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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 #3, 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.

In its present state, however, the article does not include enough information for the reader to understand what exactly are the quantitative differences and why/when they occur. Consumers of the data (ozone profiles) will want to know whether they have to be concerned with which particular flavor they choose or can they use whatever suits the coverage needs, knowing that anyone of the three flavors will be within X amount of the others.

This comment is too general to be answered here in details but we hope that with the revised manuscript we will meet the needs of customers listed by the referee. Furthermore, we hope that our answers to less general comments below will also contribute to this response.

Breaking down the differences, i.e. the mean and standard deviation of differences, between the three processors for different cases, i.e. latitude, surface albedo (bright vs. dark), clouds, would also help the reader better understand which flavor to consume.

The plots showing the mean differences and corresponding standard deviations are now supplied additionally to each mean profile plot. Same as for mean profiles the differences for different latitudes are discussed now. Because of weak influence, it does not seem to be advantageous to split the comparisons for different surface albedos and cloud scenes. Corresponding statements about the insignificance of these effects were added to "General settings" Section.

The description of the three different algorithms used should be more balanced. The SCIATRAN algorithm is explained in greater detail (maybe because the first author is more intimately familiar with it that the other two). Don't cut back on the SCIATRAN detail, instead give like detail about the other two, especially the DLR processor. It would be helpful to more clearly call-out the commonalties of the processors, eg. use of tangent height normalization, a prioris, first guess, and the distinct differences. Maybe a short summary paragraph at the end of section 2. Common: tangent height normalization, a priori, first guess, background atmospheric state, atmospheric aerosols, surface albedo, etc. Different: Forward model, minimization technique, spectral filtering (triplets vs. DOAS), different altitude for tangent height normalization.

Descriptions of all retrieval algorithms were extended and presented in a more balanced way. A table listing the differences and commonalities of the retrieval processors was added to the manuscript.

Is the configuration used for each processor that which is used in producing each of

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the respective off-line products or has it been modified here for convenience?

This issue is clarified now in “General settings” Section.

The plotting of actual ozone profiles is refreshing in that it is the quantity retrieved, but it would be helpful to the reader if differences from a reference profile were also shown. For example, a companion to Fig. 4 with the mean and standard deviation of the difference between each retrieval and the a priori, that is if the a priori is the same in each of the three retrieval methods. If the a prioris are not the same, then pick a common reference profile and also add lines showing the difference between the a prioris and the reference profile.

According to the referee’s suggestion the mean a priori profiles were added to mean profile plots. New plots showing the relative differences with respect to the Stratozone algorithm as well as standard deviations for these relative deviations were added.

Need to add a little more about the SCIA measurements, i.e. the SCIA spectra vertical sampling, vertical instantaneous field of view (IFOV), spectral resolution, typical SNR in this spectral range near the normalization tangent height and at 25 km.

Following the referee’s comment a new section describing SCIAMACHY limb measurements was added.

Page 1973: Do all three use the same retrieval grid spacing and initial atmosphere state, including temperature and pressure?

Retrieval grid spacing - no, initial atmosphere state, including temperature and pressure - yes. To clarify this issue the following changes were made. The sentence “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...” in Section “General settings” 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 communi-

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cation) containing monthly averaged vertical distributions of pressure, temperature, ozone, and NO_2 for 10 degree latitude bands." The following paragraph was added at the end of "General settings" Section: "Both SCIATRAN and Stratozone processors utilize equidistant retrieval grids of 1 km spacing whereas the grid spacing of 3.5 km is used in the DLR algorithm. The altitude discretization grids of the forward models incorporated in retrieval processors were the same as the corresponding retrieval grids."

Page 1974, line 8: What is the typical number of iterations?

The typical iteration number for each retrieval processor is mentioned now in the processor description subsections.

Page 1974, line 27 to page 1976, line 2: Might be more clear if reworded similar to "Rozanov et al., 2005a, describe the details of the retrieval method when applied to SCIAMACHY data for the retrieval of NO_2 a nd BrO vertical profiles." Now, what about when the application is the retrieval of O_3 vertical profiles? Are the details the same, just the unknown is now O_3 and the spectral range is different?

The sentence was reformulated to "A similar technique was also used to retrieve the vertical distributions of NO_2 and BrO from SCIAMACHY limb measurements (Rozanov et al., 2005a)." and moved to the beginning of the SCIATRAN subsection. Therewith the issue raised by the referee is solved.

Page 1975, lines 8-9: Does this mean that only measurements between 9 and 49 km are fed to the different processors?

You probably mean page 1976, do not you?

Yes. To make it more clear the sentence "Only limb measurements performed at tangent heights between 9 and 49 km are considered in the retrieval." was extended to "Only limb measurements performed at tangent heights between 9 and 49 km are considered in the retrieval, i.e., only these measurements are used to form the state

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vector."

What determines the lowest tangent height actually used in each processor to construct a "y" vector?

This question is answered by a new paragraph in "General settings" Section: "The upper and lower tangent heights limiting the limb measurements used to form the data vector as well as the reference tangent heights were selected based upon the analysis of the information content of the measurements as well as signal to noise ratios of limb spectra. Since the information content of the limb measurements in Chappuis absorption band at tangent heights below 14 km is quite low, these tangent heights were not considered in the SCIATRAN and DLR processors to avoid a destabilization of the retrieval by strong absorption bands of the water vapor and O_4".

That is to say, are observations containing clouds used or is there any screening for clouds and those tangent height observations with clouds discarded and the tangent height lower limit is then greater than 9 km?

