Reviewer comments in black, answers in blue and changed text passages in black/red

RC2 (30.04.2025)

Dear authors, congratulations on an interesting paper about this relevant measurement technology. In general, the article is well presented, and the topic is interesting. Although I certainly appreciate articles focused on the development and engineering of measurement systems, it must be stated that they often precede the scientific articles using data collected by these systems. Therefore, the system description articles are often a little thin on the scientific results, focusing their science mostly on the validation and trustworthiness of the newly developed system. Therefore, my review is based on these premises.

We thank Reviewer 2 for the helpful and constructive comments. All points were carefully considered, and the manuscript has been revised accordingly. We believe the changes have improved the quality and clarity of the manuscript.

Specific Comments:

1. Abstract Line 6 (and article lines 224, 226, and 298): In the abstract, you describe the RoLi's profiling speed using the more traditional SI unit of m/s. However, in lines 224, 226, and 298, you use mm/s, including a negative sign in line 224. I recommend making these units follow a standard, ideally m/s.

   We agree with this suggestion and have updated all references to the RoLi profiling speed to consistently use meters per second (m/s) throughout the manuscript, including the abstract and lines 224, 226, and 298. The negative sign in line 224 has also been removed for clarity as it is already clear from the context that the movement is downward, so the negative sign is not necessary.

2. Line 26: This sentence has a strange wording. Is the tower "AT" the core of the project?

   The sentence has been changed to:

   Line 25 to 27:

   "The central infrastructure of the project is the 325 m tall tower, which enables continuous measurements of atmospheric parameters at the forest–atmosphere interface and throughout the lower planetary boundary layer (PBL)."

3. Line 34: The wording here may need to be improved because it is confusing. Although you offer a reference, I still fail to follow the logic of the argument. How does a large "footprint" enable the integration of regional processes? Would not a network of small flux towers better represent mesoscale and regional processes?

We agree that the original sentence could be further clarified. The key point is that, due to their height, tall towers are able to sample air masses that have traveled over larger areas and are more mixed, effectively integrating signals from broader spatial scales. In contrast, smaller flux towers typically capture processes at the ecosystem or local scale due to their lower measurement height and more limited footprint. We have revised the sentence to clarify this distinction, which read now as follows:

Line 33 to 35:

"Complementary to smaller flux towers, which measure at or above canopy height and have a limited footprint area, tall towers have significantly larger footprints and thus capture atmospheric signals that reflect spatially integrated processes over broader regions."

4. Line 47: The four-dimensional argument here is overstated. Even though the RoLi is increasing resolution in the vertical dimension, it is still attached to a single tower (i.e., a single point in the region) and not a network of tall towers. This needs to be reworded not to overstate the impact of this system.

We agree that the original wording could be misinterpreted. Our intention was not to suggest that the RoLi system provides four-dimensional atmospheric data. Rather, the sentence aimed to highlight the general limitation of traditional tower-based measurements at a few fixed inlet heights, which offer only limited insight into inherently four-dimensional atmospheric processes (i.e., varying in time and three-dimensional space). To avoid any misunderstanding, we have revised the sentence in the manuscript to clarify this point.

Line 45 to 49:

However, observations at only a few fixed inlet heights are subject to experimental limitations, as they provide a simplified view of the complex spatial and temporal dynamics involved in the atmospheric exchange of gases and aerosols. In particular, aerosol measurements are often restricted to just one or a few vertical levels, mainly due to the technical challenges and limited flexibility associated with the installation of stainless steel inlet lines.

5. Line 57: The argument regarding UAS flight time is incorrect. In your scale of profiles, every 30 minutes with 0.5 m/s ascent speeds, there are several commercially available UAS that can easily achieve those flight performances. I believe the real argument against UAS use here is the pilot/or human oversight requirements and the current limitations on availability of battery recharging/swapping technologies.

It is true that certain commercially available UAVs are capable of achieving vertical profiling at the speeds and intervals described. Our intention was not to imply a general technical limitation in terms of ascent speed or flight performance, but rather to highlight practical constraints related to continuous or long-duration deployments, such as battery

and payload limitations. In contrast, our robotic lift system enables flexible vertical profiling at various speeds, including intermittent stops for sampling or static measurement, while operating autonomously over extended periods without the need for repeated battery swaps or pilot supervision. We have revised the sentence to more accurately reflect this distinction.

Line 56 to 58:

"Vertical profile measurements using UAVs eliminate the need for long inlet lines but are constrained by limited payload capacity, relatively short flight durations due to battery limitations, and the requirement for human oversight. "

6. Obs: The best argument for your system is around line 50 - 55 (the short inlet and the measurement accuracy)!

   Thanks for underlining this point.

7. Line 326: Here, you mention the nocturnal Low-level jet as "clearly visible"; Well, it is not. In part because the x-axis only has date and not time, so I can at best only estimate day and night, but also because with data for four days, the stronger winds could be associated with other features, such as the rains described. Therefore, I suggest rewording this explanation and improving the figure to mark sunrise and sunset for each day.

   Thank you for this comment. The nocturnal low-level jet (LLJ) is a well-documented feature in the central Amazon, and we believe the wind profile data presented clearly reflect this phenomenon, particularly given the absence of downdrafts or convective outflows during these periods. To improve clarity, we revised the x-axis to include both date and time and updated the figure caption of Figure 4 and 5 to explicitly state that the shaded areas in Panel A represent nighttime conditions.

