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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global carbon monoxide as retrieved from SCIAMACHY by WFM-DOAS" *by* M. Buchwitz et al.

M. Buchwitz et al.

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Authors answer to interactive comment S1134 from A. Maurellis et al. on "Global carbon monoxide as retrieved from SCIAMACHY by WFM-DOAS" (M. Buchwitz et al., 2004)

For our answers we use the same numbering as used by Maurellis et al.

1. Averaging kernels:

Maurellis et al. state that there is an "intrisic overestimation in the retrieval" because the averaging kernels exceed unity.

This is, in general, not true. The conclusion of Maurellis et al. is obviously based on a misunderstanding of what has been written in the manuscipt and what is shown in Figure 1. It is not clear for us where this misunderstanding is coming from because the manuscript contains the explicit formula that defines the averaging kernels and an explanation of each variable that is used in this formula. Nevertheless, we will do our best to better explain this in the revised version of the paper in order to avoid misunderstandings.

Why the conclusion of Maurellis et al. is not correct can be seen from the explicit formula for the averaging kernels AK(z) which is given in Section 5 of the manuscript (see also the manuscript for a detailed explanation of each term): $AK(z) = (V^{rp} - V^{tu})/(V^{tp} - V^{tu})$.

V^{tu} is the true CO column of the unperturbed CO profile. V^{tp} is the true CO column of the perturbed CO profile which has been generated from the unperturbed profile by adding a certain (small) number of CO molecules at altitude z. V^{rp} is the retrieved CO column of the perturbed CO profile.

Note: The formula given above is a finite difference approximation of the formula $AK = d\hat{x}/dx$ used in many papers (e.g., Rodgers and Connor, JGR, 108(D3), 4116, 2003) which expresses the sensitivity of the retrieved state ($\hat{x}$) to the true state (x).

As can be seen, if V^{rp} is equal to V^{tp} for all perturbation altitudes z it follows that $AK(z)$ is 1.0 (for all altitudes z). In this case the retrieval is perfect, i.e., there is no error. If $AK(z)$ deviates from 1.0 there typically is an error, the so-called "smoothing error".

If the smoothing error introduces an overestimation or an underestimation (or no error if overestimations resulting from certain altitude levels are compensated by underestimations from other levels) depends on $AK(z)$ but also (!) on the difference between the true (= observed) profile and the unperturbed (reference) profile. Why are overestimations and underestimations possible if AK exceeds unity? If the true profile has higher concentrations than the reference profile (i.e., the unperturbed profile with column V^{tu}), than the retrieved column (V^{rp}) will be overestimated (i.e., $V^{rp} > V^{tp}$). If however the true profile has lower concentrations than the reference profile, than the retrieved column (V^{rp}) will be underestimated (i.e., $V^{rp} < V^{tp}$). Lets have a look at a concrete simple example: If, for example, $AK(z)$ is 1.1 this means that (case 1:) $(V^{rp} - V^{tu}) = 110$ if $(V^{tp} - V^{tu}) = 100$ or (case 2:) $(V^{rp} - V^{tu}) = -110$ if $(V^{tp} - V^{tu}) = -100$. In the first case a "delta column" (column increase) of 110 has been retrieved although the true difference (the true delta column) is only +100. An overestimation of 10% (not of the column but of the "delta column"!). Here the retrieved (total) column is $V^{rp} = V^{tu} + 110$ but the true column is (only) $^{Vtp} = V^{tu} + 100$. In the second case a column decrease (relative to the reference profile and its column) of 110 has been retrieved although the true decrease is only 100. A clear underestimation, as the retrieved (total) column is $V^{rp} = V^{tu} - 110$ but the true column is $V^{tp} = V^{tu} - 100$.

2. Not revisited by Maurellis et al.

3. We will add that cloudy pixels - as determined by the MOPITT cloud detection algorithm - are not present in the MOPITT CO column data product.

4. Scaling factor:

We will add additional information on the scaling factor for the revised version of the paper.

We determined the scaling factor (which is 0.5) by (roughly!) adjusting the SCIAMACHY data to MOPITT. Without scaling factor the retrieved columns were about a factor of two larger than the MOPITT columns. Assuming that the MOPITT data are typically accurate to about 20% it it obvious that the uncorrected SCIAMACHY data were overestimated. At present it is not clear where this overestimation is coming from. This needs further investigation. It is shown in the paper that reasonable agreement with MOPITT can be obtained if this scaling factor is applied to the SCIAMACHY data. Because the SCIAMACHY data are scaled we focus on variability and relative differences rather than on absolute levels (for the comparison with MOPITT we focus on CO plumes, correlation of the two data sets, standard deviation of the difference).

We have not used sophisticated methods to determine the scaling factor. We deter-

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mined the scaling factor by comparing a single orbit of SCIAMACHY data with MOPITT data from the same day. Our further analysis revealed that this scaling factor is also "approriate" for (all) other data. "Approriate" means that it removes an obvious large bias.

Maurellis et al. state that they find it confusing what has been written about how the scaling factor has been determined. We do not know where this confusion is coming from. We have clearly mentioned in the abstract that the scaling factor has been determined by scaling the data to MOPITT. However, we have not mentioned this in section 6 where we discuss the scaling factor issue. We will improve this in the revised version of the paper.

5. Lower columns over clouds:

According to Maurellis et al. the comparison of Figures 7 and 8 "does not lead one immediately" to the conclusion that the CO columns for cloudy pixels are lower that the CO column for cloud free pixels. We think, however, that this effect is nicely illustrated in Figures 6-8 and we will describe this in the revised version of the paper. Fig. 6 shows an extended CO plume as measured by MOPITT (shown in red). Fig. 7 shows the same plume (apart from the time difference etc.) as measured by SCIAMACHY (also shown in red). The "SCIAMACHY plume" is however smaller (less spatially extended) than the "MOPITT plume". There are a number of reasons for this. In this context the most important one is that many of the SCIAMACHY pixels which show low columns (compared to MOPITT) are those that are identified as cloud contaminated by the PMD algorithm. This shows that (at least for this example) low CO is correlated with clouds.

6. and 7. Text missing:

We agree: A better description and discussion will be provided for the revised version of the paper.

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