Response to Reviewer #1

We sincerely thank the reviewer for the careful evaluation of our manuscript and for the constructive comments, which have helped us improve its quality. Our point-by-point responses are provided below.

General comment

We appreciate the reviewer's positive assessment of the relevance of the study, particularly the value of citizen science for assessing $PM_{2.5}$ exposure in transport microenvironments where official monitoring data are unavailable. We have revised the manuscript accordingly to address the methodological, statistical, and interpretative issues raised.

Comment: *How were the sampling days selected?*

Response: Sampling days were selected randomly whenever members of the citizen science project were able to combine the measurements with their daily activities. All measurements were conducted on working days.

Comment: *Were meteorological conditions recorded?*

Response: Yes. Air temperature and relative humidity were recorded simultaneously during all measurement campaigns. This information has been added to the Methods section.

Comment: *Were traffic intensity and ventilation considered?*

Response: Traffic measurements in the road tunnel were conducted during both off-peak and peak traffic periods. Metro measurements were performed at different times of the day. Information on the ventilation systems of the road tunnel, metro platforms, and metro carriages was not available and therefore could not be included in the analysis. This limitation has been acknowledged in the revised manuscript.

Lines 133–135

Comment: *Indicate the corresponding Supplementary Information figures and standardize the $PM_{2.5}$ notation.*

Response: All Supplementary Information figure references have been added using the requested format (Figure SI X), and the notation of $PM_{2.5}$ has been standardized throughout the manuscript.

Lines 138–140

Comment: *Include scatter plots and/or time-series comparisons between AirBeam 3 and TEOM before and after calibration.*

Response: Additional calibration results, including the coefficient of determination (R^2), have been incorporated into the Results section. A more detailed presentation of the calibration analyses and graphical comparisons has also been included in the Supplementary Information.

Lines 142–149

Comment: *Clarify the statistical analyses.*

Response: The paragraph has been reorganized into separate sections describing each statistical method individually. The purpose of each analysis is now explicitly stated, while the more detailed statistical explanations have been moved to the Supplementary Information to improve readability.

Lines 152–155

Comment: *Show georeferenced transient data on a map.*

Response: A new figure has been added showing a map of the Municipality of Madrid together with the routes followed during the field measurements.

Lines 157–166

Comment: *Provide a detailed record of each field measurement.*

Response: A new table has been added to the Results section summarizing the requested information for the road tunnel measurements, including sampling date, time, route, tunnel section, duration, tunnel entry and exit times, and other relevant metadata.

Lines 168–174

Comment: *Indicate the corresponding figure or table.*

Response: The corresponding reference to Figure 1 has been added.

Lines 168–173

Comment: *Explain the ANOVA analysis.*

Response: This issue is closely related to the following comment concerning the division of the tunnel measurements into two phases.

Artificial division into Phase A and Phase B

Comment: *The division into two equal halves appears arbitrary.*

Response: We agree with the reviewer that the division is arbitrary. Its sole purpose was to illustrate the different behaviour of $PM_{2.5}$ concentrations during the early and later stages of travel through the tunnel. The manuscript has been

revised to clarify this rationale and to avoid any implication that the division represents statistically defined change points.

Quality control criteria

Comment: *Explain the quality control criteria.*

Response: All measurements were subjected to quality control before analysis. Data showing isolated, abnormally high $PM_{2.5}$ values over very short periods (typically lasting only a few minutes) were considered measurement artefacts and were excluded from the dataset. This quality control procedure has now been described in the Methods section.

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Response to Reviewer #2
We sincerely thank the reviewer for the careful evaluation of our manuscript and for the constructive comments, which have helped us improve its quality. Our point-by-point responses are provided below.

Comments and Suggestions for Authors
The title, in its current form, is not particularly appealing. It might be more effective to remove the full stop and use “in Madrid” instead.
Performed

The literature review is strongly focused on the existing state of knowledge in Madrid, and the research gap to be addressed by the study is clearly identified. This study evaluated the performance of low-cost sensors (LCS) for monitoring PM2.5 in urban transport microenvironments, including road tunnels and metro systems. The study highlights the potential of LCS and citizen-based monitoring to assess exposure and support air quality surveillance in transport environments. The study also highlights potentially elevated PM2.5 concentrations in heavily trafficked urban tunnels and metro environments, which may pose health risks, particularly for susceptible populations. The authors recommend systematic PM2.5 monitoring in tunnels, metro platforms, and train carriages, with publicly available data and the implementation of corrective measures when pollutant concentrations exceed relevant thresholds. The division into paragraphs is clear and well structured.
Some recommendations and comments are provided:

1. Lines 113, 115, and 118: The references to the citations appear to be missing, as “n.d.” is reported. Please check and provide the appropriate references.
   References 6, 9, and 10. the “n.d.” notations have been removed.

