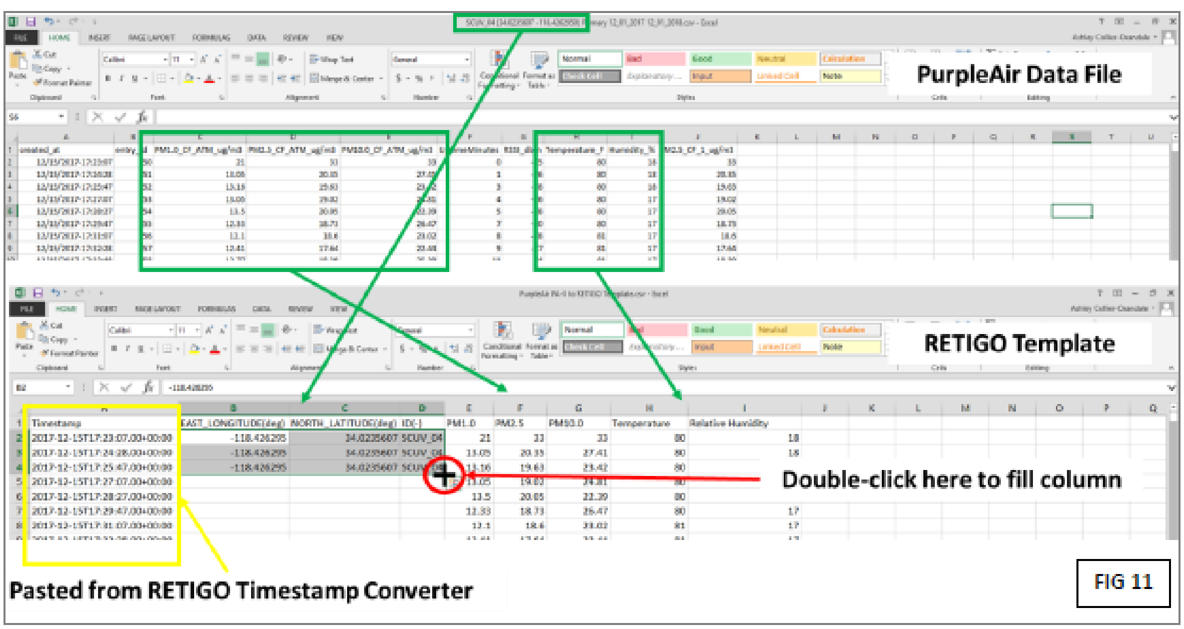
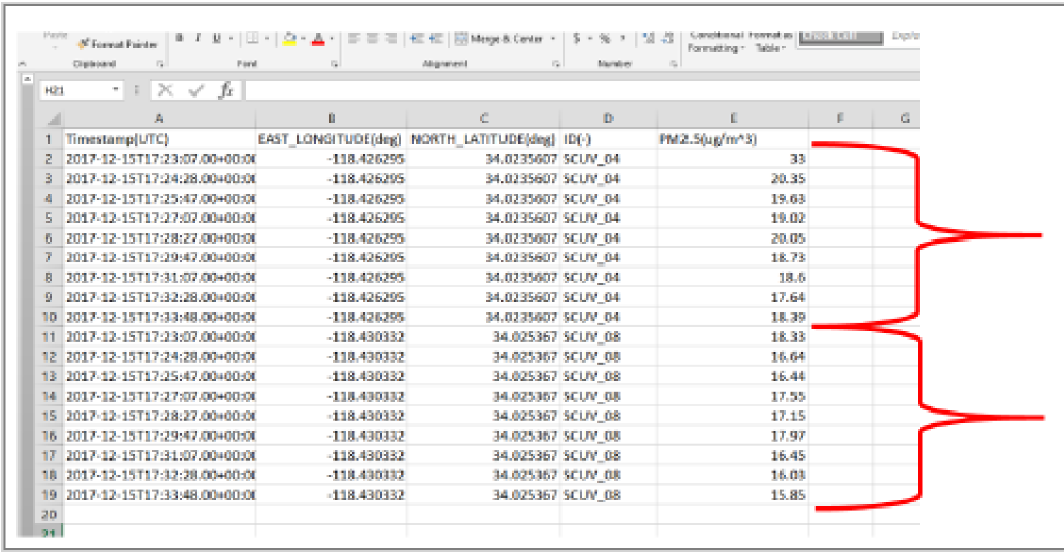


FIG 11

12. We *highly* recommend taking a look at the online tutorials as they will help you to make the most of this tool: https://www.epa.gov/hesc/real-time-geospatial-retigo-tutorials#online
13. *If you would like to plot data from multiple sites on the map*, simply prepare each data set according to the instructions above, then copy and paste the data from each sites into one template (appending each new site to the bottom of the existing data), as long as the GPS location is correct for each data point each site will be plotted in the correct location, and it is fine to have duplicate date/times and date/times out of order (due to the new sites being added to the data file); example below:
    **Note: different ID(-) values are necessary for the RETIGO tool to recognize that the data is from different sites as opposed to the same sensor being utilized in a mobile fashion.*



	A	B	C	D	E
1	Timestamp(UTC)	EAST_LONGITUDE(deg)	NORTH_LATITUDE(deg)	ID(-)	PM2.5(ug/m^3)
2	2017-12-15T17:23:07.00+00:0	-118.426295	34.0235607	SCUV_04	33
3	2017-12-15T17:24:28.00+00:0	-118.426295	34.0235607	SCUV_04	20.35
4	2017-12-15T17:25:47.00+00:0	-118.426295	34.0235607	SCUV_04	19.63
5	2017-12-15T17:27:07.00+00:0	-118.426295	34.0235607	SCUV_04	19.02
6	2017-12-15T17:28:27.00+00:0	-118.426295	34.0235607	SCUV_04	20.05
7	2017-12-15T17:29:47.00+00:0	-118.426295	34.0235607	SCUV_04	18.73
8	2017-12-15T17:31:07.00+00:0	-118.426295	34.0235607	SCUV_04	18.6
9	2017-12-15T17:32:28.00+00:0	-118.426295	34.0235607	SCUV_04	17.64
10	2017-12-15T17:33:48.00+00:0	-118.426295	34.0235607	SCUV_04	18.39
11	2017-12-15T17:23:07.00+00:0	-118.430332	34.025367	SCUV_08	18.33
12	2017-12-15T17:24:28.00+00:0	-118.430332	34.025367	SCUV_08	16.64
13	2017-12-15T17:25:47.00+00:0	-118.430332	34.025367	SCUV_08	16.44
14	2017-12-15T17:27:07.00+00:0	-118.430332	34.025367	SCUV_08	17.55
15	2017-12-15T17:28:27.00+00:0	-118.430332	34.025367	SCUV_08	17.15
16	2017-12-15T17:29:47.00+00:0	-118.430332	34.025367	SCUV_08	17.97
17	2017-12-15T17:31:07.00+00:0	-118.430332	34.025367	SCUV_08	16.45
18	2017-12-15T17:32:28.00+00:0	-118.430332	34.025367	SCUV_08	16.03
19	2017-12-15T17:33:48.00+00:0	-118.430332	34.025367	SCUV_08	15.85

FIG 12

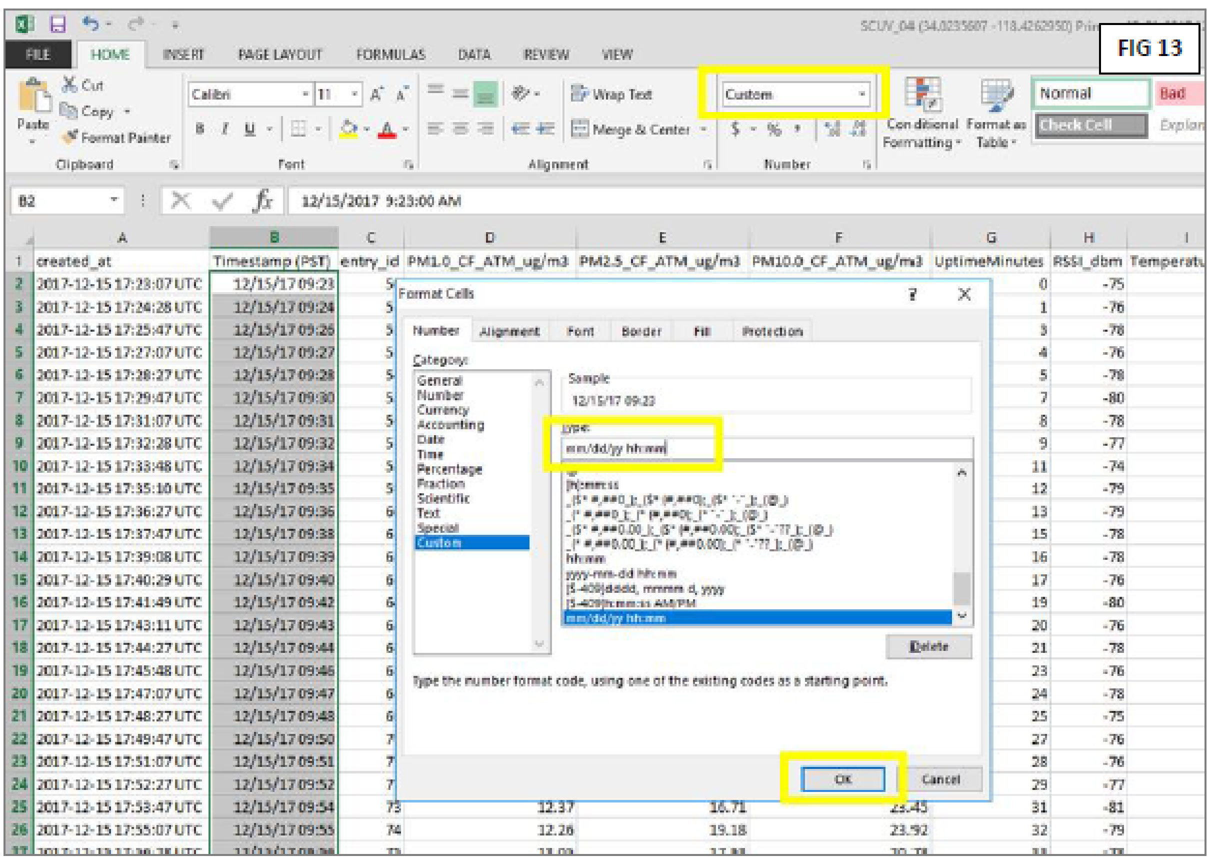
Comparing Sensor and Reference Data Using the US EPA's "Excel-based Macro Analysis Tool for Air Sensor Data"

In this section the steps for preparing PurpleAir sensor and reference data for use with the US EPA's Macro Analysis Tool are described. There are additional instructions for using the tool and interpreting the results available on the main page.

Main page for Macro Analysis Tool: https://www.epa.gov/air-research/instruction-guide-and-macro-analysis-tool-evaluating-low-cost-air-sensors-collocation

(developed by Terri Conner, Andrea Clements, Ronald Williams, Amanda Kaufman, et al.,)

1. Begin by completing the steps, listed in the section: Analyzing PurpleAir Sensor Data in Excel (the sensor data timestamp must be in the same time zone as the reference data, which is typically in Local Standard Time)
2. Download/open the Macro Analysis Tool available at the link above; as needed, "Enable Editing" & "Enable Content"
3. Review the instructions provided in the "Setup", "Data Formatting", and "AQS time matching" sheets, we also highly recommend reviewing the "Instruction Guide: How to Evaluate Low-Cost Sensors by Collocation with Federal Reference Monitors" provided by the US EPA on the main page for the tool as it will provide a clear explanation of the analysis you are conducting and how to interpret the results
4. Next, prepare and transfer your data into the Macro Analysis Tool
5. Highlight the date/time column (for PST) in the sensor data file and change the format to "mm/dd/yy hh:mm"



6. Do the same for the reference data date/time
7. In the "Sensor" tab, right click on the triangle in the upper left corner of the sheet, and select "clear contents"

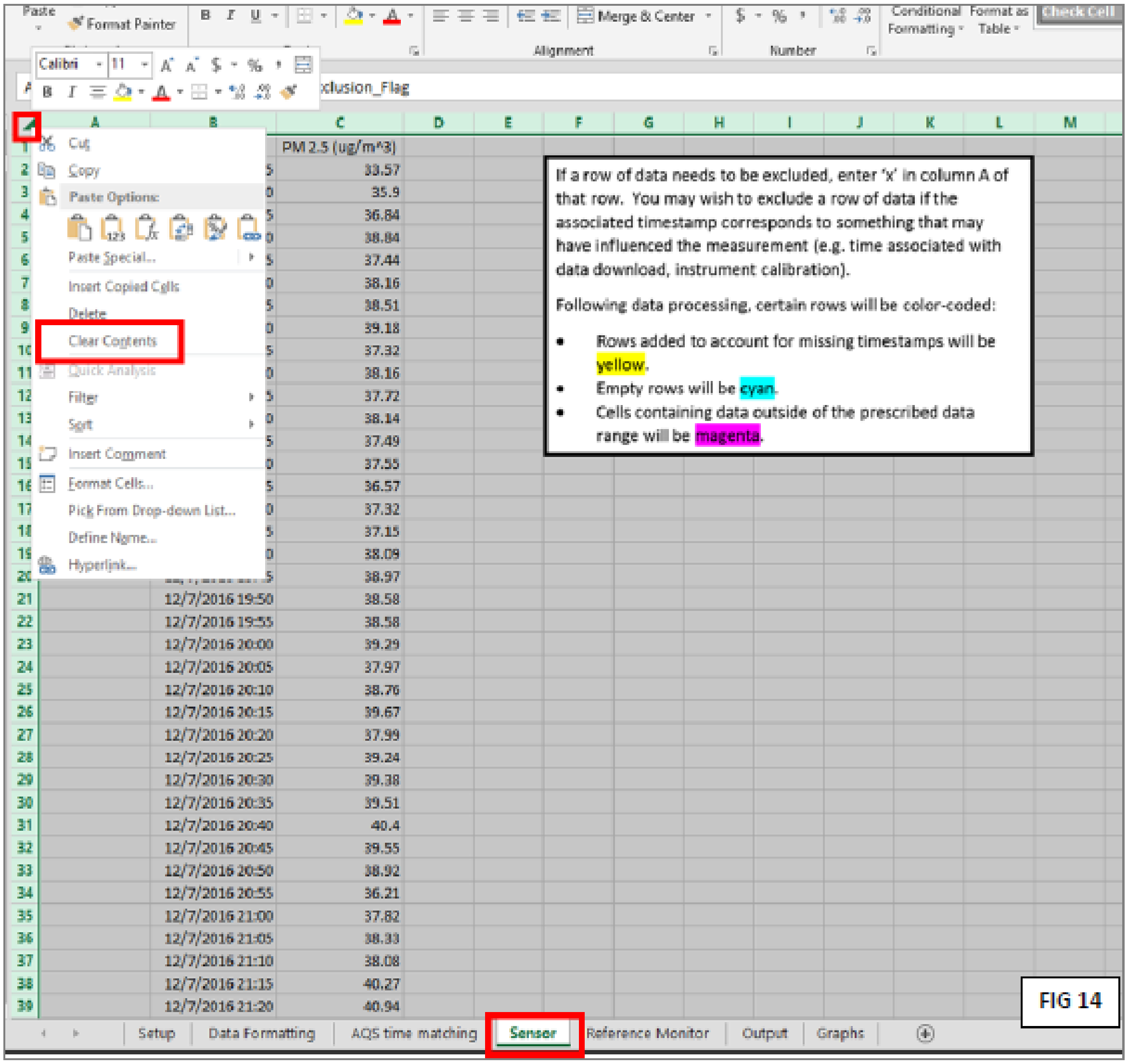


FIG 14

8. Repeat this for the "Reference Monitor" tab – they should both be blank now
9. Copy and paste the date/time columns and pollutant of interest columns into the "Sensor" and "Reference Monitor" sheets, with date/time in column B and the pollutant data in column C

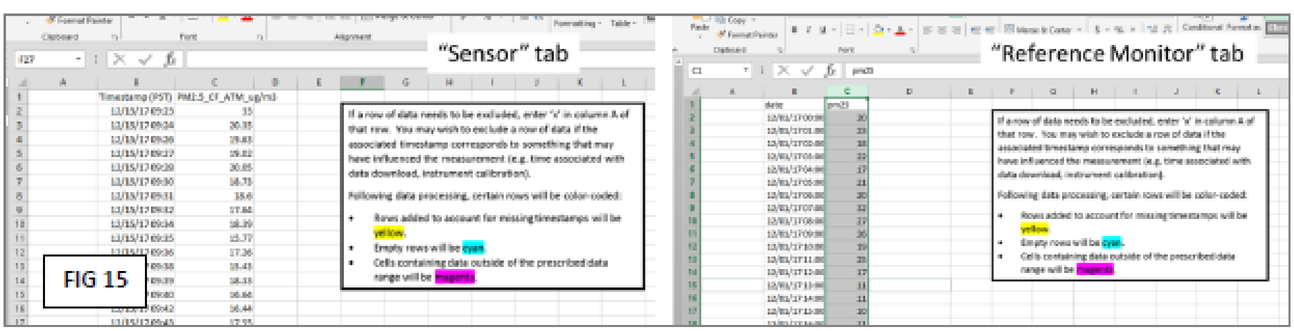


FIG 15

10. If you've read the instructions included with the tool, you are now ready to open the "Control Panel" on the "Setup" tab, enter the appropriate options, and run the analysis

Frequently Asked Questions About the PurpleAir PA-II Sensor

Q: Which pollutant does the PurpleAir PA-II sensor measure?
A: The PurpleAir PA-II measures particulate matter (PM) $PM_{1.0}$, $PM_{2.5}$, and PM_{10} as well as temperature and humidity. Although the PurpleAir map only displays $PM_{2.5}$ readings, the data for $PM_{1.0}$ and PM_{10} are recorded and available for download using the PurpleAir Download tool.