8. Line 334 - 336: Similar to the comment for line 326, this daily cycle is also not "clearly highlighted".

   X-axis and description of Fig. 4 and 5 has been modified as stated in the answer to comment 7.

9. Line 346 - 358: The wording for this paragraph is a bit strange. You start describing the behavior of particles, then transition to relating it to wind shear, only to return to addressing the particles, making it confusing. This is particularly true in line 352 when you start a sentence with "The origin of these particles" after talking about winds. Therefore, it is unclear to the reader which particles are referred to by "these".

We improved the clarity and logical order in that sentence. The sentence read now as follows:

Line 365 to 371:

Interestingly, this particle layer was poorly detected by the stationary measurements at 60 m and 325 m, as these heights were either below or above the layer (Figure 5 B). The majority of particles within this elevated layer were in the <30 nm size range. Wind direction data indicate a pronounced vertical wind shear during the same period. The layer above the canopy, up to approximately 100 m, was dominated by northwestern winds, whereas winds above 100 m predominantly originated from the northeast. This wind shear may have contributed to the accumulation or formation of the observed particle layer. However, the origin of the <30 nm particles remains uncertain, as black carbon (BC) data from 60 m were unavailable during this period. The BC data from 325 m do not indicate elevated concentrations, suggesting a predominantly natural origin.

10. Lines 359 - 367: I particularly liked that you addressed system limitations and included a section for it later. Good Job!

    Many thanks.

11. Figures 4 and 5: Improve the x-axis to include time and add markers for sunrise and sunset to make day-night cycles clearer.

    This issue was already addressed in our responses to comments 7 and 8. As a result, we have modified the x-axis of Figures 4 and 5 to include both date and time, and we have updated the figure caption to clarify that the grey shaded boxes in panel A represent nighttime periods, thereby making the day–night cycles more easily identifiable.

12. Section 3.4 is very good. Good job!

    Thank you very much for your positive feedback on Section 3.4.

13. Line 444: You conclude that "the short inlet line of RoLi avoids the effects and unavoidable losses associated with long inlet lines". Which is a confusing sentence because you are saying it avoids the unavoidable (even though the "unavoidable" adjective is attached to the long lines). Additionally, you make this conclusion without having shown a clear comparison between the short and long line systems. Therefore, I do not believe this is a conclusion that the data shown in the article supports. You have to either add the supporting data or remove the conclusion.

Many thanks for pointing this out. While we do not present a direct comparison with long inlet systems in this manuscript, it is well established in aerosol science that particle losses due to diffusion increase significantly with inlet length, especially for ultrafine particles. We modified the sentence as follows:

Line 472 to 474:

"... Furthermore, the short inlet line of RoLi helps to minimize particle losses and sampling artifacts that are commonly associated with longer inlet lines, particularly for ultrafine particles".

Conclusion: Is this system open-source? Can others use it? If so, be sure to highlight it as it would greatly increase the value of this article to the community.

General Recommendation:

1. The system is interesting, and the article is good. However, I believe it could be improved by including more intercomparison data to validate the performance of the RoLi system. As is, the data presented only indicates a minimal agreement with the expected atmospheric patterns of the region for that time of year, without a validation of the instances in which it does not.

   Thank you very much for your positive overall assessment and your constructive suggestion. We agree that including more intercomparison data would further strengthen the validation of the RoLi system. While the current manuscript focuses primarily on demonstrating the technical capabilities and profiling potential of the system through selected case studies, we acknowledge that a more comprehensive performance evaluation would be beneficial.
   The RoLi system has demonstrated reliable performance under challenging rainforest conditions, including high humidity, strong winds, heat, and heavy rain. While the presented data reflect expected patterns in several cases, this study focuses on the technical capabilities of RoLi for high-resolution vertical profiling. A follow-up study is currently in preparation to explore the atmospheric processes in greater detail.

2. Although I understand that a 330 m tower does not fit in a controlled chamber, and there are not many other towers around, I believe the authors could have demonstrated the performance of the measurements against the point measurements of the tower, the inferred profile from the tower point measurements, and a NWP simulation.

   We agree that comparison with reference measurements is important. During the RoLi campaigns, two fixed measurement heights for aerosol data (at 60 m and 325 m) were available on the ATTO tower. These data have been included in the manuscript and are shown in the relevant figures for direct comparison with the vertical profiles recorded by RoLi.

While this limits the extent of profile-based validation during the campaign, we believe the inclusion of these reference points still provides meaningful context to assess the plausibility and representativeness of the RoLi measurements. We have clarified this in the manuscript. Additional intercomparisons, including model simulations (e.g., from NWP), are part of our planned future work.

3. Finally, it is unclear if others in the community can benefit from this development. Can I also build a RoLi, or is it proprietary? Can I access and use RoLi data? If not, why should I care about it? Please make these answers clear to the reader. I believe doing so will elevate the impact of this article in the community.

   RoLi is an open-source platform, and all essential technical details required to build and operate the system are described in this manuscript. For further guidance or implementation support, interested researchers are welcome to contact us directly. We are happy to share additional documentation and assist with adaptations for specific use cases.
   Given the growing number of tall research towers worldwide, and the increasing need for vertically resolved measurements of aerosols, trace gases, and VOCs, we believe that the RoLi concept offers a valuable and scalable solution for atmospheric research.
   In addition, all RoLi data will be made publicly available through an open-access repository once the associated manuscripts are published, ensuring transparency and enabling further use by the research community.