

## South Coast AQMD Air Pollution Monitoring for Communities Grant Final Report – Executive Summary

**Period Covered by the Report:** May 1, 2021 to April 30, 2022

**Date of Final Report:** July 30, 2022

**EPA Agreement Number:** RD83618401

**Title:** Engage, Educate, and Empower California Communities on the Use and Applications of “Low-Cost” Air Monitoring Sensors

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**Research Category:** Environmental Justice, Air Quality and Air Toxics, Air, Particulate Matter

**Project Period:** May 1, 2016 to April 30, 2019 (3-yr no-cost extension until April 30, 2022)

**Objective of Research:** The overall objective of the proposed research was to provide California communities with the knowledge necessary to appropriately select, use, and maintain “low-cost” sensors and to correctly interpret sensor data. This was accomplished by pursuing the following four specific aims: (1) develop new methodologies to educate and engage communities on the use and applications of “low-cost” sensors; (2) conduct testing to characterize the performance of commercially available “low-cost” sensors and to identify candidates for field deployment; (3) deploy the selected sensors in California communities, and interpret the collected data; and (4) communicate the lessons learned to the public through a series of outreach activities.

### **Summary of Findings (Outputs/Outcomes):**

Aim 1: To engage residents, South Coast AQMD partnered with 14 communities, expanded from the initially proposed six communities. After establishing relationships with community leads, South Coast AQMD designed and conducted a series of four workshops in each community to provide background information, training on sensor installation and use, distribute the sensors, and discuss the data. Feedback was collected from the community participants throughout the project both formally (e.g., through surveys) and informally (through discussions). This feedback, the materials developed, and other experiences and lessons learned shaped the development of the key output of this work: “Community in Action: A Comprehensive Educational Toolkit on Air Quality Sensors” (<https://www.aqmd.gov/aq-spec/special-projects/star-grant>). The Sensor Educational Toolkit includes a guidebook, three training videos, data analysis and visualization tools, and resources and documents developed during the STAR Grant project (e.g., workshop slides, surveys and forms, installation guides, infographics, and reports created by communities). Together these materials offer direction and support for all stages of community-based sensor projects: background information on air pollution and measurement methods, project planning (incl. sensor selection), project implementation (incl. deployment, QC, troubleshooting, and analysis), and project follow-up (e.g., guidance for community action informed by the data collected). Responding to a need for more accessible and useful data, identified in discussions with community partners, South Coast AQMD initiated additional contract work with Mazama Science to develop an R-based open-source package and web-based data viewer. Thus, the AirSensor package and DataView tool were created to support data access, analysis, and visualization for PurpleAir PA-II sensors (Feenstra et al., 2020; Collier-Oxandale et al., 2022a). The AirSensor package has been reviewed and is available on the Comprehensive R Archive Network (CRAN).

Aim 2: In the first two years of the project period, South Coast AQMD evaluated commercially available "low-cost" air quality sensors according to field and laboratory evaluation protocols developed by the Air Quality Sensor Performance Evaluation Center (AQ-SPEC). The reports from all evaluations are made publicly available on the AQ-SPEC website (<http://www.aqmd.gov/aq-spec/evaluations>). Several publications discuss the details and results of these evaluations (Papapostolou et al., 2017; Feenstra et al., 2019; Collier-Oxandale et al., 2019). Approximately 15 air quality sensors had been evaluated at the time of sensor selection. Based on the results of these evaluations and other characteristics, South Coast AQMD identified the PurpleAir PA-II and the Aeroqual AQY v0.5 as candidates for field deployment.

Aim 3: Approximately 400 PurpleAir PA-II sensors were distributed to participants, with approximately 66% of those sensors installed. Preliminary analysis was presented in various formats, including PowerPoint presentations and printed infographics. These utilized different types of visualizations, allowing the opportunity to explore how to communicate sensor data effectively. The AirSensor package increased data accessibility and offered more systematic data validation through QC procedures and functions. These tools made possible an in-depth, multi-year analysis of all the data collected by the STAR Grant community networks (Collier-Oxandale et al., 2022a). Key results include that sensors demonstrated the capability to provide useful data (passing QC measures) for at least three years in ambient environments with negligible drift. However, sensors exhibited substantial seasonal performance variability, likely due to changes in particulate matter sources/types. Additionally, the data from sensors deployed at different times appear comparable.