Q: Do these sensors measure particles smaller than 0.5 µm (micrometers)?
A: Yes, but sensitivity and counting efficiency is reduced between 0.3 and 0.5 µm.

Q: Does the sensor connect via Wi-Fi?
A: Yes.

Q: Do I need to reconfigure my sensor's Wi-Fi settings if the sensor loses power for a time?
A: No, the sensor remains configured with the configured Wi-Fi information. As long as the Wi-Fi information (SSID name and password) remain the same, the sensor will automatically reconnect once sensor is powered.

Q: If my sensor loses Wi-Fi connection, will there be a data loss?
A: If your sensor loses its Wi-Fi connection, the data previously collected and uploaded to PurpleAir will still be available. However, the sensor will not collect data while the Wi-Fi connection is down which will result in data loss.

Q: Can I change the information I registered my sensor with?
A: Yes. The registration process can be repeated with current/updated information and the original registration will be replaced.

Q: Can I relocate the sensor after it has been connected and registered?
A: Yes, the sensor can be relocated and registered again provided the new location is within 1 mile of the focused area of the study. Registering the sensor with the updated information will replace the previously-registered information. Contact the AQ-SPEC program at South Coast AQMD [e-mail: info.aq-spec@aqmd.gov or tel: +1 (909) 396 – 2173] before a relocation is completed.

Q: Why can't I find my sensor on the PurpleAir Map?
A: It is possible that your sensor may have become inactive for an extended amount of time. On the Purple Air map, find the panel on the top left side of the page. Go to "Last Active" and select "All Time." Your sensor should now appear on the map as a gray oval icon, , indicating it is currently not reporting data. Your sensor's Wi-Fi may need to be reconfigured and/or power may need to be supplied to your sensor.
If you still cannot see your sensor on the map, it is possible that your sensor has not been registered or it was registered incorrectly. Register your sensor again by simply repeating the PurpleAir registration process with the corrected information.

Q: Where can I find the indoor sensors on the PurpleAir Map?

A: The indoor sensors are not displayed on the PurpleAir Map according to their locations but rather are displayed in the form of an alphabetical list in the left panel of the page under the display filters. Using the scroll bar, navigate through the list to find your desired sensor.

Q: Why are there two Channels for each sensor?
A: The PurpleAir PA-II sensor has two identical raw sensors. Each raw sensor is designated as its own channel (i.e., Channel A, Channel B).

Q: How do I view my sensor's information and data? What does the information from each sensor on the PurpleAir Map correspond to/mean?
A: To view your sensor's data, take the following steps (see Figure 1):

- Go to the PurpleAir Map
- Find your registered sensor (you can zoom in on the map or type the sensor's location, address, or coordinates in the search bar at the top left corner of the page)
- Click on your sensor (this will open an information panel)

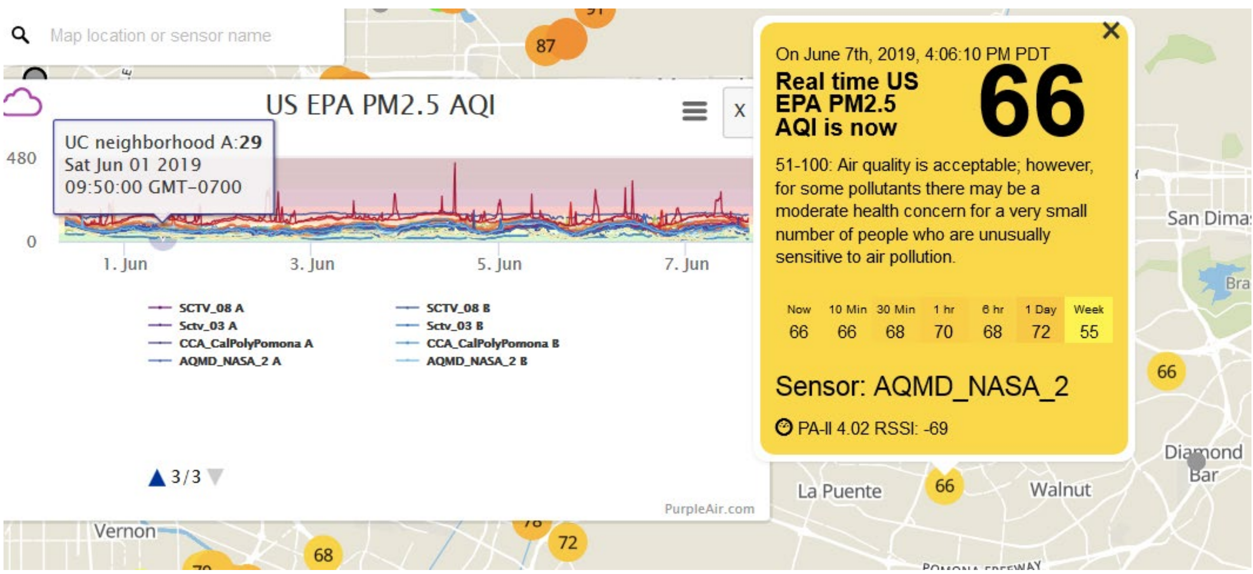


Figure 1. PurpleAir Map pop-up window with sensor data information (last accessed June 2019)

- The information in the panel is as follows:
  1. The sensor's name (e.g. AQMD_NASA_2)
  2. The Short-Term AQI number (e.g., 68): The AQI number determines which categorical range the air quality falls under, which indicates how clean or polluted the air is (the lower the AQI number, the cleaner the air).
  3. The sensor reports Now, 10 minute, 30 Minute, 1 Hour, 6 Hour, 24 Hour, and One Week average readings.
  4. The graph shows a time series of the 1-hr average AQI values for the sensor selected on the map and for surrounding sensors. The AQI value is bolded in the mouse-over and indicates which channel, A or B, the data are from.

Q: If there is a difference in values between channels, how do we know which is accurate?
A: Look at what adjacent sensors are reporting and compare. If a conclusion cannot be reached, contact the AQ-SPEC program at South Coast AQMD [e-mail: info.aq-spec@aqmd.gov or tel: +1 (909) 396 – 2173] or the sensor developer.

Q: Is the 24-hr average reading midnight-to-midnight or a rolling average?
A: The 24-hr average readings are rolling averages of the last 24 hours. They do not have set time ranges like midnight-to-midnight.

Q: How do I download my sensor data?
A: To download the data from your and all publicly-available sensors:

- Visit the PurpleAir Downloader on the PurpleAir Map page
- Enter the Start Date and End Date of your desired data timeframe
- Scroll down to find the sensor(s) you would like to download the data from (the sensors are listed by their sensor name in alphabetical order)
- Select the two options available for each sensor
  - Each sensor will have two options for downloading, each corresponding to the two identical raw sensors inside your sensor unit (designated as Channel A and Channel B)
  - The two options will have similar names, one with the sensor name and one with the sensor name followed by a "B" immediately below the first option
- Once you have selected the sensor(s), click Download Selected at the top of the page next to the data timeframe selections
- The data will be downloaded as .csv files, one file for each Channel A and Channel B for each selected sensor

Q: What is the difference between the Primary and Secondary data for this sensor?
A: Primary data output files include the particle mass concentration information. The Secondary data output files include the particle number concentration information.

Q: How do we share our sensor data with others?
A: You can share your sensor data in three ways:

1. Direct people to your sensor on the PurpleAir Map
2. Direct people to the PurpleAir Downloader website to download your sensor's data as a file
3. Send your sensor's already-downloaded data file to them directly

Q: Do all of the PA-II sensors in the USA have log sheets being recorded and collected?
A: This process is part of the EPA STAR Grant approach at the South Coast AQMD. Other users and programs may have different approaches.

Q: How do I use the log sheet?
A: The purpose of the log sheet is to record and keep track of data and observations each time you check on the sensor. It suggests that participants record the Date, the Time, Air, and Observations/Events related to the current air quality (e.g., either the presence or lack of odors, visibility issues, or activities related to emissions).:

These can include any activities, observations, or events that they feel have contributed to the measurements recorded by the sensor. This section is particularly important when there are extreme readings in the sensor data. For example, if participants observe sensor readings five times higher than a typical day's readings, they should note the event(s) that they believe may have contributed to those particularly high readings. Writing "neighbor is barbecuing," "it is raining heavily," or "road construction is taking place" are good examples.

Q: How often do I need to record measurements on the log sheet?
A: There is no required data logging frequency. Each participant has the freedom to dictate their own logging frequency.

Appendix D. Data Analysis Guide

As part of the STAR grant, South Coast AQMD project leads explored the use of different types of visualizations and approaches to sharing data. In addition to the development of the AirSensor package & DataViewer web application, other resources were developed to support engagement with data by members of the public, such as the Data Analysis Guide shown in this appendix and available here (**http://www.aqmd.gov/docs/default-source/aq-spec/star-grant/air-quality-sensor-data-analysis-guide.pdf?sfvrsn=6**).

Please note that the links provided in this appendix are not clickable.

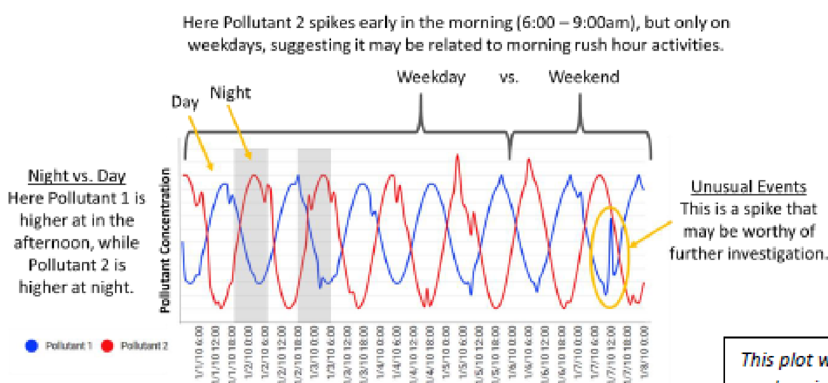
Low-Cost Sensor Data Analysis Guide

Guiding Questions

Low-cost sensors collect large amounts of data. Some sensors distributed through the US EPA STAR Grant program have been running continuously for over a year, recording data every minute (that's over 500,000 rows of data!). For this reason data analysis tools and software can be very helpful. In this guide we provide some brief instructions to help community scientists interact with the data they are collecting as well as some questions to help guide their analysis.

How do pollutant levels vary over time?

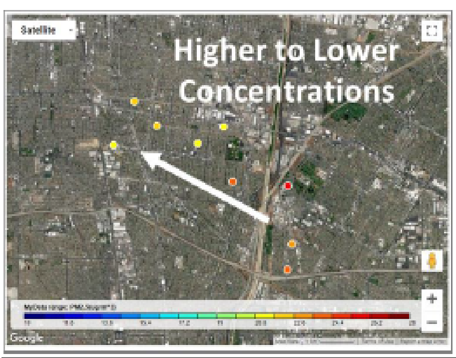
- Do you see any patterns in the data from day to day?
- Do you see any obvious differences between weekdays and weekends?
- You can also try comparing different periods, for example: the time of day, the morning and evening rush hour periods, or even seasons.

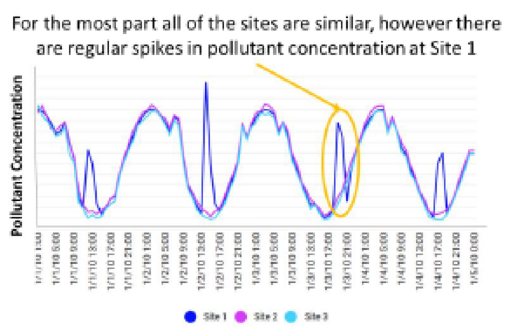


This plot was made using Excel.

Do you see any spatial trends?

- If you have data from multiple sensors available, how do the sites compare? Is one consistently higher or lower?
- Does one site experience more frequent spikes or elevations in pollution levels?

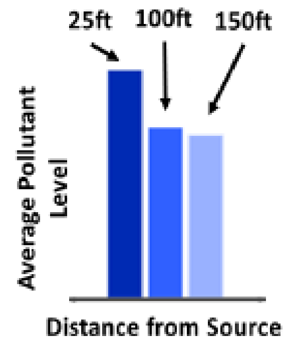




In the two plots above, RETIGO was used to create the map and Excel was used to make the time series plot.

Are there impacts from potential sources?

- Do higher levels of pollution seem to line up with certain activities (e.g., high traffic times)?
- Or do you see elevated levels at a site closer to a potential source of pollution than you do at a site further away? Another way to look at this is: how does the data vary at different distances away from the source?
- Are there any relationships between wind speed or direction and pollutant levels? (looking at the example below



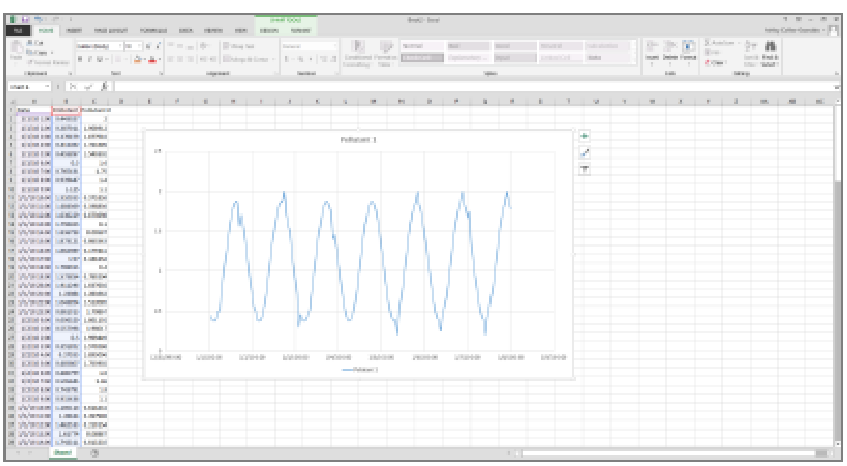
In the two plots above, RETIGO was used to create the map and time series and Excel was used to make the bar chart. For the RETIGO figure, wind speed was added in an effort to understand under what conditions enhancements in PM2.5 occur.

Resources Available

Excel

- Using Excel will provide the most freedom in terms of how the data can be plotted and what statistics may be calculated, however, using Excel may be a challenge for those with little experience with data analysis activities.
- That being said, there are many online resources and tutorials available to help with the use of Excel.

