Atmos. Chem. Phys. Discuss., 5, S373–S378, 2005
www.atmos-chem-phys.org/acpd/5/S373/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Validation of ENVISAT/SCIAMACHY columnar CO by FTIR profile retrievals at the Ground-Truthing Station Zugspitze" *by* R. Sussmann and M. Buchwitz

R. Sussmann and M. Buchwitz

Received and published: 8 April 2005

Final response to anonymous referee 2 by R. Sussmann and M. Buchwitz.

We like to thank the anonymous referee 2 for his efforts and appreciate all of his comments. Our point-to-point replies to the reviewers specific comments are presented thereafter.

Ad 1. "While the ground-based data is normalised with independently measured pressure (in which we can assume the error is negligible compared with other errors), the satellite data is normalisaed with O2 retrievied from the same instrument. Nothing is said concerning the reliability of these O2 data."

First of all, we want to state that we had performed a test using the anomaly of the SCIAMACHY data directly without the O_2 correction appplied. We found that the overall standard deviation of the daily mean SCIAMACHY data did not change significantly compared to the case wih O_2 correction. This is evidence, that the O_2 correction does not introduce any significant errors to our comparison study.

To follow the referee, we added the following description of O_2 errors to Section 3 of the manuscript:

"Details on the O_2 retrievals are given in Buchwitz et al. (2005a). Several days of global SCIAMACHY data have been compared with O_2 columns computed from ECMWF surface pressures. It is shown that the mean difference of the daily data (SCIAMACHY-ECMWF) is on the order of one percent (between -2.1 % and +0.7 %) and that the standard deviation of the difference is about 10 % (between 7.9 % and 12.0 %). The standard deviation is believed to be dominated by quasi random retrieval errors introduced by the variability of the atmosphere (distribution of scatterers, temperature profile variations, etc.) and surface reflectivity variations not yet considered accurately enough in the retrieval algorithm (the random error due to instrument noise is well below 1 %). The estimated precision of the retrieved O_2 columns of about 10 % is large but significantly smaller than the variability of the CO columns and also significantly smaller than the O_2 column variability in areas of complex surface topography such as the Alps."

Ad 2. "Is the seasonal cycle in CO captured correctly when there is a full year of data available? The treatment of a linear slope for the sample period is a simple convenient proxy for the seasonal behavior in this sample, given the apparent data quality, but is not a demonstration that the satellite can see this behavior correctly. This is already acknowledged by the authors as a point for further investigation."

We agree and understand no changes to the manuscript are required as to this point.

Ad 3. "Just how big is the vertical smoothing errors in this comparison? The averaging

ACPD

5, S373–S378, 2005

kernels certainly look similar and may well justify ignoring the smoothing error, but there *are* differences. The smoothing error is also dependent on the variability of CO the atmosphere, and this will be at a maximum in the boundary layer, which is one of the places where there *is* a noticeable difference in the averaging kernels. This difference at the boundary layer probably has a larger effect on the smoothing error in retrieved columns than the apparently larger differences at 300 HPa. Can some attempt at estimating smoothing error be made, assuming a realistic estimate of variability in the CO?

In fact the smoothing errors for both FTIR and SCIAMACHY are negligible compared to the magnitude of the scatter oberved: Using the CO covarince matrix of the operational MOPITT retrieval given by Deeter et al. (2003) and using the total column averaging kernels shown in our Figure 1, we obtained smoothing errors in the order of 1 – 2 % for FTIR and SCIAMACHY.

We added a half sentence to Section 3:

"... and the intercomparison is not impacted significantly by (differing) smoothing errors, which are in the order of $\approx$1 – 2% for both FTIR and SCIAMACHY, depending on the details of the CO covariance matrix assumed."

