Responses to Reviewer #2 of the manuscript "Vertically resolved aerosol variability at the Amazon Tall Tower Observatory under wet season conditions" by Franco & Valiati et al., submitted for publication in Atmospheric Chemistry and Physics

Dear Editor, we would like to thank reviewer #2 for the valuable comments and useful suggestions to improve our manuscript. Below, you can find answers and actions for each individual comment. In order to make it easier to identify the individual answers and actions, we used the following color code strategy:

- **In black are the reviewer's comments.**
- **In blue are the author's responses.**
- ***In blue and italics are the text modifications we made in the manuscript.***

General comment:

The study discussed vertical variations in size distribution and numerical concentration of submicron aerosols, in addition to intensive and extensive properties of aerosols. These measurements carried out at ATTO are in themselves a great scientific contribution, in addition, the authors discuss these variations satisfactorily with a vast current bibliography, which supports the justification of the study and favors explanations of the observed phenomena.

The authors found significant differences in concentrations and optical properties for different heights and explained these differences using consistent methods, such as analysis of downdraft events and analysis of the aerosol refractive index. Throughout the discussion, several processes of formation, removal, and contributions arising from aerosol transport are highlighted.

The study makes an important scientific contribution that elucidates the processes of emission, formation, and transport of aerosol along the vertical profile. The text is well structured and written, and the figures (main and complementary text) and analysis allow us to reach important conclusions that, in addition to explaining the vertical variations, quantify important parameters such as the absorption of BC, BrC, and optical properties at different heights, which contributes for future model development and tuning in inversion algorithms for satellite products.

I recommend publication after minor revision.

We thank Referee #2 for the very constructive comments and useful suggestions. They helped us to clarify important aspects of our discussions and, thus, to improve the manuscript overall.

Specific comments:

About the Introduction: The text is very well written. The information is clear and objective, and the citations are appropriate and contextualize what has already been done and what is new about the work. In my opinion, the only point that needs to be adjusted is the textual term "vertical distribution of aerosols" which is mentioned in the last paragraph, when highlighting the objective of the work. As this study analyzed measurements (optics, size distribution, and numerical concentration) at two specific heights, the authors should refer to vertical variation and avoid the terms distribution or vertical profile, unless this terminology is introduced in the text for the specific case.

Thanks for pointing this out. The terms “vertical distribution” and “vertical profile” were changed to “vertical variation” in the Introduction.

Section 2.1: Although the authors cite Andreae et al. (2015) for additional information from the study site, I encourage the authors to provide a figure with the location of the site, preferably showing a schematic with the arrangement of instruments for different heights, as well as the average canopy height. The scientific contribution of the study justifies this increase, as the work will serve as a reference for many future studies.

Thanks for the suggestion. The final version included a figure showing the location of the ATTO site in relation to the city of Manaus and the Uatumã River (Figure 1 in the revised manuscript). Regarding the canopy height, according to Lang et al. (2023), the average canopy height at ATTO is around 35 m, which is the number usually mentioned in many previous studies. This information was also added to the text.

Section 2.2: The authors justify not analyzing particles larger than 400 nm due to the limitations of SMPS. However, instrumentation definitions only appear in the next topic. I suggest an inversion of these topics.

Thanks. The “Terminology” section, which includes seasons and modes definitions, was placed after the description of the instruments in the revised manuscript.

Section 2.4: What was the cut section, 2.5? the same question for the aethalometer and MAAP. I believe it is important to add this information to the text. "As both MAAP and aethalometers measure at 637 nm, a comparison between the two was performed to ensure that there were no calibration issues." It would be interesting to add this comparison in the supplementary material.

Thanks for pointing that out. All the optical instruments measured with PM2.5 size cut. We added the following line to the revised manuscript to highlight it:

All optical instruments were operating with a size cut of 2.5 μm.

The supplementary material includes now a figure (Figure S2 of the revised manuscript) comparing both 60m instruments for a week during April 2019, showing a very high correlation (R^2 = 0.98, p-value < 0.05) between the MAAP and Aethalometer measurements.

Section 3.2: Wilcoxon rank-sum test, the authors find a significant difference using the Wilcoxon test. Were other tests also evaluated? The authors need to discuss the maximum and minimum variations for these coefficients, as visually there does not appear to be a significant difference for the different heights. I encourage the use of more robust tests using parametric statistics. Although these data do not present a normal distribution, I believe that the sample size justifies the application of parametric statistics.

The Wilcoxon rank-sum test is a commonly used tool to evaluate if two sets of data samples come randomly from the same population. For all properties shown in Section 3.2, the rank-sum test yielded a virtually null p-value, indicating that the distributions are different. Visually, indeed, the difference between the two heights is generally very small, but the notches on the boxplots indicate that the medians are significantly different in all cases. Furthermore, using parametric statistics, this thesis is again supported by comparing the distribution in both heights using the Z-test. For both scattering and absorption coefficients, the Z scores of the distributions at 60 and 325m were well above the significance level of 99% (Z~3), meaning that the distributions are different. The evaluation of these statistical tests was included in the revised manuscript as follows:

The statistical significance obtained with the Wilcoxon rank-sum test for the absorption coefficient also presented a p-value < 0.01 and a Z-score of the means above the 99\% level threshold, indicating that the differences are statistically significant.

Section 3.6: Although the study focuses on vertical differences for the real and imaginary components of the aerosol refractive index, and therefore has precise estimates for each height. I ask the authors: is there a possibility of comparing the average value of m with the AERONET inversion estimates? This would be an interesting topic for future work.

Thank you very much. We appreciate this idea for future studies. At the moment, we focused our refractive index analysis on the fine mode component at fixed heights, with calculations made using SMPS size distribution and optical

property measurements. AERONET, on the other hand, uses measurements obtained along the entire vertical profile and considers both fine and coarse aerosol size modes. Therefore, with what was done, there would be no possibility of a direct comparison with AERONET. Still, a future approach that integrates the vertical distribution of aerosols throughout the troposphere and their optical properties could be compared and validated with AERONET.

Technical corrections:

P1, P11, P16, P21, and P22: Avoid the term "slightly".
Example P11: "the absorption coefficients are slightly higher at 325 than at 60 m" replace with the absorption coefficients are greater in magnitude at 325 than at 60 m. Avoid "slightly higher".

Thanks. This was corrected in the text.

References:

Lang, N., Jetz, W., Schindler, K., and Wegner, J. D.: A high-resolution canopy height model of the Earth, Nature Ecology & Evolution, 7, 1778–1789, 2023.