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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The impact of improved satellite retrievals on estimates of biospheric carbon balance" *by* S. M. Miller and A. M. Michalak

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We thank the referees for their comments and suggestions on the manuscript. Below, we have included the referee's point-by-point suggestions and the associated changes we have made to the manuscript.

- "Throughout the text, the authors use the expression "robust constraint", but what is it? If for instance all OCO-2 L4 products had no better quality than the latest biosphere models at any scale, it could be found useless for land vegetation carbon accounting and therefore not robust for that application. I do not think that the chosen method can conclude to robustness. The authors need to qualify their conclusion better: they demonstrate improvement in the retrievals on the basis of

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Discussion paper

a specific indicator, but what does this mean in practice?"

We have removed the word "robust" throughout the text when it is used to refer to the flux constraint. The methods section of the article describes, in detail, how the experiments are set up and what they do and do not indicate about the CO_2 flux constraint. Elsewhere in the article, we often use shorter, more concise language to refer to these experiments. Where possible, we have tried to use more specific wording throughout the entire article. Specifically, we have replaced the word "robust" in the following instances throughout the text:

Pg. 2, line 22: replaced with "reliability or accuracy"

Pg. 2, line 23: deleted "and robustness"

Pg. 2, line 25: replaced "robustness" with "detectability"

Pg. 2, line 26: replaced "can be used to robustly constrain fluxes across" with "can be used to identify variations in biospheric fluxes within"

Pg. 2, line 27: deleted "robustly"

Pg. 3, line 10: We have removed this sentence in response to another review comment.

Pg. 5, line 6: replaced "robustness" with "strength"

Pg. 5, line 12: replaced "robustly constrain" with "detect and constrain variations in"

Pg. 5, line 15: replaced "provide a robust constraint" with "can be used to detect variations in"

Pg. 5, line 24: replaced "robustly constraint monthly biospheric fluxes" with "detect spatiotemporal variations in biospheric fluxes"

Pg. 6, line 11: deleted "or robustness"

Pg. 6, line 15: We have edited this sentence in response to another reviewer suggestion.

Pg. 7, line 18: replaced “as these observations rarely yield a robust constraint for smaller regions” with “as these observations can rarely be used to detect or constrain variations in CO_2 fluxes across smaller regions”.

Fig. 3 caption: deplaced “more robust” with “stronger”

- “Crowell et al. (2017) should be updated to Crowell et al. (2019, http://dx.doi.org/10.5194/acp-2019-87)”

  We have updated this reference in the revised manuscript.

- “P. 3, l.9: the authors actually do not use more than 7 biome regions and therefore do not necessarily reach the point when they are no longer able to detect any variations in biospheric CO_2 sources and sinks.”

  We have clarified the text here. We use very large regions in the first two sets of experiments and then shrink those regions down to biome-sized regions in the final set of experiments. This final set of experiments is both a challenging test of current observations and would be an ambitious, ecologically-relevant goal for future inverse modeling studies.

- “P. 3, l. 19: the choice of a year with a strong El Nino episode is surprising. How would the results change with a “normal” year?”

  We began working on the preceding companion paper in 2016, and at that time, there was only a single year of OCO-2 observations available to analyze. Hence, both that paper and the current manuscript focus on OCO-2 observations from 2015. In the current manuscript, we have examined the same time period as in the preceding companion paper – to ensure that we can make an apples-to-apples comparison between the two studies. We suspect that results for 2016 would be similar to the analysis for 2015. Environmental conditions in some regions were different in 2015 relative to 2016 due to El Nino, but those differing conditions should not interfere with the regression analysis used in this study;

many of the predictor variables used in the analysis would differ in 2015 and 2016 to reflect these differing environmental conditions (e.g., EVI, NDVI, and SIF).

- "P. 3, l. 32: the authors need to give details about the seven models so that the reader can get convinced about their realism. For instance, I understand that Miller et al. (2018) used climatological model averages for technical reasons (lack of model availability for the target year): now that model outputs for 2015 are widely available, has this issue been sorted out?"

  We have added an SI to the manuscript that describes each of these seven models. This information is also described in the preceding companion paper, and the information in this SI is a duplicate of the information in the preceding companion paper.

  Model outputs for 2015 were not available at the time that we began work on the preceding companion paper, and we want to compare apples-to-apples with that paper. There are now biospheric model outputs available for 2015. However, we require a relatively large number of flux model estimates for the statistical model, and there are not a sufficient number of biospheric model outputs that are readily available at a 3-hourly time resolution for 2015. The creation of a new flux model inter-comparison was beyond the scope of the current project. With that said, we have incorporated numerous vegetation indices for 2015 within the statistical model, including SIF, EVI, and NDVI.

- "P. 6, l. 14: I have not seen that the community has deployed significant effort to improve their transport models or their error models in the past years. In comparison, the effort on retrievals, in particular in the OCO-2 team, has been huge. It is not fair to compare them to the rest."

  We have clarified this statement in the revised version of the manuscript, and we have deleted the phrase about retrieval improvements being more attainable than improvements in transport modeling. Our intent here is not to compare improve-

ments in the retrievals against improvements in meteorology or in biospheric flux modeling. Rather, we wanted to point out that the retrievals, while important, are one factor among many that affect the CO_2 flux constraint.

- "Legends of Figs. 3 and 4: what are target mode retrievals doing here?"

  We did not see any reason to exclude target mode observations from the analysis. For example, O'Dell et al. (2018) describe the version 8 ACOS retrieval, and they do not present any evidence to indicate anomalous errors or biases in the target mode observations. We also included target mode observations in the analysis in the preceding companion manuscript, and we want to compare apples-to-apples with the results of that study. The objective of the present manuscript is to compare how the flux constraint has improved as the retrievals have evolved from version 7 to versions 8 and 9. We feel it would be difficult to make that comparison if we used a different approach to analyze versions 8 and 9 than we used to analyze version 7 in the preceding manuscript.

References

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