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Atmospheric Measurement Techniques Discussions

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Interactive Comment

Interactive comment on "Validation of six years of SCIAMACHY carbon monoxide observations using MOZAIC CO profile measurements" *by* A. T. J. de Laat et al.

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— Referee #1 —

We would like to thank the referee for his/her useful comments. See below for our reply, and the supplementary information for the revised paper (changes highlighted).

General)

We have added references to the other existing SCIAMACHY CO retrieval algorithms, something which was lacking in the paper, as correctly noted by the referee.

However, most of these algorithms have not been developed beyond their initial stages, and in most of these cases the validation was limited and sometimes only qualitative by cross comparison with MOPITT.

Only recently some new algorithms have been introduced with also only limited validation results.

Given the considerations above, we have limited ourselves in this manuscript to including references to the earlier work without going into too much detail about their validation results.

Page 1988, lines 16-17)

From the remarks by the referee we realize that we had not included a brief discussion on how we use SCIAMACHY measurements with regard to clouds, which is important for the argument made here.

Therefore we added the following explanation to the paper:

"Similar to Gloudemans et al. [2009] and de Laat et al. [2010a, 2010b], we use SCIAMACHY CO observations over both land and oceans. Over land, only SCIAMACHY observations with cloud fraction < 20% are used. Over oceans, measurements over low altitude clouds between the surface and 800 hPa are used. For both land and oceans only measurements with instrument-noise errors < 1.5×1018 molecules/cm2 are used."

Effectively this means that over land we use (nearly) cloud free observations, noting that the estimates of cloud fractions are in most cases overestimating the actual cloud fraction (see discussion in de Laat et al. [2007] , and references therein). Over oceans, in this way SCIAMACHY measures the partial column over low altitude clouds, which we convert to a total column using model results.

It was previously shown that the potential systematic error of SCIAMACHY CO over oceans due to modeling uncertainties cannot be larger than 2-3 % on average [de Laat

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et al., 2010a].

For land measurements, the cloud contamination effect can under conditions of a strong vertical gradient in carbon monoxide and optically thick clouds be larger. However, tests with different cloud fraction filters did not reveal a relation between cloud fraction and measured CO columns for cloud fractions < 20%, the threshold we use, indicating that the effect of clouds on land measurements is a second order effect (at best).

A more detailed discussion on how clouds are treated can be found in the references.

Furthermore, we have shown in a previous paper that differences between SCIAMACHY and chemistry-transport model results clearly depend on the amount of averaging, and that the smaller the instrument-noise error of a SCIAMACHY average, the closer the SCIAMACHY average gets to the model results (until other processes like model uncertainties start playing a role) [Gloudemans et al., 2009]. This relation is linear, hence the notion that single SCIAMACHY measurements are dominated by the instrument-noise error and that averaging is required – but also can be achieved.

Hence, we argue that the weighting is necessary and justified.

Page 1988, line 21)

We made the necessary modification. The 1×1017 molecules/cm2 refers to the precision of SCIAMACHY CO averages. See further de Laat et al., [2007]. See also the response to the comments for page 1992 (below).

Page 1989, line 24)

The referee is correct. It is unclear what happened, the submitted draft does not show this error. The text was changed to:

"A detailed description of the model can be found in Huijnen et al. [2010]. The horizontal resolution of this TM5 version is $3^{\circ}\times2^{\circ}$ longitude-latitude with 34 vertical levels."

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Page 1992, line 1)

The value of 1×1017 molecules/cm2 was determined using SCIAMACHY CO measurements and not based on simulations alone as erroneously written in the previous version of the manuscript. Moreover the reference to the paper describing how we obtained the estimated measurement accuracy was missing, we therefore changed the sentence to:

"The length of the time interval was chosen such that instrument-noise error of the average SCIAMACHY CO columns was 1×1017 molecules/cm2 or smaller, which is an estimate of the measurement accuracy based on both retrieval algorithm sensitivity studies as well as a detailed comparison of SCIAMACHY measurements with chemistry-transport model results [de Laat et al., 2007]."

Instrument degradation has led to loss of number of useful detector pixels in the CO spectral window (and to more noisy detector pixels). These detector pixels are identified and not used in the data analysis, and this thus effectively only gives more noisy measurements. The validation results for CO using measurements averaged to 1×1017 molecules/cm2do not notably degrade in time but more measurements are on average needed to obtain an average with measurement noise of 1.10ˆ17 molec/cm2.

Page 1992, lines 4-5)

We added the following discussion about the choice of comparison area.

"De Laat et al. [2010] studied the effect of area size on the comparison between ground-based measurements. There are two competing trade-offs: the larger the area, the more SCIAMACHY measurements available for averaging and thus the better the temporal resolution. On the other hand, the larger the area, the less representative the averages for that area are for a single location. By varying the area size and comparing statistical measures like correlations and root-mean-square difference, de Laat et al. [2010b] found that beyond an 8°×8° grid there is no gain. Hence, we compare

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SCIAMACHY CO with MOZAIC within an 8°×8° grid.”

Furthermore, as discussed below, for one MOZAIC location we actually have indications that averaging over a smaller area could improve the validation results, but the a cost of reducing the number of collocations and thus how the seasonal cycle is represented in the validation.

Page 2004)

The caption of table 2 has been changed (‘of’ to ‘or’)

Page 2010, figure 4)

First of all, every data point is taken into account in the calculation of statistics (red), so the reader can see what the impact of excluding –or including- these three stations is. Secondly, there are good reasons to exclude these stations for the final statistics, see below.

From figure 3, panels 11 (Lagos, Nigeria), 21 (Teheran, Iran) and 24 (Beijing, China), it is immediately clear that there is no correspondence between what is measured by SCIAMACHY and MOZAIC for these locations. An additional comparison with TM5 model results – not presented in the paper – shows similar differences between MOZAIC and the model. Only for Lagos we have indications from the model that by using a smaller averaging area CO increases in the model. Although models are by no means perfect, there is sufficient knowledge about carbon monoxide that models can be trusted to reproduce the global larger scale spatio-temporal variations (confirmed by for example comparison with surface measurements of carbon monoxide).

Thus, the discrepancy between MOZAIC and SCIAMACHY or TM5 for the three airports mentioned above suggests that certain local processes are not captured by SCIAMACHY and TM5. In the case of Beijing and Teheran these are apparently really local processes, in case of Lagos this is more related to the large SCIAMACHY averaging area. Either way, these results justify the exclusion of these locations from the final

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statistical analysis.

We added a few sentences on what the TM5 results suggest as discussed above.

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Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/5/C1134/2012/amtd-5-C1134-2012-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 1985, 2012.