Atmos. Meas. Tech. Discuss., 1, S231–S240, 2009
www.atmos-meas-tech-discuss.net/1/S231/2009/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Multi-year comparison of stratospheric BrO vertical profiles retrieved from SCIAMACHY limb and ground-based UV-visible measurements" *by* F. Hendrick et al.

F. Hendrick et al.

Received and published: 17 March 2009

Firstly we would like to thank Anonymous Referee #2 for his helpful comments and suggestions.

General:

This paper was greatly improved by the inclusion of Figure 2 (not included in the original manuscript).

Reply: We agree and thank again Referee #2 for having suggested to include a figure with measurement response functions.

With regard to the smaller biases in the partial columns as compared to the profiles,

two explanations come to mind: -actual vertical resolution of the ground-based (GB) retrievals is not equal to the calculated one. -problems with retrieval of profile shape in one or both retrievals (likely the GB data).

Reply: In profile comparisons, we see that there is a tendency to have SCIAMACHY smaller than GB at some altitude levels and the opposite feature at other adjacent levels, resulting in smaller biases in the partial columns. Due to the low vertical resolution of the GB profiles, we cannot exclude that there are sometimes some compensating effects in the GB vertical profiles (too low BrO concentration at some altitude levels are compensated by too large BrO concentration at other adjacent altitude levels). However, we have shown in Hendrick et al. (2007) that the GB retrieval is not only a scaling of the a priori profile and the shape of the retrieved profile can be quite different from the a priori.

Please provide a reason why measurements from Reunion Island [Theys et al., Atmos. Chem. Phys., 7, 4733-4749, 2007] have been omitted in this study. Note that comparisons at sites with poorer agreement should not be omitted, otherwise the authors may be painting a biased picture of the agreement between SCIAMACHY and GB data.

Reply: We have applied our profiling algorithm to the ground-based measurements at Reunion Island and the quality of the retrievals was found to be not good enough (e.g., averaging kernels rather flat compared to those obtained at the other stations). So we decided not to include the measurements at Reunion Island in our study. In collaboration with INTA (Instituto Nacional de Técnica Aeroespacial, Madrid, Spain), we are currently working on the consolidation of ground-based UV-visible measurements at Izaña (Canaries Islands; 28°N, 16°W) for the 2004-2007 period. The idea is to see how do the ground-based UV-vis and SCIAMACHY limb BrO observations compare in tropical regions.

An estimate of Bry would be a valuable addition to this paper and may be inferred from BrO by the authors since they have a photochemical modeling capability.

AMTD

1, S231–S240, 2009

Reply: In this study, we have decided to concentrate our efforts on the comparison of BrO. We do not think that adding an estimate of Bry would be a highly valuable addition to the paper mainly because this has already be done in the past for both SCIAMACHY limb (Sioris et al., 2006) and ground-based UV-vis observations (e.g., Hendrick et al., 2007). Both total inorganic Bry estimates were found to be within their combined error bars (about 23+/-2 pptv)

The GB averaging kernels for the morning retrievals do not peak at the correct height.With the exception of the 23 km kernel, the rest of them all peak too high by 2-4 km. The evening retrieval does not show this problem except for averaging kernels above 30 km.

Reply: Looking at the BrO weighting functions which are used to calculate the averaging kernels, it appears that the morning weighting functions at SZAs larger than 90°SZA are shifted higher by about 2 km compared to the corresponding evening weighting functions. Since the same ozone profile is used to calculate both morning and evening weighting functions, it is more likely due to differences between sunrise and sunset BrO photochemistry: the release of BrO from its nighttime reservoir (BrONO2) at sunrise is more rapid than the formation of the nighttime reservoir at sunset, resulting in different BrO profile shapes at sunrise and sunset. This feature is confirmed by plotting the diurnal variation of the BrO profile calculated with our stacked box photochemical model PSCBOX.

A small amount of effort is needed until this paper is acceptable for publication in Atmos. Meas. Tech.

Specific:

Section 2 "a constant surface albedo of 0.3" why not use a surface albedo database? This would account for high surface albedo in high latitude winter, even though the impact of albedo is small.

AMTD

1, S231–S240, 2009

Reply: In Rozanov et al. (2005), it has been shown that the surface albedo has a negligible impact on the stratospheric BrO profiles retrieved from SCIAMACHY limb measurements.

Why are the a priori standard deviations set at 25 pptv? Does this not seem large considering the natural variability of BrO is much smaller than this?

