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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A comparison of atmospheric CO_2 flux signals obtained from GEOS-Chem flux inversions constrained by in situ or GOSAT observations" *by* Saroja M. Polavarapu et al.

Anonymous Referee #1

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This paper compares the atmospheric distributions of CO2 resulting from two sets of optimized fluxes derived from GEOS-Chem using different observing systems based on in situ data and GOSAT data respectively. The results show the differences in the optimized fluxes and how their correction is transported in the atmosphere. An evaluation of the seasonal cycle and inter-hemispheric gradient is also provided. Finally, the zonal variability of the flux correction signal at different vertical levels (boundary layer, free troposphere and stratosphere) is also explored. The differences between the two sets of posterior fluxes and their atmospheric distributions highlight problems

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associated with spatial and temporal coverage of obseving systems and their ability to constrain the surface CO2 fluxes at different temporal and spatial scales. Overall, the results point to the conclusion that the in situ observations do a better job at constraining the fluxes at global and annual time scales, leading to smaller biases in their fit with independent observations. While GOSAT data is able to better capture the seasonal cycle at northern extratropical sites. The paper is well written and well structured. However, I have some concerns on the use of atmospheric differences associated with flux correction patterns to draw conclusions on the potential representation of zonally asymmetric patterns by different observing systems. It is not possible to say that GOSAT is (potentially) better at constraining the zonal patterns without substantiating this with an assessement of the errors in zonal variability based on independent observations (e.g. zonal gradients using TCCON or in situ data). The analysis of the seasonal cycle could also be improved by looking at the seasonal amplitude and phase, instead of just providing seasonal biases which is too qualitative in my opinion. The results and conclusions would also be more robust if more than just one year and a half of data was used.

GENERAL COMMENTS

* The use of CO2 flux signal to denote the cumulative impact of the flux corrections/adjustments in the atmosphere is a bit misleading. A flux signal gives the impression that it is associated to a process or phenomenon, while here it just reflects a correction (or analysis increment) which depends on the specific model, prior flux and observation used. I would think that using the term 'posterior atmospheric adjustment' would be a better term to describe the difference between posterior and prior atmospheric distributions of CO2 or alternatively 'flux correction signal'.

* Spatial variability of flux correction signal in the atmosphere does not necessarily translate in better provision of information by observations nor an improvement in spatial/regional patterns. If the observations are very noisy (e.g. GOSAT has larger errors than the in situ observations assimilated in flux inversion systems) or observations are

not homogeneously distributed (e.g. many more data over land than sea as it is the case in northern extratropical regions) then the flux corrections can create artifacts in the zonal variability which increase the zonal variability but are nevertheless not realistic.

* The paper would benefit from a better quantification of error reduction at different scales based on TCCON and in situ observations which could be presented in tabular format.

* The fact that the minimal level of uncertainty in the zonal variability associated with imperfect knowledge of winds is around 0.5 ppm and the global zonal variability of flux corrections is of similar magnitude does not make the posterior zonal flux correction pattern is unreliable. The objective of the flux inversion systems is to reduce the uncertainty of the posterior fluxes and the flux corrections on their own do not necessarily reflect the uncertainty reduction. The posterior zonal patterns should be assessed with independent observations and their standard error compared to the minimal level of uncertainty associated with transport.

SPECIFIC COMMENTS

- Page 7, Line 14: Isn't the uncertainty of 22% associated with NEE very low? - Page 7, Line 19: I would not call GOSAT coverage "dense". - Page 8, Lines 2-3: "Note that ... " sentence is not clear. - Page 9: Please provide a quantitative estimate of standard error and bias per month/season for the surface in situ evaluation in order to assess the seasonal cycle quantitatively. When the bias is shown to be smaller, it would help to know by how much - Page 10, Line 2, Page 11, Line 23: Is the flux correction signal in the atmosphere "propagated" or "transported"? - Page 12, Line 16: Why is GOSAT reducing meridional gradient? From Figs 8 and 10 it looks that the meridional gradient from the GOSAT posterior fluxes is worse than that from the in situ data. - Page 14, Lines 22-25: How do you reconcile this with the larger bias of GOSAT versus TCCON in SH? - Page 16, Line 2: How do you explain that GOSAT produces better fit with

observations in middle to upper troposphere in boreal winter? - Page 21, Lines 11-18: The message that GOSAT observations have the potential benefit of improving the zonal structure seems to be contradicted by the results from flux inversions using GOSAT data published in Houwelling et al (2015). Therefore, the conclusion of the potential benefit of GOSAT highlighted in the abstract can be misleading. - Page 23, Line 15: "GOSAT better captures zonally asymmetric structure ..." should be rephrased as this has not been proven in the paper. - Page 23, Lines 24-27: Note that this type of comparison has already been done by Locatelli et al. (2013, ACP) for CH4. - Page 24, Line 10: .. seasonal correlation of "error" covariances. - Figure 4 and Page 9: It would be good to include GEOS-Chem in Fig. 4.

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