Sensor Evaluation from the Community Perspective – Tools and Techniques

Teri Conner[1], Andrea Clements[1], Ronald Williams[1], Amanda Kaufman[2]
[1]U.S. EPA, Office of Research and Development, Research Triangle Park, North Carolina, USA
[2]U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, USA

Introduction

EPA scientists have been conducting performance evaluations of low-cost sensor technologies for air quality measurement by comparing the data they produce with data from collocated reference monitors. With the increasing accessibility and ease-of-use of these devices, EPA recognized the need to help non-experts, such as community groups, conduct their own sensor evaluations. To meet this need, the EPA's National Exposure Research Laboratory was awarded an internal grant through a citizen science initiative competition to conduct a community-led air sensor evaluation project. In the fall of 2016, EPA partnered with one community group and one tribal nation to conduct a sensor performance evaluation using their choice of sensor devices.

Project Goals

Help citizen scientists and community groups learn how to use low-cost, portable air sensors, and effectively evaluate their reliability and performance via collocation with reference instruments.

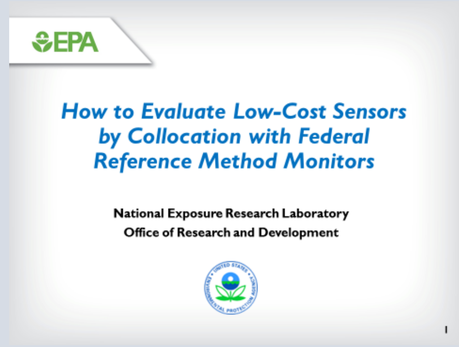
Project Partners

Clean Air Carolina (CAC - www.cleanaircarolina.org) is a community action group comprised of a mix of paid staff and volunteers. Their mission is to ensure cleaner air quality for all North Carolinians through education and advocacy and by working with partners to reduce sources of pollution. Their activities include working with citizens to conduct air quality monitoring with low-cost sensors and conducting environmental educational programs for local school-based children.

Eastern Band of Cherokee Indians (EBCI – www.EBCI.com) is a federally recognized Native American tribe living in and around Cherokee in western NC. Their citizens conduct the EBCI Air Quality Control Program which is responsible for operating three air quality monitoring stations supporting the State of North Carolina's and the EPA's regulatory requirements (www.ebcienvironmental.com).

Tools Developed by EPA

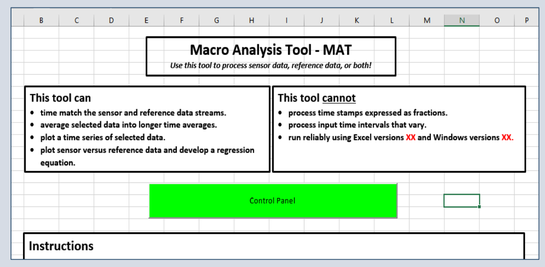
Instruction guide for conducting a successful collocation evaluation of air sensors with regulatory grade instruments, provided as a PowerPoint presentation for easy reading and ample visual tools.



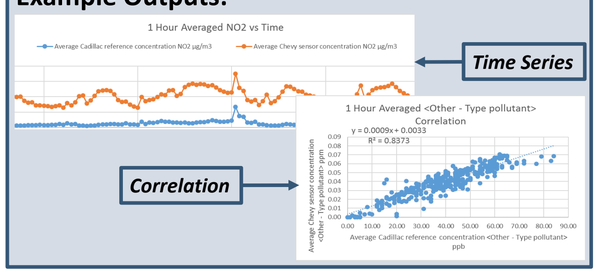
Topics covered:

- Background – Low-cost sensors vs reference instruments
- Introduction to collocation
- Planning collocation
- Making measurements
- Data recovery and review
- Data comparison
- Using sensors

Easy-to-use spreadsheet based macro analysis tool for performing data comparisons and interpreting the results. Tool tackles one of the biggest hurdles in citizen-led community air monitoring projects – working with the data.



Example Outputs:



- EPA developed these tools to be suitable for citizen scientists and other non-experts, and anticipate they will be of use to the broader sensor user community.
- Project partners provided feedback on each product.
- EPA used partner feedback to make improvements and finalize these products.
- Both tools are anticipated to be released by the end of 2017 through EPA's online Air Sensor Toolbox (www.epa.gov/air-sensor-toolbox).

Approach

EPA provided each project partner

- Three copies of their selected low-cost (<$2500) air quality sensor
- A custom weather shelter
- Quality assurance and operating procedures for non-experts
- In-person training
- Bi-weekly conference calls to provide updates and address issues
- Tools and guidance to analyze data and understand results
- Template for non-experts to summarize findings

Training for CAC staff, Mecklenburg County staff, and citizen volunteers

Particulate matter sensors deployed in triplicate inside weather shelter at EBCI monitoring site

CAC staff and citizen volunteer checking on ozone sensors at deployment site

Project partners

- Conducted pre-deployment evaluations of sensors
- Conducted data collections with sensors (May-June 2017) with frequent visits to monitoring site
- Used the Macro Analysis Tool developed by the EPA (see "Tools Developed") to statistically compare the low cost sensor data with the reference monitor data
- Reported to the EPA on their experience as non-experts in deploying the sensors and data recovery and analysis

EPA and EBCI partners reviewing assembly of weather shelter provided by EPA

Keys to Success

Recommendations for a successful community-government partnership:

- Agree upon goals
- Plan an approach
- Collaborate with stakeholders
- Assign responsibilities
- Communicate regularly
- Work and educate through community connections

Citizen volunteers with staff from CAC, EPA, and Mecklenburg County

Partner Feedback

"This felt like a fantastic bridge of national, regional, community, and individual efforts all working together for a common goal. Citizen Science is most often attributed to data collection, but this opens up a new arena for validation, review, and resources for citizens, by citizens thanks to the diligent planning of the pros."

Calvin Cupini, Clean Air Carolina

"Creating a bridge between local NGO's, regional air monitoring and the EPA is an asset that will continue to pay dividends in air monitoring, health and environmental protection."

Terry Lansdell, Clean Air Carolina

"Now that community based science, "citizen scientist", has become more popular, it is nice to have something explain how to collect more viable data using the low-cost sensors because most community members don't consider the accuracy of a sensor compared to a FRM/FEM."

Katie Tiger, Eastern Band of Cherokee Indians

Acknowledgements: The authors thank Jeff Francis, Megan Green, and Kevin Dunham of Mecklenburg County Air Quality Commission for generously providing access to the reference monitor site and data, and for their technical advice and review comments; Calvin Cupini, Terry Lansdell, and June Blotnick of Clean Air Carolina and their volunteers Gordon Miller, Coraline Xu, and Alex Alcorn for their participation and review comments; Katie Tiger and Amy Smoker of the Eastern Band of Cherokee Indians and their interns Ada Sloop and Misha Griffis for their participation and review comments; Manu Strivastava of Jacobs Technology Inc. for his excellent work on the Macro tool and other project support.

U.S. Environmental Protection Agency
Office of Research and Development