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Atmospheric Chemistry and Physics Discussions

Interactive comment on "SCIAMACHY CO over the oceans: 2003–2007 interannual variability" *by* A. M. S. Gloudemans et al.

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We would like to thank the referee for his/her useful comments on our paper. We have included the technical corrections. The general and specific comments are addressed below.

General comments:

1. A wrong cloud top height does not have an effect on the retrieved CO partial column above the cloud, since the cloud top height is not used in the retrieval of the CO partial column above the cloud. The cloud top height is only used when comparing the CO partial columns to other data sets. In the case of a too large cloud top pressure,

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i.e. the CH_4 method indicates that the cloud is at a lower altitude than the actual cloud, the CO partial column is compared to a too large partial column of the comparison data set or the filling-up below the cloud is too small resulting in too low total columns over the oceans. However, the average differences between the CH_4 cloud top pressures and the FRESCO+ cloud pressures are $<$20 hPa (Fig. 6). This corresponds to errors in the total column after filling-up below the cloud which are smaller or - in the case of small instrument-noise errors - at worst comparable to the instrument-noise error. This is in agreement with the statistics in Fig. 8 where SCIAMACHY CO measurements over the oceans are compared with the corresponding TM4 values: no significant bias is found here (Fig. 8b) and the spread in the differences in Fig. 8a is within the instrument-noise error. Thus, the error in the cloud top height does not have a significant impact on the comparison of the CO partial columns above clouded ocean scenes with other data sets nor on the total columns over the oceans after filling-up the column below the cloud. This has been added to the paper in section 3.2.

2. The fact that the SCIAMACHY CO observations agree well with the TM4 model values in Figs. 12–14 indicates that instrument performance changes and/or degradation does not have a significant effect on the interannual changes observed. The CO columns may be affected by some minor remaining instrumental effects as described in Gloudemans et al. (2008), but these are not expected to vary from year to year. The fact that the spread and bias as shown in Figs. 3, 4, and 8 do not change significantly from year to year shows that there is no evidence for significant degradation. This indicates that the observed variability is not significantly affected by instrument errors. This has been added to the paper at the end of section 4.1.

Year-to-year changes in cloud statistics results in different numbers of clouded ocean measurements. When comparing SCIAMACHY CO with TM4 in figures 12–14 this has been taken into account by averaging over variable time periods, i.e. when less clouds are available over a region, the average is taken over a longer time period in order to ensure a certain precision of the SCIAMACHY CO columns. In Figs. 12–14 as many

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measurements as needed to obtain an instrument-noise error of 1×10^{17} molec/cm^2 are averaged. This can be clearly seen in Figs. 12–14 where the grey vertical bars differ in width from year to year. This has also been added to the paper at the end of section 4.1.

3. The word 'trend' has been replaced by 'interannual variability' or 'changes' throughout the paper.

Specific comments:

1. As described in Gloudemans et al. (2008) the IMLM method fits the observed detector counts instead of the radiances as is done in most retrieval algorithms. Hence the units BU/s on the y-axes in Fig. 1. The forward model of the IMLM method consist of an atmospheric model and the SCIAMACHY instrument model. This has been added to the caption of Fig. 1.

2. p. 5588, line 25: this is a typo: the TM4 model is sampled at 10:00h, the overpass time of SCIAMACHY.

3. The sign of the bias indeed seems to be systematically different for the different years. There is no clear explanation for this yet, but changes in emissions from year to year, e.g. due to biomass burning, may play a role as described at the end of section 2.3.

4. The CO column is independent of the cloud fraction as long as a cloud is present in the SCIAMACHY foot print. By using only measurements with a cloud fraction > 0.2 the presence of some cloud is ensured. We have added this to page 5591.

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5. The ratio mentioned in line 21 on p. 5595 refers to the ratio of observed CH_4 over modeled CH_4 and thus not refers to a CO/CH_4 ratio. The selection criteria are thus not based on the CO/CH_4 ratio. In order to avoid confusion this sentence has been rephrased.

6. p. 5592, line 13-14: This sentence has been omitted.

7. The fact that the CH_4 cloud pressures are smaller than those of FRESCO+ is in agreement with the fact that the CH_4 cloud pressures are representative for the cloud top height and the FRESCO+ cloud pressures for the optical mid-level of the cloud. But, clouds are expected to be generally thicker than the average difference of 14-17 hPa found here, typically around 100 hPa. So, at present we cannot draw any more detailed conclusions on this. Since the CH_4 cloud pressures are representative for the cloud top height the CO partial columns do not depend on the thickness of the cloud.

8. Since the monthly-mean error can differ somewhat with season - due to surface albedo changes - the monthly-mean errors for each month of 2004 have been computed and then these 12 monthly-mean error maps have been averaged to produce figure 2. For clarity we have added the word 'average' to the figure caption of figure 2 and omitted the word 'year'.

9. The fact that only data over land are used in Figs. 3 and 4 has been added to their captions.

10. The differences over land for larger noise errors are negative for 2004, but for the other years they are sometimes positive and sometimes negative (see also specific comment 3). Over sea the differences for larger noise errors are positive for most years. This may have to do with too low emissions in the model and/or

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too slow vertical transportation into the free troposphere. Consequently fewer CO is transported over the oceans compared to the measurements, but it is not clear yet whether this can explain the seemingly systematic bias over the oceans. On the other hand, the differences are still within the 2 sigma instrument-noise error and mostly within the 1 sigma noise error.

11. The scatter is somewhat smaller in 2006, but there is also fewer data in 2006 and 2007. This probably has to do with annual changes in occurence of cloud cover over this region and thus the available number of measurements over clouded ocean scenes.

Technical corrections:

Corrections 1, 2, and 4 have been incorporated in the revised manuscript.

3. p. 5590 line 6. This sentence refers correctly to Fig. 3a. The figures for the spread are not shown in the paper since they are similar to Fig. 3a for all years. The confusion is understandable, therefore we have omitted the sentence in line 4-5: 'The results .. Fig. 4.' and now line 7 starts with: 'Fig. 4 shows that the biases..' .

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Interactive comment on Atmos. Chem. Phys. Discuss., 9, 5583, 2009.