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Atmospheric Measurement Techniques Discussions

Interactive comment on "Issues related to the retrieval of stratospheric aerosol particle size information based on optical measurements" *by* Christian von Savigny and Christoph Hoffmann

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Reply to comments by reviewer 2

Comment: This paper investigates the bias in retrieved particle size properties between occultation and lidar measurements due to differing sensitivity. In particular, errors due to the assumption of a unimodal lognormal distribution are investigated when the true distribution is bimodal. Error in retrieved distribution parameters as well as integral properties are explored. This paper represents a useful addition to the understanding of bias in retrieved stratospheric aerosol properties, and is clearly and concisely written. I think the discussions and conclusions are at times too broad given

the analysis (discussed below) but would recommend publication after minor edits.

Reply: We thank the reviewer for his/her encouraging comments. As described in detail below, we essentially followed all the suggestions made by the reviewer.

Comment: In general, the choice of assumed bimodal distribution parameters seems reasonable, however I think some further discussion or analysis of the sensitivity to the choice of these parameters and retrieval algorithm is needed with regards to Figs. 3-6. Without that it is difficult to say exactly how broadly this analysis can be applied. For example, in SAD the increase in error as CMF grows seems reasonable, but then it decreases as CMF grows further. Presumably this is due to the fixed width, and the retrieved median radius of the distribution shifting smoothly between the two modes. But this seems dependent on the retrieval assuming a fixed width and the choice of a priori values and bimodal state. Similarly, do other, commonly retrieved quantities such as effective radius show this effect? How large is the error in the retrieved Lidar extinction?

Reply: We see the reviewer's point and will add further retrieval examples for different sets of PSD parameters to test, how sensitive the results are with respect to the specific input parameters chosen. The results certainly depend to some extent on the assumed input parameters, but the overall conclusions are not affected.

We also follow the reviewer's suggestion and test the effect on the effective radius and the retrieved lidar extinction.

We would like to point out that we do not claim that the actual PSD is bi-modal. The study investigates, how size retrievals based on an assumed single-model PSD behave if the actual PSD is bi-modal.

Comment: L203: It is to be expected that the systematic differences in retrieved aerosol sizes for lidar and occultation retrievals will increase during periods of enhanced volcanic activity, because then the second particle mode at radii of several hundred nm will be enhanced (e.g., Deshler, 2008).

By “size” do the authors mean median radius? It is not discussed how other size metrics such as effective radius may react, and SAD and volume are not necessarily worse.

Reply: Yes, we implicitly assumed the median radius to be representative for the overall "size“ of the aerosols, which is not entirely correct and may cause confusion. This aspect was also criticized by reviewer 1. We try to avoid this issue by explicitly stating, which representation of aerosol size is meant. These changes – also motivated by the comments of reviewer 1 – affect several parts of the manuscript (changes to the manuscript are highlighed).

The reviewer raises a good point, and we now also include results and a discussion on how retrievals of the effective radius are affected.

Comment: Is this error not dependent on the assumed properties of the retrieval? If the a priori width was too small, could the error not decrease after volcanic activity?

Reply: Yes, we agree that the error will certainly depend to on the assumed properties of the retrieval to some extent. We add some more examples for bimodal distributions with other parameters (median radius and width) to test the overall dependence of the results on the specific input parameters chosen (as also suggested by the reviewer in the previous point).

Comment: It is not clear that volcanic activity necessarily leads to an increase in

particle size. While true for large eruptions such as Pinatubo, smaller, more recent eruptions have a more ambiguous signal, at least in terms of the wavelength dependence.

Reply: We fully agree with the reviewer. We also have evidence for a temporal decrease in effective radius of stratospheric aerosols after small/moderate eruptions. We now limited the scope of the statement to larger volcanic eruptions, such as, e.g. Pinatubo.

Comment: L215-219: It is also important to note that the correct particle size parameters can in principle be retrieved from measurements in any observation geometry (neglecting here issues related to potential non-uniqueness of the solutions), if the assumption of a mono-modal log-normal particle size distribution is correct ... Is this meant to apply to the 2-wavelength retrievals investigated here? If so, I think it should be noted that not only must the unimodal assumption be satisfied, but one size parameter must also be known a priori. If more general, I think non-uniqueness is not an issue that can be neglected.

Reply: We agree with the reviewer that not only the unimodal assumption must be correct, but also one of the size parameters must be known. We also agree that the non-uniqueness of the solution is a general issue, which is particularly important in the expected radius range for the lidar measurements (see the discussion in Zalach et al., AMTD, 2018). We adjusted the statements to become more precise and added some additional text.

Comment: L220: The results presented here are also of importance for model simulations of stratospheric aerosols, some of which model aerosol growth processes more

or less explicitly

Is this a recommendation to not compare with derived quantities, but more direct measurements of extinction/back-scatter?

Reply: This is a very good point, which we had not thought about. Our intention was to point out potential problems if models are verified or validated using stratospheric aerosol size information, e.g. retrieved from solar occultation measurements, which is sometimes done (e.g. in Hommel, 2008). We expanded this sentence. We think the comparison of all quantities (size information and extinction etc.) is important and should be carried out.

Comment: L83/L201: The effects studied here should, however, also be investigated for aerosol size retrievals from limb-scatter measurements in future studies.

Some aspects of these effects, and the sensitivity of limb scattering measurements to particle size have been previously investigated by Malinina et al., (2018) and Rieger et al., (2015).

Reply: The reviewer is again correct and we included references to the two papers, as well as short descriptions.

Comment: There's a few orphan sentences that should probably be incorporated into surrounding paragraphs or reorganized/expanded (L95, L203, L114, L220).

Reply: Thanks for pointing this out. The sentence in line 95 is now combined with the following paragraph (that was actually our intention). The sentence in line 114 was combined with the previous paragraph. The sentence in line 203 was extended to a short paragraph based on the above comments by the

reviewer. Similarly, line 220 was extended following the reviewer's suggestion.

References:

Hommel, R.: Die Variabilität von stratosphärischem Hintergrund-Aerosol. Eine Untersuchung mit dem globalen sektionalen Aerosolmodell MAECHAM5-SAM2., Ph.D. thesis, Universität Hamburg, 2008.

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