

## ***Interactive comment on “The importance of***

## **transport model uncertainties for the estimation of CO<sub>2</sub> sources and sinks using satellite measurements” by S. Houweling et al.**

**Anonymous Referee #2**

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Houweling et al. present a much needed analysis of how differences in transport will effect the interpretation of satellite observations of column CO<sub>2</sub> in their study entitled “The importance of transport model uncertainties for the estimation of CO<sub>2</sub> sources and sinks using satellite measurements”. Although this study is not without bias in the sense that these models and the underlying transport are not completely independent from each other the result speak for themselves. Transport matters and is likely to limit our ability to estimate fluxes from satellite measurements even if the satellite mea-

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surement is able to be unbiased and meet the design specifications for resolution and accuracy.

Despite significant limitations in this study, this reviewer would recommend that this paper be published as long as the authors are clear about the limitations of the study. Most of these limitations are obvious but need to be more clearly defined in the abstract and the text. In summary, the limitations:

1) Transport model: The authors should take more care describe possible errors that might arise from the meteorological model that underlies each inversion and “transport model” that actually carries the CO<sub>2</sub> tracer in the inversion. Say how they are different. As the authors note the underlying meteorological model in three out of the four models used is the same. As it turns out, on land where there is a lot of data (like North America) the two meteorological datasets are very similar but differ widely in the way the models assimilate ocean data. If things like resolution of the inversion transport are a major player in the difference this should be noted. As noted below, no inversion transport can rectify an underlying bias in the meteorological data. Finally, the authors talk about the need for good transport models but they do not specify how one might assess this.

2) Model – Data comparison: The authors do not highlight the main significance of the Model verses FTS comparison which suggests that sampling from multiple models with different transports may be missing a major bias that is shared by all transport models. This is demonstrated by the comparison with Darwin data whose season cycle may depend uniquely on inter-hemispheric transport. In this sense all the models may be sharing similar traits that serious bias the way that the seasonal cycle at Darwin manifests itself. From this perspective it seem like the transport errors determined from running multiple models is a low estimate at best.

Minor Comments

P. 14739 Line 7. Is this common co2 flux priors?

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- P. 14739 line 8 – “[Forward] simulations of column averaged CO<sub>2</sub> ...”
- P. 14739 line 9. It should be noted that this is not the case below the equator. It should also be noted that FTS is being used as a way to validate the forward models.
- P. 14739 Line 16 - Be more specific about GOSAT (and OCO) requirements given the result that you have here.
- P. 14739 Line 19. A path forward needs to be outlined about how one would identify a "good" transport field.
- P. 14740 line 2 - heterogeneous is not the right word. "sparse" would be more appropriate.
- P. 14743 Line 16. "transport model difference only". As mentioned later there this is not true since the inversion resolutions are different so the representativeness error will play a role.
- P. 14743 Line 17. Maybe it should be worded that "As a requirement for forward and inverse models used in this study it was confirmed that both the forward model and the inversion using forward model data had the same fluxes. Differences were all less than x and can be attributed to rounding errors(?).
- P. 14743 Line 18. Not clear what "this" is referring to. A further explanation of why inverting for the difference between two models is helpful is also needed.
- P. 14743 line 25. Unclear what IFS was being used for.
- p. 14744 Line 1 not sure why representative error should be small is the foot print is 100m - thought that representativeness error was a function of small error.
- P. 14745 line 13 - ocean not sea.
- P. 14747 Line 3. The lack of disagreement between FTS and forward models may suggest that the inter hemispheric mixing is not accurate. It would seem like this kind

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of bias is demonstrative of what this study does not adequately test (i.e. large scale biases in mass transport that lead to biases in any inversion.) It should be pointed out that this is where the global data coverage provided by satellites will be very useful.

- P. 14747 Line 7. Explain offset why TCCON calibration might effect this in more detail.

P.14747 line 12 - not fully mass conserving

P. 14747 line 22- Aircraft data shows a more complicated set of north-south and east west gradients in FT which are seasonally controlled. This should be a reviewed reference.

P. 14748 line 11. This statement is a little misleading since there should be averaging out on a monthly time-scale as well as the seasonal time scale.

P. 14748 line 14 - sea should be ocean.

P. 14750 Line 2 “also” should be as well.

P. 14750 Line 9 put error in context of expected fluxes.

P. 14751 Line 8. The supposition that influence of model error will be less in an inversion that accounts for errors in measurements and representativeness seems counter intuitive and should be explained further. In particular, it would seem like the reduction in precision noted would also be accompanied by a reduction in the ability of the inversion to give us a whole lot more information than we might get from the prior. In other words, it would seem like in addition to decreasing the precision the addition of transport error will give the prior more control over the outcome of the inversion.

P. 14751 Line 14-18. Explain how this relevant. Be explicit about how temporal and spatial covariance in transport will add to or take away from the uncertainty of the flux.

P. 14751 line 20 should read "improve the [transport] model themselves". Some explanation should also be given in the text about the difference between the transport model in the context of the inversion at a specific resolution and the meteorological

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model from which the transport in an individual model is derived (see Transport model summary above).

P. 14752 line 12. "... the fluxes that were ..." is this referring to prior fluxes?

P. 14752 line 15-16 "leads to [more] realistic simulation ..."

P. 14752 Line 19-21. not exactly clear what the optimized fluxes refer to but if the carbon tracker fluxes are what is being referred to they suffer from the same problem as the TRANSCOM fluxes in the sense that the prior for CarbonTracker is CASA which also has a seasonal lag. The lag in seasonal cycle will act to dampen the seasonal cycle posterior flux. See CarbonTracker comparison with data- the seasonal lag is still there even after it has been optimized.

P. 14752 Line 24-29. Compare FTS with aircraft to see if the amplitude is explained. This can be done with at LEF. Although LEF samples only go to 4000 m a 30% discrepancy should be detected.

p. 14753 LINE 20- the model to model comparison is a little bit fictitious because these are monthly averages.

P. 14753 line 27 not sure that remaining spectroscopic uncertainties was explained in the text.

P. 14754 LINE 7 mentions "certain aspects of transport that need to be evaluated by tracers - what are these tracers?"

Figure 6 text is unclear. Maybe "Top panel: TM5 inversion using ..." no parenthesis.

Figure 7 – same as above

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 14737, 2010.