

Answers to reviewer 2

We thank the reviewer for their comments, suggestions and spotted typos. In the following we respond to their comments.

Comment: *Although the present improvement of the overlap retrieval is described as "streamlined" in the abstract, chapter 3 mentions an "alternative retrieval" and states: "... we have found a way ... other than the daunting Eq. (4) ...". This gave me the impression that the two papers provide different solutions, which is not true. In fact, to my understanding, the two retrievals are the same, but the calculation of β_{a0} , that seems to be additional in Eq. (5), is embedded in Eq. (4) (Eq. (15) in the previous version), while it is done externally with Eq. (8) in the present version.*

This equivalence should be made more clear.

Answer: the reviewer is right in their interpretation. Actually, the two-step method is fully equivalent to the one presented in Comerón et al. 2023. To stress this and avoid confusion, we have added a clarification in line 21 (within the abstract) of the revised manuscript ("... we propose a streamlined, yet equivalent to the one already published, two-step explicit formulation...") and in line 116-117 within the conclusions ("...we propose a two-step explicit formulation for the retrieval of the overlap function, easier to apply than that proposed in (Comerón et al., 2023), but otherwise equivalent")

Comment: *As already mentioned by reviewer 1, the assumption that the overlap function in the elastic channel is the same as in the Raman channel is critical. It should be mentioned that not only interference filters can have a considerable impact on the overlap function, but also the mechanical misalignments of the detectors and optical elements like lenses and apertures with respect to each other, and that these misalignments, as well as the transmission characteristic of the interference filters, are possibly subject to environmental conditions like temperature changes.*

Hence the equality of the two overlap functions should not be blindly assumed, but should be verified with appropriate test setups.

Answer: we agree with the reviewer. See in this respect the text added in lines 48-57 of the revised manuscript, in particular the sentence "In fact, the failure of the identical overlap function assumption at short ranges is acknowledged in (Comerón et al., 2023) and made evident by the unrealistic aerosol backscatter coefficient behavior (sudden drop) at short ranges visible in fig. 2 of (Comerón et al., 2023)" (lines 55-57 of the revised manuscript) and in the conclusions (lines 123-127, final paragraph) of the revised manuscript.

Comment; *It would be furthermore very helpful if the present error analysis could be extended in a follow-up of these two papers to include the impact of different overlap functions in the elastic and Raman channels.*

Answer: we fully agree. We thank the reviewer for the suggestion and take up the challenge of a follow-up paper dealing with this... expecting we can find useful results.

Comment: *The figures 3 and 4 of the previous paper give the impression that the differences between the overlap functions retrieved with differently assumed aerosol lidar ratios below about 300 m become small and negligible, but this seems only because the*

slope of the overlap functions is so steep towards the near range. This wrong impression could be corrected in the present paper.

Answer: We agree with the reviewer that this apparent equality of the overlap functions retrieved for different lidar ratios in Comerón et al., 2023 is an impression induced by the steep slope. However, we don't see a way of pointing this out in the present paper without introducing more confusion. Moreover, although not directly related to the reviewer's comment, note that in Comerón et al. 2023 we already warned that the results below 400 m must be considered "suspicious" anyway, because of the anomalous behavior of the aerosol backscatter coefficient retrieved through Eq. (9) of that paper (Eq. (13) of the present one's revised version), which assumes equality of overlap functions in the elastic and Raman channels. See in this respect the last paragraph (lines 123-127) in the conclusions of the revised paper.

Typos

In Eq. 4 in the fourth exponential term it should be " $\beta_{m0}(x)$ ". → Corrected

Line 53: probably $O'(R)$ instead of $O(R)$. → Corrected. Note as well that we have added "resulting" in the previous phrase ("and the resulting overlap function as $O'(R)$ ", line 77 of the revised manuscript). We thank the reviewer for spotting this typo, which might have originated to a lot of confusion