Triggered by the referee's argumentation, however, we decided to additionally add the following discussion of the differences expected for the variabilities of Zugspitze FTIR versus SCIAMACHY columns based upon the above mentioned CO covariance matrix:

"Now we want to estimate the differences in the variabilities of the Zugspitze FTIR total columns versus SCIAMACHY total columns, which are expected due to two effects, i) the different column–ground altitudes (i.e., 2964 m for Zugspitze FTIR and 230 m for the average SCIAMACHY columns ground altitude for a selection radius of 2000 km around the Zugspitze), and ii) the (slightly) differing averaging kernels. For this purpose, we calculated the total–column standard deviation using

ACPD

5, S373–S378, 2005

$$stdv_{col} = \sqrt{\mathbf{a}^T \, \mathbf{S}_a \, \mathbf{a}}, \quad (1)$$

where the vectors **a** are the total column averaging kernels shown in Fig. 1, and $\mathbf{S}_a$ is the CO covariance matrix adopted from the operational MOPITT retrieval given by Deeter et al. (2003). Thereby we obtain an expected total–column standard deviation of 27 % for Zugspitze FTIR and 38 % for SCIAMACHY. We note, that these numbers essentially reflect the variances given by the MOPITT $\mathbf{S}_a$ (which is an estimation of true variability only), and the different ground altitudes of Zugspitze versus SCIAMACHY columns, i.e., they can not be compared directly to the real absolute FTIR and SCIAMACHY columns varibility. These numbers are not significantly impacted by the averaging kernels, i.e., using the ideal averging kernels $\mathbf{a}^T = (1, 1, ...1)$, there is only a slight change to 28 % for FTIR and 36 % for SCIAMACHY (in other words, the fact that there is a slight change only, is due to the small smoothing errors for both instruments, see above). However, these numbers can be interpreted in relative terms, i.e., we learn for the discussion of our results in Section 4, that, mainly due to the differing column–ground altitudes we would expect a higher day—to–day variability for SCIAMACHY relative to FTIR by a factor in the order of 38/27 = 1.4."

Ad 4. "How big are differences from horizontal variation in CO? with a small sample there's pressure to extend the coincidence criterium to a larger distance in order to get a statistically meaningful sample. However there will be differences introduced from horizontal variation in CO. The reader isn't sure whether the large scatter in the SCIAMACHY retrievals is from this or from measurement noise, so something should be said about the likely magnitude of these two things.

In order to illustrate this important point we added the following discussion to Section 4:

"Fig. 2 shows that the day-to-day scatter of the FTIR data is in the order of 10 %, while the scatter of SCIAMACHY daily data within the 2000-km selection radius is signifi-

ACPD
5, S373–S378, 2005

cantly higher. While a somewhat higher columns variability (factor ≈1.4) is anyway expected for SCIAMACHY due to the lower average ground altitude (and the slightly differing averaging kernels, see Section 3), the question is, whether horizontal CO inhomogeneity (hot spots) within the 2000 km selection radius is the dominant additional cause for the scatter or the limited SCIAMACHY individual pixel precision. We investigated SCIAMACHY scenes within a large (≈2000-km radius) selection area around the Zugspitze for several days using the $<$ 60 % retrieval error selection rule. Thereby we found that only about 10 % of the pixels showed columns that deviated by more than 30 % from the average value and only about 3 % deviated by more than 50 %. This means that the fractional area of hot spots is small, and hot spots are obviously only a minor contribution to the observed SCIAMACHY scatter for a large selection radius. This is corroborated by our investigation of a stepwise increase of the selection radius (250 – 2000 km) and subsequent comparison of the daily mean values for a few selected days which contained enough pixels also for the smallest selection radius. It was found that the daily average values were impacted only on the 10 % level by the choice of the selection radius. Obviously, the inclusion of hot spots within a large (2000 km) selection radius does not significantly perturb the scatter of daily means. The advantage of such a large selection radius however, is that the order of 100 individual pixels are covered per day and this is sufficient to reduce the scatter of the daily means to a reasonable order of magnitude as shown in Fig. 2. So while a small selection radius (250 km) is approximately not contaminated by pollution hot spots, it just does not yield enough data for the small SCIAMACHY data set at hand, i.e., a significant fraction of days would contain none or only a few pixels and this is not enough keeping the large individual pixel precision in mind."

Ad 5. "Obtaining more satellite measurements will allow these differences to be better characterised and accounted for in comparing satellite and ground based data. Until more is done I would hesitate to use the word "validation" in this exercise, perhaps "early characterisation" might be more appropriate. A compromise might be "preliminary validation"."

ACPD

5, S373–S378, 2005

We replaced "validation" by "initial validation" or "comparison" throughout the text.

End of response.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 557, 2005.