Aim 4: Lessons learned and results from the project were communicated to the public through the workshops, conference presentations, publications, presentations/webinars, and informal meetings with members of the public. These included presentations to academic researchers working with communities to use sensors presentations as well as to other air agencies at meetings such as NESCAUM (Northeast States for Coordinated Air Use Management). Shortly after the publication of the Sensor Educational Toolkit, South Coast AQMD led a district-wide lunch and learn for South Coast AQMD staff to increase awareness of this new resource. At the Air Sensors International Conference in Pasadena, CA, in May 2022, printed copies of the guidebook were made freely available to attendees, which included researchers, industry, and community members. The lessons learned are also discussed in detail in a publication (Collier-Oxandale et al., 2022b).

Through this project, community participants became more familiar with their local air quality and ways to reduce their exposure. In turn, feedback from these community participants enabled the project team to develop more refined deployment strategies, create data analysis tools, identify intuitive data visualizations, and create a range of supporting resources. These outputs and outcomes benefited and engaged the communities participating in the STAR Grant and will continue to benefit future communities interested in engaging in this type of project.

#### **Publications, Presentations, and Reports:**

Collier-Oxandale, A., Papapostolou, V., Feenstra, B., Der Boghossian, B., & Polidori, A. Towards the Development of a Sensor Educational Toolkit to Support Community and Citizen Science. *Sensors*, 22(7), 2543. 2022b.

Collier-Oxandale, A., Feenstra, B., Papapostolou, V., & Polidori, A. AirSensor v1. 0: Enhancements to the open-source R package to enable deep understanding of the long-term performance and reliability of PurpleAir sensors. *Environmental Modelling & Software*, 148, 105256. 2022a.

Connolly, R. E., Yu, Q., Wang, Z., Chen, Y. H., Liu, J. Z., Collier-Oxandale, A., Papapostolou V., Polidori, A., & Zhu, Y. Long-term evaluation of a low-cost air sensor network for monitoring indoor and outdoor air quality at the community scale. *Science of The Total Environment*, 807, 150797. 2022.

Collier-Oxandale, A., Papapostolou, V., Feenstra, B., & Polidori, A., An Overview of Low-cost Sensors, an Educational Toolkit, and Resources to Engage and Educate the Public on the Topic of Air Quality, presented at 2021 AGU Fall Meeting, Online/New Orleans. 13-17 Dec. 2021. (Podium presentation)

Collier-Oxandale, A., Papapostolou, V., Feenstra, B., Der Boghossian, B., & Polidori, A., An Educational Toolkit to Ensure the Successful Operation and Use of Air Quality Sensors by the Public, presented at 2021 AAAR Annual Conference, Online. 18-22 Oct. 2021. (Podium presentation)

Feenstra, B., Papapostolou, V., Collier-Oxandale, A., Cocker, D., & Polidori, A. 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. 2020

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Feenstra, B., Papapostolou, V., Hasheminassab, S., Zhang, H., & Boghossian, B., Cocker, D., Polidori, A., Performance evaluation of twelve low-cost PM<sub>2.5</sub> sensors at an ambient air monitoring site. *Atmospheric Environment*. 216, 116946. DOI: 10.1016/j.atmosenv.2019.116946. 2019

Collier-Oxandale, A., Feenstra, B., Papapostolou, V., Zhang, H., Kuang, M., Der Boghossian, B., Polidori, A. Field and Laboratory Performance Evaluations of 28 Gas-Phase Air Quality Sensors by the AQ-SPEC Program. *Atmospheric Environment*. 220, 117092 DOI: 10.1016/j.atmosenv.2019.117092. 2019.

