Response to Referee #3

We thank the referee for their review and valuable feedback, which helped us improve the quality of our manuscript. Below are the original comments in italics with our responses in bold text.

The paper by Floutsi et al. introduces a novel aerosol classification method based on lidar derived intensive properties. The main results of the study are of interest. However, authors should point out the novelty of their study also regarding the existing typing schemes. I recommend the publication of the manuscript after minor revisions*, considering some general and specific issues detailed below in my review.*

Thank you for your positive evaluation of our work as well as for helping us to improve our manuscript by proposing to add further important information and clarifications.

General comment

Why did authors not mention all the existing typing schemes based on lidar intensive parameters? The added value of their aerosol classification method should be pointed out.

In the manuscript, we did not mention extensively the existing typing schemes based on lidar-derived intensive parameters because the list is long and we aimed for a rather short introduction, focussed on space-borne lidars. Since HETEAC-Flex will be a supporting algorithm mainly for the ground-based EarthCARE cal/val efforts, we thought it would be appropriate to mention the CALIPSO typing scheme, as we did in lines 28-32 as well as the drawback of Aeolus with respect to aerosol typing in lines 43-46 of the original manuscript. Nevertheless, we realize the importance and added value that this new information would bring to the manuscript and have included a new paragraph in lines 93-101 of the revised manuscript.

Line 112. Authors state that: «the covariance matrix S_ describes the measurement errors». How are measurement errors are being calculated?

The aforementioned description in line 112 is rather generic. In fact, the actual contents of the measurement vector, along with the covariance matrix are discussed in Sec. 2.2. Now we have included a statement regarding the measurement error calculation in lines 163-164 of the revised manuscript.

Line 117. Authors state that: «Typically, the process converges within 30 iterations and if not, then it fails to converge and, consequently, there is no optimal solution.» How this value is being selected?

Usually, the algorithm provides a solution within five iterations, regardless of whether this optimal state is statistically significant or not. We, therefore, determined this number empirically as it is large enough to reflect that even if the process converges the solution will not be optimal nor statistically significant, as the cost function is most likely "trapped" in a local instead of the global minimum.

Reviewer #4 (RC2) raised a similar comment as well, and we have justified the choice of the maximum number of iterations in lines 126-128 of the revised manuscript to provide more clarity.

§3 Application of HETEAC-Flex. How are layers been defined? Authors should provide information on the layering detection.

Thank you for commenting on layer detection. Indeed, we had omitted to include information about it. For all cases, including the long-term dataset from Haifa, the aerosol layers have been identified

manually. At the moment aerosol layer detection is not included in HETEAC-Flex and one should perform it separately and beforehand. This information is now included in lines 297-298 of the original manuscript. In the future, we would like to include aerosol layer detection in the HETEAC-Flex methodology, most likely following the wavelet covariance transform (WCT) method, similarly to EarthCARE (Wandinger et al., 2023b).

Figure 7. Errors should be added in all products.

We have updated both Fig. 7 and the figure caption to include the errors of the color ratio and the particle linear depolarization ratio (with faint error bars). Reviewer #4 had a comment related to the errors in Fig. 7 as well; please refer to our response (Reply on RC2) for further details.

§3.3 has different structure than the 3.1 (Case, Overview and Aerosol characterization) and 3.2 (Case, Overview and Aerosol characterization). Paragraph 3.3 should be homogenized with the previous ones.

Thank you for pointing out that the structure of Sect. 3.3 is not consistent with the previous sections. We have updated this part of the manuscript accordingly.

Figure 6. Why are these retrievals modes selected? Authors could present all the available modes for this specific case study.

You are right, all retrieval modes were applicable in this case. Therefore, we have updated Fig. 6 and we have revised accordingly the discussion in Sect. 3.1.2.

Specific comments

Figure 8. Legend shouldn't be color filled.

Indeed, Fig. 8 has been updated accordingly in the revised version of the manuscript.

References

Wandinger, U., Haarig, M., Baars, H., Donovan, D., and van Zadelhoff, G.-J.: Cloud top heights and aerosol layer properties from EarthCARE lidar observations: the A-CTH and A-ALD products, Atmos. Meas. Tech., 16, 4031–4052, https://doi.org/10.5194/amt-16-4031-2023, 2023b.