Response Letter to Referee #2

We thank Referee #2 for the careful review and constructive suggestions. All the comments (in **bold** text) are addressed below point by point, with our response following in non-bold text and the corresponding revisions to the manuscript in blue. All updates of the original submission are tracked in the revised version.

This study presents the development and validation of a UAV-based sampling platform designed for vertically resolved chemical sampling of aerosol particles within the planetary boundary layer (PBL). The primary goal of this platform is to address the spatial flexibility limitations associated with traditional fixed-site monitoring or manned aircraft. The system employs a DJI Matrice 350 drone to collect particulate matter onto a PTFE filter membrane, which has an outer diameter of 25 mm and a deposition diameter of 9 mm. Once the UAV lands, these filter membranes can be directly analyzed using the FIGAERO-CIMS system. Several concerns need to be addressed before publication.

1. **As shown in Figure 1, it seems that no size-selective inlet was used. Please clarify whether TSP samples are collected and explain why TSP sampling is preferred over $PM_{2.5}$.**

We thank the reviewer for this comment. As also noted by Referee #1, the platform currently targets bulk aerosol chemical characterization and therefore samples TSP without applying a dedicated size-selective inlet. We have clarified the effective sampled size range and inlet transmission characteristics in Section 2.1 (lines 90–98).

"The current application of the platform focuses on bulk aerosol characterization, thus no size-selective inlet is applied and the system nominally sampled total suspended particulate (TSP). However, estimations of the transmission efficiency of the inlet (von der Weiden et al., 2009) indicate that larger particles (10 µm in diameter) may suffer losses exceeding 80%, while particles smaller than 2.5 µm are expected to have a transmission efficiency over 95%. In the present platform configuration, these losses primarily occur at the inlet interface and are largely independent of the downstream inlet architecture. Consequently, similar inlet conditions are expected for the ground-based sampling configuration used for comparison. The platform design nevertheless allows straightforward integration of size-selective inlets for studies targeting specific research objectives, such as size-resolved chemical composition or health-relevant aerosol fractions."

2. **The demonstration study was conducted at night. The filter holder lacked a solar radiation shield, so sampling during the day could result in the loss of volatile**

components due to heat absorption by the filter holder. The author needs to clarify whether the system is intended solely for nighttime sampling.

We thank the reviewer for this insightful comment. While the majority of the work presented here, as well as our ongoing studies, focuses on nighttime chemistry, the system is designed to operate under both daytime and nighttime conditions. Validation experiments of filter collection were also conducted under sunlit conditions. During our Nordic winter and spring deployments, low ambient temperatures and limited solar radiation resulted in negligible heating of the filter holder relative to ambient air. We acknowledge, however, that operation in warmer environments or under stronger solar radiation could enhance heating of both the drone body and filter holder, potentially affecting gas–particle partitioning on the filter. We have therefore added a discussion in Section 2.1 (lines 84–86) noting that a solar radiation shield or alternative filter holder materials with higher thermal inertia may be required under such conditions. This modification has now also been implemented in the current system configuration.

"In this configuration, no solar radiation shield was used, as all tests were conducted under Nordic cold to mild temperature conditions with limited direct solar radiation. When operating in warmer environments, the use of a shielded filter holder may be necessary to minimize sampling artifacts related to thermal effects."

3. **In section 2.5 the authors state that "The filter sampling period was ~1.5 hours". Does this refer to the sample shown in Figure 7? How many flights were conducted to achieve the 1.5-hour sampling?**

Reply: We thank the reviewer for pointing out that certain details regarding our demonstration study are not clearly presented in section 2.5. Three flights of ~30 min each carried out in succession were performed to a total of 1.5 hours sampling. Preceded and followed by additional flights, where only meteorological data was gathered. Section 2.5 has been edited to present the details of the demonstration study with more clarity. Lines 182–183:

"The filter sampling period was a combination of three 30-minute flights, with a total ~1.5 hours sampling time."

4. **The author should provide a lookup table enabling users to determine the recommended minimum sampling duration for each $PM_{2.5}$ concentration level based on local typical OA concentration ratios. This ensures sufficient sample volume is collected to meet the CIMS detection limit. $PM_{2.5}$ measurements can be conducted by equipping UAVs with a scattering-based PM sensor (e.g., Plantower). The workflow is now as follows: first, obtain the PM sensor reading at the desired height; then, determine the sampling duration threshold from the lookup table. This allows users to quickly determine the necessary filter sampling times on-site.**

We appreciate this thoughtful suggestion aimed at enhancing operational usability. However, because transmission efficiencies and detection limits of the FIGAERO-CIMS vary substantially between instruments and operating conditions, and the organic mass fraction of $PM_{2.5}$ can also differ significantly across environments. Consequently, a generalized lookup table linking $PM_{2.5}$ concentration to required sampling duration would not be broadly transferable. Instead, we provide estimated filter mass loadings from our deployments (Section 2.4, L 174–179) as a practical reference point and recommend that users calibrate sampling duration based on instrument-specific sensitivity.

5. **Please specify the total sampling duration for each sample shown in Table S1.**

Table S1 has been revised to include the total sampling duration for each measurement.

6. **Please also include RH and T comparison scatter plots in Figure 2.**

These plots are now included in the Supplement (Figs. S3 and S4), and shortly discussed in section 3.1 lines 211–212.

"T and RH are also important parameters in meteorological sounding as they are commonly used to discern atmospheric stratification (Jiang et al., 2024). T and RH measured during the same testing period exhibited a very good agreement (Fig. S3, S4) (RMSE in the order of 0.1 °C and 0.1% RH)."

7. **Please clarify whether the drone sample shown in Figure 7 was collected when hovering at a height of 120 m or during ascending and descending.**

Section 2.5 was edited to clarify where in relation to the ground level the aloft particle measurements were made.

Lines 183–184: "Both ground and drone-based filter collections were started simultaneously when the drone reached 120 MAGL, and were intermittently stopped during descent and re-ascent periods to swap drone batteries."

We hope that the revisions and clarifications have addressed the reviewer's concerns and improved the clarity of the manuscript.

References

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