Reply: The a priori standard deviations are larger than the natural variability of BrO for assuring good retrieval results even if a priori profiles are totally incorrect or if atmospheric BrO concentrations are abnormally large (e.g., due to volcanic eruption). Furthermore, there is no need to tighten the a priori standard deviation if it is not required for the stability of the retrieval because a loose a priori constraint makes the retrieval more independent from a priori information.

Justification should be provided as to why the Fleischmann et al. BrO cross-sections are used for SCIAMACHY data analysis while Wilmouth et al. cross-sections are used in the GB retrievals (considering that Sioris et al. already reported that spectral fitting residuals are smaller when Wilmouth et al. cross-sections are used). Since the choice of BrO cross-sections is very important to the conclusion, consistency in this choice between instruments makes the most sense.

Reply: We think that the most relevant way to perform comparisons between SCIAMACHY limb and ground-based UV-vis BrO profiles is to compare data products retrieved with what we find to be the best settings for each retrieval. Regarding the BrO cross sections, the Fleischmann et al. cross sections were selected for SCIAMACHY retrievals at IUP Bremen because they are available at 5 temperatures while Wilmouth et al. cross sections are measured at only 2 temperatures. So Fleischmann et al. allows to take into account the temperature dependence more properly. Furthermore, investigations performed at IUP Bremen did not confirm the conclusions of Sioris at al. with respect to the spectral residuals: they could not achieve a substantial decrease in the retrieval residuals when using the Wilmouth et al. cross sections instead

AMTD

1, S231–S240, 2009

of Fleischmann et al. Regarding the DOAS analysis of ground-based UV-vis spectra, Wilmouth et al. cross sections gave clearly the lowest fit residuals and were therefore chosen for this reason. These cross sections were also recommended in the Aliwell et al. (2002) paper on the intercomparison of ground-based DOAS observations of BrO. As suggested by Referee #1, we have added a plot in Section 5.2 to illustrate the impact on the partial column comparison results of using Wilmouth et al. instead of Fleischmann et al. in the SCIAMACHY retrieval. This impact is about 10% (8% to be precise) in average as expected.

P456, L11: MIPAS does not measure BrO. P456, L11: a personal communication is not adequate here. More detail is needed regarding the a priori BrO and the time period of MIPAS measurements. Why not reference Sinnhuber et al., 2005? MIPAS measures CFC-11, but where does the Bry come from?

Reply: The BrO a priori climatology is calculated from an estimate of Bry based on MIPAS measurements of CFC-11 for 2003 using the empirical relation between CFC-11 and Bry of Wamsley et al. (1998) with updated surface mixing ratios for the individual source gases (Sinnhuber et al., 2005). The BrO profile climatology is then calculated from these Bry profiles assuming a BrO/Bry-ratio of 50%, which is a reasonable approximation for daytime conditions. This comment is included in the revised version of the manuscript.

Section 4 P459 (Eq.1): minor (but not trivial) point: when convolving with averaging kernels, you could take into account the fact that the SCIA measurement is already convolved with its own "3-5 km" averaging kernel.

Reply: We think the difference in the vertical resolution between SCIAMACHY and ground-based profiles is large enough that we can just neglect the vertical resolution of SCIAMACHY when convolving the SCIAMACHY profiles with the ground-based averaging kernels. As mentioned by Referee 2, this point is not trivial and would require a study in itself.

AMTD

1, S231–S240, 2009

Section 5 P460, L16: It may be worthwhile to test the impact of changing the coincidence criterion for latitude (e.g. to +/-4°).

Reply: We have done such a test for the Harestua station. In the paper, the spatial coincidence criterion is latitude and longitude of the station is +/-5° and +/-10°, respectively. This corresponds to a maximum distance of about 750 km between SCIAMACHY and ground-based UV-vis observations. By reducing this distance to 250 km, we did not find any real improvement in the profile and partial column comparisons.

P460, L17: What is the temporal criterion: same morning or evening?

Reply: Yes, same morning or evening. That means that a morning (or evening) SCIAMACHY profile is compared to the ground-based profile retrieved from the same morning (or evening) slant column densities. We have added a sentence on this point in the revised version of the paper.

Section 6 P461, L18-19: It would be appreciated if you quantify (or illustrate) the mean and standard deviation at one or more heights below 18 km in the unsmoothed SCIAMACHY data to investigate the significance of this observed difference.

Reply: The standard deviation on the unsmoothed SCIAMACHY profiles (not shown in the plots) is similar to the one calculated for the smoothed profiles. We add a sentence on this in each legend of the profile comparison plots.

Section 7 P464, L25-27: This statement seems to contradict the results on P463, L10-15.

