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Interactive comment on “Aerosol profile information from high resolution oxygen A-Band measurements from space” by A. Geddes and H. Bösch

Anonymous Referee #5

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The paper presents results of theoretical estimations of the retrieval accuracy of tropospheric and boundary layer aerosols from space-borne instruments. Although the paper contains some information which can be useful for future investigations its scientific content is rather low. In its present form the paper is more suitable to be published as a technical report. The investigations of the retrieval precision under assumption of the planned SNR values are of very low importance as it is widely known that most of the instruments never reach the technical SNR performance because of unpredictable instrumental issues. In this respect I am wondering why the authors haven't made any attempt to look in the real measurements, e.g. from GOSAT or from older instru-

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ments like GOME/SCIAMACHY/GOME-2. This is actually the only way to convince the reader that the retrieval algorithm is working properly and all necessary parameters are taken into account. Furthermore, looking at the real measurements, e.g. from GOSAT, one can analyze if the obtained residuals are really on the level of the SNR defined by the technical requirements. If not, theoretical investigations with an unreachable SNR have very low value. I am sure the authors know that a reliable estimation of the surface uncertainty is crucial when retrieving real measurements. However, the authors completely ignore this issue just saying that a good estimation of the surface albedo increases the retrieval accuracy. No discussion on the methods to do it and eventually needed addition parameters is presented. Even the theoretical study analyzing the influence of atmospheric parameters is done in a quite simplified manner. Authors assume aerosol layers of a Gaussian shape with a fixed width and make no efforts to investigate what happens if the real width of the layer is different or if the vertical distribution of the aerosol is continuous. The paper contains no plot comparing the true, a priori, and retrieved LAOD profiles although providing these kind of plots is usual for sensitivity studies. To my opinion the only scientific goal of the paper is the conclusion that the aerosol in the lower atmosphere can theoretically be retrieved with the accuracy mostly lower than 30% if SNR requirements are reached, no unexpected instrumental issues are present, and the uncertainty of surface reflection is fixed.

To my opinion the paper requires a major revision including simulations with more realistic scenarios for aerosol vertical distribution and a discussion of real measurements (e.g. GOSAT). The latter should include an estimation of the real measurement uncertainty in comparison with used SNR values and a demonstration that the suggested method provides reasonable results when applied to real measurements.

Detailed comments:

- The title of the paper is misleading as it does not contain information on the vertical range. One might think e.g. stratospheric aerosols are meant.

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- Abstract: “retrieval errors typically exceed a value of 0.05” - please clarify if you mean relative or absolute error. In the latter case some information on the typical value of AOD in the lower atmosphere is needed.
- Page 6028, lines 11 - 15: Where these dependencies of SNR come from? What are the reasons for this behavior. Is this assumption for GOSAT confirmed by real measurements?
- Page 6029, lines 13 - 15: “An aerosol extinction profile with a Gaussian-shaped vertical distribution has been assumed for all scenarios.” - a justification for this choice is needed. Furthermore, more work needs to be done to investigate what happens with the results if the “true” profile has a different width or shape. In any case, a continuously decreasing aerosol amount with the altitude is of interest.
- Page 6029, lines 16 -19: “All simulations use the same aerosol optical properties as described in Cogan (2012) for type 2b aerosol from Kahn et al. (2001)” - as the aerosol is in the focus of the paper it is inappropriate to skip a detailed description of aerosol parameters used for the investigation.
- Page 6030: the averaging kernels for all considered instruments have to be plotted and discussed.
- Page 6030: the inclusion of the intensity offset to account for the fluorescence effect is fine for estimations of the a posteriori covariance and DoF but questionable for the rest of the study. To do it correctly one has to simulate measurements including the fluorescence contribution and perform the retrieval excluding the fluorescence from the forward model. However, from the description in the paper it looks like the author completely neglect the fluorescence in the modeling. Furthermore, the fits with the intensity offset might be affected by the noise. To account for this all simulations/retrievals need to be done including a random

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- noise added to spectra. As I can judge from the text this was not the case in the presented study.
- Page 6030, line 14: “For the 4 top-most levels ...” - it would be useful if you provided the pressures/altitudes for this layers.
 - Section 2: As shown in Figs. 6 and 7 DoF values for the total vertical range are somewhere between 5 and 6. Does it make any sense to use the retrieval grid with 39 layers?
 - It would be nice if you listed the layers of the vertical grid both in mb and km in text.
 - Section 4.1: In the beginning of the section a trivial fact is reported that the retrieval precision increases with increasing SNR and DoF increases with the increasing resolution. Everybody who has ever done a retrieval knows it already. The only thing which deserves a short discussion here is the influence of the intensity offset. However, since the authors come to the conclusion that its role is rather minor, the Fig. 3 and the discussion around it is actually unnecessary. The concluding paragraph starting at line 5 of page 6033 is totally sufficient.
 - Section 4.1: More complicated scenarios with continuous aerosol distributions and layers with different widths need to be investigated.
 - Section 4.1: Some plots showing the true, a priori, and retrieved profiles have to be shown.
 - Influence of the temperature has to be analyzed
 - Investigations for higher surface albedo e.g. 0.7, 0.9 need to be done
 - Section 4.2: It is unclear how the a priori information is given in that case. Some plots with true, a priori, and retrieved profiles are needed.

- Sections 4.1 and 4.2: The presented results do not contain any information about dependence of the retrieval results on the a priori information.
- Section 5.1: It is questionable if the representation of the aerosol vertical distribution with a fixed-width Gaussian shape is useful. Clearly, large error can be expected if the real shape is different. To my opinion one can only justify this approximation by a statistical analysis of real distributions.
- Section 5.2: What happens in a case of a partial cloudiness?
- Section 5.2: Where the information to constrain the surface albedo should come from? As far as I know this is one of the most crucial issues when working with the real data. The authors have to pay more attention at this issue taking into account the fact that the need for a proper estimation of the surface reflectivity may result in a completely new retrieval making all previous estimations useless.
- Section 6.2: Details on aerosol types have to be summarized in the paper. Providing a reference is not sufficient.
- Section 6.2: Uncertainties of AOD are given in percent while they were given in AOD units everywhere above. Percentage errors for the height make no sense.
- Conclusions: “Although this retrieval does not result in a more precise AOD retrieval if the aerosol is in the boundary layer, it allows very precise retrievals of AOD and height for elevated aerosol layers.” - the latter statement is only true if the real aerosol layer has a similar shape and width as the assumed one. Otherwise large errors might occur. In general, I do not agree that the parametrized retrieval is more advantageous as it has much higher uncertainty when applied to an unknown aerosol distribution in the real atmosphere.
- Figures 4 and 5 are hardly readable. They have to be made larger. Please provide second y-axis in km. Include additional plots showing the measurement

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response.

- Legend in Figs. 6 and 7 is difficult to understand.
- Real measurements have to be analyzed to convince the reader that the presented algorithm is usable for the aerosol retrieval in a presence of real measurement uncertainties.

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