

Answers to reviewer 1

We thank the reviewer for their thoughtful reading of the manuscript and for their valuable suggestions. We agree that, in most of the cases in practice, the overlap functions for the elastic and the Raman channels will differ at short ranges, as already acknowledged in the previous paper by the authors. Studying that case of non-equal overlap functions would be of great value, but it is beyond the scope and the purpose of the present paper. See the added text related to this issue 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. Anyway, we take up the challenge for a possible follow-up paper.

Specific comments:

Comment: *Line 14: Is this a rotational or vibrational channel? Single channel or 2 different channels? If single, why both gases are mentioned?*

Answer: We meant either a N₂ vibro-rotational Raman channel, a vibro-rotational O₂ Raman channel, or a purely rotational Raman (which includes N₂ and O₂ rotational Raman lines). To make the meaning clearer, we rephrase: “in an aerosol lidar equipped with a Raman channel of wavelength close to the elastic one, i.e. either a O₂ or a N₂ vibro-rotational Raman channel, or a purely rotational Raman channel collecting lines of the N₂ and O₂ rotational Raman spectra” (lines 14-16 in the revised manuscript).

Comment: *Line 54: The term β_{mR} / β_{m0} can be, in fact, slightly dependent on the temperature because of the temperature dependence of the cross-section of the rotational Raman (RR) lines in combination with the transmission of the interference filter. The interference filter is often not taken into account in the lidar equation. Adam et al. 2009 and 2012 showed that the temperature dependence is generally small enough to be considered negligible for elastic channels. I suggest to refer to those papers here and rephrase the text indicating that the range dependence is negligible. The temperature dependence of β_{mR} should be also small for vibrational Raman channels. For RR channels temperature effects can be introduced if the filter is not configured properly so that cross-section changes at the transmitted lower J lines are compensated well by the higher J lines.*

Answer: We agree with the reviewer. We have clarified these points and introduced the reference Adam 2009 and Adam 2012, as well as the references Veselovskii et al. 2015 and Zenteno-Hernández et al. 2021 regarding the temperature insensitiveness of pure rotational Raman channels with adequately chosen filters. In this respect, text in lines 58-69 of the revised manuscript has been added.

Comment: *Eq 5: I have repeated the calculations mentioned by the authors (substituting Eq 3a and 3b in Eq 4) and I can confirm that they result to Eq 5. It might be worth showing how the last exponential term of Eq 4 becomes much simpler after substituting X and X_R (showing that the integrals from 0 to x and from x to R_m add up to an integral from 0 to R_m which is constant and can get out of the double integral). This part requires some*

“imagination” and might not be straightforward to all readers. The rest of algebraic calculations are straightforward.

Answer: we thank especially for this comment, as, indeed, the original manuscript left too much to the reader’s imagination in contradiction with the promise in the abstract. To tackle this, we have added text and equations in lines 79-91 of the revised manuscript.

Comment: *Eq. 7: Please mention the equivalent equation from Comeron et al. 2023.*

Answer: We think the reviewer refers rather to Eq. (1), as Eq. (7) (Eq. (12) in the revised manuscript) is “almost” Eq. (1), but in fact is the last part of the explanation to arrive to it, and did not appear in Comerón et al. 2023. Therefore, we have modified line 29 to read “relates to the “true” overlap function, $O(R)$, through (Eq. (18) of Comerón et al., 2023)”

Technical comments:

Eq 3a: Please change β_{ao} to β_{a0} . → Done.

Eq 4: Please change β_{mo} to β_{m0} in the second exponential term. → Done

We thank the reviewer for their careful reading and noticing these typos.