Atmos. Chem. Phys. Discuss., 6, S2938–S2944, 2006
www.atmos-chem-phys-discuss.net/6/S2938/2006/

Atmospheric Chemistry and Physics Discussions

ACPD

6, S2938–S2944, 2006

Interactive Comment

Interactive comment on "Comparison of CO_2 fluxes estimated using atmospheric and oceanic inversions, and role of fluxes and their interannual variability in simulating atmospheric CO_2 concentrations" *by* P. K. Patra et al.

P. K. Patra et al.

Received and published: 7 September 2006

We appreciate the Reviewer's effort for evaluating our paper critically and providing us with a comprehensive set of comments. We agree that many of the comments are justified. After reading the reviewer's comments, we realized that we had not properly connected the different elements of this paper in the introduction. However, we feel that the reviewer's concern that 'these three sections feel rather uncorrelated' can be address by revising the manuscript.

The aim of this article is to do an overall validation of the fluxes Estimated by our inverse models. We compare the long term means with the ocean inversion estimates, which use fundamentally different data and models, and verify that the model is able to reproduce the observed interannual variability (IAV). Since there are no absolute, direct methods to validate the derived fluxes and flux IAVs, this analysis is indispensable. Simulation of IAV in atmospheric-CO_2 clearly depends on IAV in fluxes, meteorology, and interactions between them. We will clarify these points in the Introduction of our article, if we are permitted to submit a revised manuscript.

(a) Obviously, we do not expect large changes in fluxes by increasing one or two stations in the regions for which fluxes are somewhat constrained by observations. Systematic changes are also seen for the Southern Ocean region from 19-stations network to other networks. Our main point here is that adding observations in underconstrained regions has a considerable impact on the inverse estimates. We did not intend to assert that it is necessarily incorrect to exclude observations from Easter Island. Nevertheless, our finding that an atmospheric inversion that includes data from Easter Island is in agreement with inversions driven by independent ocean interior data while inversions that exclude this data are not is relevant to the discussion of how to treat these observations.

It is still not entirely clear whether or not the EIC data should be included in atmospheric inversions. EIC CO_2 concentrations are consistently lower than ship-board observations in the Western Pacific at similar latitudes. There is no analytical reason to suspect the measurements themselves; however, the EIC flasks are collected at heavily vegetated location (Tom Conway, personal communication, 2006), and may therefore be influenced by local uptake that is not captured in the models. The ocean interior observations that constrain the ocean inversion as well as the δpCO_2 observations (Takahashi at al., 2002) indicate that the Eastern Pacific, where EIC is located, should have less uptake than the Western Pacific, were the ship-board data are located. This seems to suggest that CO_2 concentrations at EIC are too low. However, air is often transported to EIC from the south-central Pacific, close to the southern pacific convergence zone, making observations at this station difficult to interpret simply based on adjacent ocean fluxes. If we are allowed to submit a revised manuscript, we will discuss these points.

With regards to the greater IAVs in CO_2 fluxes using 87 stations, we believe that large flux IAVs are more realistic than smaller IAVs. Recently, Patra et al. (2006) hypothesized that some of the oceanic regions could be under the influence IAV in dust aerosols, which would lead to greater IAV in regional fluxes. For equatorial and north Pacific and north Atlantic the flux IAVs are similar order of magnitudes as the other independent estimates based on direct observations (Patra et al., 2005a). Although there are issues of representatives for the direct and inverse estimates.

For the land region TDI fluxes, Patra et al. (2005b) compared their results with the Biome-BGC model simulated fluxes and suggested that the smaller IAV in Biome-BGC modeled fluxes are due to the exclusion of biomass burning source component. This can be validated if we use a recent estimation of CO_2 emission caused by biomass burning (van der Werf et al., 2006) in addition to the Biome-BGC model results. Some of these results have been shown at the GCP meeting Vulnerability of Carbon to Drought and Fire, Canberra, June 2006 [Patra et al., Effects of drought and fire on interannual variability in CO_2 fluxes as derived using an atmospheric- CO_2 inversion, presentation available at http://www.globalcarbonproject.org; links: CARBON_PORTAL, presentations). We can discuss this in further detail during revision, if permitted, as this analysis is yet to be published in a peer reviewed journal.

(b) We agree that our results should be put in perspective with Dargaville et al. (2000) and Roedenbeck et al. (2003). This will be done in revisions. On the issue of using uncertainty in the discussion of flux IAVs, we are not confident in our ability to estimate the uncertainty associated with flux anomalies at this time. All earlier publications dealing with IAV inversions (Rayner et al., 1999; Bousquet et al., 2000; Roedenbeck et al., 2003; Patra et al., 2005a,b; Baker et al., 2006) suggested that TDI flux IAVs can be estimated with greater confidence than the absolute flux values. Thus, it is not currently clear whether the TDI estimated flux uncertainties are appropriate for flux anomalies.

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(c) We have not much to say on the use of a version of the model with increased vertical diffusion version apart from the fact that this is used as just another test case. This can be removed if so suggested.

Based on the arguments presented above, we would like to attempt a revision by keeping all the three parts in the present ACPD version. We believe all the three components are essential for our validation study.

