Response Letter to Referee #1

The authors thank the reviewer for the careful review of our manuscript and helpful comments and 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.

Review of "A drone-based sampling platform for vertically resolved chemical characterization of aerosol particles using chemical ionization mass spectrometry" by Håkansson et al.

General comments:

The authors present a drone-based aerosol filter sampling platform designed to collect particulate matter in the planetary boundary layer for subsequent analysis using FIGAERO-CIMS. The platform integrates particle sampling together with real-time meteorological sensing (temperature, relative humidity, wind speed/direction, pressure). The authors validate the meteorological sensor performance by comparison against a stationary tower system, and assess potential drone-rotor impacts on particle sampling by comparing drone-based vs ground-based co-located filter sampling under "hovering" and "grounded" conditions. Finally, the authors demonstrate the platform's capability in a case study where strong nocturnal stratification leads to clear vertical differences in aerosol concentration and molecular composition. Overall, the work addresses a meaningful instrumentation gap: molecular-level aerosol composition and volatility information measured with height resolution within the boundary layer remains scarce, and this platform provides a flexible way to expand spatial sampling coverage for FIGAERO-CIMS analysis. The manuscript is well suited for Atmospheric Measurement Techniques and will be valuable to the community.

We appreciate the reviewer's positive assessment of the scientific relevance and suitability of the work for *Atmospheric Measurement Techniques*.

I have some general comments and questions. First, it is not fully clear what the intended purpose and practical advantages are for operating the system in "semi-online mode" compared to "offline mode". The manuscript introduces semi-online and offline sampling early in the text, but the distinctions between these modes (and why semi-online mode is useful and/or necessary) could be explained more clearly and earlier in Section 2.2.

We thank the reviewer for this helpful suggestion. We agree that the motivation for distinguishing between semi-online and offline operation required clearer explanation. We have therefore revised Section 2.2 to more clearly explain the advantages and limitations of both approaches. The following text has been added (lines 126–131):

"For offline analysis, the same sampling procedure is applied; however, chemical analysis using the FIGAERO-CIMS is conducted in the lab days to months after sampling collection. While the semi-online mode enables near-real-time characterization of particle chemical composition and allows direct comparison with stationary online measurements, the offline approach increases operational flexibility as it eliminates the need to deploy the mass spectrometer in the field or in a nearby laboratory. However, the offline approach may introduce potential artifacts associated with the potential condensation, re-evaporation, and reactions on the filter during storage, which may result in both positive and negative sampling biases (Cai et al., 2023a)."

Second, it would be helpful if the authors specify and explain the aerosol size range that is effectively collected by the drone-based method. The manuscript would benefit from clarifying whether this configuration should be interpreted as approximately "PM2.5-like," "PM1-like," or closer to total suspended particulate, and from briefly discussing potential inlet losses and how these might affect the measured chemical composition, especially for larger particles.

We thank the reviewer for this important comment. We agree that clarification of the effective aerosol size range is necessary for proper interpretation of the measurements. As no dedicated size-selective inlet is employed, the system nominally samples total suspended particulate (TSP). However, any potential inlet losses are size dependent and will therefore influence the effective size range sampled. Section 2.1 has been revised to include a quantitative description of the inlet transmission efficiency and its implications for effective particle collection (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) indicated 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."

Third, given that this work relies on filter collection followed by FIGAERO thermal desorption (semi-online/offline), I encourage the authors to provide a brief discussion of potential sampling/handling artifacts (e.g., evaporation of semi-volatiles, adsorption of gas-

phase species onto filters, and possible reactions during storage) and how these artifacts are minimized or quantified.

We thank the reviewer for this suggestion. A discussion of potential artifacts associated with offline sampling/handling has now been added in Section 2.2 (see response above).

I also have a few specific questions and comments.

Specific comments:

1. **Line 1: "exhibits" should be "exhibit"**

Corrected.

2. **Figure 1: There seems to be a 90-degree angle right before the filter holder, which would increase particle losses, especially for larger particles. Have the authors considered moving the filter holder before the 90-degree bend to minimize particle loss?**

We thank the reviewer for this constructive suggestion. We agree that minimizing sharp bends is generally desirable to reduce particle losses, particularly for coarse particles. During the platform design phase, the placement of the filter holder was primarily constrained by drone stability considerations and the need to avoid interference with onboard sensors. Based on inlet transmission estimates and comparison with the ground-based sampling configuration, we expect that relocating the filter holder upstream of the bend would result in only minor improvements in overall transmission efficiency. This point has now been clarified in Section 2.1 (lines 94–95), as detailed in our response above.

3. **Line 87: It seems that "diameter mm" should be "mm diameter"**

Corrected.

4. **Line 88-89: There is a grammar issue in the sentence beginning with "The online …"**

Corrected.

5. **Line 128: Please clarify what is meant by "offset by 52-minute". Do you wait for 52 minutes after finishing the first sample before analyzing the second one?**

We thank the reviewer for this call to clarify our analysis process. Amendments were made to lines 143–144.

"When collecting two simultaneous filters (e.g. one from the drone platform and one from the ground-based sampler), the second is offset by 52-minute, i.e. desorption of the second filter is started immediately following the first."

6. Line 199: It would be helpful to briefly explain what "potential temperature" is and why it is used here instead of temperature, for general readers.

We thank the reviewer for urging us to make the study more accessible to the general reader. A brief description of potential temperature and its advantages to temperature is included in the paragraph where it is first mentioned (lines 221–224).

"Potential T was used here as it is a common parameter used to estimate boundary layer height (Jiang et al., 2024; Baumgartner et al., 2020). Potential T represents the T an air parcel would have when adiabatically brought to a reference pressure (e.g 1000 hPa). As opposed to tracking T, potential T is used to evaluate the atmosphere's actual vertical T gradient, excluding any diabatic change in the probed air."

7. Line 200: "T" or "potential T"?

Corrected to "potential temperature."

8. Figure 3: Please specify what the error bars represent in the caption.

Figure caption edited to specify what the error bars represent.

9. Line 221-222: It appears something may be missing inside the bracket, or the bracket may not be formatted correctly

Corrected.

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

References

Baumgartner, M., Weigel, R., Harvey, A. H., Plöger, F., Achatz, U., and Spichtinger, P.: Reappraising the appropriate calculation of a common meteorological quantity: potential temperature, *Atmospheric Chemistry and Physics*, 20, 15 585–15 616, https://doi.org/10.5194/acp-20-15585-2020, 2020.

Cai, J., Daellenbach, K. R., Wu, C., Zheng, Y., Zheng, F., Du, W., Haslett, S. L., Chen, Q., Kulmala, M., and Mohr, C.: Characterization of offline analysis of particulate matter with FIGAERO-CIMS, *Atmospheric Measurement Techniques*, 16, 1147–1165, 2023.

Freeman, S. W., Bukowski, J., Grant, L. D., Marinescu, P. J., Park, J. M., Hitchcock, S. M., Neumaier, C. A., and van den Heever, S. C.: Characterizing Thermodynamic Observations from Unshielded Multirotor Drone Sensors, *EGUsphere*, https://doi.org/10.5194/egusphere-2024-2425, 2025.

von der Weiden, S.-L., Drewnick, F., and Borrmann, S.: Particle Loss Calculator – a new software tool for the assessment of the performance of aerosol inlet systems, *Atmospheric Measurement Techniques*, 2, 479–494, https://doi.org/10.5194/amt-2-479-2009, 2009.