

## ***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.**

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Firstly we would like to thank Anonymous Referee #1 for his helpful comments and suggestions.

Referee comment: The authors present a comparison of BrO profiles retrieved from SCIAMACHY limb observations and different ground-based stations. The comparison is performed for three stations (Observatoire de Haute-Provence, Lauder, Harestua) and different time ranges (the longest one is for Harestua from September 2002 to October 2006). The paper is well organized and well written, also the figures are of good quality, and the subject of the article fits very good into the AMT journal. Moreover, it is to my knowledge the first article that compares SCIAMACHY BrO profiles to ground

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based retrievals for a set of stations at different latitudes on a long term scale. The article is therefore of large relevance for atmospheric sciences. However there are two important issues that need to be improved: a) The result of the comparison should be put into the context of current research, in particular the following questions should be addressed: How well do the retrieved profiles agree with those reported by i) Sinnhuber et al., 2005 and ii) Sioris et al., 2006? Also a short discussion regarding the Bry could be given, since this is of recent interest. However, such a discussion should of course be made only if the datasets allow such implications.

Reply: Point a)i): A comparison with older SCIA retrievals needs to be quite extensive to be representative because the main difference is due to the calibration of SCIAMACHY L1 data and pointing issues which may vary with time, season, location, etc. Thus, such a comparison is a study in itself and would change the focus of our paper substantially. So we do not think it is relevant to include it in the present paper but rather in a further paper which will update Sinnhuber et al. (2005). Point a)ii) (comparisons to current SCIAMACHY retrieval versions of other groups) is discussed in a paper in preparation (Rozanov et al., 2009). Regarding an estimation of Bry, we think that it is a bit beyond the scope of the current paper where we concentrated our effort on BrO comparisons. Moreover we think that adding an estimate of Bry would not 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)

Referee comment: b) The comparisons should be performed with both retrievals (SCIAMACHY and ground based (GB)) applying the same cross sections for BrO. If this is not possible, then the retrieved profiles for one dataset need to be scaled with a factor that is given by the difference of the cross-sections. Without this scaling, the differences of the profiles that are given in the abstract and also the comparison plots themselves include an offset, and therefore are misleading or to be precise, incorrect.

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One possibility would be to add a study (and a figure) where the SCIAMACHY retrievals are performed with i) the usual setting and ii) with the Wilmouth et al. cross section for a number of selected matches. The difference in the retrievals (which should be on the order of 10-15 %) could then be applied to scale all the SCIAMACHY profiles. This will in fact also decrease the difference to the GB retrieval. For the revised version it is necessary that all numbers regarding the agreement of the comparison and also the plots of the profiles are given for the same cross sections, or a scaling is performed so that the retrievals can be compared without an arbitrary bias.

Reply: We do not agree with Referee #1. 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, the investigations performed at IUP Bremen did not confirm the conclusions of Sioris et 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 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. According to these arguments, we decided to keep the comparison plots as well as the corresponding discussions as is. However, 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.

Specific points:

Referee comment: Abstract line 6 The comparison extends from Sep. 2002 to Oct. 2006 only for the Harestua station. For the other stations the time of comparison is shorter, in the case of OHP much shorter.

Reply: In this comparison study, we have used all the ground-based data available at the time the paper was submitted to AMTD. At OHP, no ground-based data were available from mid-2002 to early 2005 due to instrumental problems.

Referee comment: Abstract line 14 The large BrO column events should be due to bromine activation not due to chlorine activation.

Reply: Corrected.

Referee comment: Introduction line 21 please provide a short explanation (in brackets) of nadir and limb

Reply: Done.

Referee comment: p453, line 16 The reference to Dorf et al., 2006 should be given here.

Reply: Done.

Referee comment: p454, line 27 The authors state that the parameters for the SCIA-MACHY retrieval differ quite strongly from those applied for earlier publications. Considering the importance of the BrO profiles for atmospheric sciences (SCIAMACHY is still the only instrument providing global profiles), I suggest to discuss in how far the retrieved BrO profiles are different from those reported earlier. This point could be elaborated in a chapter "discussion", which I think should be added to the article (see below).

