Response to Reviewer's Comments

Dear reviewer,

We appreciate your valuable comments. We tried an effort to answer your comments and revise the contents. Please see the answer and revised contents below and give us your advice if needed.

Reviewer's comments and our answers

General Comments:

I have minor concerns which I pointed out in the attached supplement. Please, read the annotations I made in the highlighted text inside the file egusphere-2023-2138-manuscript-RC_1.pdf.
My main concern about the manuscript is the clarity of some procedures, being hard to be able to reproduce them.
The description of the method to obtain alpha_ref is not totally clear to me. Lines 119-131 mention the identification of the reference distance (r_ref) but end using 5 km for a reason that I don't understand.
In my opinion, the descriptions should be expanded to increase clarification in order to be reproduced by the community.
I would like to read more information about the implementation of the Angstrom exponent and the discrimination of the aerosol alpha profile in fine and coarse particles.

→ We appreciate your valuable comments on our research. We have carefully reviewed the annotations provided in the attached file, "egusphere-2023-2138-manuscript-RC_1.pdf," and wish to respond sincerely to each point you raised.

Regarding your main concern, we understand that the clarity of some procedures in our manuscript, particularly the method to obtain αref, needs improvement to ensure reproducibility and understanding by the community. We appreciate your feedback and will take the necessary steps to enhance the clarity of our descriptions.

You raised a specific question about the reference distance (r_{ref}) mentioned in Lines 119-131 and our choice to use 5 km. The current approach has been applied to our lidar system and has gotten reproducibility. The main emphasis of the multi-section method, which is the key aspect of this paper, is to address potential errors associated with the conventional Klett method. The conventional Klett method calculates data using a reference at a distant point in a backward manner. To mitigate this, we employ a stable RCS gradient as the reference signal, which we apply over the maximum analysis distance of 5 km. Typically, when there are no emissions or noise at 5 km, the reference obtained using the multi-section method matches that obtained at 5 km. However, in cases where emissions or noise exist at 5 km, we avoid designating that point as the reference and instead select references from multiple other points to apply at 5 km. This approach allows us to reliably account for extinction due to both emissions and background particles.

Regarding the implementation of the Ångström exponent and the discrimination of aerosol alpha profiles in fine and coarse particles, these aspects are indeed vital but fall outside the main theme of this paper. Our current focus is primarily on the methodology described in the manuscript. Nevertheless, we have recorded this information to aid in understanding the visualization system's development. It is essential to note that our team is actively engaged in further research and work to advance the sophistication of mass concentration calculations, which may be covered in more detail in future publications.

Once again, we appreciate your thoughtful comments and will make the necessary enhancements to ensure our procedures are more transparent and reproducible.

Specific comments:

Lines 30-33.
I do not completely understand this sentence.
If you are talking about "horizontally scanning lidar", how do you find a pure molecular range?

→ We appreciate your valuable questions. We would like to clarify that we did not account for the effects of air molecules. In reality, we should subtract the extinction coefficient contributed by air molecules. However, since we used a lidar system in a horizontal configuration (with an elevation angle near zero), we considered the extinction coefficient of air molecules across all ranges. Our method identifies representative values for reference extinction coefficients at various points.

Line 36. Lower. Elevation angle =0 --> horizontal shots

→ Thank you for your revision. We changed the sentence as per your comments.

"The selection of a reference distance and a reference value is less straightforward in measurements with lower elevation angles as all range bins might contain considerable aerosol contributions."

Line 59. if the sampling frequency is 30 MHz, the range resolution is 5 m.
dz = c/(2*f) = 3*10^8 / (2*30*10^6) = 5 m

→ We appreciate your point. We had a mistake to write. The range-resolution is 4.8 m.

"Data are acquired with a maximum sampling rate of 30 MHz, which corresponds to a range-resolution of 4.8 m."

Lines 67-71: I agree with this sentence, but why the comparison of the retrieved alpha is done only with PM2.5?
I think this procedure deserves more attention, and has to be expanded with equations.