Excel Screenshot

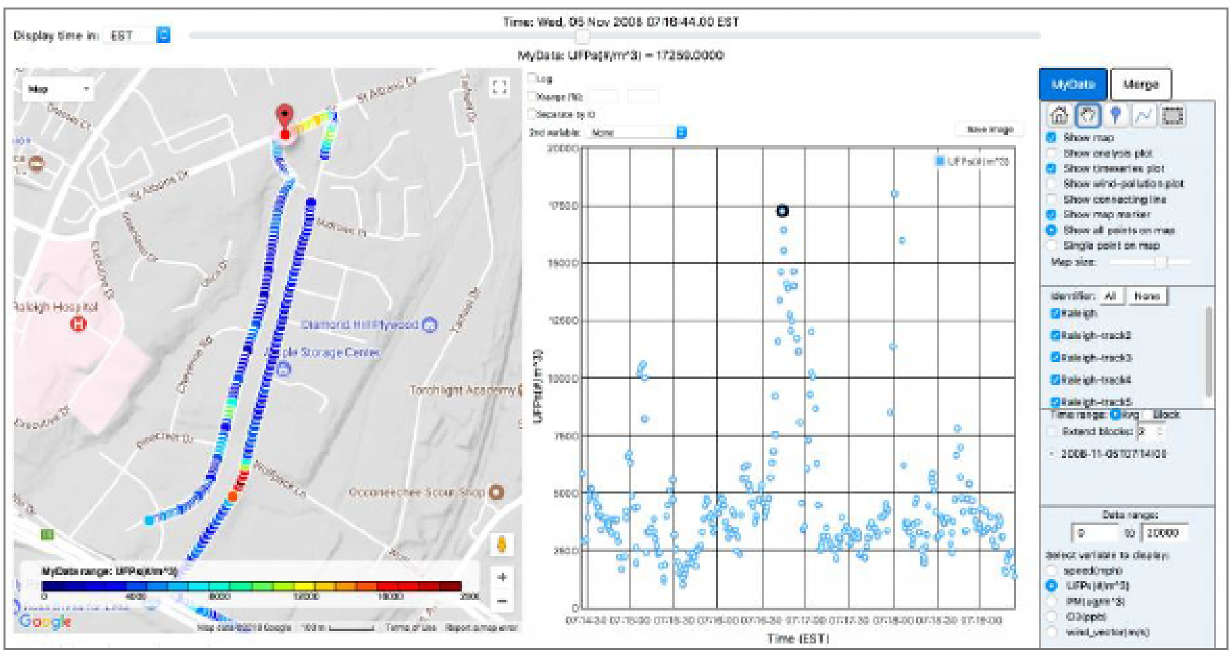


US EPA's RETIGO (REal TIme Geospatial Data Viewer) Tool

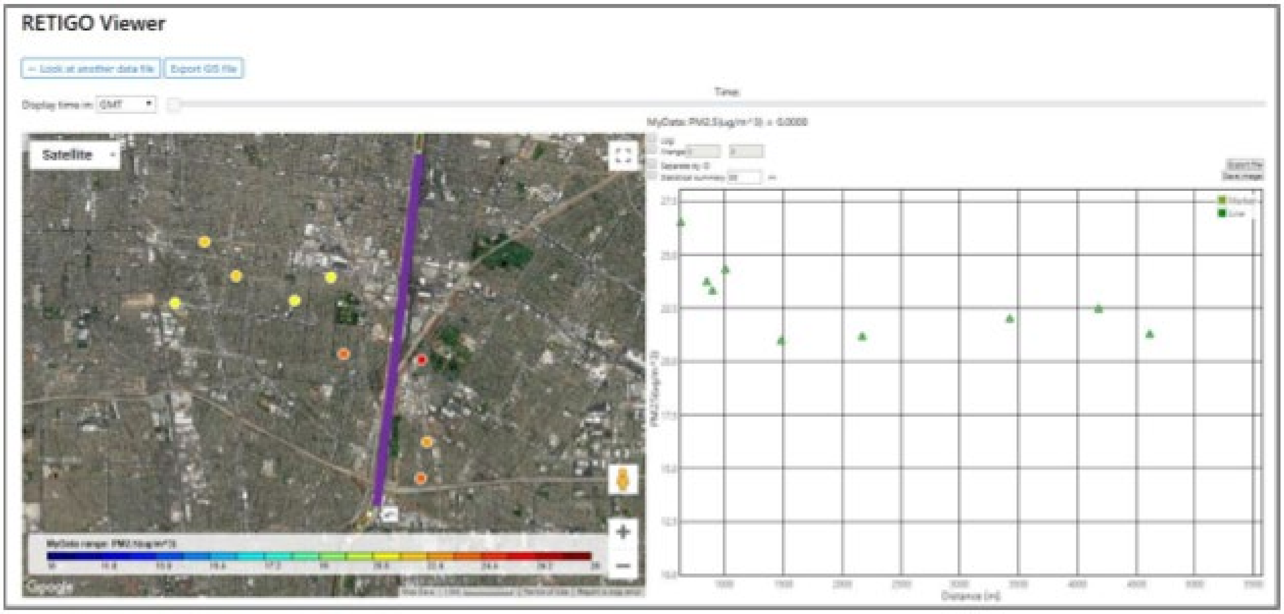
Contact for help: retigo@epa.gov

- This is a free, web-based tool that allows users to upload their air quality data and explore this data in maps and plots.
- This tool has a user friendly interface helpful for analyzing data, it can also produce nice visuals.
- Additionally the tool helps users look at how pollution levels change with respect to a particular point, line, or area that they can define. Users may also add in data from reference monitoring sites or wind speed/direction data which they can qualitatively compare to their sensor data.
- When uploading data, users have the option to share their dataset; meaning a single member of a community group could upload the data from all of the sensors in their network and attach key words (making the datasets easy to find), then any member of this community could more easily access the data and assist with analysis.
- The tool does not process sensor data to compare against the National Ambient Air Quality Standards (e.g., averaging PM to 24 hour intervals).
- More about RETIGO: https://www.epa.gov/hesc/real-time-geospatial-data-viewer-retigo

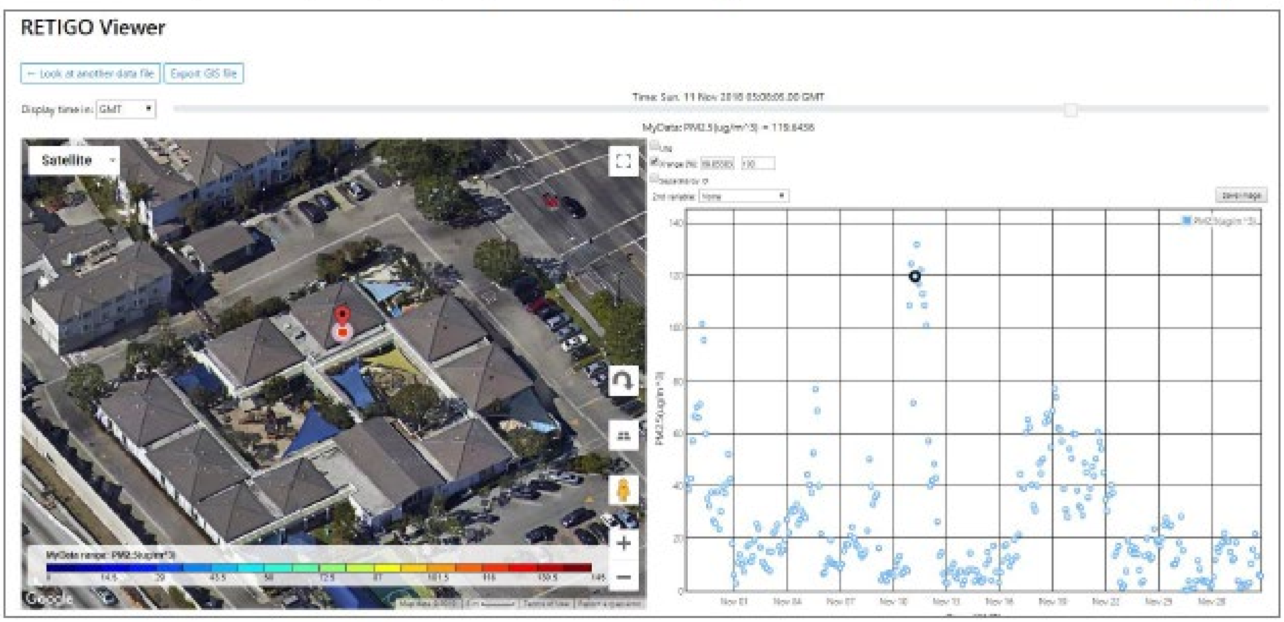
RETIGO Screenshot (source: US EPA, example of mobile data)



RETIGO Screenshot (source: AQ-SPEC, example of sensor network data with added analysis on the right illustrating pollutant levels in relation to the road highlighted in purple; in this example pollutant levels seem to be higher closer to the road)



RETIGO Screenshot (source: AQ-SPEC, example of sensor data from a single site with an interactive time series to the right)

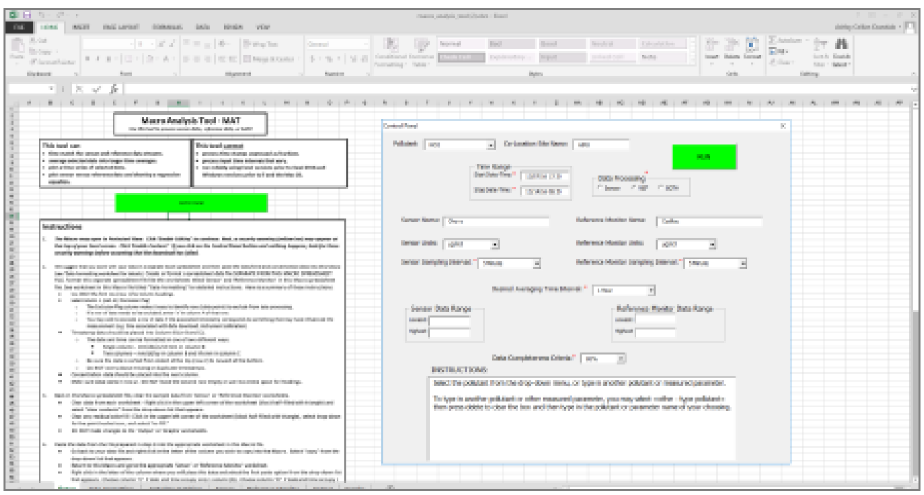


US EPA's "Excel-based Macro Analysis Tool for Air Sensor Data"

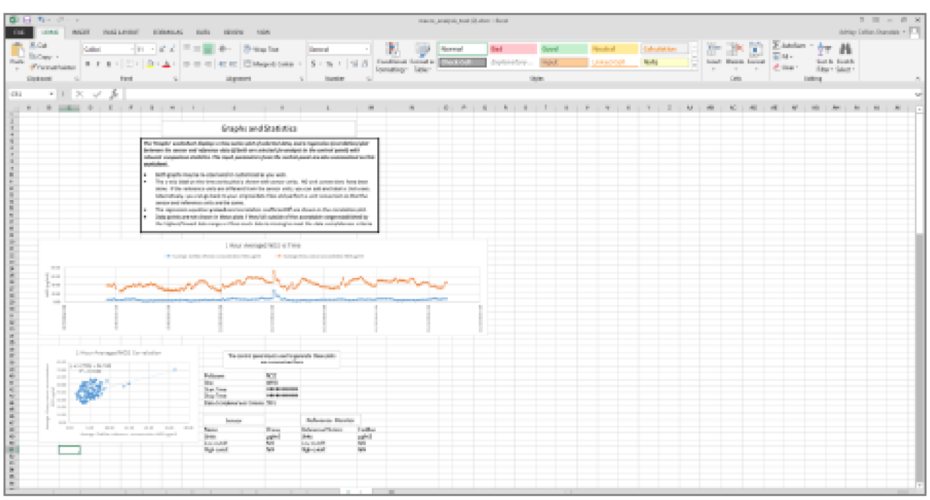
(developed by Terri Conner, Andrea Clements, Ronald Williams, Amanda Kaufman, et al.,)

- This tool was developed to help sensor users compare their low-cost sensor data to data from more reliable reference instruments, which is useful for understanding how well a sensor is performing.
- To use this tool, the user provides their sensor data as well as reference data and then the program time-averages the data, matches the two data sets in time, and runs a simple regression analysis.
- The final output of this program is a time series plot of the sensor and reference data, and a scatter plot depicting the regression analysis. The program also shares quantitative statistics indicating how well or poorly the sensor data matches the reference data.
- More on the Macro Tool: https://www.epa.gov/air-research/instruction-guide-and-macro-analysis-tool-evaluating-low-cost-air-sensors-collocation

Screenshot of the Macro Tool (Source: AQ-SPEC)



Screenshot of the Macro Tool Output (Source: AQ-SPEC, output generated using default data)



A Few Quick Notes Regarding Data Quality

- Low-cost sensors are still an emerging technology, which means they may not be as reliable or as accurate as conventional monitoring instruments and methods.
- It's always good to consider whether your sensor data is "realistic", for example data that remains at the same level for a long time likely indicates an issue with the sensor. Similarly, very high or even very low levels of pollution indicated by a sensor may be reflecting local air quality trends, however, it is also possible that the sensor is malfunctioning.
- At this point it is not appropriate to compare low-cost sensor data with health-based regulatory standards, due to the previously discussed issues with accuracy and reliability. The data used to determine whether or not regulatory standards are being met is not only collected with higher-cost and higher-quality instrumentation, but also this instrumentation must be sited according to very intentional and specific criteria, the instruments undergo strict and routine maintenance, and the data is evaluated according to specific protocols to ensure important decisions about public health are only made using the best and most reliable data. Given the current challenges with low-cost sensors, it is possible for sensor data to suggest there are high levels of pollution when in reality there are not. However, the reverse is also true, it is possible that sensors may miss important air quality issues. For this reason, it is vital that low-cost sensors are used along with higher quality instruments for verification and validation purposes.
- Another thing to keep in mind is that sensor manufacturers typically calibrate their sensors or apply correction factors to improve the accuracy of their sensors. In some cases, the user can adjust the calibration models if they wish. It is also possible for users to calculate and apply their own correction factors, if there is interest in improving the accuracy of sensors being used.
- Despite these apparent limitations, there is still a lot we can learn from low-cost sensors. For example, comparing levels across a network of sensors can help to highlight "hot-spots" that may have been previously unknown, comparing trends across sensors can also highlight anomalies potentially caused by local sources, and a better understanding of our local air quality can give us information that might help us to reduce our exposure.