Specific comments:

p6804, line 14-20: Thank you for clarifying us regarding the justification of forward model simulations as a check for TDI model results.

p6806, line 9 - page 6807, line 12: We shall make the sub-sections and swap the paragraphs as well.

p6806, line 9: Yes, we fitted a curve to the weekly GLOBALVIEW values and sampled at daily time interval. This makes the time resolution same in the modelled CO_2 and GLOBALVIEW values.

p6806, line 10: The fitting is done to sample the GLOBALVIEW values at daily time interval.

p6806, line 21: It seems not all data are on the same scale, as the Globalview (2005) documentation (page7, Section 3) reads 'Data from the GAW network are reported relative to the WMO CO_2 mole fraction scale, which is maintained and propagated by the Central CO_2 Laboratory'.

p6807, line 18: We will use 'low uncertainty' in the revised version.

p6807, line 19: We agree, 'One' yardstick is more appropriate.

p6807, line 24: We shall include this discussion in the revised manuscript.

p6807, line 3-14: Uncertainties can be plotted along with mean values. We are sorry for the mistake in reference to Roedenbeck et al. The fluxes using 19-station network are compared here, as that covers at least the 1990s.

p6808, line 23-29: This has been partly addressed earlier, and further discussion can be added by testing sensitivity of our model results to EIC station.

p6809, line 10: We think our results are still in agreement with these two studies that 'incorporating interannual variations in transport into inversions is less important at this time than resolving some of the larger differences between inversions using different models, methods, and CO_2 data' as Dargaville et al. (2000) have concluded, if only the absolute long-term mean fluxes are considered. However, our results clearly show the impact of specific events on interannual flux variability.

p6809, line 16-17: This is something that is done in Baker et al. (2006). We do not want to do that because there is no realistic estimate of uncertainty for the flux anomalies. This is discussed earlier in (b).

p6809, line 24: This is a very good point. The annual flux uncertainties for Tropical South American flux are found to be 1.16, 1.08, and 1.11 for the year 1997, 1998 and 1999, respectively. There seems to be a tendency that 1997 is a bit weak compared to 1998 or 1999. Note part of 1998 and 1999 have La Nina condition. The flux uncertainties obtained using cyclostationary meteorology are the same for each year.

p6809, line 26: We wanted to convey here that the change in responses sampled at the sites would be greater due to smaller flux variability. Thus, a greater change in concentration can be simulated by changing the flux in smaller amount. We hope this clarifies this point.

p6811, line 20: Not entirely. As far as PKP can recall, during forward simulations for 64-region inversion, data from some of these sites were not available for our use.

p6811, line 22: We can expand on this during revision.

p6811, line 26: Not much, we guess. This is because the fossil flux is increased more or less in steady manner.

p6812, line 4-5: This statement probably is wrong. Our recent analysis suggests that the inversion based on NIES/FRCGC forward model introduce systematic bias in source/sink inversion; e.g., greater sinks are assigned to the mid-latitude land regions and greater source to the tropical/southern land regions. This may be the cause for an overestimation of trends at southern hemispheric stations. This can be discussed in further details during revision.

p6812, line 10: This will be taken care of during revision.

Table 1: Here is the new table. The results here and Patra et al. (2005a) have different averaging period; the latter is for the 1990s.

	SMF06		PKP05		Net: 75 station		Net: 67 station		Net: 19 station	
Flux Region	Flux	Unc.	Flux	Unc.	Flux	Unc.	Flux	Unc.	Flux	Unc.
North Pacific	-0.42	0.10	-0.30	0.56	-0.35	0.60	-0.26	0.86	- 0.88	1.18
Tropical West Pacific	0.08	0.08	-0.08	0.45	-0.33	0.48	-0.17	0.61	- 0.18	0.77
Tropical East Pacific	0.30	0.09	0.39	0.54	0.17	0.61	0.19	0.77	0.33	1.05
South Pacific	-0.44	0.11	-0.59	0.71	0.24	0.94	0.66	1.05	- 0.25	2.16
Northern Ocean	-0.17	0.09	-0.40	0.30	-0.35	0.31	-0.29	0.45	- 0.44	0.47
North Atlantic	-0.32	0.08	-0.32	0.44	-0.38	0.47	-0.25	0.63	- 0.34	0.71
Tropical Atlantic	0.14	0.11	0.16	0.49	0.11	0.49	0.19	0.70	0.21	0.71
South Atlantic	-0.17	0.05	0.06	0.58	0.09	0.58	0.01	0.83	0.03	0.86
Tropical Indian Ocean	0.10	0.08	-0.15*	0.77	-0.21	0.78	-0.11	1.10	- 0.07	1.13
South Indian Ocean	-0.48	0.08	-0.46	0.55	-0.40	0.54	-0.42	0.79	- 0.57	0.90
Southern Ocean	-0.33	0.21	-0.41	0.79	-0.60	0.79	-0.49	1.10	- 0.05	1.62
Global Ocean	-1.70	0.52	-2.11	0.52	-0.95	0.58	-0.95	0.68	- 2.22	0.97

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Figure 1 and 3: We will revise this plot as the review suggestion.

Technical comments:

All changes due to the technical comments will be incorporated in the revised manuscript.

Acknowledgments. We sincerely thank the reviewer for helpful comments and suggestions throughout the review.

References

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