

Manuscript Title: Development and Validation of an Integrated Ambient Air Test Facility (AATF) for Multi-Instrument Aerosol Characterization

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We thank the reviewers for their constructive, thorough, and supportive feedback. Their insights have helped us clarify several technical details and improve the manuscript's transparency. Below, we provide our point-by-point responses (AR) and the corresponding manuscript changes (MC) with corrected line numbers based on the final revised document.

PART 1: RESPONSES TO REFEREE #1

RC1.1: The manuscript claims a detection range up to 20 μm , but no validation data is presented for particles larger than 10 μm , and the instruments cited cannot measure up to 20 μm .

AR: We acknowledge this concern. Our original claim was based on the AATF's design capabilities, but the presented experimental validation robustly supports a range up to 15 μm . We have therefore revised the manuscript to claim this more defensible validated upper limit.

MC:

1. **Abstract (Line 7), Introduction (Line 51), and Conclusions (Line 479):** The claimed particle size range has been changed from "50 nm to 20 μm " to "50 nm to 15 μm ".

RC1.2: How is aerosol homogenisation ensured along the horizontal test section despite particle settling?

AR: We have expanded Section 2.2 to include a detailed explanation of the AATF's fully developed turbulent flow regime ($\text{Re} \approx 40,000$). The turbulent fluctuation velocity is over 30 times greater than the terminal settling velocity of a 10 μm particle, ensuring particles remain suspended and homogenized.

MC:

1. **Section 2.2 (Lines 130-141):** A paragraph has been added detailing the mitigation of particle loss via turbulent diffusion, which dominates gravitational settling in this flow regime.

RC1.3: The authors compare instruments without having any reference instruments available.

AR: We apologize that this was not clear. Key instruments (the two TSI APS units, the Palas Promo, and the UHSAS) were calibrated by their respective manufacturers immediately prior to this campaign and served as our internal reference standards. We have updated the manuscript to state this and have also added a commitment to implement a routine data quality assurance protocol.

MC:

1. **Section 2.3 (Lines 166-168):** Text has been added stating that "The two APS units, the Palas Promo 2000, and the UHSAS were calibrated by their respective manufacturers prior to the validation study and their performance verified in our lab prior to installation at the AATF."

2. **Conclusions (Lines 487-490):** The following sentence has been added: "...and implementation of a routine data quality assurance protocol, such as periodically introducing PSL aerosols, to monitor the long-term stability and performance of the reference instruments."

RC1.4: The accuracy of the size measurements should be checked by generating size-certified particles.

AR: We agree. This was a critical validation step that we have now clarified in the manuscript. Section 2.3 now includes the results of a side-by-side baseline comparison of the two APS units performed using NIST-traceable polystyrene latex (PSL) spheres.

MC:

1. **Section 2.3 (Lines 168-174):** The results of this baseline comparison have been added. (See exact text in response to RC2.1 below).

PART 2: RESPONSES TO REFEREE #2

RC2.1 (Main Concern): Lack of an intercomparison study for the instruments. It is not clear whether observed differences are due to aerosol mixing or instrument response.

AR: We agree that a side-by-side intercomparison is a crucial baseline. To address this, we have updated **Section 2.3** to include the results of a comparison of the two APS units performed with NIST-traceable PSL spheres. Using this verified baseline, we have revised **Section 3** to confidently attribute the minor discrepancies observed in the flow tube to this inherent inter-unit variability and temporary instrument-level anomalies (e.g., pump debris), rather than to poor mixing within the highly turbulent facility flow.

MC:

1. **Section 2.3 (Lines 168-174):** The following text has been added:

"Specifically, to decouple inherent instrument variability from potential spatial sampling differences within the facility, a side-by-side intercomparison of the two APS units was performed in the lab. Using NIST-traceable polystyrene latex (PSL) spheres, the two units demonstrated excellent agreement, showing a percent difference of less than 5% at 2 and 4 μm sizes. A higher percent difference of approximately 45% was observed at 1 μm ... To ensure the highest fidelity... standard operating procedures for future studies at the AATF will include side-by-side baseline comparison..."

2. **Section 3 (Lines 344-358):** The discussion of APS differences has been completely revised to incorporate the baseline data and provide a more robust conclusion. The new text reads:

"Since each test section is equipped with an APS... when differences arose between the two APSes in the 10–20 μm range, it was consistently APS 1 that displayed a greater number of counts. This discrepancy would continue until APS 1 was restarted and is possibly due to trapped debris that is released when the pump is power cycled. Given the verified instrument baseline agreement (described in Section 2.3)... the minor discrepancies in response between the two APS units during facility testing are attributed to inherent inter-unit variability and temporary instrument-level anomalies..."

RC2.2-RC2.10 (Minor Comments):

AR: We have addressed all minor comments as follows:

- Specified **APS 1/APS 2** throughout the manuscript.
- Updated captions for **Figures 2, 9, and 10** to define the shaded area as “standard deviation.”
- Corrected the caption for **Figure 3** to state it used a “polydisperse calibration aerosol”, adopted the suggested phrasing for “variation of particle counts,” and specified $V_{max} = 2$ m/s.
- Clarified in **Section 2.3 (Lines 162-165)** that sample probes were placed to avoid obstruction.
- Defined **GC/MS** (Gas Chromatograph/Mass Spectrometer) at its first use on **Page 9, Line 215**.
- Moved the reference to **Event 4** into the caption of **Figure 5**.
- Changed the y-axis of **Figure 7** to a log scale to show the full data range.
- Acknowledged the suggestion of an aerosol dryer in the **Conclusions (Lines 490-491)** as a difficult future enhancement.
- Standardized subfigure labeling to a), b), c) for all figures.

MC: All changes listed above have been implemented in the revised manuscript at the corresponding locations.