

EPA Assistance Agreement Annual Report Summary

Period Covered by the Report: May 1, 2019 to April 30, 2020

Date of Report: July 31, 2020

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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Project Period: May 1, 2016 to April 30, 2019 (2-yr no-cost extension until April 30, 2021 was requested and approved during the previous year)

Objectives: The overall objective of the proposed research is to provide California communities with the knowledge necessary to appropriately select, use, and maintain “low-cost” sensors and to correctly interpret sensor data. This will be 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.

Progress Summary/Accomplishments (Outputs/Outcomes):

Aim 1. South Coast AQMD continued to work with STI (co-Principal Investigator) on the draft Guidebook for the Educational Toolkit with a focus on finalizing the content, which encompasses the three major stages of community air monitoring: planning, deployment, and community action. In addition to finalizing the content, STI has begun working to establish a consistent graphic design for the Guidebook which will enhance the resource’s effectiveness at communicating the content. South Coast AQMD and STI also continued to revise and develop additional components that will be included in the Educational Toolkit (i.e., training videos, data collection checklists, e-surveys, questionnaires.). South Coast AQMD worked with UCLA (co-Principal Investigator), Special Service for Groups (Asian Pacific Forward Movement), and other project partner organizations and air quality agencies to conduct workshops that provided the opportunity to share project results and gather additional feedback from participants. The “during-the-deployment” workshops were completed during this period, and the team began conducting the final workshops (four of which have been completed). As deployments came to an end, an analysis was undertaken of all survey data, feedback from community members (gathered in workshops and in reports from community leads), and data related to sensor usage. This analysis provides insight into the usability and usefulness of low-cost sensors, which has informed the development of the Educational Toolkit and is being shared with communities in the final workshops. During this period, South Coast AQMD entered into a contract with Mazama Science and the collaborative work has resulted into the development of the AirSensor and DataViewer package. The AirSensor is a publicly available, open-source, R-package that facilitates easier access to data from the project sensors, functions to process that data, and tools for analysis and visualization. The DataViewer is a web-based application that leverages the capabilities of the AirSensor to allow project participants to engage with their sensor data in an intuitive way (i.e., this tool is user friendly and no programming experience is required). **Aim 3.** In the past reporting period, the

deployments in all communities were concluded. In total, 395 low-cost PM sensors were distributed on a 1-to-1 (host-sensor) basis to community members in the participating communities and approximately 66% of those sensors were installed and reported fine and coarse particulate matter (PM_{2.5} and PM₁₀) concentration levels (see Figure below). Furthermore, 91% of installed sensors provided either continuous data for at least 6 months (often far longer) or were maintained by project participants (i.e., participants addressed issues as needed to keep sensors functioning, such as connections to WiFi). This willingness to maintain sensors speaks to the engagement of the participants and resulted in the collection of longer datasets. An analysis of the community-level data was shared with each community in which final workshops have been conducted, leveraging the AirSensor package and DataViewer. Some communities also completed their own analysis of the local data and produced reports. Included in the development of the AirSensor and DataViewer package was the establishment of procedures for data processing and QA/QC. These procedures will support additional comprehensive and systematic analysis of the aggregate sensor data from all communities.

Aim 4. During this reporting period, a manuscript was drafted and submitted providing an overview of and introduction to the AirSensor and DataViewer package. Another manuscript was drafted sharing lessons learned and results pertaining to sensor usability and usefulness that may benefit both the low-cost sensor research community and members of the public interested in using sensors.

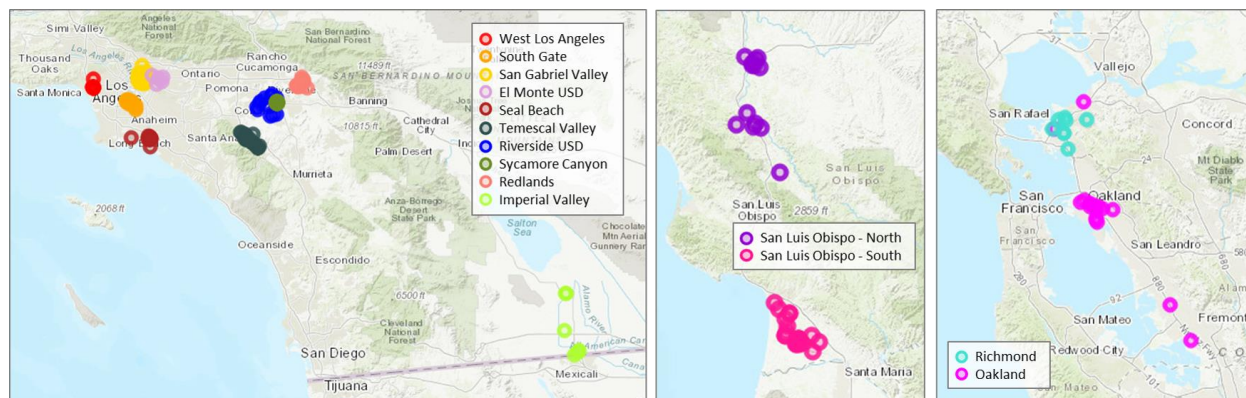


Figure. Sensors deployed in 14 California communities between October 2017 and April 2020.

