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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Regional CO_2 flux estimates for 2009–2010 based on GOSAT and ground-based CO_2 observations" *by* S. Maksyutov et al.

Anonymous Referee #2

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The authors have conducted an inversion analysis of GOSAT XCO2 and ground-based CO2 data to determine the additional information provided by GOSAT observations, compared to the surface data, to reduce uncertainty in regional CO2 flux estimates. Although GOSAT was launched almost four years ago, issues with biases have made using the data challenging and, as a result, much work is still needed to assess the utility of the data. In this context, the work described in the manuscript is a useful first step in understanding complementarity between GOSAT and existing ground-based CO2 data. I recommend publication of the manuscript in ACP after the authors have adequately addressed the comments below.

Major comments.

1) The reduction in the flux uncertainty depends on the a priori error, the observation error, and the Jacobian (G). I would like to see the authors provide more information about the observation errors used in the inversions. As stated on page 29250, "the diagonal elements of matrix C_D, were determined as the standard deviations of GOSAT XCO2 retrievals found in each of the 5 x 5 grid cells in a month." This standard deviation reflects the spatial variability of the CO2 columns within the 5 x 5 boxes as well as the retrieval uncertainty. It is not the same as the observation error specified in Equation (2), which should reflect the statistics of the model-observation mismatch (assuming that the model transport is unbiased and that the mean differences between the model and observations are due to flux errors). How do the observation errors compare with the statistics of the model-observation mismatch? It would be helpful to see maps of the assumed observation errors for the monthly mean 5 x 5 data shown in Figure 6. It would also be helpful to know what is the reduced chi-squared for the assumed observation errors and by how much it is reduced in the inversion. If the reduced chi-square is too small it means that the observation errors are too conservative and therefore the inversion might be underestimating the error reduction.

For the ground-based data, on page 29251, the authors explain that they used the statistics of the model-observation mismatch to filter the GLOBALVIEW data, but used the reported GLOBALVIEW residual standard deviation as the observation error. As with the GOSAT XCO2 data, it would be helpful to know what is the reduced chi-squared with this assumed observation error? What was the motivation for tripling the observation error if the reported GLOBALVIEW data record was less than 70% complete? What is the justification for using only GLOBALVIEW sites where the RMS of the model-observation mismatch was less than 2 ppm?

2) The authors examined the diagonal of the a posteriori error covariance matrices to estimate the uncertainty reduction. If the GOSAT observations are providing additional information to better constrain the flux estimates in particular regions, one would ex-

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pect to also see a reduction in any covariance between the flux estimates. Since the inversion is done at a coarse resolution, it should be easy for the authors to examine the correlations between the regional flux estimates to see if this is indeed the case. The correlations may also provide insight as to why some poorly constrained regions are showing large departures from the a priori estimate.

3) The authors invested significant effort in obtaining an optimized a priori forward model, but there is insufficient discussion about the quality of the a priori simulation to enable the reader to properly assess the benefit of combining the GOSAT observations with the GLOBALVIEW data. For example, Figure 10 should include a comparison of the a priori timeseries with the TCCON data. Similarly, Table 1 should give the biases and RMS differences for the a priori, the GLOBALVIEW a posteriori, and the combined GLOBALVIEW and GOSAT a posteriori. The authors state that the a priori bias with respect to the TCCON data is +/- 0.2%, but also acknowledge that site-by-site GOSAT validation revealed a bias in GOSAT XCO2 of -1.20 ppm relative to the TCCON data. So the GOSAT data have a mean bias of about -0.3%, which suggests that the inversion with the GOSAT data should degrade the agreement between the model and TCCON. It is difficult to reconcile this with the suggestion on page 29259 that the addition of GOSAT data to the inversion acts to suppress deviations from the prior in regions where the fluxes are poorly constrained, indicating that the GOSAT data do not contradict the prior flux estimates.

4) The inferred fluxes are sensitive to biases in the initial CO2 distribution and the authors have tried to account for this, but they have provided only a brief explanation of the approach. On page 29252, lines 6-9, they mentioned that they added two additional columns to the G matrix to adjust the initial conditions with respect to the surface data, and the GOSAT XCO2 data with respect to the surface data. However, G represents the change in the CO2 concentrations per unit flux. It is not clear to me how G is used to adjust the initial model CO2 relative to the surface data? I would like more information about how this is done. How large was the correction on the initial conditions? Is the

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adjustment to the GOSAT XCO2 described here carried out in addition to the XCO2 bias correction described on page 29253, line 23?

Minor comments

1. Page 29241, lines 12-14: Over what period was the model optimized? Was it from 1979-2010?

2. Page 29241, lines 17-22: The authors state that the atmospheric CO2 data used in the VISIT optimization came from GLOBALVIEW, but that the atmospheric CO2 variability was estimated by a transport model. I do not understand this. Was this necessary because GLOBALVIEW is a smooth data product and not actual observations? The authors need to better explain how the optimization is done.

3. Is there a problem with using the GLOBALVIEW data in the VISIT optimization and then using them again in the atmospheric inversion? It seems that the same information is being used twice in estimating the fluxes.

4. Page 29250, line 25: Why set a minimum observation error of 3 ppm? As suggested in my major comment #1 above, it would be useful to know how this impacts the reduced chi-square?

5. Page 29254, lines 5-11: The authors should explain how Equation (5) was used in the spatial and temporal averaging of the data. Did they calculate a monthly mean averaging kernel and a priori XCO2 for each 5 x 5 box and then transform the model? Or did they obtain a transformed model profile for each GOSAT XCO2 retrieval and then averaged the transformed model fields?

6. Page 29256, lines 22-24: Is the larger uncertainty reduction over the Middle East, southern Africa, and central Asia driven mainly by the greater number of GOSAT observations in these regions? Or are the XCO2 observation errors smaller in these regions, which would lead to greater uncertainty reduction?

7. Table 1: Please explain which model simulation is used. As suggested in my major

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comment #3, why not also include the a priori and the combined GLOBALVIEW and GOSAT a posteriori statistics in the table?

8. Figure 1, top panel: The y-axis in the plot of the fields at Mauna Loa is too compressed. Why not plot this between 365 - 385 ppm so that the reader can better see the two lines and assess their agreement?

9. Figure 10: Please include the a priori CO2 in the comparisons.

10. Figure 11: Please add a more descriptive caption that explains what is the reference XCO2 concentration field.

11. Supplementary information: It would be useful to others in the community who might be interested in comparing their results to those presented here if the authors would include a table in the supplementary material that gives the a priori and a posteriori (GLOBALVIEW and the combined GLOBALVIEW and GOSAT) annual mean flux estimates and their uncertainties for all land regions.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 29235, 2012.