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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Comparison of the inversion algorithms applied to the ozone vertical profile retrieval from SCIAMACHY limb measurements" *by* A. Rozanov et al.

A. Rozanov et al.

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Dear Referee #1, thank you very much for reviewing our manuscript and for your helpful comments. Please find below our responses to your criticism. Your comments are repeated in italic face whereas our responses are written with normal font.

It appears that a detailed study has already been carried out to validate two of the three retrieval methods presented in this paper by Brinksma et al. (Geophysical validation of SCIAMACHY Limb Ozone Profiles, Atmos. Chem. Phys., 6, 197-209, 2006). However, there is little mention of the results of the previous work.

The main conclusion on the validation results of the Stratozone retrieval processor

published by Brinksma et al. is presented now in the introduction. The reasons not to discuss previous validation results for the DLR retrieval processor are also listed in the introduction now.

It is noted that newer versions of the Stratozone and ESA/DLR products have been used in this paper, but no information is given as to the changes from the versions considered by Brinksma et al. and whether these changes are expected to produce significantly different results. It appears that the main change for the ESA/DLR products was a switch in spectral region, but this change is not explicitly mentioned in the paper.

The changes from the versions considered by Brinksma et al. are now discussed in the introduction.

The new work here is the inclusion of the SCIATRAN method. However, the analysis here is much less indepth than that of Brinksma et al., and thus the relevance of this paper is not clear.

If the main purpose of the paper is to study the results from the SCIATRAN method or of the newer versions of the other methods, significantly more focus should be placed on this. In particular much more data should be included. In the Brinksma et al. paper the Stratozone and ESA retrievals were compared to hundreds of lidar profiles (compared to only 3 in this paper) and data from satellite instruments, ozone sondes, and groundbased microwave instruments.

Looking at this comment we realized that the explanation of the objectives and goals of our study was not sufficient. The introduction of the paper was extended to emphasize that the presented study is not a validation study in the common sense and is intended to separate the uncertainties related to the modeling-retrieval problem and investigate them, which was never done before.

What would a data user gain from this paper, other than the conclusion that the methods are "generally in good agreement"?

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The user is expected to get an impression how the choice of the retrieval approach (consisting of a forward model and an inversion algorithm) can affect the resulting profiles. The introduction and the conclusion of the paper were adapted appropriately to clarify this issue.

The methodology of the comparisons is also questionable. Except for the lidar comparisons, the results are only shown as comparisons of average profiles (and the associated standard deviations). This averaging will tend to minimize individual differences and is not the correct quantity to study. More appropriate would be to show the mean and standard deviation of the individual profiles (relative to the Stratozone method, for example). This would highlight the magnitude of the differences and would support values quoted in the text that are not obvious in the current figures (e.g. percent differences).

According to the reviewers suggestion the corresponding plots containing the mean relative deviations and the standard deviations relative to the Stratozone method were added.

It is also not clear exactly what the conclusions of the paper are. It is stated that "The intercomparison shows that all retrieval methods are generally in good agreement." However, for ozone retrievals the 10-15% differences seen are surprisingly large and not what I would consider " good agreement" for comparisons of very similar measurements of the same quantity.

Conclusions were extended to be more meaningful. The corresponding paragraph reads now as

“The intercomparison shows that between 19 and 33 km all retrieval methods are mostly within 5% agreement. However, discrepancies up to 10% can occur at altitude layers located between measurement sampling heights due to different vertical interpolations specific to different retrieval approaches. In particular, due to a coarser retrieval grid used in the DLR retrieval processor, this algorithm can under the circum-

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stances miss values in the ozone maximum, whereas both Stratozone and SCIATRAN retrievals can introduce fake vertical features between the measurement sampling altitudes. The ozone vertical profiles resulting from the the Stratozone processor exhibit slight oscillations of about 5% amplitude with respect to other results due to a higher sensitivity of the triplet method employed in this processor to the oscillations in radiance profiles. The results of the DLR retrieval processor often show a lower bias of about 5–10% as compared to other methods, especially above 33 km. Below 19 km, where the information content of the limb measurements decreases with the altitude causing an increased influence of the retrieval constraints as well as systematic errors, the disagreement between different retrievals increases up to 50 – 80% at 15 km. However, even for these high relative deviations, the absolute values of deviations remain below 8×10^{11} molec/cm^3 which is about 20% of the maximum values. Generally, in the lower atmosphere, the SCIATRAN results show the largest and the DLR results the smallest deviations from a priori. Being vertically integrated between 15 and 40 km, the results of all retrieval processors agree within 3%."