2. Line 124: How is cPM2.5 defined? It would be useful to provide its definition at its first occurrence. If it refers to PM2.5 concentration, clarification is needed because “PM2.5 concentration” is used instead in Lines 217–218.
   Corrected in line 123 y 216.

Do these terms refer to different quantities? The term “mean cPM2.5 concentration” is also used in Lines 249–250. Please clarify the distinction between these terms.
Corrected in line 248.

3. Line 181: A full stop appears to be missing.
Corrected

4. It might be appropriate to move the section on public health implications, currently included in the Discussion section, to an earlier position, closer to the literature review. This section contains several references to previous studies and could therefore be more effectively integrated into the background and state-of-the-art discussion.
Although this point is debatable, as the reviewer indicates, we believe that this is the appropriate section of the discussion in which to address the potential health implications of our findings. If the editor considers that this approach should be modified, we would be happy to relocate this passage within the manuscript.

5. Tables 1 and 2: These tables could potentially be converted into graphical representations, which might provide a clearer visualization of the correlation between the LCS measurements and the reference values.
The data from all M30 routes were pooled into a single database. A paragraph has been added to the text presenting the mean cPM2.5 values from the published government outdoor monitoring data for the study days.

A column has been added to Table 2 showing the values recorded at the government monitoring station closest to the station under analysis. The data are shown graphically in Figure 5.

For Table 3, it is very difficult to collect this information from outdoor government monitoring stations, as trains in service travel for several kilometers, with highly variable journey durations.

6. The number of figures is relatively limited. Consider including additional graphical representations of the results. It might also be useful to plot the reference measurements alongside the LCS measurements to facilitate a direct comparison.
A column has been added to Table 2 showing the values recorded at the government monitoring station closest to the station under analysis. The data are shown graphically in Figure 5.

7. Where are the reference monitoring stations located? Please provide information on their location and, if relevant, their proximity to the measurement sites.
We have added a new figure (figure 2) showing the locations of the government-operated air quality monitoring stations.

8. Sensor performance over time: How do you assess the potential degradation or drift of the sensors over time? What methodology is used to evaluate the long-term reliability and stability of the system under study?
   Our sensor validation study was conducted between december 2023 and January 2024 (see the attached supplementary information). The field studies in the M30 road tunnel and the Madrid metro were carried out between January and November 2024.

   Therefore, the field measurements were conducted shortly after sensor validation, within a time interval that we considered appropriate.

9. It would be useful to include a dedicated section describing the specific characteristics of the sensors used in the study. Providing detailed information on the instrumentation used as the validation basis could strengthen the interpretation and reliability of the validation results.
   This information has been added to the supplementary information section describing the validation of the sensor used in the study.

10. Figure 2: The x-axis is missing. Since the x-axis represents the time variable, this should be explicitly indicated. Alternatively, considering that the measurements were performed during a journey, would it be more appropriate to express the x-axis in terms of distance travelled rather than time?
    We are unaware why the x-axis label did not reach the reviewer. the label is: “time in seconds”

Comments for Editors

The manuscript addresses a relevant and timely topic, namely the use of low-cost sensors to assess PM2.5 exposure in urban transport microenvironments. The study is potentially valuable, particularly because it combines sensor validation with measurements in road tunnels and metro environments and involves citizen participation.

Overall, the manuscript is clearly structured and the research gap is well presented. However, I believe that some aspects should be clarified or strengthened before publication. In particular, further details on the sensors and reference instrumentation, the definition and use of cPM2.5, the location and characteristics of the reference stations, and the assessment of sensor stability and potential degradation over time would improve the scientific robustness of the manuscript. The presentation of the results could also be enhanced through additional figures and a clearer comparison between LCS and reference measurements. Therefore, I believe that the manuscript has merit but requires major revisions before it can be considered for publication.

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