→ The comparison of the reference alpha with background PM concentrations was primarily unstable in cases where PM10 levels were significantly elevated. This might be because of the presence of emission sources such as steel mills and coal depots in the observation area, which are located near the coastal region. In comparison to PM2.5, the correlation between background concentrations and the reference alpha was found to be strong. We attribute this observation to the combined effects of emission sources and the significant variation in mass extinction efficiency within the size range of PM2.5. We believe that a comprehensive analysis of these various influencing factors is a topic for future research, particularly in the context of mass concentration calculations. Our current focus was to address the stable retrieval of extinction coefficients from lidar backscatter signals.

Line 86: Check the range resolution.
Before it was mentioned as 4.5 m, which for me its 5m. Now it is mentioned as 4.8 m.
I think this is the method implemented in this work, but here is the first time it is mentioned in this way: "background correction based on the signal-to-noise ratio (SNR)".

→ Thank you for your review. We have carefully considered your feedback and have made the necessary revisions to the manuscript in accordance with your comments.

Line 89. Eliminate the sentence.

→ We appreciate your comments. We erased the sentence.

Line 110. Why the lower?

→ We selected the smaller value because the error in the RCS occurred due to the large background values. In fact, the background value was overestimated by abnormal peaks and caused the signal to be below zero when we used the average values of noise as background. In most cases, the background signals were the same for the average method and fitting method; however, the fitting method was selected when there were abnormal peaks in long-ranged distances because the fitting method can easily ignore abnormal peaks by the big peak in near-range distances.

Lines 117-120. I can not picture this procedure.

→ We described the procedure in Figure 3.

Lines 130-131. The paragraph describe how to arrive to alpha Ref, but, How it is arrived to the range_ref value = 5km? I understand that the reference range r_ref is identified in the method.

→ Our research aims to find a stable reference value that enables data retrieval over long distances. The Fernald-Klett method calculates data either backward or forward from a designated reference point. However, a significant limitation of this approach arises when there are peaks or noise at the reference point, leading to errors in the overall data calculation. As mentioned in the introduction, in most studies, especially when dealing with high-concentration data, the analysis scope is often restricted to a short range, even if there is signal presence, due to these issues.

Our novel approach assumes that the reference value is valid except for points with peaks or noise and is characterized by the slope of the RCS (Range-Corrected Signal). This allows us to replace the obtained reference value with a value at our desired maximum range of 5 km. The choice of 5 km as the maximum range is based on the stability of observations, as most data are reliably captured up to 5-6 km. While occasional signal instability may occur even at 5 km, the key focus of this paper is the development of an algorithm that identifies a representative reference value, thus applying it to the analysis over the maximum range, rather than reducing the overall analysis distance.

Line 158. But in lines 67-68 it is mentioned that:
"This method assumes that the lidar-derived extinction coefficients correspond to the sum of fine particles for PM2.5 and coarse particles for PM2.5−10."

→ As mentioned earlier, we compared the alpha_reference calculated based on background concentrations with PM2.5 due to the substantial variability in PM10 levels in the region. This discrepancy may be attributed to emission characteristics and the influence of extinction efficiency at different size ranges. We acknowledge the complexity of this issue and will further investigate and incorporate it into our ongoing research on lidar extinction coefficients and mass concentration calculations.

Lines 166-169. As I mentioned earlier, I think this is an important part of the method that should be expanded and supported a bit more with equations or plots.

→ I apologize for not providing more detailed information. As mentioned earlier, the details regarding the calculated extinction coefficients and the mass concentration calculation algorithm are not the primary focus of this paper. However, I would like to emphasize that these aspects are currently under investigation by my affiliated research team, and we are working on a manuscript submission in the near future. I appreciate your understanding in this matter.

All Figures. Put the small title at the bottom of each figures and Change time as HH:mm.

→ We modified all the details in the figures as per your comments.

Figure 1. Please put the letters (a), (b), (c) and (d) at the bottom of each figure. (Change captions: 13:17). Plot (c) It would be great to have they y-=0 line, so the wrong background subtracted lidar signals and more visible.
Y axis for (c) and (d) : "Background correction signals"

→ We changed the figures and caption.

Figure 4. Caption: (a) Location ....
Suggestion: "The yellow dot designates the position of a site within the national air quality monitoring network.".

→ We changed the caption.