U.S. EPA's AirNow International Air Sensor Applications and Initiatives in Accra, Ghana

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Build Capacity with Air Quality Monitoring in Ghana, Africa

Under the Africa Megacities Partnership, the U.S. Environmental Protection Agency (U.S. EPA) is collaborating with the Ghana Environmental Protection Agency (EPA Ghana) to deploy and operate a low-cost particulate matter (PM) air sensor network in Ghana's capital city of Accra. This network complements Ghana's existing network of monitors, other low-cost sensors by academia, and regulatory-grade monitors planned to be deployed as part of the World Bank's Pollution Management and Environmental Health (PMEH) program.

Goals

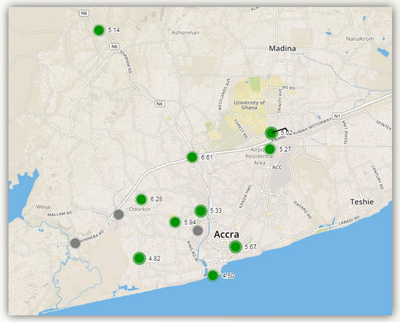
- Increase EPA Ghana's air quality management capabilities by measuring continuous $PM_{2.5}$ (less than 2.5 microns in diameter) and PM_{10} (less than 10 microns in diameter) and characterizing $PM_{2.5}$ and PM_{10} spatial variability in Accra.
- Showcase low-cost sensor devices and systems for other low- and middle-income cities worldwide.
- Characterize sensor performance in environments with high PM concentrations, temperatures, and humidity.

Scope

- Select sites and sensors *(completed)*
- Conduct sensor collocation study *(completed)*
- Operate sensors from August 2018 to July 2019
- Manage collected data
- Interpret findings from data
- Build EPA Ghana's real-time monitoring capacity

Instrument & Siting Considerations

In selecting sensors for deployment, we considered pollutants measured, monitoring methodology, sensor performance, data handling transparency, power requirements, communications, affordability, customer support, and troubleshooting options. Site locations were selected in consultation with EPA Ghana to represent a variety of urban emissions sources (near-road, industrial, and residential). Siting was dependent on access, security, and power.

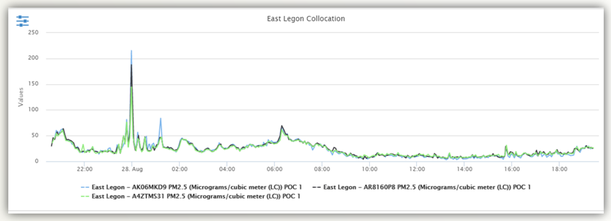


Sensor Data Management

The U.S. EPA's AirNow International (AirNow-I) system is set up in the cloud for EPA Ghana to manage data collected from the low-cost sensors, existing PM_{10} monitoring stations, and future monitoring sites.

The AirNow-I database provides a secure repository, with the scalability to process and store high-time-resolution data. The AirNow-I web-based interface allows EPA Ghana staff to query and visualize the data.

For this project, raw sensor measurements from the Node-S sensors are transmitted to the Clarity Cloud (where "Smart Calibration" is performed) and also directly to the AirNow-I system.



Time series of measurements from three collocated sensors at one of the two sites that also has 1-in-6 day PM_{10} Federal Reference Method measurements.

Instruments

- **Clarity Node-S** sensors measure $PM_{2.5}$, temperature (T), and relative humidity (RH), and each includes a battery and solar panel to reduce the need for line power at the monitoring sites. Sensors collect 90-second averages of PM_{10}, $PM_{2.5}$, T, and RH approximately every five minutes. Data are transmitted via cellular network. We deployed 18 of these sensors.
- **PurpleAir** sensors using on-board storage provide 80-second data for $PM_{1.0}$, $PM_{2.5}$, and PM_{10} along with T, RH, and pressure. We deployed five of these sensors.
- Three **Campbell Scientific all-in-one MetSens600** weather stations were deployed to measure T, RH, barometric pressure, wind (speed, direction), and precipitation.

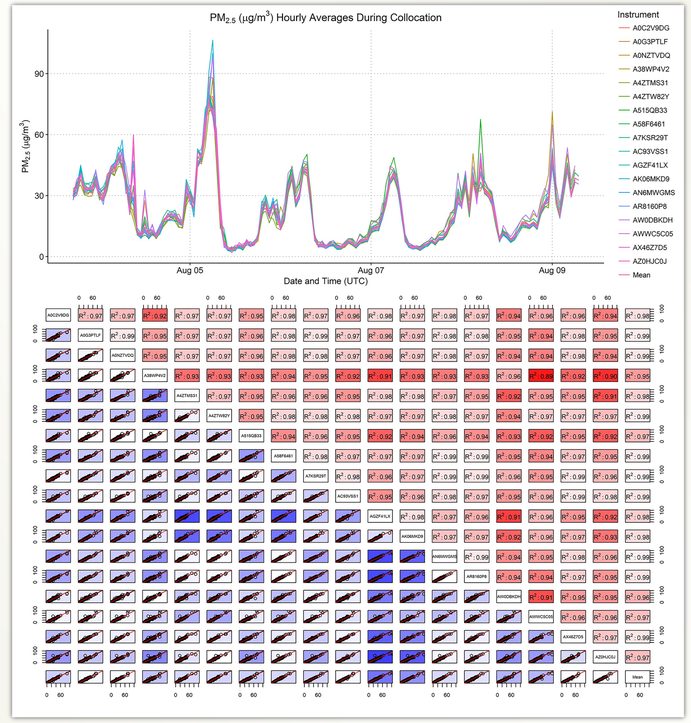
Collocation Study

Collocation is performed to assess sensor precision, accuracy, and bias.

1. All sensors and meteorological instruments were collocated at the EPA Ghana building for one week before being deployed to sites.
2. Pending the upcoming deployment of regulatory-grade PM instruments by the PMEH program, we will collocate all sensors with the reference instruments in the middle of the measurement period.
3. At the end of the measurement period, all sensors will be collocated again for inter-comparison.

Instrument collocation (top) and training (bottom) to help build capacity among EPA Ghana staff to operate the network.

Collocation Results



*Time series of data collocated at EPA Ghana for six days, and a scatter plot matrix for all sensors during the collocation **showing good correlation** among the sensors. Darker red indicates a lower R^2 ($0.89 \le R^2 \le 0.99$), and darker blue indicates a greater deviation of the slope from 1 ($0.0 \le |1\text{-}m| \le 0.12$).*

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