Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., author comment AC3
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Reply on RC3

Jeffrey Bean

Author 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-AC3, 2021

The author thanks the reviewers for the comments. The manuscript has been updated and more information on the updates is provided below.

This manuscript describes a co-location calibration of low-cost optical PM2.5 sensors. Overall the manuscript is topically relevant and well-written.

My major concern is that the Methods need more detail. The author does not reveal the brand of sensor used in this study, so a lot of the methods seem like a black box. For example, there needs to be some detail on the conversion of signal to PM concentration. Does the author simply rely on the factory calibration? Is there any compensation for humidity or other meteorological parameters?

Response: The sensor models are withheld in part to allow focus on evaluation methods, rather than specific sensors, but models are also withheld to avoid giving the impression that the author endorses or disparages one sensor company over another. Additional details on sensor measurements have been added to the manuscript, as requested, but the specific makes and models are still withheld for the reasons stated.

A second important consideration is the range of PM concentrations shown in many of the figures. There seems to be a lot of emphasis on high concentrations (e.g., Fig 4), but I think it's more important to understand the performance of these sensors at typical ambient PM concentrations. Several examples are given in the specific comments below.

Response: More references to performance at ambient concentrations have now been added as discussed in the responses below and in responses to other reviewers.

Comments:

Line 90 discusses the value of co-locating two sensors to catch instances of erroneous measurements from a single sensor. Some commercially available sensor packages, like the Purple Air, already do this.

Response: It is true that Purple Air already includes two sensors in each package. The discussion in this manuscript could easily be applied to a setup such as this to eliminate data that cannot be quality checked.

What is the time resolution of Figure 1? Also, it seems strange that the R^2 generally decreases as the allowed difference shrinks. Is this perhaps because a small allowable absolute difference ends up scrubbing data from higher concentration events?

Response: Data was averaged to 1-hour intervals in this analysis for comparison to the BAM. The reviewer is correct that higher concentration data tends to get removed with stricter data agreement requirements. This is an important point and an argument for using a combination of absolute and percent data agreement requirements. This has now been noted in the manuscript.

Line 187 - why was 70 ug/m^3 selected as the cutoff point?

Response: 70 µg/m3 was chosen because it approximately split the 5% of data during high concentration events from the rest of the data. The random sampling below this line meant that the model and prediction intervals were a result of 50% of data below 70 µg /m3 and 50% of data above that point – a relatively even distribution of data. If the model instead used 95% of data below 70 µg /m3 and only 5% above then the model is fit in a way that is more weighted towards lower concentration. If the transformation is done well and the residuals are the same across the domain then the weight of lower/higher concentrations does not significantly impact the resulting model. However, since residual distribution is not perfect it is ideal to fit the model using an equal amount of data across the range of observed concentrations.

The example in Figure 4 focuses on a very high concentration. Perhaps it would be more useful for readers to show this example for a more typical PM2.5 concentration.

Response: The high concentrations in Figure 4 are useful as it provides a clear picture of how uncertainty changes as concentration does. The reviewer is correct that more discussion of lower concentrations can add relevance to the discussion. Examples have been added of how this analysis applies to uncertainty at relevant concentrations (35 µg/m3) and how that varied between different sensors.

The analysis in Figure 4 relies on a transform of the data to the 0.4 power. I assume that this is sensor-specific, and if someone wants to repeat this analysis they will need to find a transform that works for their sensor. Revealing the specific sensor used in this work would help others try to repeat the same transform.

Response: It is true that this is sensor specific and could even be location specific since different particles may result in different sensor responses. This has been clarified in the manuscript (line 208).

I like Figure 5, but I wish I could see the typical ambient range (let's say up to 40 ug/m^3) better. I think that understanding the uncertainty for sensor measurements at typical ambient conditions is important, because in many cases these sensors will be deployed to examine neighborhood-level variations in PM concentration. Those variations can be small.

Line 225-226 note that in Fig 5, the daily average PM2.5 PI's can only be calculated for concentrations between 5 and 25 ug/m^3. This echoes my comments above - the performance of the sensors at low concentration is very important.

Response: This is a good recommendation and a zoomed-in window has been added to Figure 5 to better show how uncertainty varies at lower concentrations.

Figure 6 - I'm a little confused by exactly what is plotted in this figure. However it seems to me that the results are showing noise reduction via signal averaging. It's not clear to

me why the R^2 is so low for the 1-day case (though errors are similar to, or slightly lower than, the 7- and 14-day cases).

Response: 1-day errors can be very low if the day contained only a narrow range of concentrations, especially if all concentrations were very low. In these cases there may be little correlation with the reference but errors are small.