

## ***Interactive comment on “Global satellite validation of SCIAMACHY O<sub>3</sub> columns with GOME WFDOAS” by A. Bracher et al.***

**A. Bracher et al.**

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We thank Anonymous Referee 2 for his positive review and his comments.

1. Major shortcoming mentioned by referee #2: "Ozone columns derived from DIFFERENT INSTRUMENTS retrieved with DIFFERENT ALGORITHMS are compared. Hence the detected distinctions may be either due to instrumental features or due to the retrieval, and the discussion is rather speculative. It is not definitely clear that (and how far) the observed differences are due to the SCIAMACHY V5.01/5.04 algorithm. To overcome this problem, similar retrievals must be used! As the authors state in the last paragraph, they plan the adaptation of WFDOAS to SCIAMACHY. This would be the best solution for the current study! Then it would be free from comparing algorithm performance what is done elsewhere (Coldewey-Egbers et al., 2004), but instead

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compares GOME to SCIAMACHY directly, and we could learn something about instrumental features (or possibly also other factors like different viewing time etc.). If the reprocessing of the whole SCIAMACHY dataset would take too long, it could be at least done for e.g. a week of data. If the implementation of the WFDOAS algorithm for SCIAMACHY cannot be realized within the next months (but I would really favour this solution!), the authors should at least compare SCIAMACHY 5.01/5.04 to GOME GDP 2.4 for a data subset!"

We were already able to adapt the WFDOAS algorithm to SCIAMACHY level-1 data and extract total ozone columns for a few days (10) in 2003. These data were now compared to the SCIAMACHY V5.01/5.04 and GOME WFDOAS results in order to elucidate which differences can be attributed to the instruments and which to the algorithm. The results are now included in Figs. 1, 2, 4, and 5 and discussed. GOME GDP 2.4 data are not available for the time frame of this study.

2. Major shortcoming mentioned by referee #2: "A second aspect is the comparison method using 2.5 bins and afterwards calculating means for bands of constant latitude. With this method, the data is averaged twice before comparison! Longitudinal variations (arctic vortex!) are not resolved any more. And within 2.5 North-South there are several (6-8) GOME/SCIAMACHY observations! The calculated variances are difficult to interpret, as the input data itself are averaged values."

We in fact compared each data bin for all days of the first half in 2003, but thought when submitting the paper to ACP that the plots were not impressive. Now, we understand that those plots are important and therefore we present global maps on the comparisons of 12 May 2003 (see Fig. 2 new). Because we saw the latitudinal dependencies we showed only these plots before. Now we are showing in the latitudinal plots besides the mean and rms also each individual comparison using both, the direct and the binning methods.

"It is essential to correlate directly collocated GOME and SCIAMACHY measurements

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to quantify not only deviations of the means but also learn about actual fluctuations for single measurements. As both datasets have the same total cross track width (960 km), the higher resolved SCIAMACHY data (16 pixels of 60 km cross track) can easily be reduced to GOME resolution (3 pixels of 320 km cross track). For the scans along track one GOME scan (40 km) usually covers two or three SCIAMACHY scans (30 km). These SCIAMACHY pixels could be averaged (for instance weighted by the area of overlap) to match the GOME pixel."

As we showed already in Fig. 2 we did perform both methods, binning and direct comparisons and as one can see from Fig. 2 there are hardly any differences in the results looking at individual comparisons, We now clarified in the manuscript that for the direct comparisons we compared the mean of the total ozone columns of all SCIAMACHY pixels which were measured 30 min. before than GOME within the same ground scene of the (generally larger) GOME pixel.

"The authors state that a direct comparison took 3 days. It is hard for me to understand this, as one GOME orbit consist of 1000 pixels, i.e. 15000 pixels per day, and half of them drop out as no SCIAMACHY measurements exist (limb mode gaps). I cannot believe that it takes half a minute to find the SCIAMACHY pixels covering a given GOME pixel. The authors should think of possible optimisations and in any case explain in detail how they collocate GOME and SCIAMACHY observations. At least for one day, it is essential to study the correlation of SCIAMACHY and GOME results directly without gridding or taking zonal averages!"

As we pointed out above, we did/do show in Fig. 2 that there are hardly any differences in the results of comparisons using binned data or direct comparisons. We now optimised the direct comparison and it takes now about 60 min for 1 day opposed two 2 minutes using the binning method. Because of that we still prefer to use the binning method for the analysis of a half of year data (which saves computing time).

"For the whole dataset, however, binning is probably needed. To illustrate the bin-

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ning effect, Fig. 2 should rather compare the correlation of GOME and SCIAMACHY observations for the binned and the unbinned case instead of taking zonal means!"

As stated above, in addition to the zonal means we also show the results of each comparison as function of latitude (Fig. 2 upper right panel) for both using the direct and binning method for comparing SCIAMACHY v5.01 to GOME WFDOAS.

