Authors' Response to Reviewers' Comments
Manuscript ID# ar-2024-39
Revised Title: "Impact of Sampling Frequency on Low-Cost PM Sensor Performance including Short-Term Temporal Events in High PM Environments"
Original Title: "Impact of Sampling Frequency on Low-Cost PM Sensor Performance"

The authors would like to thank the editor and reviewers for their valuable feedback on the manuscript. We have addressed the comments which has considerably improved the quality of the manuscript. Our responses to the comments and suggestions are provided in this document, and suitable changes have been incorporated in the revised version of the manuscript. For the reviewer's convenience, the reviewer comments and our response to the reviewer comments are shown in **black** color font and the modified parts of the manuscript are shown in **blue** color font.

Reviewer 1

General Comment

The revised manuscript was greatly improved thanks to reviewer comments with better clarity and suitable additional information about power consumption. Some minor points should be accounted for to give the reader the best understanding of the results.

Response: The authors thank the reviewer for the feedback and valuable suggestions which allowed us to revise the manuscript and improve its overall quality.

Comment 1.1 — Page 6, § 3
The authors should give some more details about the comparison between the five LCS measurements to justify further analysis based on only one unit. In particular:

- Is the CV=4.38% corresponding to just one daily average comparison is representative of other daily periods?
- Does the US EPA standards mentioned: SD≤ 5 µg/m3 and CV≤ 30% are especially related to intercomparison between same instruments? Does the CV≤30% should be related to only one daily measurement serie or to a 30 days serie?

Response: Thank you for the comment. The coefficient of variation (CV = 4.38%) was calculated using daily averages of 15-second data over the 30-day period and is not a single day average. This ensures that the reported CV value reflects long-term consistency across all five LCS units. The low value of CV indicates strong inter-sensor agreement, validating the use of a single representative unit for further analysis. The cited US EPA precision targets (SD $\leq$ 5 µg/m³ and CV $\leq$ 30%) are applicable for intercomparison between identical instruments over a 30-day period, as specified in:

- Duvall et al. (2021), Section 3.1.3: Precision metrics for collocated sensors.
- Duvall et al. (2021), Section 2.1: Requirement for 30-day evaluation to assess sensor precision.

Our analysis adhered to these guidelines, with collocated data collected over 30 days to compute SD and CV. As suggested we have now revised the 1st paragraph of Section 3 to improve clarity. The revised part of Section 3 is reproduced below:

"Daily averages for all the LCS units were computed using 15 second resolution data over the 30 day study period. This month-long dataset allows for diverse ambient exposure conditions and diurnal variations. During the study, hourly averaged reference BAM measurements ranged from 11 to 303 $\mu g/m^3$, with a mean value of 84.41 $\mu g/m^3$. Despite this wide $PM_{2.5}$ concentration range, the calculated standard deviation (SD) of 3.92 $\mu g/m^3$ (below the USEPA limit of < 5 $\mu g/m^3$) and coefficient of variation (CV) of 4.38% (significantly lower than the USEPA limit of $< 30\%$) indicates high precision among the five LCS units (Duvall et al., 2021). Given this high level of precision, a single LCS unit (Sensirion-1) was used for the subsequent analysis, as repeating the analysis with the other LCS units would yield similar results."

Comment 1.2 — Give the precise reference for the USEPA standard in the References list P14: 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.

Response: Thank you for the feedback. In the revised manuscript, this reference has been corrected.

Comment 1.3 — Page 8 §3.1
Give definition for MAE

Response: Thank you for the feedback. In the revised manuscript, MAE has now been included in Section 3.1 alongside the other performance metrics. For a detailed description of MAE and other performance metrics, we have cited the work of Zimmerman (2022). The revised part of Section 3.1 is reproduced below:

"To assess the impact of LCS sampling interval on the correlation of the LCS data with BAM, we compute the coefficient of determination (R^2), slope (m), intercept (b), mean absolute error (MAE), root mean square error (RMSE), and normalized root mean square error (NRMSE) (Duvall et al., 2021; Zimmerman, 2022)."

Comment 1.4 — Page 9, figure 4

I understand, figure 4 corresponds to an average of a define number of 15 s measurement taken at the mid-point of the sampling frequency. So each point fig 4a corresponds to an average of 240 values, fig 4b average of 12 values, fig 4c average of 6 values, fig 4d average of 4 values, fig 4e average of 2 values and fig 5c single value. Surprisingly the data are not more scattered when single or two values are considered for the hourly average. Could the authors add more comment on that in the text § 3.1. May be also starting to introduce fig 5 in § 3.1 showing the 15 s raw data on a one-hour serie with the different averaged values.

Response: We thank the reviewer for this insightful observation and comment. We would like to clarify that the reference BAM data in our study is available only at hourly resolution. Thus, in Figure 4, each subplot compares hourly averaged LCS measurements (derived from LCS measurements at different sampling frequencies) against the corresponding hourly BAM values. Regardless of the LCS sampling interval (15-second, 5-minute, etc.), the LCS data in that hour is aggregated to hourly average before comparing with the BAM data. So, each subplot in Figure 4 contains 720 hourly points (30 days $\times$ 24 hours). As the temporal resolution of comparison (hourly) remains the same for each subplot the scatter does not increase with different sampling intervals for LCS data. To clarify this, we have revised Section 3.1 and the revised part is reproduced below:

"Each subplot in Figure 4 corresponds to a different sampling interval (e.g., 15 minutes, 30 minutes, etc.), where hourly LCS averages are computed from the raw measurements within that hour. Despite the different number of data points per hour (e.g., four data points for 15 minutes interval, two data points for 30 minutes interval), each subplot contains 720 hourly points (30 days $\times$ 24 hours), resulting in the same temporal resolution."

Comment 1.5 — Page 12, line 205

Recall that the value 4.38% corresponds to coefficient of variation between five SPS30 units on single daily analysis.

Response: We have modified the concerned sentence in the revised manuscript for better clarity. The revised sentence from Section 4 is reproduced below:

"The SPS30 LCS units demonstrated high precision, with a CV of 4.38% during the 30 days study period."

Comment 1.6 — Page 12, line 209

Precise "minimal impact on the hourly measurement accuracy

Response: Thank you for this comment. We have now revised the referred sentence from Section 4 which is reproduced below:

"In addition, our analysis revealed that varying the sampling frequency had minimal impact on the hourly measurement accuracy, however only high frequency sampling (15 seconds sampling interval) was effective in capturing the transient plume events."