Publications/Presentations:

During this reporting period, there have been 2 peer-reviewed publications submitted to or in preparation for submission to scientific journals, 2 reports developed by/for communities, and 4 podium/poster presentations at conferences:

Collier-Oxandale, A., Papapostolou, V., Feenstra B., Boghossian, B., & Polidori, A. Lessons Learned from Deploying Low-Cost Air Quality Sensors with 14 California Communities. *manuscript in preparation for submission to Citizen Science: Theory and Practice*. **2020**.

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. *submitted to Environmental Modelling and Software - in review*. **2020**.

Feenstra, B., Papapostolou, V., Hasheminassab, S., Zhang, H., & Boghossian, B., Cocker, D., Polidori, A., Performance evaluation of twelve low-cost PM2.5 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**.

Williams R, Duvall R, Kilaru V, Hagler G, Hassinger L, Benedict K, Rice J, Kaufman A, Judge VR, Pierce G, Allen G, Bergin M, Cohen RC, Fransioli P, Gerboles M, Habre R, Hannigan M, Jack D, Louie P, Martin N, Penza M, Polidori A, Subramanian R, Ray K, Schauer J, Seto E, Thurston G, Turner J, Wexler AS, Ning Z. Deliberating performance targets workshop: potential paths for emerging PM2.5 and O3 air sensor progress. *Atmospheric Environment: X*. 2, **2019**.

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)

Jia, S. An Analysis of Effects of Woolsey Wildfire on UCLA University Village Air Quality using low-cost sensors. UCLA. ProQuest ID: Jia_ucla_0031N_17934. Merritt ID: ark:/13030/m50s4ngz. Retrieved from <https://escholarship.org/uc/item/8s65z1fw>, 2019. (Master's Thesis)

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)

Feenstra, B., Papapostolou, V., Pikelnaya, O., Polidori, A., Doraiswamy, P., Gupta, P. Lessons learned and analysis from a year-long deployment of a network of low-cost particulate matters sensors. American Geophysical Union, Fall Meeting 2018, December 2018, Washington D.C. (Poster 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)

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)

Feenstra, B., Papapostolou, V., Cheung, R., Polidori, A. Cloud-based Application to Manage Data from Distributed Air Quality Sensors Networks. 10th International Aerosol Conference, September 2018, St Louis, Missouri. (Podium presentation)

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)

Hagler GSW, Williams R, Papapostolou V and Polidori A. Air quality sensors and data adjustment algorithms: When is it no longer a measurement? *Environmental Science and Technology*, DOI: 10.1021/acs.est.8b01826, **2018**.

Papapostolou V, Zhang H, Feenstra BJ and Polidori A. Development of an environmental chamber for evaluating the performance of low-cost air quality sensors under controlled conditions. *Atmospheric Environment*, 171: 82-90, **2017**.

Papapostolou V, Feenstra B, Zhang H, Polidori A. “Low-cost” Sensors for Measuring Gaseous and Particle Air Pollutants: Performance Results from Three Years of AQ-SPEC Field and Laboratory Testing and

Network Applications at the Fenceline and Community Level. Air and West Management Association – 2017 Air Quality Measurement Methods and Technology, November 2017, Long Beach, California. (Podium presentation).

Papapostolou V, Zhang H, Feenstra B, Polidori A. Development of an Environmental Chamber for the Laboratory Evaluation of "Low-Cost" Air Quality Sensors. 36th American Association for Aerosol Research, October 2017, Raleigh, North Carolina. (Podium presentation)

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)

Feenstra B, Papapostolou V, Pikelnaya O, Zhang H, Polidori A. Spatial and Temporal Variability of Particulate Matter Using a Network of Air Quality Sensors in a Southern California Community. 36th American Association for Aerosol Research, October 2017, Raleigh, North Carolina. (Poster presentation)

Upcoming Activities:

Aim 1. The Educational Toolkit will be completed during the next reporting cycle. This resource will include the Guidebook, and items such as training videos, data collection checklists, e-surveys, and questionnaires. A new contract with Mazama Science will support the expansion and enhancement of the AirSensor and DataViewer package, another component of the Educational Toolkit. These tools will be enhanced based on feedback from participating community members as well as internal experience of project staff resulting in more robust tools with expanded capabilities.

Aim 3. We will complete a final analysis and interpretation of the data for each community. This analysis as well as other results and lessons learned will be shared at the remaining final workshops. We will also complete a final validation, analysis, and interpretation of the aggregate data collected in all communities. This aggregate data includes multiple years and many sensors from networks in 14 different communities.

Aim 4. During the upcoming reporting period, the remaining final workshops will be held to share the results from the project (including lessons learned), distribute incentives, and gather final feedback. These meetings also provide an opportunity to disseminate new resources that have been made developed through this project, including the AirSensor and DataViewer package. South Coast AQMD and partners also intended to continue to disseminate results, lessons learned, and project outputs through publications, conferences, and webinars.

Supplemental Keywords: community recruitment, community engagement, community education, community empowerment, sensor testing, sensor selection, sensor deployment, particulate matter, PM2.5, PM10, ozone, data interpretation, public outreach, community outreach, educational outreach, STEM

Relevant website: www.aqmd.gov/aq-spec