Reply: As mentioned above, a comparison with older SCIA retrievals needs to be quite extensive to be representative because the main difference is due to the calibration of

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SCIAMACHY L1 data and pointing issues which may vary with time, season, geolocation, etc. Thus, such a comparison is a study in itself and would move the focus of the paper substantially. So we do not think it is relevant to include it in our paper but rather in a further paper which will update Sinnhuber et al. (2005).

Referee comment: p455 line19 What is the spectral correction  $l_0$  ? Probably  $1/l_0$  is meant here.

Reply: Yes, you are right. This has been corrected in the revised version.

Referee comment: p455 line20 The reference to Sioris et al., 2006 is fitting for the spectral correction "tilt", but the spectral corrections ring, eta, and  $1/l_0$  are not applied there. One possible reference could be Köhl et al., 2008 (JASR, 42, 1747-1764)

Reply: Yes, you are right. We have added this reference in the revised version.

Referee comment: p455 line 22 The term global fit method should be explained.

Reply: In the revised version, we have added a sentence to explain this method (the spectra obtained at all tangent heights are fitted simultaneously)

Referee comment: p456 line 11 Since MIPAS does not measure BrO it should be explained here in how far the BrO climatology is based on these measurements.

Reply: The BrO a priori profile 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.

Referee comment: p456 line 22 Concerning the settings for albedo, aerosols and clouds: Did you investigate how sensitive the different retrievals are to this assumption

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? You are using the same settings for all retrievals, but discrepancies from this assumption should effect the GB and limb observations differently. I recommend to add a chapter "Sensitivity studies and discussion" where this point could be investigated in detail.

Reply: For albedo and aerosols it was already done in Rozanov et al. (2005) for SCIAMACHY and in Hendrick et al. (2007) for ground-based UV-vis. Regarding clouds, we have checked if the comparison results change when using cloud free SCIAMACHY measurements. The effect was found to be negligible.

Referee comment: p459 line 6 To determine the FWHM of the AK from Figure 1 is a difficult task for the reader. I suggest adding a figure that displays the spread. This would also give additional information on the retrieval quality.

Reply: We think that with the AK in figure 1, the reader can already have an estimate of the vertical resolution of both retrievals and combining this to the measurement response (figure 2), detailed information on the quality of both retrieval is already given in the paper. Regarding the spread, it is questionable that if the Backus and Gilbert approach commonly used to calculate the spread can still be used to characterize the vertical resolution of the ground-based retrieval since for the ground based measurement the averaging kernel peaks are sometimes displaced from their nominal altitudes.

Referee comment: p462 line 4 As mentioned above this point should be corrected for in the plots and the numbers summarizing the agreement. Also, this bias is not additional. A scaling by the difference of the cross sections would decrease the differences to the GB profiles to approx. 0 to -5%. However, it should also be discussed whether such a perfect agreement is reasonable, considering the different observation geometries and retrieval approach. The best would be to run the GB and SCIA retrieval for simulated spectra with a known BrO profile. Together with sensitivity studies on the impact of clouds, albedo and aerosols this would increase the significance of the found agreement very much.

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Reply: As extensively discussed above, we do not agree with Referee #1 on this point and 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, including the BrO cross sections. Referee #1 is right when saying that the bias is not additional (actually it is negative if the Wilmouth et al. (1999) BrO cross sections is used in both retrievals). We have corrected this in the revised version of the manuscript. Regarding a sensitivity study using simulated spectra: we find a bit peculiar to ask for such a study for explaining a good agreement. Generally, investigations using synthetic spectra are performed for trying to explain discrepancies. Therefore we think that it is beyond the scope of the present paper.

Technical points:

Referee comment: Chapter 6 and 7 are probably meant as 5.1 and 5.2

Reply: Corrected.

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