Reply: We agree. Looking again carefully at Figs. 5, 6, and 10, we cannot say that the relative difference is smaller in summer than the rest of the year. Actually the tendency is to have positive relative difference values in winter-spring and more negative values in summer. This has been changed accordingly in the revised version of the manuscript.

Technical:

AMTD

1, S231–S240, 2009

Abstract P452, L2: "daily retrieved"-> "retrieved daily"

Reply: Corrected

Section 1 P452, L20: "has been launched" -> "was launched"

Reply: Corrected

P453, L8: "kind of measurements" -> "kind of measurement"

Reply: Corrected

P453, L15: "In case of bromine" -> "In the case of bromine"

Reply: Corrected

P453, L15-16: list references since not all references from preceding sentence apply.

Reply: Corrected

Section 2 P454, L12-13: "of the scattered solar radiation" -> "of scattered solar radiation"

Reply: Corrected

P454, L17: "accounted for" -> "taken into account."

Reply: Corrected

P454, L21: The reader should be pointed to a more specific website, e.g.: http://www.iup.uni-bremen.de/sciatran/free_downloads/users_guide_sciatran_v2-2.pdf

Reply: The main SCIATRAN web site is referenced. A more specific choice of the web site depends on what the reader needs. So we do not think this reference should be changed.

Reply: Corrected

AMTD

1, S231–S240, 2009

P454, L24: "the version 3.2 of the retrieval": omit either the 1st "the" or "of the".

Reply: Corrected

P455, L7: a more specific reference is again needed

Reply: We add the following reference: http://www.iup.physik.uni-bremen.de/˜sciaproc/CDI/DOCU/.

P455, L10: "ratioed" -> "divided"

Reply: Corrected

P456, L10: refer to: McLinden, C. A., J. C. McConnell, E. Griffioen, and C. T. McElroy (2002), A vector radiative transfer model for the Odin/OSIRIS project, Can. J. Phys., 80, 375-393.

Reply: Done

Section 4 P458, L21: start a new paragraph

Reply: Corrected

P459, L1: start a new paragraph discussing GB averaging kernels

Reply: Corrected

Section 5 P461, L20: "8-10 km" -> "10-12 km"

Reply: Corrected

Section 6 P463, L19: remove "indeed"

Reply: Corrected

P463, L23: "higher" -> "larger"

Reply: Corrected

AMTD

1, S231–S240, 2009

Interactive Comment

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Hendrick, F., Van Roozendael, M., Chipperfield, M. P., Dorf, M., Goutail, F., Yang, X., Fayt, C., Hermans, C., Pfeilsticker, K., Pommereau, J.-P., Pyle, J. A., and De Mazière, M.: Retrieval of stratospheric and tropospheric BrO profiles and columns using ground-based zenith-sky DOAS observations at Harestua, 60°N, Atm. Chem. Phys., 7, 4869-4885, 2007.

Rozanov, A., Bovensmann, H., Bracher, A., Hrechanyy, S., Rozanov, V., Sinnhuber, M., Stroh, F., and Burrows, J.: NO2 and BrO vertical profiles retrieval from SCIAMACHY limb measurements: Sensitivity studies, Adv. Space Res., 36, 846-854, doi:10.1016/j.asr.2005.03.013, 2005.

Rozanov, A., et al.: BrO vertical distribution from SCIAMACHY limb observations: Comparisons of algorithms and retrieval results, to be submitted to ACP, 2009. Sinnhuber, B.-M., Rozanov, A., Sheode, N., Afe, O. T., Richter, A., Sinnhuber, M., Wittrock, F., Burrows, J. P., Stiller, G. P., von Clarmann, T., and Linden, A.: Global observations of stratospheric bromine monoxide from SCIAMACHY, Geophys. Res. Lett., 32, L20810, doi:10.129/2005GL023839, 2005.

Sioris, C. E., Kovalenko, L. J., McLinden, C. A., Salawitch, R. J., Van Roozendael, M., Goutail, F., Dorf, M., Pfeilsticker, K., Chance, K., von Savigny, C., Liu, X., Kurosu, T. P., Pommereau, J.-P., Bösch, H., and Frerick, J.: Latitudinal and vertical distribution of bromine monoxide in the lower stratosphere from Scanning Imaging Absorption Spectrometer for Atmospheric Chartography limb scattering measurements, J. Geophys. Res., 111, D14301, doi:10.1029/2005JD006479, 2006.

AMTD

1, S231–S240, 2009

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Interactive comment on Atmos. Meas. Tech. Discuss., 1, 451, 2008.

AMTD

1, S231–S240, 2009

Interactive Comment