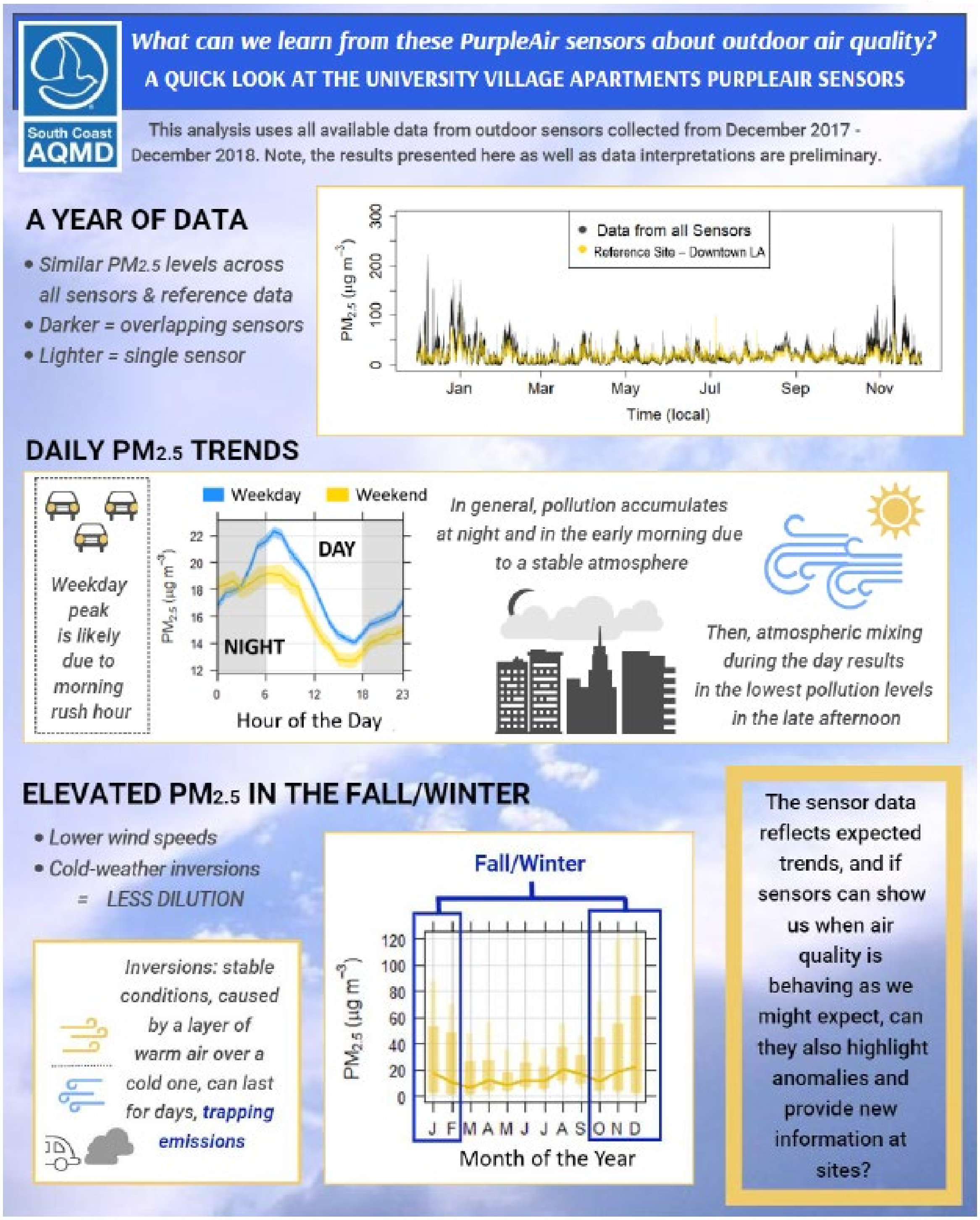
Read more about sensor calibration in the following resources:

The Air Sensor Guidebook, is a great resource in general and calibration specifically is discussed in Appendix C. (Available here: https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=519616&Lab=NERL)

The guide: "How to Evaluate Low-Cost Sensors by Collocation with Federal Reference Method Monitors", which accompanies the Macro Tool described above also provides great information.
(Available here: https://www.epa.gov/air-research/instruction-guide-and-macro-analysis-tool-evaluating-low-cost-air-sensors-collocation)

The following journal article provides an interesting and more advanced discussion around the use of complex algorithms in sensor calibration: Air Quality Sensors and Data Adjustment Algorithms: *When Is It No Longer a Measurement?* Gayle S. W. Hagler, Ronald Williams, Vasileios Papapostolou, and Andrea Polidori, Environmental Science & Technology. 2018, 52 (10), 5530-5531, DOI: 10.1021/acs.est.8b01826

Appendix E. Sample Infographic



February 2019 STAR Grant Workshop

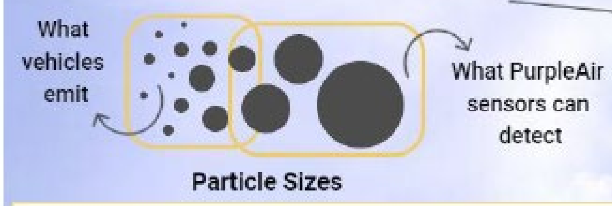
(turn over for page 2)

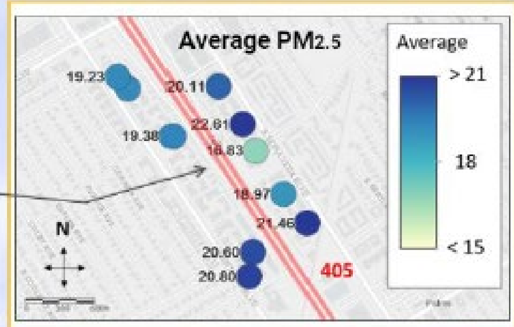
Page 2

What can we learn from these PurpleAir sensors about outdoor air quality?
A QUICK LOOK AT THE UNIVERSITY VILLAGE APARTMENTS PURPLEAIR SENSORS

SPATIAL DIFFERENCES

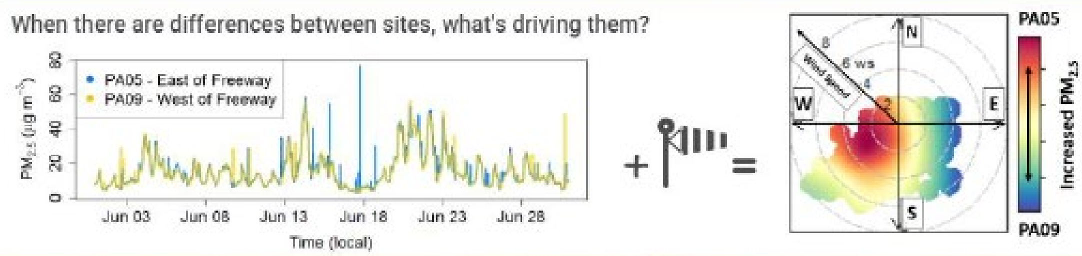
- *No clear differences in averages due to freeway (possibly due to sensor limitations - BELOW)*
- *Lower average PM at sites sheltered by walls and vegetation vs. roof tops (e.g., childcare facility)*





Units: µg/m^3

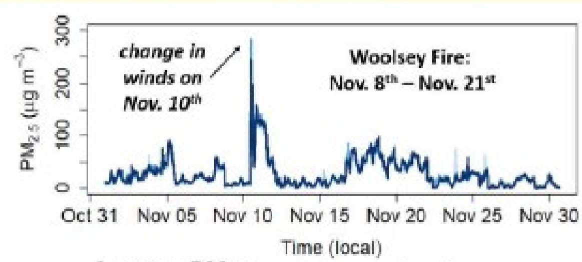
When there are differences between sites, what's driving them?

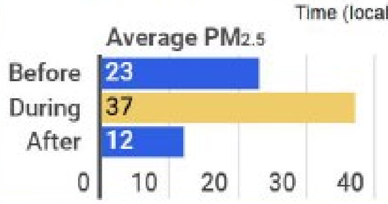


- *Polar plots tell us where emissions are likely coming from by adding wind speed & direction data*
- *Here, the spikes on the east are coming from the west, and vice versa*
- *Possible sources: traffic (emissions and/or road dust), cooking, outdoor grilling, or landscaping*

UNIQUE EMISSION EVENTS

- *Enhanced PM2.5 was observed when the fire was active*





For all sensors, through the month of November, before, during, and after the Woolsey fire
Units: µg m⁻³

> While it is important to keep in mind the limitations of the PurpleAir sensors and their nature as a low cost tool, they can provide indicative information about local air quality and air quality trends.

Conducted as part of the US EPA STAR Grant: "Engage, Educate and Empower California Communities on the Use and Applications of Low-cost Air Monitoring Sensors"

Feel free to contact us with questions:
Phone: +1 (909) 396-2713
Email: info.aq-spec@aqmd.gov

Appendix F. Installation Guide Template (For Other Sensors)

HINT: Keep the text minimal using bullets rather than paragraphs. For example, add a labeled photo or diagram for every step of the instructions (from mounting and powering the sensor to linking the device to the Wi-Fi, if appropriate).

Sensor Name:

Pollutant(s) Measured:

[add labeled photo of all parts and accessories]

Step 1 – Finding a Location and Installation *(adjust and add to this text as needed)*

- Look for a shady place, usually a north-facing part of the house, away from tall trees or other obstructions such as nearby homes or buildings. Note: Location will need a nearby power outlet and Wi-Fi signal.
- Mount sensor away from local sources of pollution (A/C units, vents, BBQs), unless the objective of the project is to measure a nearby source, in which case mount the sensor with line of sight to that source.
- Mount the sensor using either cable ties (railing) or a screw (beneath the roof edge). Ideally the sensor should be at least a couple of feet away from the nearest wall of the home or building. Note: The power supply should be mounted so it will not be submersed in water. Ensure that the cord is secured safely to avoid a tripping hazard.

Step 2 – Power and Setup the Sensor *(complete this section)*

- Provide step-by-step instructions with labeled photos for powering on the sensor
- Provide step-by-step instructions for any additional requirements (e.g., connecting to Wi-Fi and registering your sensor), see the PurpleAir Installation Guide as an example

Step 3 – Ensure the Sensor is Collecting Data *(complete this section)*

- Provide step-by-step instructions with labeled photos so the user to check if their sensor is successfully collecting data

Helpful Information:

- List troubleshooting help here for common issues with the sensor (see the PurpleAir Installation Guide as an example)

Appendix G. Project One-Pager Template

This template will help you to develop a resource that can be used to recruit project participants, project partners, or communicate about your activities with local regulatory agencies.

Title of the Project;

Project partners: (list here)

Project Overview

(Brief paragraph 3-4 sentences on (1) what you are doing and why you are including the project objectives, a rough timeline, and the approximate location/community, (2) note what sensors you are using, (3) describe your tentative plan for the data or briefly sate how the data will be used.)

Sensor Technical Specifications

(Provide a bulleted list of the size/weight of each sensor, the power usage, other requirements such as a need for Wi-Fi; also include any additional requirements related to siting or using sensors, or anything else someone participating in the project or hosting the sensors might need to know)

*Add a photo of the sensor(s)

Contact Information

(Include the appropriate contact information for more information about the project, or if troubleshooting of sensors is required.)

*Additional optional information: if this form is being used to recruit sensor users, be sure to include all of the actions they are committing to on their side, as well as any compensation they will receive for participating.

Appendix H. Blank Log Notes Form

Community Scientist Log Notes Form

Use this form to conveniently note your air quality observations.

1. Date & Time: Location:
2. How does the air quality seem to you? (circle the an option below)

   Hazardous Very Unhealthy Unhealthy Moderate Good
3. Describe the air quality, what do you…

   See (e.g., blue skies, haze, etc.):

   Smell (e.g., fresh air, smoke, etc.):

   Hear (e.g., strange sounds, like machinery):
4. If this is an air quality event, do you see any potential sources or causes? Yes No

   If so, please explain:
5. Any other notes?

Community Scientist Log Notes Form

Use this form to conveniently note your air quality observations.

1. Date & Time: Location:
2. How does the air quality seem to you? (circle the an option below)

   Hazardous Very Unhealthy Unhealthy Moderate Good
3. Describe the air quality, what do you…

   See (e.g., blue skies, smoke, haze, etc.):

   Smell (e.g., fresh air, smoke, chemicals, etc.):

   Hear (e.g., relevant sounds, like-machinery):
4. If this is an air quality event, do you see any potential sources or causes? Yes No

   If so, please explain:
5. Any other notes?

Appendix I. Release of Liability Sample

RELEASE OF LIABILITY

READ CAREFULLY – THIS AFFECTS YOUR LEGAL RIGHTS

In exchange for participation in the activity of hosting an air particle monitor in my home organized by [project leaders and/or lead organizations],

I, ______________________________ [include name and other important identifying information (e.g., business name if applicable)], agree for myself and (if applicable) for members of my family, to the following:

1. AGREEMENT TO FOLLOW DIRECTIONS. I agree to follow any written or oral instructions or directions given by the representative of the [project title or lead organizations] with respect to the placement, operation, and maintenance of the air particle monitor to be placed in my home. I agree to return the [sensor device] if requested to the [project title or lead organizations] at the end of the activity period.

2. ASSUMPTION OF THE RISKS AND RELEASE. I recognize that there may be certain unforeseen risks associated with the above described activity and I assume full responsibility for personal injury to myself and (if applicable) my family members, and further release and discharge the [project leaders and/or lead organizations] for injury, loss or damage arising out of my or my family's use of the [sensor device], whether caused by the fault of myself, my family, the [project leaders and/or lead organizations].

3. INDEMNIFICATION. I agree to indemnify and defend the [project leaders and/or lead organizations] against all claims, causes of action, damages, judgments, costs or expenses, including attorney fees and other litigation costs, which may in any way arise from my or my family's use of the [sensor device].

4. APPLICABLE LAW. Any legal or equitable claim that may arise from participation in the above shall be resolved under California law.

5. NO DURESS. I agree and acknowledge that I am under no pressure or duress to sign this Agreement and that I have been given a reasonable opportunity to review it before signing. I further agree and acknowledge that I am free to have my own legal counsel review this Agreement if I so desire. I further agree and acknowledge that

6. The [project leaders and/or lead organizations] will not pay me nor will I pay any of them anything in order to participate in this activity.

7. ARM'S LENGTH AGREEMENT. This agreement and each of its terms are the product of an arm's length negotiation between the Parties. In the event any ambiguity is found to exist in the interpretation of this Agreement, or any of its provisions, the Parties, and each of them, explicitly reject the application of any legal or equitable rule of interpretation which would lead to a construction either "for" or "against" a particular party based on their status as the drafter of a specific term, language, or provision giving rise to such ambiguity.

8. ENFORCEABILITY. The invalidity or unenforceability of any provision of this Agreement, whether standing alone or as applied to the particular occurrence or circumstance, shall not affect the validity or enforceability of any other provision of this Agreement or of any other applications of such provision, as the case may be, and such invalid or unenforceable provision shall be deemed not to be a part of this Agreement.

9. EMERGENCY CONTACT. In case of an emergency, please call [project contact and phone number].

10. I agree to use the information derived from the use of the air quality monitor device in a responsible way and will not expect nor request that [include any lead or partner organizations as appropriate] or take any action in response to whatever the information may disclose. I understand that there are appropriate governmental bodies and private companies who may be able to address any concerns I may have based on the information.

I HAVE READ THIS DOCUMENT AND UNDERSTAND IT. I FURTHER UNDERSTAND THAT BY SIGNING THIS RELEASE, I VOLUNTARILY SURRENDER CERTAIN LEGAL RIGHTS.

Signature:_________________________ Dated:______________________

Print Name:________________________

Witness: __________________________ Dated:______________________

Appendix J. Local Regulatory Agency Contacts (Sample List)

The list below is an example based on contact information from October 2020. A web search can help you locate your local regulatory agency's "Contact Us" page (or equivalent information) to get started. To find the name of your local air quality/natural resource board or agency, a good place to start is the Association of Air Pollution Control Agencies (https://cleanairact.org/) or the National Association for Clean Air Agencies (http://www.4cleanair.org/).

Agency	Phone	Email
Bay Area AQMD Includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, and Santa Clara counties, and the western portion of Solano and southern portion of Sonoma counties	(415) 749-5000 1.800.HELP AIR	No email listed For Technical Services: contact the Meteorology & Measurements Program at 415.749.4985
California Air Resources Board Includes the state of California	(800) 242-4450	helpline@arb.ca.gov
CalEPA Includes the state of California	(916) 323-2514	cepacomm@calepa.ca.gov
EPA Region 9 Includes Arizona, California, Hawaii, Nevada, Pacific Islands, and 148 Tribes	(866)-EPA-WEST (866)-372-9378	r9.info@epa.gov
Imperial County APCD Includes all of Imperial County	(442) 265-1800	
San Diego County APCD Includes all of San Diego County	(858) 586-2600	airinfo@sdcounty.ca.gov
San Joaquin Valley APCD Includes all of Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, and Valley air basin portions of Kern counties	(559) 230-6000	sjvapcd@valleyair.org
San Luis Obispo County APCD Includes all of San Luis Obispo County	(805) 781-5912	info@slocleanair.org

Agency	Phone	Email
Santa Barbara County APCD Includes all of Santa Barbara County	(805) 961-8800	apcd@sbcapcd.org
South Coast AQMD Includes Los Angeles County except for areas covered by the Antelope Valley AQMD, Orange County, and the western portion of San Bernardino and Riverside counties	(909) 396-2713	info.aq-spec@aqmd.gov

Appendix K. Examples of Sensor Performance

The table below provides a detailed discussion of application-specific considerations regarding sensor performance and several examples of relevant pollutant concentrations based on past studies. Note, these examples should be considered an initial reference only, and what you see during your project may vary.

