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Interactive Comment

Interactive comment on "Regional data assimilation of multi-spectral MOPITT observations of CO over North America" *by* Z. Jiang et al.

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We thank the reviewer for the thoughtful and detailed comments. Below we respond to the individual comments.

General comments.

(1) This paper presents a regional (N. America) inversion of CO fluxes using MOPITT observations and the GEOS-Chem CTM. The main thesis of the paper is that a high resolution regional inversion, with proper boundary conditions, can overcome some of the major difficulties facing CO flux inversion. These are transport and prescribed OH

errors, which can contaminate the inversion results if they are very large.

This is a well written and easy to follow paper, and I recommend a minor revision before the paper is published. My main comments (described in more detail below), are that some further analysis of the errors would be helpful, particularly in the comparisons with in situ data.

Thanks for the comments!

Specific comments

(1) P. 5336, line 5. It would be useful to know how these differences vary with height, and how they compare with in situ measurements. Do higher altitude differences have larger differences (because of the impact of long range transport)?

P. 5336, lines 24-26. Similarly, it would be good to know more about how these differences vary with altitude. Can comparisons with in situ observations bet shown here (in the same format as panel (d))? This can help to understand how the boundary conditions are affected by long range transport.

Thanks for your suggestion! The bias is largest in the southern boundary and we now include a figure (Figure 6) showing the vertical distribution of the relative differences between the model and MOPITT. There are large positive biases in lower troposphere and negative biases in upper troposphere, in the vicinity of the outflow of biomass burning emissions from South America. Liu et al. (2010) conducted an evaluation of the GEOS-Chem model in this region using data from TES and MLS. We have added a paragraph at the end of Section 4.1 discussing this and summarizing the results of Liu et al. (2010).

Regarding the use of in situ data, in Figure 9 we compare the model with aircraft data from the INTEX-A campaign. The Kalman filter produces initial and boundary conditions (our a priori) with a small bias of 7.2 ppb relative to the in situ data in the free troposphere (Figure 9a).

ACPD
15, C3230–C3233, 2015

(2) Also (from P. 5336) the use of MOPITT CO retrievals for the initialization and boundary conditions should make the a priori correlated with MOPITT observation errors. How will this affect the inversion results, given that it is generally assumed that model and observations are uncorrelated?

The inversion is linear and across North America the CO state (distribution) reflects a background contribution, transported from lateral boundaries and the initial state, and a location contribution from fresh North American emissions. (Fresh here means since the beginning of the assimilation period.) Use of the MOPITT data to optimize the initial and boundary conditions means that the background contribution of the state will be correlated with the MOPITT data. That is not a problem since our objective is to "remove" that background influence in the context of the inversion, so that model-data mismatch in the cost function, Eq. (2), will be dominated by the perturbations to the state associated with fresh North America emissions. In this approach, we use the MOPITT data to adjust the fresh North American emissions and not the influence of the initial and boundary conditions.

(3) P. 5339, lines 11-21. It would also help the error analysis to show how the differences with INTEX-B (and perhaps adding NOAA aircraft data) vary with altitude. It seems that if the inversion is relatively unbiased, then the errors should be smaller near the surface, and become larger at higher altitudes where transport errors become important.

Actually, we expect the bias to be larger in the boundary layer because we are using optimized boundary and initial conditions, in which we are forcing the model to match the MOPITT data on the boundaries and at the beginning of the inversion period. As mentioned above, in this approach, the largest model-data mismatch in the cost function will be near the fresh source emissions in the domain. Unfortunately, as shown in Figure 6 in the revised manuscript, there is a large transport bias in the southern boundary. However, despite this discrepancy on the southern boundary, the mean bias relative to the aircraft data across North America is small, 7.2 ppb. The inversion further

ACPD

15, C3230–C3233, 2015

reduces this, suggesting that transport within North America is unbiased in the model. If the vertical transport over North America were biased the inversion would degrade the agreement with independent data that was obtained with the optimized initial and boundary conditions. We have added text at the end of Section 4.2 explaining this.

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ACPD

15, C3230–C3233, 2015

Interactive Comment