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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. Helen Worden and Dr. Zhe Jiang for their comments. They are discussed hereafter.

> *We do not think the authors have demonstrated their conclusion that assimilating MOPITT total column CO is superior to assimilating CO profiles since they did not show results from both assimilation types. Rather, they show comparisons to MOPITT retrieved profiles and other correlative data after assimilating the column quantities.*

Our demonstration is about the importance of retrieval and model biases for the CO profiles when assimilating CO retrievals to infer CO surface fluxes. Indeed, these model

and retrieval biases vary with the altitude and are poorly (retrievals) or not (model) constrained for this particular application (atmospheric inversion).

> *These comparisons show biases already noted in MOPITT validation (Deeter et al., 2013;2014) and other assimilation results (e.g., Gaubert et al, 2016, Jiang et al., 2015;2016).*

We already cited these papers that have helped setting the stage.

> *The paper states: "the number of retrieved layers exceeds the number of independent information available vertically". While this is true, the MOPITT CO profiles still have degrees of freedom for signal (DFS) > 1, (Deeter et al., 2015), where DFS=1 is the most that can be obtained from a total column quantity. A method to assimilate only the independent layers (using singular value decomposition) along with the transformed full aposteriori error covariance is described in Mizzi et al., (2016).*

We are well aware of this paper and of the underlying Migliorini papers that we cited in another study. However, this strategy (developed in the context of a 6-hour data assimilation system for a regional model) does not help here for a typically 1-year global inversion system that can change the vertical structure of the modelled profiles only marginally.

> *In particular, the authors should demonstrate the following to substantiate their conclusion: 1) That assimilation results with MOPITT profile data, after bias corrections. are significantly worse than column assimilation as compared to independent CO observations.*

Our point gets hidden behind the words "after bias corrections". Retrieval and model biases vary in time and 3D space (as shown here and in the studies mentioned above) and are not well constrained, or not constrained at all.

> *2) That the vertical information (DFS $\sim$ 2.0 for profile vs. 1.0 for column) has no significant impact on the assimilation in correcting the vertical distribution of CO.*

We do appreciate the value of profile retrievals. However, in atmospheric inversions, the state vector is mainly made of surface CO fluxes, that are not enough to significantly change the vertical distribution of CO to the needed extent (as shown in Figure 4, the vertical gradients are similar between the prior and the posterior simulations even though the surface emissions are significantly changed). The situation is different for Numerical Weather Prediction (NWP)-type applications where the target quantity is the profile itself.

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