References for Table K-1:

1 Hasheminassab, S., Pakbin, P., Delfino, R. J., Schauer, J. J., & Sioutas, C. (2014). Diurnal and seasonal trends in the apparent density of ambient fine and coarse particles in Los Angeles. *Environmental pollution*, 187, 1-9. https://www.sciencedirect.com/science/article/pii/S0269749113006489

2 Asimakopoulos, D. N., Flocas, H. A., Maggos, T., & Vasilakos, C. (2012). The role of meteorology on different sized aerosol fractions (PM10, PM2. 5, PM2. 5–10). *Science of the Total Environment*, 419, 124-135. https://www.sciencedirect.com/science/article/pii/S0048969711015300

3 Vingarzan, R. (2004). A review of surface ozone background levels and trends. *Atmospheric environment*, 38(21), 3431-3442. https://www.sciencedirect.com/science/article/pii/S1352231004002808

4 Paoletti, E., De Marco, A., Beddows, D. C., Harrison, R. M., & Manning, W. J. (2014). Ozone levels in European and USA cities are increasing more than at rural sites, while peak values are decreasing. *Environmental Pollution*, 192, 295-299. https://www.sciencedirect.com/science/article/pii/S0269749114002073

5 Sillman, S. (1999). The relation between ozone, NOx and hydrocarbons in urban and polluted rural environments. *Atmospheric Environment*, 33(12), 1821-1845. https://www.sciencedirect.com/science/article/pii/S1352231098003458

6 Trends in Atmospheric Carbon Dioxide, NOAA Global Monitoring Laboratory, https://www.esrl.noaa.gov/gmd/ccgg/trends/mlo.html

7 Trends in Atmospheric Methane, NOAA Global Monitoring Laboratory, https://www.esrl.noaa.gov/gmd/ccgg/trends_ch4/

8 Pinto, J. P., Lefohn, A. S., & Shadwick, D. S. (2004). Spatial variability of PM2. 5 in urban areas in the United States. *Journal of the Air & Waste Management Association*, 54(4), 440-449. https://www.tandfonline.com/doi/abs/10.1080/10473289.2004.10470919

9 Lyman, S., & Tran, T. (2015). Inversion structure and winter ozone distribution in the Uintah Basin, Utah, USA. *Atmospheric Environment*, 123, 156-165. https://www.sciencedirect.com/science/article/pii/S1352231015304842

10 He, C., Morawska, L., Hitchins, J., & Gilbert, D. (2004). Contribution from indoor sources to particle number and mass concentrations in residential houses. *Atmospheric*

environment, 38(21), 3405-3415.
https://www.sciencedirect.com/science/article/pii/S135223100400250X

11 Fazli, T., & Stephens, B. (2018). Development of a nationally representative set of combined building energy and indoor air quality models for US residences. *Building and Environment*, 136, 198-212.
https://www.sciencedirect.com/science/article/pii/S0360132318301823#appsec1

12 Pickett, A. R., & Bell, M. L. (2011). Assessment of indoor air pollution in homes with infants. *International journal of environmental research and public health*, 8(12), 4502-4520.
https://www.mdpi.com/1660-4601/8/12/4502/htm

13 Indoor Air Quality (IAQ), US EPA, https://www.epa.gov/indoor-air-quality-iaq/how-much-ventilation-do-i-need-my-home-improve-indoor-air-quality

14 Guo, H., Morawska, L., He, C., & Gilbert, D. (2008). Impact of ventilation scenario on air exchange rates and on indoor particle number concentrations in an air-conditioned classroom. *Atmospheric Environment*, 42(4), 757-768.
https://www.sciencedirect.com/science/article/pii/S1352231007008758

15 Thoma, E. D., Brantley, H. L., Oliver, K. D., Whitaker, D. A., Mukerjee, S., Mitchell, B., & Gross-Davis, C. A. (2016). South Philadelphia passive sampler and sensor study. *Journal of the Air & Waste Management Association*, 66(10), 959-970.
https://www.tandfonline.com/doi/full/10.1080/10962247.2016.1184724

16 Brantley, H. L., Hagler, G. S. W., Kimbrough, E. S., Williams, R. W., Mukerjee, S., & Neas, L. M. (2014). Mobile air monitoring data-processing strategies and effects on spatial air pollution trends. *Atmospheric measurement techniques*, 7(7), 2169-2183. https://www.atmos-meas-tech.net/7/2169/2014/amt-7-2169-2014.pdf

17 Apte, J. S., Messier, K. P., Gani, S., Brauer, M., Kirchstetter, T. W., Lunden, M. M., & Hamburg, S. P. (2017). High-resolution air pollution mapping with Google street view cars: exploiting big data. *Environmental science & technology*, 51(12), 6999-7008.
https://pubs.acs.org/doi/abs/10.1021/acs.est.7b00891

18 Lim, S., Kim, J., Kim, T., Lee, K., Yang, W., Jun, S., & Yu, S. (2012). Personal exposures to PM2. 5 and their relationships with microenvironmental concentrations. *Atmospheric environment*, 47, 407-412. https://www.sciencedirect.com/science/article/pii/S1352231011011228

Table K-1. Measurement Metric Considerations for Different Application Types.

Application	LDL (Lower Detection Limit) and Effective Ranges	Accuracy & Precision	Response Time
Outdoor, Ambient	When selecting a sensor for outdoor ambient measurements, it is important to understand the expected pollutant range. For this application, the expected pollutant range is likely to be small, relative to the variations that might occur indoors or near a source. Additionally, variations in pollutant levels are likely to occur on daily and seasonal timescales. As an example, studies in urban and suburban areas have found that $PM_{2.5}$ levels tend to vary from ~10 – 25 µg/m^3 daily [1,2]. The expected range will depend heavily on your location. Ozone generally fluctuates between background levels of ~20 ppb to 60 ppb [3]. However, peaks up to and beyond 100 ppb may be observed [3,4]. Ozone minimum levels are likely to be much lower than 20 ppb in urban areas as a result of atmospheric chemistry [5]. For some pollutants, there is also a global background level to consider. The current global background concentrations for CO_2 and methane (CH_4) are approximately 410 ppm and 1.8 ppm respectively [6,7]. Use tools like the ones	Consider the level of difference in pollutant concentrations that you would like to be able to confidently detect to guide your review of accuracy and precision for potential sensors. A study comparing 90th percentile differences in absolute $PM_{2.5}$ concentrations across different cities found differences ranging from 14 to 108 µg/m^3 between sites [8]. A more extreme example of ozone spatial variability was seen in one study where differences in the 4th highest daily maximum 8-hr ozone average were on the order of ~70 ppb over a distance of ~50 km [9]. Variability in ozone concentrations is generally much smaller than this example because ozone is a regionally distributed pollutant.	Trends in ambient air pollution tend to occur over longer time frames, such as days or seasons. If you are trying to understand these trends and how they vary over time or across different locations, consider comparing daily trends, weekday/weekend trends, and/or seasonal trends. For these larger timescales you may be able to use a sensor with longer averaging times or lower temporal resolution (e.g., a sensor that provides data on a 15-minute or hourly timescale).

Application	LDL (Lower Detection Limit) and Effective Ranges	Accuracy & Precision	Response Time
	described in Section 3.2.2 to gain an understanding of the typical ranges of pollutants in your area.		
Indoor Air Quality	Pollutants can accumulate in an indoor environment more so than in an outdoor environment. Therefore, you may see larger ranges of pollutant concentrations indoors. The US EPA states that pollutant concentrations are likely to be at least 2 to 5 times higher indoors. As an example, one study measuring during cooking events found $PM_{2.5}$ peaks ranging from 13 to 745 µg/m^3 [10]. Another study found that homes with gas stoves generally had NO_2 levels 1.2 to 3.2 times higher than outdoor levels [11]. A third study found hourly average values of CO and CO_2 ranged from 0.37 to 1.9 ppm and 412 to 1194 ppm, respectively [12].	The preferred accuracy and precision needed for an indoor air quality monitoring project will depend on what level of difference in pollutants you would like to be able to confidently predict. Given the large variability in pollutant ranges and accumulation in different indoor environments, accuracy and precision needs will vary. Consider your pollutant of interest, potential sources in the indoor environment, ventilation, and potential for accumulation.	Indoor environments can result in both the accumulation of pollutants as well as the slower dispersal of these accumulated pollutants. The rate at which dispersal occurs is typically governed by ventilation. As an example, ASHRAE recommends a minimum of 0.35 air changes per hour for residential environments [13], but air exchange rate can vary quite a bit in different indoor environments. For example, a study on the impact of different ventilation scenarios on indoor air quality in classrooms found air exchange rates varying from 0.12 to 7.9 changes per hour [14]. Changes in pollutant levels indoors are likely to occur more slowly than they would outdoors.
Outdoor, Near-source	When making near-source measurements, the changes in concentration from source emissions will be in addition to typical concentrations farther away from the source. These background concentrations vary daily and seasonally. Thus, take into consideration a sensor's ability to measure both the typical pollutant range and higher concentrations. In a fence line study at a	Consider what accuracy and precision would be needed for you to confidently distinguish between typical daily fluctuations and unusual events or increases in pollutant levels from a local source of interest. Try researching past studies on the same type of source you are interested in to help you anticipate what the data may look like and what concentrations you might see.	The impact of the emissions from a source may vary. For example, a continuous leak may result in a continuing increase in pollutant levels (above what is typical or expected). Alternatively, short-term events may also occur resulting in increases on much smaller timescales; this is what was seen in the refinery fence line study with increases occurring on the order of minutes [15]. Thus, sensors with faster

Application	LDL (Lower Detection Limit) and Effective Ranges	Accuracy & Precision	Response Time
	refinery, researchers found that benzene could be 20 to 100 times higher than measured background levels [15]. Concentration enhancements by other sources may be much smaller.		response and higher temporal resolution can help capture these short-term events (such as minute or sub-minute data).
Outdoor, Mobile (Personal Monitoring While Walking/ Jogging, or on a Vehicle)	Similar to near-source scenarios, measurements may include both typical trends (e.g., daily) and higher concentrations coming directly from nearby sources (e.g., vehicles). The measurements may be even more dynamic as the measurement device is in motion, especially at higher speeds. In these situations, concentration ranges are likely to change quickly. Examples of pollutant concentration ranges recorded during on-road studies included ~400 to 10,000 ppb for CO [16], and ~10 to 40 ppb for NO_2 [17].	For mobile monitoring, the needed accuracy and precision depend on the nature of the monitoring and the project objectives. Consider what situations you intend to compare and the potential differences in concentration that you hope to resolve. As an example, a study involving personal exposure monitoring observed the following average $PM_{2.5}$ values for various microclimates (in μg/m^3): residential – 13.4, transportation – 18.6, outdoor – 21.0, and restaurant – 188.5 [18]. For other types of mobile monitoring, consider whether you are interested in characterizing an area (e.g., mapping a community with repeated vehicle-based measurements) or recording short-term on-road dynamics of air quality (e.g., during a bicycle ride).	The ability to record data with high time resolution is even more important in this application. As an example, in the 'LDL and Effective Range' section the increase to the peak concentrations cited for CO and NO_2 and the decrease back to baseline values sometimes occurred in under a minute [16,17]. Remember that the higher the speed you are traveling, the larger the spatial distance will be between measurements.

Appendix L.

User Guide for the AirSensor DataViewer

How clean is the air in my neighborhood?

Which days had the worst air quality last year?

Can I trust the data from this air sensor?

You can answer these questions and more using the AirSensor DataViewer!

South Coast AQMD AQ-SPEC Air Quality Sensor Performance Evaluation Center

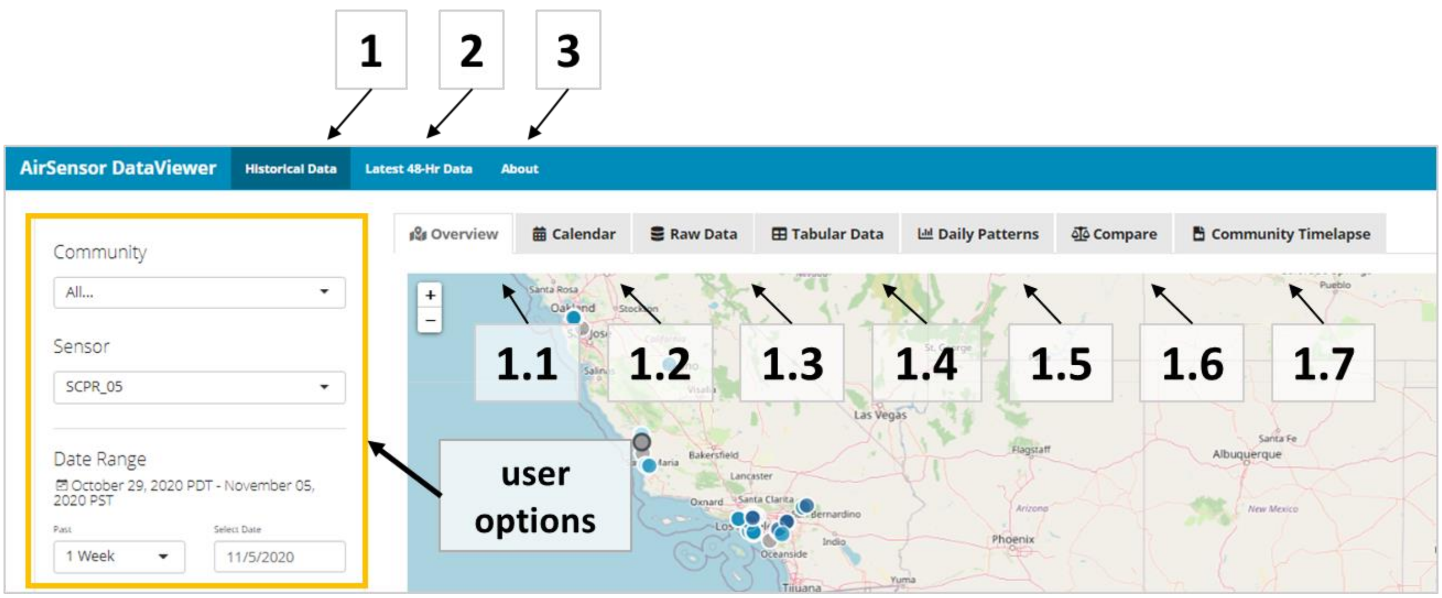
About the AirSensor DataViewer

Particulate matter sensors can answer questions about your local air quality. $PM_{2.5}$ includes particles that are 2.5 µm (micrometers) in aerodynamic diameter or smaller. These particles are of concern to human health because they are able to penetrate deep into the lungs and in some cases enter the bloodstream. The US EPA funded South Coast AQMD to develop tools that you can use to learn about the levels of $PM_{2.5}$ mass concentrations (µg/m^3; micrograms per cubic meter of air) in your area.

