Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
https://doi.org/10.5194/amt-2021-154-RC2, 2021

Comment on amt-2021-154

Anonymous Referee #2

Referee comment on "Evaluation methods for low-cost particulate matter sensors" by Jeffrey K. Bean, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-154-RC2, 2021

General Comments:

In this work, the author examines the impact of controllable factors, such as averaging time and type of reference instrument, on performance metrics used to evaluate low-cost sensors. In addition, the author demonstrates that pairing two sensors together with a data agreement requirement can act as an easy quality assurance check. Also, the author proposes and tests using a prediction interval as a method to evaluate low-cost sensor performance. Both of which would enhance our current methods of evaluating and comparing low-cost particulate matter sensors. However, the methods used in this paper are not well described and further work could be done to strengthen some of the conclusions.

Major:

Line 31: The EPA recently published a report on performance testing protocols, metrics, and target values for $PM_{2.5}$ low-cost air sensors. In this report they recommend using various indicators to evaluate sensor performance and offer performance target values for those indicators. This report may better address the concerns of using R^2 and RMSE to evaluate sensor performance in addition to other performance metrics.

Duvall, R., A. Clements, G. Hagler, A. Kamal, Vasu Kilaru, L. Goodman, S. Frederick, K. Johnson Barkjohn, I. VonWald, D. Greene, AND T. Dye. Performance Testing Protocols, Metrics, and Target Values for Fine Particulate Matter Air Sensors: Use in Ambient, Outdoor, Fixed Site, Non-Regulatory Supplemental and Informational Monitoring Applications. U.S. EPA Office of Research and Development, Washington, DC, EPA/600/R-20/280, 2021.

Line 66: Multiple times in this paper agricultural burning emissions are listed as the cause of the high PM events, what other evidence can be provided to confirm these burning events? Do particles generated by these events have different optical properties than those present in ambient air?

Line 72: "…while the T640 uses an optical counting method that is more similar to the method used by the low-cost particulate matter sensors." Please provide a little more detail on the similarities and differences between the T640 and the low-cost PM sensors

used in this study.

Line 73: "The BAM was used throughout the entire period of evaluation but often struggled to maintain sample relative humidity below 35%, which is a FEM requirement. Any data which did not meet this criterion was removed prior to analysis." Please clarify which data was removed, is this the cause of the gaps in Figure 2E?

Line 78: More information should be provided on the initial testing of the 4 low-cost PM sensors of different brands. Why is this one-month test indicative of how the sensors will perform over the ten-month test? Why was only R^2 used to determine the best-performing brand?

Line 79: It would be helpful to state the brands of the low-cost PM sensors in addition to the OEM of the optical sensors inside the devices. Additionally, more information such as sampling/averaging time of these sensors should be provided.

Line 113: "It is noteworthy that sensor measurements correlated so closely from one sensor to another (Figure 2A) despite such a large range of variation from reference measurements." Figure 2A only shows the correlation for 2 sensors, is this same trend seen when comparing all 8 sensors? Did all sensors have the same response to the environmental conditions?

Line 218: The paper states that the prediction interval can be used to evaluate/compare multiple sensors, however data is only provided for 1 sensor when 8 were tested. It would be interesting to examine the PI between all 8 of the same brand and even compare the prediction intervals of the 4 brands initially tested. Including the results of these tests would strengthen the argument to include prediction interval as a performance evaluation metric for low-cost PM sensors.

Line 280: "The question remains on how much distance can be allowed between the reference sensor and the network sensors before this method fails." The EPA recommends mounting sensors within 20m horizontal from the FRM/FEM monitor. See above citation which also includes recommendations on setting up low-cost sensors at test sites.

Minor:

Line 98: "As more stringent data agreement requirements are put in place (moving to the right in Fig. 1) there are not significant improvements in correlation." Change not to no.

Line 107: "The bottom figure shows how R^2 between the sensor pair (average of the pair) and reference measurement changes as when these disagreeing data points are removed." Reword this sentence in the Figure 1 caption. Suggestion: "The bottom figure shows how the R^2 between the sensor pair (average of the pair) and reference measurements changes when disagreeing data points are removed."

Line 273: "Figure 6 suggests that this method will have mixed results if calibrating over short time periods but is reliable if enough time is allowed to capture all variations in slope, concentration, and residual standard error." Reword second part of this sentence. Suggestion: "…but can be reliable given enough time to capture all variations in slope, concentration, and residual standard error."