

Interactive comment on “On biases in atmospheric CO inversions assimilating MOPITT satellite retrievals” by Yi Yin et al.

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We thank Dr. Merritt Deeter for his remarks that will help clarify our text in the revised version. They will all be accounted for and are individually discussed hereafter.

As listed below, the manuscript submitted by Yin et al. contains a number of errors with respect to the interpretation and treatment of the MOPITT data.

In practice, none of the comments contradict our treatment and interpretation of the MOPITT data, but the text will be changed to reflect this better.

Section 2.1 includes several potentially serious errors. First, MOPITT total column values are not ‘total column integrated dry air’ values (line

C1

135), since retrieved MOPITT total column values quantify all of the CO molecules in a vertical column (per unit area), regardless of the moisture profile. Does this error affect the way X_{co} is calculated?

Our expression was awkward indeed and will be corrected. We have treated X_{co} as the number of CO molecules in a vertical column per unit area (in unit $molec/cm^2$), regardless of the moisture profile.

There are also several problems with respect to the authors’ understanding of the MOPITT retrieval algorithm.

The wording did not express our understanding well and will be improved.

Eq. 1 is not itself used in the MOPITT retrieval algorithm to calculate retrieved CO profiles or total column values, as the manuscript implies; really this equation just describes the expected relationship between the retrieved profile, a priori profile, and true atmospheric state in a ‘maximum a posteriori’ retrieval method. Eq. 1 contains a term A which should actually be the total column averaging kernel (a vector) and not the averaging kernel matrix (line 144).

We agree and will change the paragraph accordingly.

Did the authors use the total column averaging kernel or the averaging kernel matrix in their calculations?

We used the total column averaging kernel for the total column and the averaging kernel matrix for the profile retrievals.

C2

Also, the term in parentheses in Eq. 1 generally represents the difference between the true atmospheric state and the a priori profile (rather than the difference in a model profile and the a priori). The paper also suggests that the x_{mod} term in Eq.1 (which should be replaced by x_{true}) is somehow based on information gained from a 'radiance transfer model' (line 141). This is also incorrect.

We will change the text accordingly.

Calculation of the total column averaging kernel depends on assumed delta-pressure values for the MOPITT retrieval grid. The level-layer scheme which defines the delta-pressure values for V6 is described in the V5 validation paper (and V5 User's Guide). The level-layer scheme used in V5 and V6 products is the same, but is different than the scheme described in the V4 User's Guide. Did the authors use the proper level-layer scheme?

Yes. We updated the delta-pressure values following User's Guide V5. But the conversion between A and A' was documented in User's Guide V4, that's why User's Guide V4 is cited. We did not think this point could cause any confusion, as by default, the pressure grid should match the corresponding product. We will add this information regarding delta-pressure values in the revised version.

Finally, it is not reported exactly how X_{co} is derived from C, the MOPITT CO total column.

As it is detailed in the User's Guide V4, section 7.4 (page 20-21), we considered it not necessary to duplicate the information. We will add more detailed references in the revised version, if it helps clarifying things.

C3

The manuscript cites the MOPITT V6 validation paper, but does not include a review of the validation results for the V6 TIR/NIR product, and does not make use of those results when interpreting the posterior simulations. These earlier results represent the most direct method for quantifying the MOPITT retrieval bias and are clearly relevant to the work presented in this manuscript.

We cited the MOPITT papers that we consider most relevant and latest - in total four papers by Deeter et al.

In Section 4, posterior simulations based on MOPITT X_{co} observations are compared with MOPITT retrieved profiles. However, for these comparisons, it is not clear whether or not the posterior simulations have been transformed with the 'observation operator' (i.e., $x_{sim} = x_a + A(x_{posterior} - x_a)$), which is necessary to make a proper comparison.

It is calculated exactly as you suggest here, which is described in Section 2.4.4. line 315 – 318. We put it into a different section than the one describing the data assimilation, in order to make it clear that the vertical profiles are not directly assimilated. In fact, it was the reason we modified the expression compared to the original MOPITT documents (e.g. x_{true} to x_{mod}) to reflect how we calculate corresponding CTM retrievals in a consistent manner.

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C4