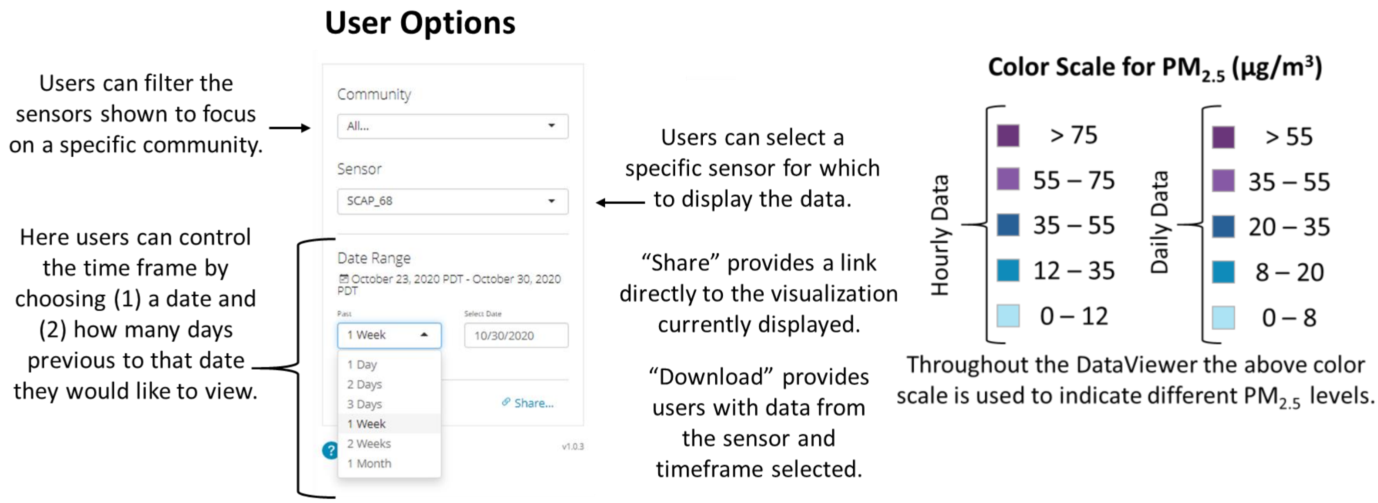
The Science To Achieve Results (STAR) Grant provided funds to deploy networks of sensors in California communities. This guide will show you how to use the AirSensor DataViewer, which displays publicly accessible $PM_{2.5}$ data from PurpleAir PA-II sensors deployed under the STAR Grant. You can focus on sensors in a specific community, search for $PM_{2.5}$ data on specific dates, and discover local pollution patterns. The AirSensor DataViewer can generate visuals and graphs that help you interpret your data. If you have questions or comments about the AirSensor DataViewer, please contact the AQ-SPEC group at South Coast AQMD: http://www.aqmd.gov/aq-spec/contact.

Link to DataViewer Tool: http://tools.mazamascience.com:6709/asdv/test/

Overview of the interface:



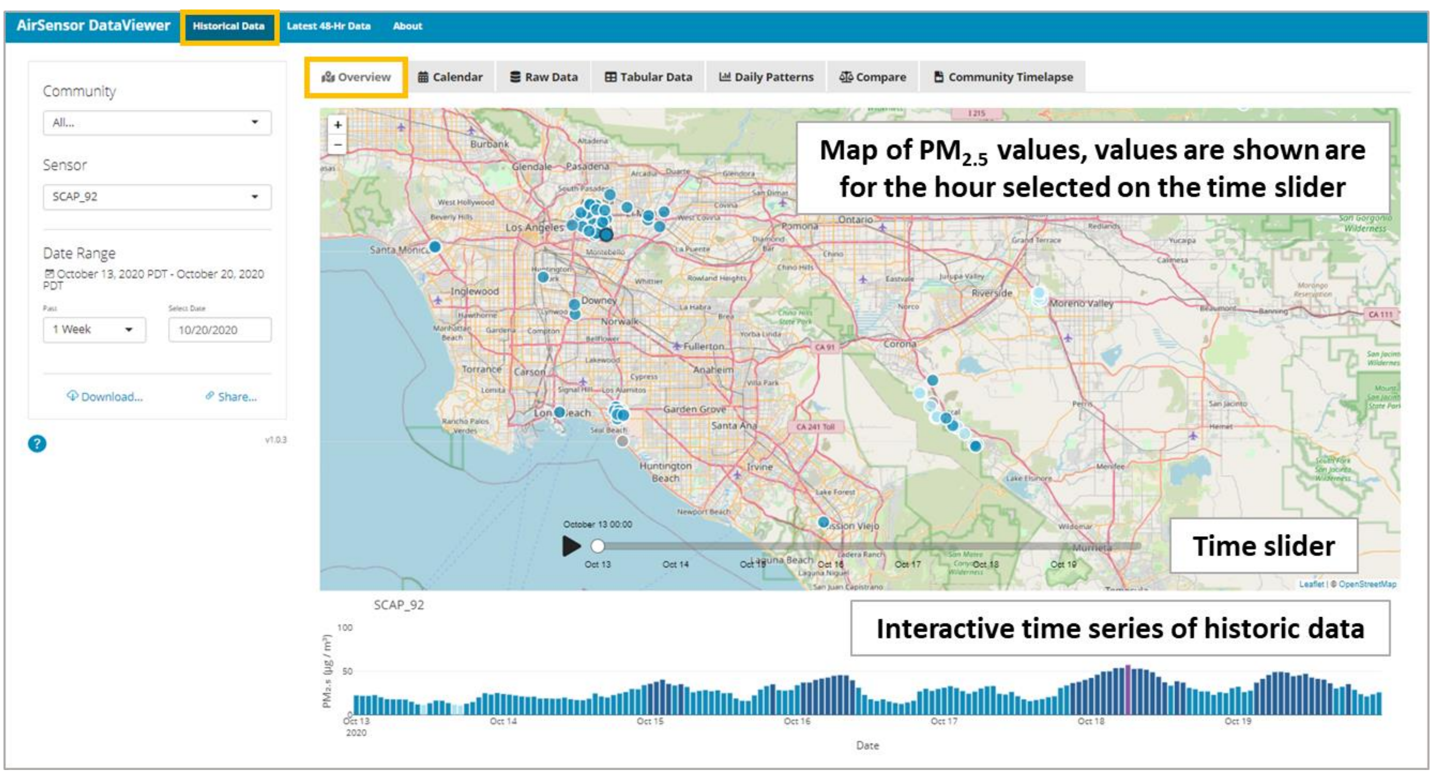
*At the top of the main/home page, there is a main menu bar that allows users to navigate between the **"Historical Data"**, **"Latest 48-Hr Data"**, and **"About"** pages. Below is a figure depicting the user options available on the "Overview tab" on the "Historical Data" page (on the left side of the tool). While available options will vary depending upon which tab is currently selected, the figure provides an idea of the user options available. Also depicted is the color scale used throughout the tool to illustrate pollutant levels.*



1. *The **"Historical Data"** page is where users can analyze sensor data using a variety of different data visualizations, each tab leads to a different visualization.*

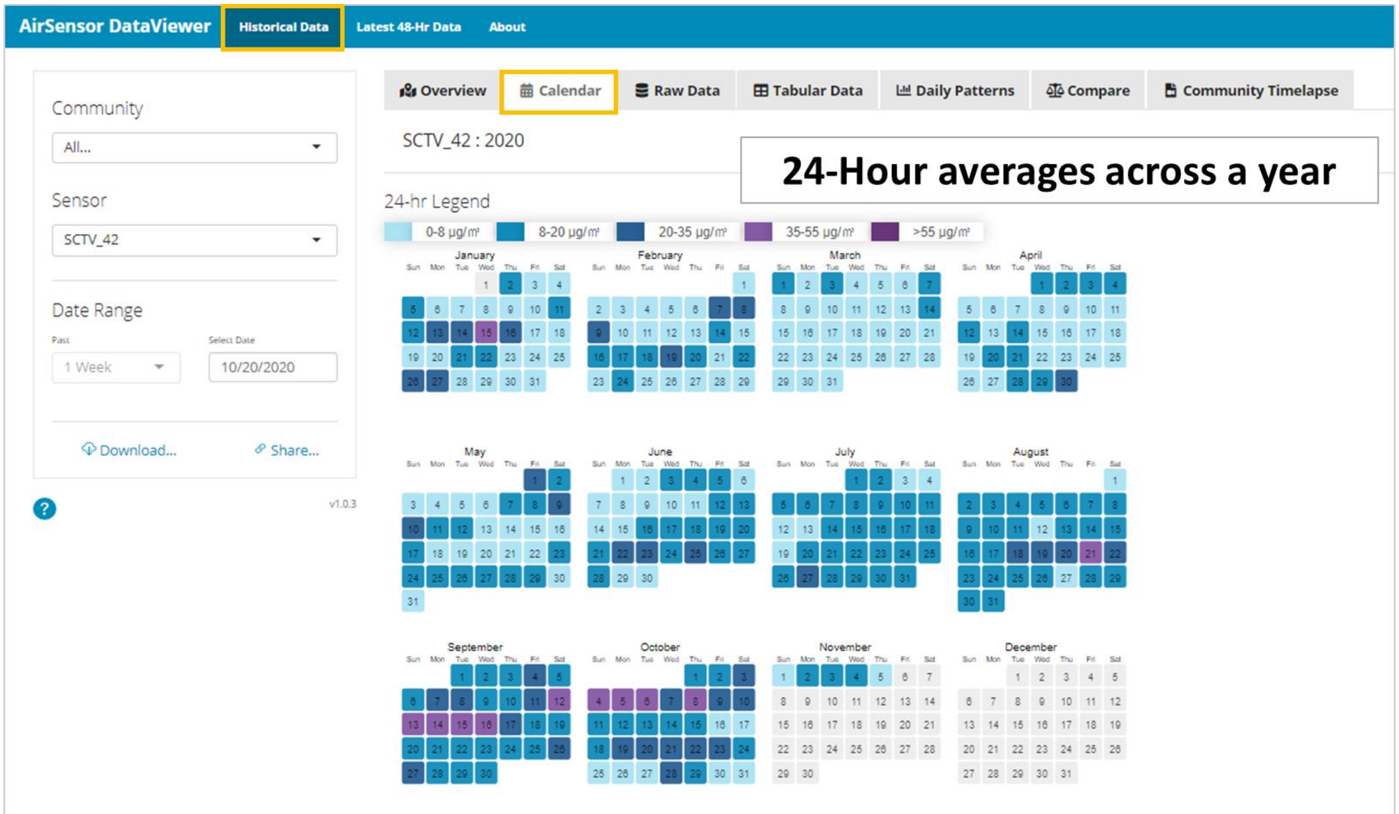
1.1 *There are different ways you can use this tool to analyze your data.*

- *Beginning with the **"Overview"** tab on the **"Historical Data"** page, a map illustrates where sensors are located and provides a customizable and interactive time series. Sensors are located in West Los Angeles, Alhambra/Monterey Park, El Monte, South Gate, Seal Beach, Redlands, Riverside, Sycamore Canyon, Temescal Valley, Imperial Valley, Nipomo, Paso Robles, Oakland and Richmond.*
- *Looking at the time series, consider how $PM_{2.5}$ levels have varied in the previous week or over the previous 30 days.*
- *You can also examine the effects of specific events on local $PM_{2.5}$, for example, how did 4th of July fireworks emissions impact your neighborhood?*



*1.2 The **“Calendar”** tab on the **“Historical Data”** page, provides an overview of the data from an entire year.*

- *Use this plot to spot interesting trends or events.*
- *How do $PM_{2.5}$ levels vary from season to season?*
- *Do the days where elevations in $PM_{2.5}$ occur correspond to days when you might expect elevated $PM_{2.5}$ levels?*

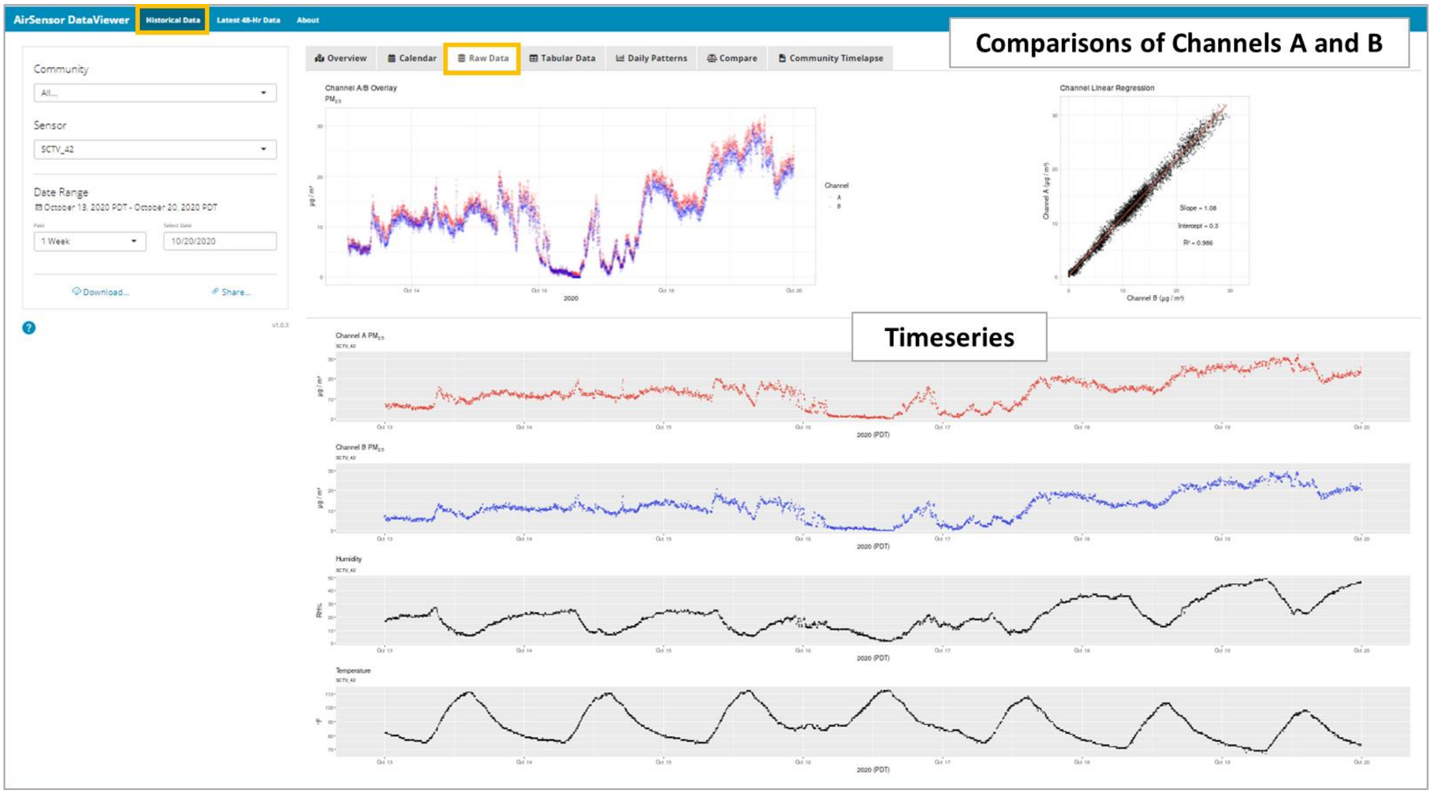


Usage:

- Select a sensor using the drop-down menus.
- The calendar shows the average daily $PM_{2.5}$ mass concentrations. The greater the $PM_{2.5}$ concentration, the darker the day is shaded. If the daily cell is white, a value was not recorded for the day. Hover over a specific day to view the exact 24-hour average $PM_{2.5}$ mass concentration.