The influence of clouds is completely neglected. This is now clarified by the following new paragraph of "General settings" Section: "The influence of clouds was completely neglected in the comparison which is also the case when generating the off-line products with the current version of the Stratozone retrieval processor. Generally, the impact of clouds is not considered to be an important issue for the current study since it is not expected to cause additional deviations between the results of different retrieval processors. Furthermore, for typical SCIAMACHY limb retrievals the effect of clouds is quite small anyway."

Page 1975, lines 14 thru 19: This discussion is confusing to me. How is "enough regularization" defined or determined?

The sentence was removed when extending the description of the DLR processor.

Page 1975, line 21: How were the look-up table corrections created, i.e. what radiative

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transfer model was used?

This is the SCIATRAN model. The corresponding information is added to the description of the DLR processor.

Section 3: What NO_2 profile is used in Sciarays?

Sciarays does not use any NO_2 information. This is clarified in "General settings" Section.

Page 1976, second paragraph: Is the spectrum from a single tangent height used for the normalization or several spectra averaged to increase the reference SNR, which should decrease with increasing altitude?

The single spectrum is used. This is also clarified now in "General settings" Section as follows: "As reference spectra, single measurements at reference tangent height were used, since, due to a rapid decrease of the signal to noise ratio of SCIAMACHY limb spectra with increasing altitude, averaging of several spectra measured at upper tangent heights does not change substantially the signal to noise ratio of the resulting reference."

Page 1976, line 24: Using a SNR different by a factor of 10 seems like a disconnect in the description of the instrument. Is the SNR of the Stratozone algorithm accounting for more than instrument errors, i.e. also forward model errors and cross sections?

This issue is clarified now in "General settings" Section in conjunction with the new section describing SCIAMACHY limb measurements as follows: "The lower signal to noise ratio for the triplet method results from the overall degradation of the limb signal quality around 600 nm as well as larger systematic errors due to a usage of information from different spectral channels to form the data vector (both SCIATRAN and DLR retrievals use only the spectral information from channel 3, whereas the Stratozone processor uses both channels 3 and 4)."

Do any of the processors account for the correlation in altitude of the "y" vectors in-

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troduced by the tangent height normalization step? This should lower the estimated uncertainty of the retrieval.

Yes, this correlation is accounted for in all retrieval processors when forming the weighting function matrix. This should be much more clear from the revised description of the retrieval algorithms.

Page 1977, end of main paragraph: Did the authors test the hypothesis of similarity between the three by using a perturbation analysis of a synthetic profile, i.e. what is the impulse response function of each processor.

No, these tests were not performed, since, due to technical reasons, an adaptation of the DLR processor for reading of synthetic data is quite complicated and could not be done in the framework of this study. The similarity hypothesis relies on the retrieval experience of the coauthor team.

Page 1978: Is the finite IFOV accounted for in calculating the averaging kernels or in the forward models?

Yes. This is now mentioned in “General settings” Section.

Page 1978: Since only a SNR of 100 is used in the Stratozone processor, wouldn't processors 2 & 3 have less of a dependence upon the a priori?

No, the reasons are discussed now in “General settings” Section: “However, this does not mean that the Stratozone retrievals are stronger constrained because the effective differential signal from the entire Chappuis absorption band, as exploited by the Stratozone processor, is much stronger as compared to that in the short wavelength wing of the band exploited by both SCIATRAN and DLR algorithms.”

Page 1980, line 3: This IFOV information should be moved to or repeated in a section describing the SCIA measurements.

The IFOV information is now repeated in a section describing the SCIA measurements.

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Page 1981: Are the sample sizes the same? If not, then how do the results compare when the set is limited to those events that are common to all three?

The sample sizes are the same. This is now clarified in the first paragraph of Section "Comparison of the retrieval processors": "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."

Page 1981, lines 3-5: Yes, modeling of the scattering process maybe to blame, but aren't there other possibilities? This seems like a good place to look closer and try to discern the root of the difference.

The discussion of discrepancies was extended.

Page 1982: Shifting the profiles based upon the TRUE algorithm: Did the authors test the similarity between shifting the retrieved ozone profile (level 2) and shifting the input tangent height scans (level 1)?

Yes, we did. This is now stated in Section " Comparison to lidar measurements": "According to our previous investigations this post-processing correction, i.e., vertical shift of the retrieved number densities, results in nearly the same profiles as compared to the retrieval of the pointing corrected limb spectra."

Page 1983, line 12: Under-regularization: Is this true of other cases and it is just hidden in orbital and zonal averages?

No, the problem is not common. See, for example, two other lidar comparisons, where no oscillations occurred.

Page 1990: One small set of data consumers may be those folks that use the ozone profile to better estimate the tropospheric ozone amount from nadir total column ozone measurements. For their understanding, what is the comparison (amongst the three processors) of the ozone column integrated from the top of the atmosphere down to particular altitudes, most specifically down to the tropopause?

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As a quick look, the comparisons of the stratospheric columns between 15 and 40 km as well as between 20 and 40 km are now included in the paper: “Integrated between 15 and 40 km, the SCIATRAN and DLR profiles agree within 0.3% whereas the corresponding partial column obtained from the Stratozone profiles is about 3% larger. However, performing the integration only between 20 and 40 km, an agreement of about 0.1% between the SCIATRAN and Stratozone processors is reached whereas the corresponding partial column obtained from the DLR retrievals is about 6% lower.”

However, to answer the question accurately one has to determine first the tropopause height which is clearly beyond this study.

Minor comments

All minor comments are incorporated into the revised manuscript.

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