Response to Referee #4

We thank the referee for carefully reading and reviewing this 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 with high flexibility in terms of channel configuration. The output considers aerosol mixtures of four aerosol components that are directly linked to the lidar intensive properties. The authors provide the necessary information and guidance to understand the optimal estimation method, and, furthermore, to perceive the methodological ramifications through suitable visualization and specific case studies. The language and presentation are commendable throughout. The paper therefore is suitable for publication with only typographical corrections.*

In the following, I included only a few minor comments and corrections that I hope will improve the manuscript.

Thank you for your positive feedback on our work as well as for helping us to improve our manuscript.

Minor Comments:

Ln117: I suppose that 30 iterations is an empirical estimate. How long does it take for the algorithm to provide output? Can it be used operationally?

Indeed, the choice of a maximum of 30 iterations as the convergence failure is made empirically and usually, the algorithm provides output within five iterations. Of course, this threshold does not prohibit the algorithm from being used operationally. For clarity, we have provided further justification for our choice of maximum iteration number in lines 126-128 of the revised manuscript.

Ln144-148: Do you apply quality screening to the input optical parameters? If yes, what are the threshold of acceptance for these parameters? Also, what does "order of appearance in the vector" mean ? Does it imply the discriminatory power of the intensive properties?

At the moment, there is no dedicated quality screening within HETEAC-Flex for the optical parameters, and we are currently completely relying on the quality assurance procedures applied to the input by the data providers, i.e., ourselves or ACTRIS (e.g., Bravo-Aranda et al., 2016; Wandinger et al., 2016b; Freudenthaler, 2016; Belegante et al., 2018; Freudenthaler et al., 2018). In particular, the PollyXT lidar systems (as well as their predecessors) follow the EARLINET (European Aerosol Research Lidar Network) standards.

No, the phrase "order of appearance in the vector" does not refer to the discriminatory power of the intensive properties, only to the order in which the input parameters must be compiled in the input file. As each element of the measurement vector is involved in different computations the order needs to be respected for the algorithm to work properly. Thus, it is just a technical prerequisite.

Ln236-239: Why the penalty term is not enough? Is the second criterion only invoked when the total relative contribution is greater than 1?

The penalty term covers only the scenario of a retrieved relative volume contribution per component being either below 0 or above 1. The other criterion (normalization) is invoked when

the retrieved relative volume contribution of a component is smaller than 0 or indeed as you mentioned, when the total relative contribution is greater than 1.

Ln320: It would be better to stress earlier that the input is layer-averaged values. Could it be possible to apply HETEAC-Flex to high temporal resolution lidar maps?

Thank you for this suggestion. In fact, we had mentioned in line 144 of the original manuscript that the input is layer-averaged values. To emphasize this, we have slightly rephrased our statement (line 155 of the revised manuscript). In theory, yes applying HETEAC-Flex to high temporal resolution lidar data is possible but computationally expensive.

Figure 7 and Ln370-371: Why color ratio and particle depolarization ratio do not have error bars? This is a bit confusing for me. Also, do you consider the standard deviation of the averaged intensive profiles for the error estimation?

The data used in Fig. 7 have not been analyzed in this study, but in Tesche et al. 2011a, b, as indicated in the figure caption and in the text (lines 344-345 of the original manuscript). The absence of errors is also mentioned in lines 371-372, along with the errors that we assumed to enable the HETEAC-Flex retrievals. For the aforementioned reasons, we initially chose not to include the assumed errors in Fig. 7. Reviewer #3 raised a similar comment, and 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).

Ln354: Can you expand on how you defined the aerosol layers? Is layer detection part of the methodology?

Layer detection is not part of the methodology, and, therefore, not mentioned in the manuscript. For the case studies presented in the paper we have identified the aerosol layers by manually inspecting the vertical profiles of the optical properties. We have included a relevant statement in lines 297-298 of the revised manuscript.

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