1.3 *The **"Raw Data"** tab on the **"Historical Data"** page, displays the data available from each sensor prior to processing and QA/QC.*

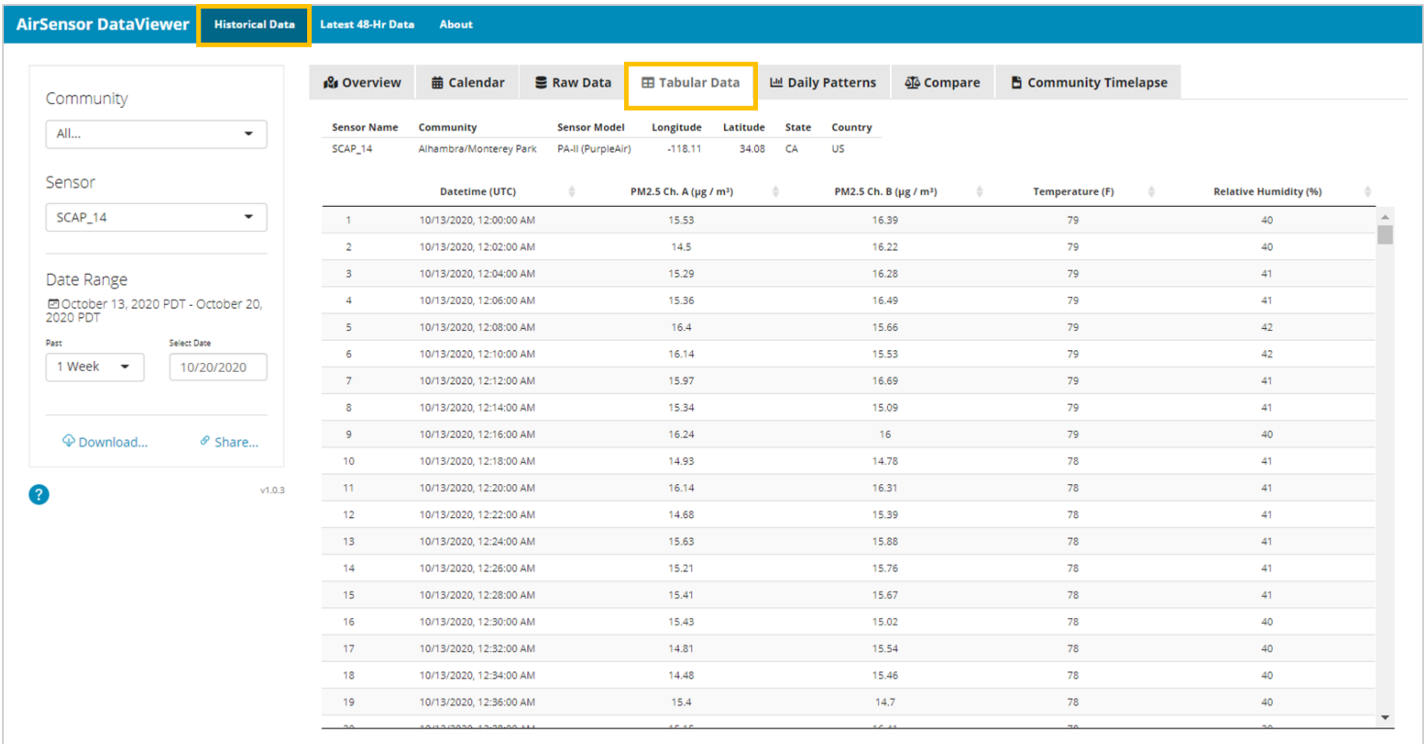
- *You'll notice that there are two graphs of $PM_{2.5}$ data labeled Channel A and Channel B, this is because there are two sensors inside each individual PurpleAir unit.*
- *For more information on Channels A and B data and the data processing please refer to the final page of this guide.*
- *At the bottom, this tab provides plots directly comparing Channels A and B, which may be used to better understand how well a sensor is functioning.*
- *Additionally, you can see temperature and humidity data in this tab.*



Usage:

- Select a sensor using the drop-down menus and select a timeframe using "Select Date" and "Past".
- The plots in this tab show the "raw data" (or data that comes directly from the sensor, before any time averaging or processing has been applied).
- Below the time series plots are two more plots that illustrate how well the two $PM_{2.5}$ signals from Channels A and B agree with each other – significant differences between the channels may be an indication that either one or both of the duplicate sensors is malfunctioning (agreement is signified by a 'Slope' and an R^2 close to 1.0).

1.4 The ***"Tabular Data"*** tab, on the ***"Historical Data"*** page, displays raw numeric data from the selected sensor in a table format. On this page, users can view, search, and download data from the specified period and from the selected sensor. You can also use this tool to view the precise values that occurred at specific times, for example to find the peak value on a given day.



Sensor Name	Community	Sensor Model	Longitude	Latitude	State	Country
SCAP_14	Alhambra/Monterey Park	PA-II (PurpleAir)	-118.11	34.08	CA	US

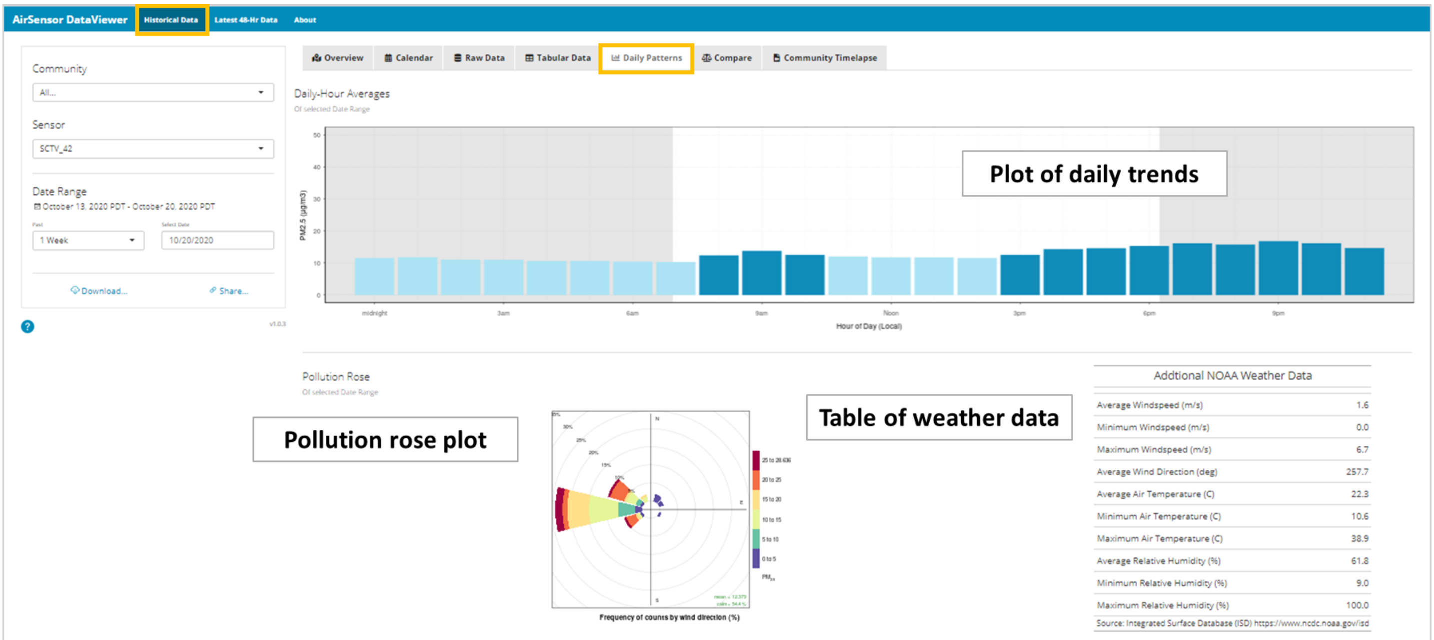
	Datetime (UTC)	PM2.5 Ch. A (µg / m³)	PM2.5 Ch. B (µg / m³)	Temperature (F)	Relative Humidity (%)
1	10/13/2020, 12:00:00 AM	15.53	16.39	79	40
2	10/13/2020, 12:02:00 AM	14.5	16.22	79	40
3	10/13/2020, 12:04:00 AM	15.29	16.28	79	41
4	10/13/2020, 12:06:00 AM	15.36	16.49	79	41
5	10/13/2020, 12:08:00 AM	16.4	15.66	79	42
6	10/13/2020, 12:10:00 AM	16.14	15.53	79	42
7	10/13/2020, 12:12:00 AM	15.97	16.69	79	41
8	10/13/2020, 12:14:00 AM	15.34	15.09	79	41
9	10/13/2020, 12:16:00 AM	16.24	16	79	40
10	10/13/2020, 12:18:00 AM	14.93	14.78	78	41
11	10/13/2020, 12:20:00 AM	16.14	16.31	78	41
12	10/13/2020, 12:22:00 AM	14.68	15.39	78	41
13	10/13/2020, 12:24:00 AM	15.63	15.88	78	41
14	10/13/2020, 12:26:00 AM	15.21	15.76	78	41
15	10/13/2020, 12:28:00 AM	15.41	15.67	78	41
16	10/13/2020, 12:30:00 AM	15.43	15.02	78	40
17	10/13/2020, 12:32:00 AM	14.81	15.54	78	40
18	10/13/2020, 12:34:00 AM	14.48	15.46	78	40
19	10/13/2020, 12:36:00 AM	15.4	14.7	78	40

Usage:

- Select a sensor using the drop-down menus and select a timeframe using "Select Date" and "Past".
- You can use the search bar in the top right to help you explore the data.
- You can also download the data as a .csv file.

1.5 *In the **"Daily Patterns"** tab on the **"Historical Data"** page, there is another plot to help reveal interesting trends as well as tables and plots providing supplemental weather data.*

- *Looking at the Daily Trends plot, is there a particular time of day when $PM_{2.5}$ is highest? When is $PM_{2.5}$ lowest?*
- *What can the pollution rose tell you about potential sources of $PM_{2.5}$?*
- *In a pollution rose, the shape summarizes where the wind was coming from during the specified period and the colors indicate where the wind was coming from when various pollutant concentrations were observed.*
- *Additionally, the table provides some statistics related to weather conditions, these can help you check whether rain may have occurred during the selected timeframe, or learn what the temperature highs and lows were.*

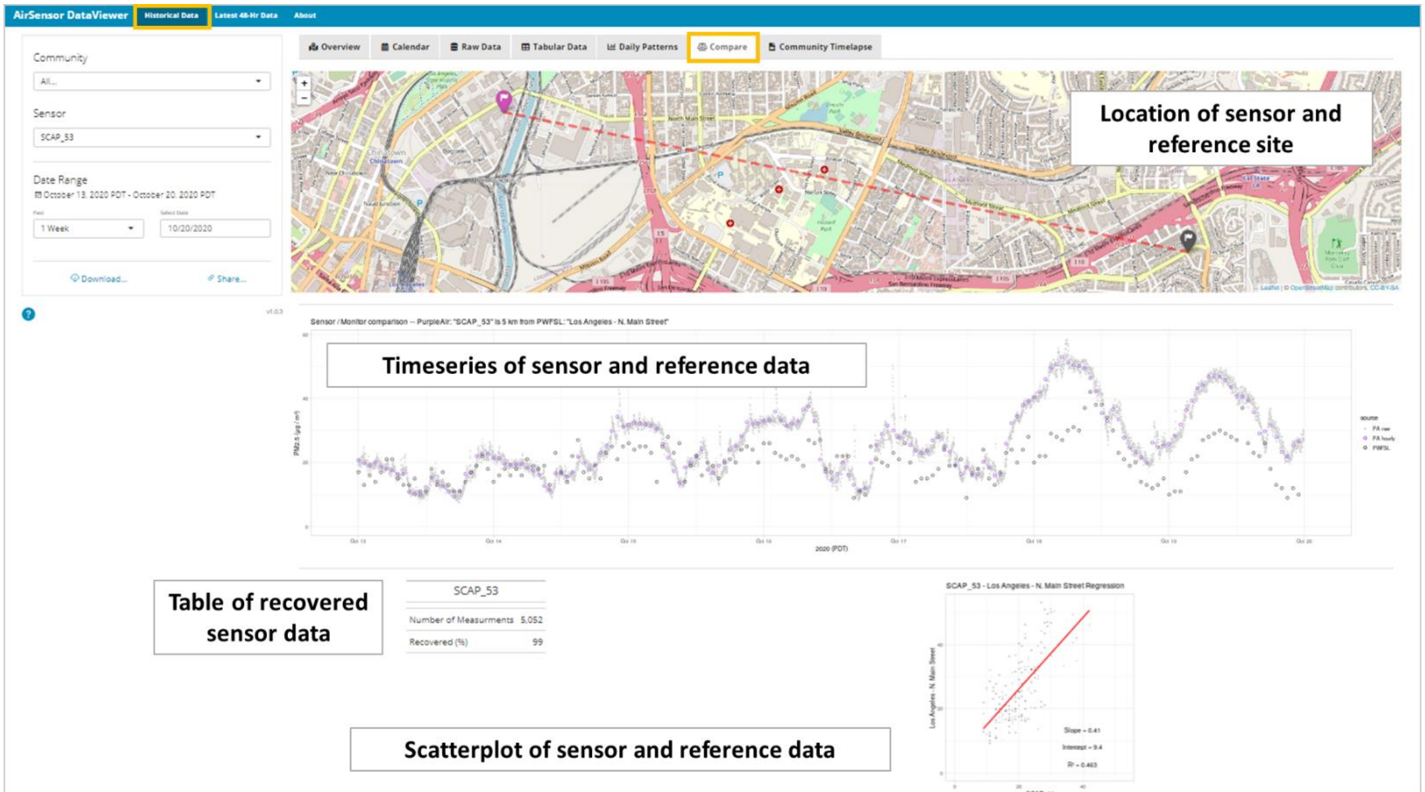


Usage:

- Select a sensor using the drop-down menus and select a timeframe using "Select Date" and "Past".
- The first plot shows the average for each hour of the day across the timeframe selected.
- Below the plot, the table of weather data and the pollution rose can provide additional useful information. For example, a high humidity value may be an indication that a precipitation event occurred in that timeframe while the pollution rose can illustrate the direction from which the wind was blowing when high or low $PM_{2.5}$ levels were observed – possibly providing some insight into potential sources.
- The weather data is accessed from the National Oceanic and Atmospheric Administration's (NOAA) Integrated Surface Database (ISD) using the worldmet R-package.

1.6 *The "**Compare"** tab on the **"Historical Data"** page, allows users to compare the data from a sensor to the data from the nearest reference site (or monitoring site operated and maintained by a government agency).*

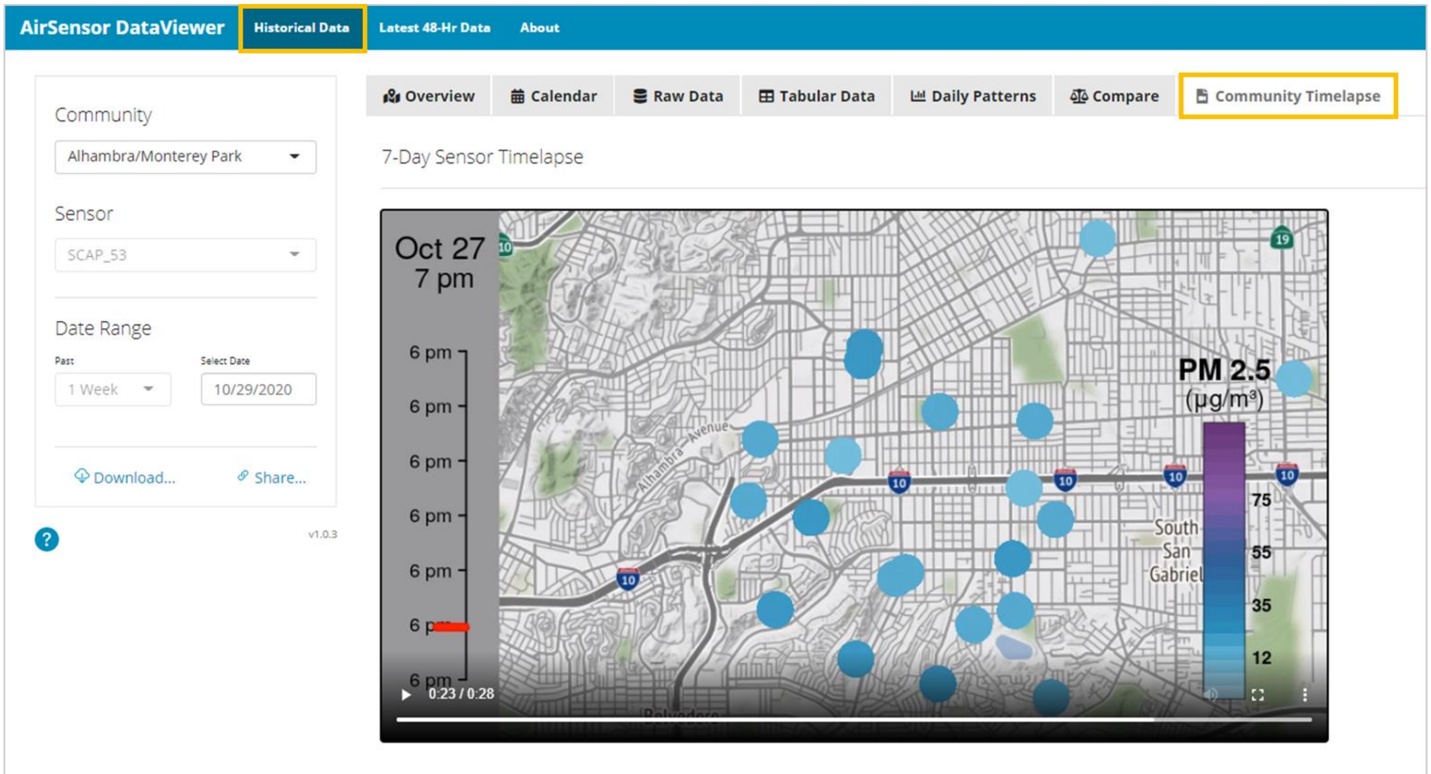
- *Consider, does the sensor data agree with the reference data in terms of trends and levels?*
- *If not, why might this be the case? Consider the distance to the reference site, the geography of the region, and potential sources nearer to one site or the other.*



Usage:

- Select a sensor to compare to the nearest reference site by clicking on the map or by using the drop-down menus, then select a timeframe using "Select Date" and "Past".
- The plots below the map illustrate (1) how well the sensor and nearest reference site agree with each other (see the 'Sensor-Monitor Correlation' plot) and (2) how the trends between the sensor and the reference site compare (see the 'Sensor-Monitor Comparison' plot). Remember, that many factors influence how similar or different the data may be from the two sources. This tab is intended for informational purposes and not to quantitatively assess the performance of an individual sensor.
- The distance between the reference site and the sensor is available on the map and it is stated in the title of the 'Sensor-Monitor Comparison' plot.
- In terms of the statistics, a slope close to 1.0 indicates that the low-cost sensor and the reference site are reflecting similar levels. A slope greater than 1.0 indicates that higher values are seen at the regulatory monitoring site and vice versa for a slope of less than 1.0. The intercept can be an indicator of bias (e.g., whether the sensor may be consistently under or over-predicting pollutant concentrations). The coefficient of determination R^2 tells us how well the trends agree between the two sites; an R^2 closer to 1.0 indicates more agreement and an R^2 closer to 0.0 indicates less agreement.
- There is also a sensor status table, which provides insight into how well the sensor is functioning. For example, if the percent of data recovered is small, then this may be an indication of a performance issue with the sensor.