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Marino, E., Collier-Oxandale, A., Zhang, F., Wang, Z., & Yifang, Z. The Air You Breathe: Lessons from the Community Air Monitoring Project at UCLA's University Village Apartments. Los Angeles. 2019. (Report)

Watanabe, K., Choy, E., Boerboom, S., Cohen, E., Ranheim, E., Mendell, C., & Mora Solis, B. PM 2.5 Air Quality Trends at Mark Keppel High School for Asian Pacific Islander Movement. Roberts Environmental Center at Claremont McKenna College. 2019. (Report)

Papapostolou, V., Collier-Oxandale, A., Feenstra, B., Ranheim, E., Martin, H., Callahan J., Polidori, A., Exploring Different Ways of Communicating Results and Visualizing Data from Low-cost Sensor Networks. American Geophysical Union, Fall Meeting 2019, December 2019, San Francisco (Poster presentation)

Collier-Oxandale, A., Papapostolou, V., Feenstra B., Boghossian, B., & Polidori, A. Lessons Learned from the Deployment of Low-Cost Air Quality Sensors in 14 California Communities. American Geophysical Union, Fall Meeting 2019, December 2019, San Francisco (Poster presentation)

Martin, H., Callahan J., Collier-Oxandale, A., Feenstra, B., Papapostolou, V., Ranheim, E., R Package for Air Sensors. American Geophysical Union, Fall Meeting 2019, December 2019, San Francisco (Poster presentation)

Collier-Oxandale, A., Papapostolou, V., Feenstra B., Boghossian, B., & Polidori, A. Preliminary Assessments of Sensor Performance and Data Analysis for California Communities under a US EPA STAR Grant Project. 37th AAAR Annual Conference. October 2019, Portland (Poster presentation)

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DeWinter, J., Hafner, H. R., Papapostolou, V., Polidori, A. Community-Based Air Quality Monitoring with Low-Cost Sensors: Developing a Toolkit, Best Practices, and Lessons Learned. American Geophysical Union, Fall Meeting 2018, December 2018, Washington D.C. (Poster presentation)

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Papapostolou, V. Air Quality Sensing & Monitoring in Citizen Science. Brown Bag Lunch Meeting Presentation at the South Coast Air Quality Management District. October 2018. (Podium Presentation)

Papapostolou, V., and Hafner, H. Community Sensor Training: Best practices and lessons learned for Engaging Communities in Air Quality Monitoring. Air Sensors International Conference. September 2018, Oakland, California. (Pre-Conference Training Session and Panel Discussion)

Feenstra, B. Development of a cloud-based application to ingest, validate, analyze, and map data from a large PM sensor network. Air Sensors International Conference. September 2018, Oakland, California. (Podium Presentation)

Papapostolou, V. South Coast Air Quality Management District – Air Quality Sensor Performance Evaluation Center. Air Sensors International Conference. September 2018, Oakland, California. (Podium Presentation).

Papapostolou, V. Air Quality Sensing & Monitoring in Citizen Science. Brown Bag Lunch Meeting Presentation at the South Coast Air Quality Management District. October 2018. (Podium Presentation)

Feenstra, B., Papapostolou, V., Cheung, R., Polidori, A. One Year Spatial and Temporal Variability of PM in a Southern California Community using an Air Quality Sensors Network. 10th International Aerosol Conference, September 2018, St Louis, Missouri. (Podium presentation)

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Papapostolou, V., and Feenstra, B. Low-Cost Sensors: The “How” of Performance Evaluation, Network Design and Data Handling. 10th International Aerosol Conference, September 2018, St Louis, Missouri. (Presentation and Tutorial Session)

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Polidori A, Feenstra B, Papapostolou V, Zhang H. Performance Evaluation of "Low-Cost" Sensors for Measuring Gaseous and Particle Air Pollutants: Results from Three Years of Field and Laboratory Testing. 36th American Association for Aerosol Research, October 2017, Raleigh, North Carolina. (Podium presentation)

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**Supplemental Keywords:** sensors, air quality, community monitoring, environmental justice

**Relevant Websites:**

- <http://www.aqmd.gov/aq-spec>
- <http://www.aqmd.gov/aq-spec/evaluations>
- <http://www.aqmd.gov/aq-spec/special-projects/star-grant>
- <http://www.aqmd.gov/aq-spec/special-projects/airsensor>
- <https://github.com/MazamaScience/AirSensor>

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