

Interactive comment on “Carbon monoxide column retrieval for clear-sky and cloudy atmospheres: a full-mission data set from SCIAMACHY 2.3 μm reflectance measurements” by Tobias Borsdorff et al.

Anonymous Referee #1

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This manuscript discusses carbon monoxide column retrievals from the SCIAMACHY instrument under cloudy conditions complementing previous work that was limited to clear-sky observations over land. The analysis includes comparisons with MOZAIC/IAGOS airborne measurements and with measurements of the NDACC and TCCON network at coastal sites.

The manuscript falls into the scope of AMT, is well written, and I recommend publication after the following comments have been addressed.

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General Comments

Extension of the spatial coverage (especially over the ocean) by analyzing cloudy scenes is desirable. However, for thick clouds the sensitivity to CO below the cloud is very limited. As shown in the manuscript this does not hamper validation, because the corresponding null-space error can be taken into account mathematically by applying the averaging kernels. One could argue that this makes good validation results even easier to achieve, because potentially highly variable CO partial columns below clouds are essentially substituted by a priori partial columns for both the satellite data and the validation data set in the comparison. This makes physical interpretation of the retrieval results in cases of high clouds, in particular above CO source regions, difficult, because the retrieved parameter is rather the CO partial column above the cloud (extended by the a priori below the cloud) than the CO total column and the most interesting part may be hidden below the cloud. In this sense, validation and physical significance can potentially be two different stories. Please elaborate a little more on this issue in the manuscript.

Therefore, I assume that retrievals for (too) high clouds are filtered out in the post-processing. Please describe in more detail what the corresponding threshold for the presented SCIAMACHY data set is (e.g., in Figure 10). I would propose to omit scenes with cloud heights larger than about 2 or 3 km: This would still allow retrievals above low-étage clouds like stratocumulus (Sc) over the ocean.

Specific Comments

Page 8, Lines 13-14 and Figures 4-6: Why are cloudy conditions defined as high clouds here (condition (3) in Sect. 2.3)? The comparison with airborne measurements is mainly above CO source regions (Teheran, Beijing). This is an example of the interpretation problems described in the “General Comments”. Figure 6 confirms that a lot of CO is hidden below the clouds (comparison of yellow and pink bars). I would prefer

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to use condition (2) here or an alternative condition (2b) with $h_{cld} < 2$ or 3 km.

Page 9, Lines 23-24: How about applying TCCON/NDACC averaging kernels to profile information from the TM5 CO model?

Page 10, Line 16: The given range of h_{cld} corresponds to condition (3) in Sect. 2.3, not (2). Which condition is actually used, (2) or (3)? I would recommend to do the analysis for low clouds only (Condition (2) or (2b)).

Page 10, last paragraph and Figure 10: 1) Which conditions for the full-mission SCIAMACHY cloudy-sky measurements are used? As described above, I would propose to omit scenes with cloud heights larger than about 2 or 3 km.

2) You describe CO outflow over the ocean. As the retrievals over the ocean are from cloudy-sky measurements only and the retrievals over land are a mixture from clear-sky and cloudy-sky measurements, are there any indications of land-sea-biases due to cloud shielding? This is hard to see in Figure 10, because the color-scale is often saturated at the mentioned source regions.

3) It would also be interesting to show a global map illustrating the fraction of cloudy-sky measurements. Are the source regions dominated by clear-sky or cloudy-sky measurements?

Figure 8: Why is TCCON data release GGG2012 (instead of GGG2014) used for Ny-Alesund?

Technical Corrections

Page 8, Line 30: Typo? “Thus” → “This”

Page 9, Line 26: Please add “.”: “...is most reliable: Ny-Alesund, ...”

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