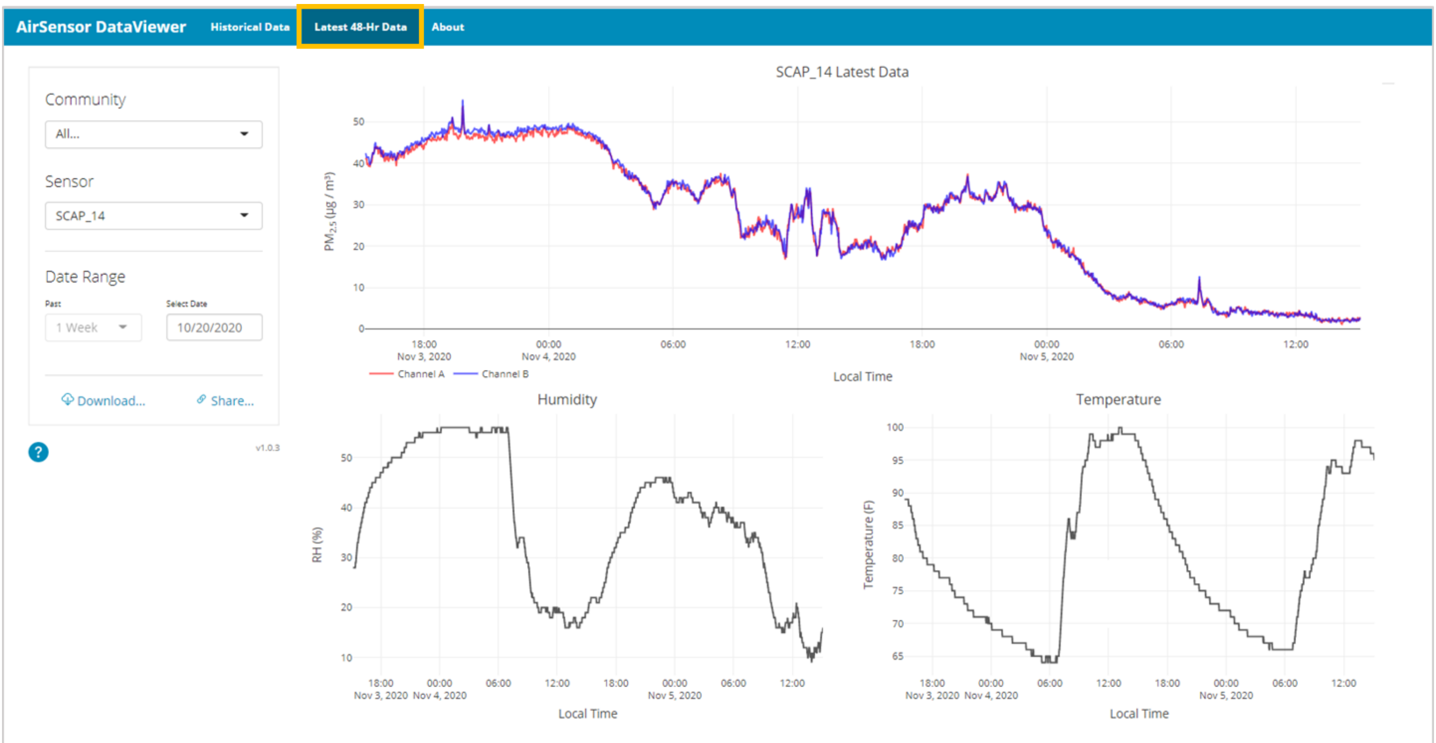
1.7 *The "**Timelapse**" tab on the **"Historical Data"** page, provides users with animations of PM$_{2.5}$ and how they change over time in each STAR Grant community. Are the changes consistent throughout the community? Do any sensors stand out?*



Usage:

- Select a community and a date in the panel on the left.
- Note that the date selected will be the end date of the time-lapse animation.
- The corresponding 7-day time-lapse illustrates the changes in PM$_{2.5}$ pollutant concentration over time.

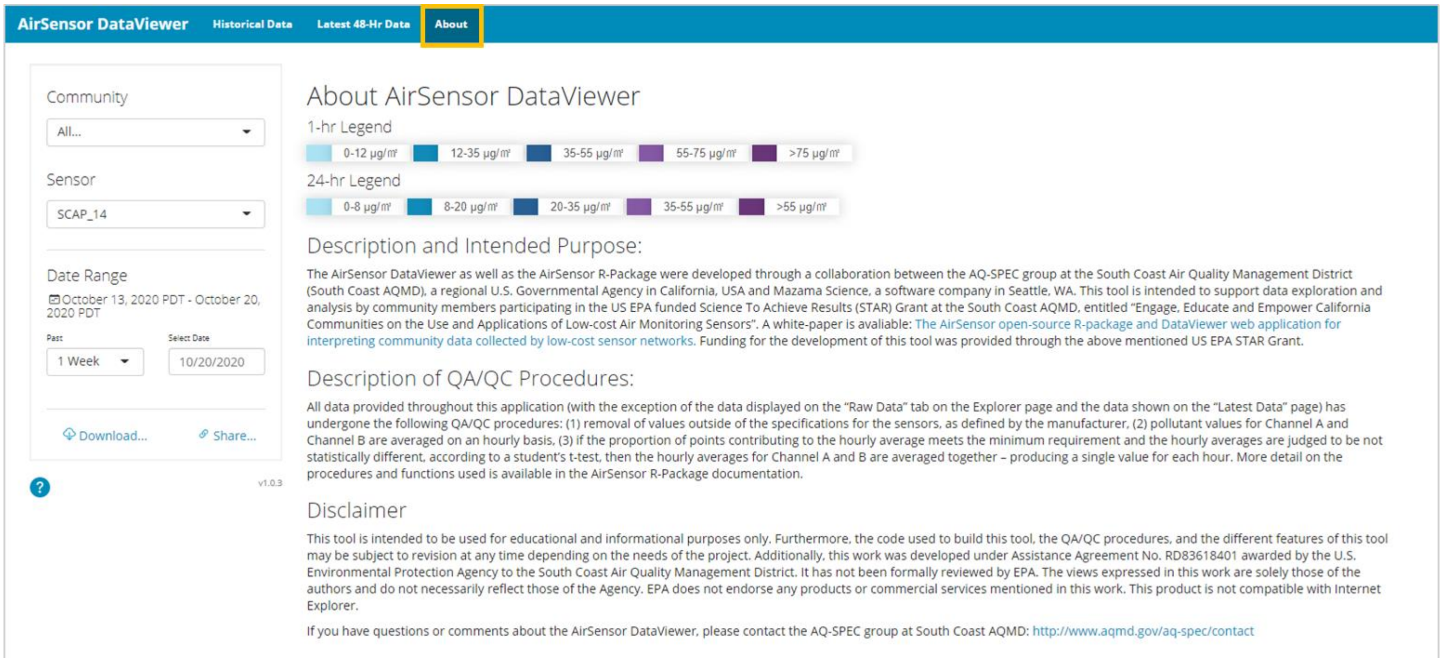
2. *On the **"Latest 48-Hr Data"** page, you can view the most recent data from the selected sensor. This page is a particularly useful reference during air quality events, for example when a sensor is detecting wildfire emissions. You can use this page to compare sensor data to your own observations about the air quality, such as what you see or smell. Consider whether your observations and the sensor data agree or disagree?*



Usage:

- Select a sensor using the drop-down menus and select a timeframe using "Select Date" and the most recent up-to-date data will automatically be shown.

3. *On the **"About"** page, you can find background information on the DataViewer and its intended purpose. You can also find a description of the QA/QC procedures applied and important disclaimer information.*



Information Regarding the Data Processing and QA/QC Procedures:

Raw Sensors
(i.e., Channel A and Channel B)

Each PurpleAir PA-II sensor unit includes two raw, duplicate sensors referred to as Channel A and Channel B. Processed data is data for which Channels A and B have been compared and averaged together. Unless otherwise stated, all the visuals in the DataViewer display processed data (averages of both Channels). Wherever unprocessed or "raw" data is shown (e.g., the "Raw Data" tab on the "Historical Data" page or on the "Latest 48-Hr Data" page), both Channel A and Channel B are shown separately. Processed data has undergone the following QA/QC procedures: (1) removal of values outside of the manufacturer defined specifications for the sensors, (2) pollutant values for Channel A and Channel B are averaged on an hourly basis, (3) if the proportion of points contributing to the hourly average meets the minimum requirement and the hourly averages are judged to be not statistically different, according to a student's t-test, then the hourly averages for Channels A and B are averaged together – producing a single value for each hour. More detail on the procedures and functions used is available in the AirSensor R-Package documentation (https://mazamascience.github.io/AirSensor/index.html).

South Coast AQMD AQ-SPEC Air Quality Sensor Performance Evaluation Center

Guide last updated: November 10, 2020

About the DataViewer

The DataViewer tool was built using the code and functionalities available in an open-source R package, called the AirSensor package. The DataViewer tool as well as the AirSensor R-Package were developed through a collaboration between the AQ-SPEC group at the South Coast Air Quality Management District (South Coast AQMD), a regional governmental agency in Southern California, and Mazama Science, a software company in Seattle, WA. This tool is intended to support data exploration and analysis by community members participating in the US EPA-funded Science To Achieve Results (STAR) Grant at the South Coast AQMD, entitled "Engage, Educate and Empower California Communities on the Use and Applications of Low-cost Air Monitoring Sensors." Funding for the development of this tool was provided through the abovementioned US EPA STAR Grant.

The tool accesses publicly available data from low-cost sensors in the Particulate Matter (PM) sensor (model PA-II, PurpleAir, Draper, UT) network associated with the STAR Grant project. Unless otherwise stated, the DataViewer displays processed, hourly-averaged $PM_{2.5}$ data. Processed data is data to which quality assurance and quality control (QA/QC) procedures have been applied in order to exclude data from sensors that may be malfunctioning.

A journal article is available introducing the AirSensor package and DataViewer web application: Feenstra, B., Collier-Oxandale, A., Papapostolou, V., Cocker, D., & Polidori, A. (2020). "The AirSensor open-source R-package and DataViewer web application for interpreting community data collected by low-cost sensor networks." Environmental Modelling & Software, 134, 104832. https://doi.org/10.1016/j.envsoft.2020.104832

Disclaimer

This tool is intended to be used for educational and informational purposes only. Furthermore, the code used to build this tool, the QA/QC procedures, and the different features of this tool may be subject to revision at any time depending on the needs of the project. This work was developed under Assistance Agreement No. RD83618401 awarded by the U.S. Environmental Protection Agency to the South Coast Air Quality Management District. It has not been formally reviewed by EPA. The views expressed in this work are solely those of the authors and do not necessarily reflect those of the Agency. EPA does not endorse any products or commercial services mentioned in this work.

Appendix M. Sample Community Reports and Resources

The AQ-SPEC website contains links to reports and resources created by partners and community participants: http://www.aqmd.gov/aq-spec/special-projects/star-grant. Some communities performed data analysis or developed resources to support engagement with the data.

- Report_PM2.5 Air Quality Trends at Mark Keppel High School. This report documented analysis to identify air quality trends and implement solutions for minimizing harmful health effects due to poor air quality. $PM_{2.5}$ data from March 2018-February 2019 for four PurpleAir sensors was converted to its air quality index (AQI) and analyzed for trends by hour, day of the week, and month. One finding was the recommendation for students to limit outdoor activity during 8 AM-10 AM, especially on Wednesdays.
- Report_the air you breathe_University of California Los Angeles. South Coast AQMD, UCLA researchers, and the University Apartments South Resident Association worked together to document findings from the air monitoring project at University Village Apartments. The apartments are located adjacent to a major freeway (I-405). Twelve PM sensors were installed outdoors in the community and 18 sensors were installed indoors. Findings include that residents can protect their indoor air quality by using their stove fan and opening windows during cooking and cleaning activities, using an air purifier, and turning on the HVAC system.
- Report_Interpreting Nipomo Mesa Air Quality Data_San Luis Obispo County. A STAR grant participant in San Luis Obispo performed data analysis to better understand the data being collected with low-cost sensors and improve interpretation of the data when dust events occurred.
- http://www.wawzat.com/. This website was developed by a STAR Grant participant to provide links to educational information, data visualizations, and python code developed by the participant to support analysis of the sensor data.

One STAR Grant participant developed a web page for his community. This site includes links to educational information, data visualizations, and python code developed by the participant to support the analysis of the sensor data.

Webpage: http://www.wawzat.com/

Animated data visualization of the Holy Fire:
https://www.youtube.com/watch?v=pybUqMPfjjc&feature=youtu.be

GitHub Repository of Python code: https://github.com/wawzat/purpleair-data-tools

Screen shot of web page:

Particle Scanner Resources and Data - wawzat

Residents of Temescal Valley have installed Purple Air particle detectors as part of the South Coast Air Quality Management District's EPA Star Grant program. This site provides information about the program and resources for downloading and analyzing the collected particle data.

- SCAQMD EPA STAR Grant Program
- Air Quality Standards and Information
- PurpleAir Map
- PurpleAir PA-II Sensors
- Downloading Historical PurpleAir Sensor Data
- Download Precompiled Temescal Valley Sensor Data
- Download SCAQMD AQ Details - Historical Data
- Particle Sensor Visualization
- Graphics
- Other Resources
- Python Code
- Frequently Asked Questions
- Contact

On February 2nd, 2021, 4:03:45 PM PST

10 Minute Average US EPA PM2.5 AQI is now **57**

51-100: Air quality is acceptable; however, if they are exposed for 24 hours there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.

Now	10 Min	30 Min	1 hr	6 hr	1 Day	Week
63	57	46	37	24	16	20

Sensor: SCTV_26

A B √100% PA-II 6.01

PurpleAir Map