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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The importance of transport model uncertainties for the estimation of CO_2 sources and sinks using satellite measurements" *by* S. Houweling et al.

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We would like to thank the referee for having a careful look at our manuscript. Our response to the comments is listed below, including the corrections that were introduced to the manuscript.

'The assumption of random model errors'

It is not clear to us what the referee means by the remark that model errors are assumed to be random. Our approach of estimating the impact of transport models on inversion-derived CO2 fluxes makes no assumption about the distribution of the errors. Any systematic bias between transport models would show up in our results (and probably does so). It is true that the inverse modeling procedure finds the optimal solution under the assumption of random and Gaussian errors. The model errors are part of the observation errors, along with measurement errors and representation errors. In this study we assume that it is zero so that we can evaluate the part of the posterior errors, which is specifically caused by model errors. The only errors we do neglect are those that are not represented by our transport model ensemble. The potential importance of those errors is discussed in section 4.

'The lack of recommendations regarding model development'

Here the referee indeed points to an omission in the manuscript. The problem is that our research team is not as well positioned to answer this question as it may seem. The CO2 modeling community has been investigating the problem of transport model uncertainties for many years (for example within the Transcom project). Besides quantification of the uncertainties, it is has proven very difficult to identify causes, and suggest improvements. Therefore we certainly do not consider this a fair requirement for our study. There is an important difference between modeling atmospheric dynamics and modeling the atmospheric transport of long-lived gases. Improving transport models requires collaboration between experts in both fields, which is the most constructive recommendation we felt can be made at this stage.

We revised the abstract and the conclusion section as follows:

Abstract "Improving the accuracy of these models should receive high priority, which calls for a closer collaboration between experts in atmospheric dynamics and tracer transport."

Conclusions "Further development of these models should receive high priority. To

improve the accuracy of atmospheric transport models we recommend a closer collaboration between experts in atmospheric dynamics and tracer transport."

"The abstract requires some simple statistical measures of the differences between different model XCO2 fields"

The abstract includes the following sentence: "Simulated column averaged CO2 (XCO2) mixing ratios vary between the models by σ=0.5 ppm over the continents and σ=0.27 ppm over the oceans."

"Page 14744, line 1. Are all the models sampled in a similar way?" Yes.

"I disagree with the statement on page 14744, line 7. Substantial scatter in the model XCO2 fields (even though 3 out of the 4 use the same met fields) does not mean that this model ensemble captures the major components of the real uncertainty. I would like to know why the authors think that."

Relevant in the context of our study is only whether or not the model-to-model differences span a range of model-to-reality differences. The latter we can only assess where there are measurements. For the surface measurements that are discussed in the paper, model-to-measurement differences are about in the same range as model-to-model differences, which supports our assumption that inter-model differences are a valid measure of the modeling error.

"Page 14744, line 15. Some brief information about convergence criteria would be useful"

The following text has been added: '(corresponding to a gradient norm reduction by a factor 103)'

"Page 14745, line 20. Both sides of the globe. Do you simply mean that you take measurements during day and night? This is definitely an advantage over passive instruments that rely on an external light source."

We changed "both sides of the globe" into "during day and night".

"Page 14745, line 25. It would useful to this reader if the authors included a figure of the averaging kernel. I think that having a measurement of a tropospheric column with equal weight through the troposphere would be more difficult to interpret than a measurement that is weighted towards the lower troposphere. It would also be useful to see how many cloud-free measurements are available per degree latitude for a few months."

A graph of the applied averaging kernel would not add any information that is not provided in the text already. We did plot the measurement density as function of latitude. The result is shown in Figure 2. The spatio-temporal variations represent mostly variability in cloud cover, and the increased sampling density at high latitude due to the orbit of A-SCOPE. Since the figure has no direct relevance for the study and mostly calls for an explanation about orbit dynamics, we decided not to include it in the manuscript.

Figure 1: Number of A-SCOPE measurements per month and per 1 degree latitude interval. Red, January; Green, April; Blue, July; Cyan, October.

"Page 14747, line 22. Please replace or remove reference to the AGU fall conference presentation. To my knowledge, this is not publicly available and not peer-reviewed."

This reference has been removed.

"Section 3.2. Are the modes of XCO2 variability similar between models? Would an EOF analysis be useful? This is only a suggestion but without a more rigorous statistical analysis I think that the authors cannot confirm a substantial spatial coherence of transport model differences."

Our approach was to calculate parts of the covariance matrix spanned by the model results to determine spatial and temporal correlation length scales. (see line 15 on page 14751) These scales are rather long confirming the importance of correlated error.

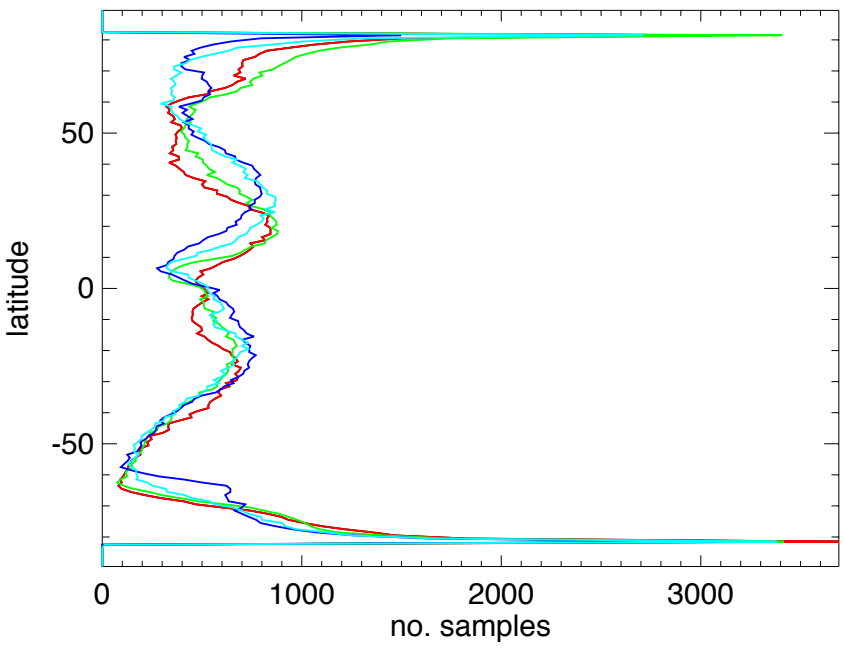

Fig. 1.