It surprises me that on such a long-running instrument, with tens of thousands of orbits, only 5 were selected for comparison. Perhaps this is due to limitations on one of the processors, but this is not mentioned.

This issue is clarified by the new paragraph in the "Comparison of the retrieval processors" Section: "This section deals with a comparison of averaged retrieval results obtained using different algorithms. Since the DLR processor is still a prototype in a development phase and the SCIATRAN is a pure scientific algorithm, both processors were not applied to retrieve larger datasets so far and, thus, only limited datasets generated during the verification activities are available. For the comparison below, a data subset was selected were the results of all three retrieval processors are available assuring the averaging of the same sample distributions."

In the introduction you state that "A detailed description of the retrieval processors will be presented in the next section.", but this is not the case. Only overviews of the three

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algorithms are given, with the details left largely to references. Though perhaps appropriate for the Stratozone and SCIATRAN methods, the information appears insufficient for the ESA/DLR method.

Descriptions of all retrieval algorithms are extended and presented in a more balanced way.

You state that "The retrieval problem in atmospheric remote sensing...". Of course there are many other retrieval problems that could be formulated, so please reword to state that you are referring to a particular retrieval problem.

The sentence was reformulated as follows: “The inverse problem related to the interpretation of space-borne observations of the scattered solar light performed in the limb viewing geometry is to retrieve vertical distributions of various atmospheric parameters from spectroscopic measurements.”

In the General settings section you describe the initialization settings for the three methods. Of note are the assumptions of a constant surface albedo (0.3) and a pure Rayleigh atmosphere. Are these the settings that are generally used, or are they specific to this comparison exercise? What is the expected impact of these assumptions on the three methods?

This issue is now clarified in Section “General settings” as follows: “For compatibility reasons, all processors were initialized with a constant surface albedo of 0.3 and an aerosol-free background atmosphere, whereas geographical databases are used in the Stratozone retrieval processor for the surface albedo and aerosol loading to generate off-line products provided to external users. However, since the influence of these atmospheric parameters on the retrieved ozone profiles is rather small, this simplification is not expected to affect the intercomparison of different retrievals.”

In section 4 you spend a great deal of time discussing the sensitivity of the limb measurements (to the true state). This is interesting since, though you do not explicitly

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state it, you are presumably using the same a priori information for all three retrievals.

Actually it is stated by the first sentence in section “General settings”: “The forward models incorporated in the considered retrieval processors were initialized using the climatological data base provided by C.A. McLinden (Personal communication), a constant surface albedo of...” to make it more clear, this sentence was changed to “The forward models incorporated in the considered retrieval processors were initialized using **the same** climatological data base provided by C.A. McLinden (Personal communication) containing monthly averaged vertical distributions of pressure, temperature, ozone, and NO_2 for 10 degree latitude bands.”

As such you would expect that the methods would agree in regions where there is a lack of sensitity. It may not be as simple as this when the different methods of regularization are considered, but I think this would be the general expectation.

This general expectation has an unlimited validity only for Gauss-Newton iterative schemes in the absence of systematic errors. However, in this study only 2 of 3 retrieval methods employ the iterative schemes of the Gauss-Newton type and SCIAMACHY measurements are definitely contaminated by systematic errors. So, we do not agree that this expectation is general enough in relation to the presented study.

In any case since you are comparing three retrieval processors (of the same data), I would think it would be appropriate to compare over all regions where the individual processors report results without any caveats as to the sensitivity (in their respective data products). You should consider the differences at, for example, 15 km, if these values are accessible to the data user, perhaps with some comments on the sensitivity, but these regions should not be ignored.

The differences are now discussed down to 15 km. It does not make any sense to go to the lower layers because the limb measurements at tangent heights below 14 km are not fed to both SCIATRAN and DLR retrieval processors.

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As noted in the General comments, the presentation of the results is inadequate. Since the focus of the paper is on the differences between the methods, this is what the figures should illustrate. As well, the mean and standard deviation of the differences is what is important, not the difference of the means.

As mentioned above, the corresponding plots containing the mean relative deviations and the standard deviations relative to the Stratozone method were added.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 1969, 2007.