"I recommend to reduce the grid resolution in North-South; in any case the authors should motivate their choice of 2.5 and explain their gridding procedure: E.g. are observations taken if their center is inside the grid cell, or any part of the GOME/SCIAMACHY pixel, etc."

We use the centre coordinate in order to decide if a pixel is within or outside a bin. Since the GOME pixel are larger especially across track as opposed to SCIAMACHY to use 2.5° by 2.5° seems to cover the best a whole GOME pixel although the plotting of the GOME binned total ozone does exactly reflect the ground pixels. Also before submitting the manuscript to ACP, we tried different grid sizes and results were compared with the direct GOME-SCIAMACHY comparison. It turns out that the 2.5° times 2.5° gives the best results. We understand that choosing the binned data do not reflect exactly the location of the GOME and SCIAMACHY footprints as indicated by unevenly sized gaps in the upper and middle panel of Fig. 1, where SCIAMACHY limb measurements have been made. Although global coverage is reached for GOME above 65°N, there are small white gaps in between (Fig. 1 lower panel) that are due to the small area of each bin at high latitudes in relation to the large GOME pixel size such that the centre coordinate cannot fall into each bin.

"This aspect is related to Fig. 1: SCIAMACHY and GOME have the same cross-track width, but the SCIAMACHY orbits are wider than the GOME orbits in Fig. 1! Furthermore, the gaps during the SCIAMACHY limb observations are partly filled up. On the other hand, the GOME orbits show strange white spots for  $\text{abs}(\text{latitude}) > 30$ . (These white spots are also in contradiction to the statement p.798, line 22 that at

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latitude higher than 65 complete coverage is provided daily). So it looks to me that the gridding procedure was different for SCIAMACHY and GOME." See our explanation above.

"The discussion of differences is rather speculative as far as aspects 1 & 2 are not resolved. I recommend to use SCIAMACHY O3 columns with WFDOAS for this comparison study and analyze the direct correlation of GOME and SCIAMACHY data without binning/averaging for one week or at least one day. The methods (collocating SCIAMACHY and GOME pixels, gridding etc.) have to be explained sufficiently. The direction of paragraphs 4 and 5 depends on the results of the revised comparison." As described above in response to major comments 1. and 2. we added more information and results in the paper and therefore also change and clarified large parts in paragraphs 4 and 5.

Specific comments by referee #2: "1. The GOME and SCIAMACHY measurements are not taken synchronous, but with 30 minutes shift. You should at least discuss how far this could cause differences in the observed ozone columns. I expect an effect at least for wintertime measurements of high latitude, i.e. shortly after sunrise."

We discussed now this issue in chapter 5 of the manuscript "The much larger negative bias between the SCIAMACHY and GOME algorithms in the polar winters of our study compared to other regions might be explained that generally at high SZA and in polar regions satellite and ground based UV-VIS measurements have larger errors due to lower signal to noise ratio at low light conditions. Because the two instruments are flying in the same orbit 30 min. apart from each other the SCIAMACHY measurements at high northern latitudes during sunrise are taken at higher solar zenith angles than GOME measurements and therefore may probably show a larger error than collocated GOME data. The situation is reversed at high solar zenith angle in the southern latitudes. This also explains why the scatter increases at high latitudes (this is also true for SCIAMACHY WFDOAS to GOME WFDOAS comparisons). We probably observed this in the Arctic region only, because Antarctic winter season observations was not

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covered in our study."

"2. Page 800 line 20: Please motivate why you choose the maximum SZA different for GOME and SCIAMACHY."

We changed the analysis (and the text accordingly) using as for GOME only SCIAMACHY measurements taken at solar zenith angles below 88°.

Technical corrections / minor remarks / suggestions by referee #2: 1. Abstract first line: SCIAMACHY measures spectra rather than ozone columns. - This was changed accordingly. 2. Page 796 end of line 9: times or x instead of and. This was changed accordingly. 3. Page 797 line 4: Do satellites die? This was changed to " stop measuring". 4. Page 797 line 11: Please add a reference for SCIAMACHY. - We added the reference "Bovensmann et al., 1999". 5. Page 797 line 19 ff: sentence sounds strange; grammar correct? The sentence was corrected. 6. Page 797 line 24: Please give a reference for the statement that GDP 4 is comparable to WFDOAS 1.0. - We added the reference "Lambert et al., 2004b". 7. Page 799 line 2: since could be mistaken as because; the sentence could be reorganized. - This was changed accordingly. 8. Page 799 line 8: Add also after SCIAMACHY. - This was changed accordingly. 9. Page 800 line 17: correct grammar? Two times available. This was changed accordingly.

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Interactive comment on Atmos. Chem. Phys. Discuss., 5, 795, 2005.

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