Biogeosciences Discuss., 11, C976–C980, 2014
www.biogeosciences-discuss.net/11/C976/2014/

Biogeosciences
Discussions
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Interactive comment on "Interannual sea–air CO_2 flux variability from an observation-driven ocean mixed-layer scheme" *by* C. Rödenbeck et al.

Anonymous Referee #1

Received and published: 11 April 2014

The manuscript by Rödenbeck et al. provides a new estimate of the sea-air exchange of CO2 and its interannual anomalies using a novel diagnostic model of mixed layer biogeochemistry, driven by observations of the SOCAT v2 dataset. The authors clearly discuss strengths and weaknesses of the approach and focus their analysis (of the main manuscript) on the tropical Pacific, given that the tropical Pacific is one region with the best data constraint and that the authors find the strongest variability of the sea-air flux in this region. One interesting aspect discussed is the time lag in the sea-air flux of CO2 between East and West in the tropical Pacific in response to ENSO. Furthermore, the authors find that sea surface pCO2 data constrain the sea-air flux variability of CO2 better than atmospheric CO2 data, hence their recommendation to use pCO2 data as prior to improve land flux estimates in atmospheric inversions.

While the method as well as seasonal variabilities have been previously published in Rödenbeck et al. (2013) this manuscript focuses on interannual signals, areas where these signals are best constraint by observations and the APO flux. The manuscript is well written, although it lacks clarity in some cases (see specific comments below). Studies focusing on basin-wide and global interannual CO2 flux anomalies based on observations are rare, hence this study clearly provides an important contribution to our current understanding of the global carbon cycle. I would therefor like to recommend this manuscript for publication, after consideration of the minor points below.

Specific comments:

The introduction is very short. One strong point mentioned above is the lack of (surface ocean) observation based estimates regarding interannual variations of the CO2 flux and the challenges arising from the heterogeneity of observations. Rödenbeck et al. (2013) do provide this information in the introduction, hence I do not recommend to repeat what has been done already. However, I do believe that the current manuscript as a stand-alone-publication needs to include at least one paragraph highlighting current knowledge in terms of interannual variations of the sea-air CO2 flux.

There are several occurrences (page 3169 line 2; page 3169 line 23; page 3171 line 15; page 3190 line 2) where the authors refer to the SOCAT pCO2 observations. To the extend of my knowledge SOCAT reports fCO2. How has this been dealt with? Has fCO2 been converted to pCO2? Please clarify.

Page 3171 line 1: "We further compare the SOCAT-based estimates to ocean process model results." Here, the reader gets the impression that a comparison to several (plural) model results will follow. Although the authors mention more models in section 3.6, the comparison is only done for one model, hence I would change plural to singular here.

Page 3171 line 10: The authors mention the use of the Wanninkhof 1992 wind speed parametrisation but later on (page 3176 line 1-2) they use the the range of Naegler

2009 in their sensitivity test. Furthermore, Rödenbeck et al. (2013) uses the wind speed dependency of Wanninkhof 1992 with the parametrisation of Naegler 2009, hence I was wondering if the authors forgot to mention the use of Naegler 2009 on page 3171 line 10, or if they decided to use the parametrisation of Wanninkhof 1992 instead?

Page 3171 line 12: The authors mention that environmental variables are listed in Table 1. Individual data like e.g DIC and MLD are first mentioned later on (page 3172 line 15 and page 3182 line 6, respectively). It would help the reader if the authors would refer to Table 1 again when new data are mentioned, so the reader can quickly check what has been used.

Page 3172 line 1: Did you average the observations onto the same 4x5 grid? Please clarify.

Page 3174 line 5-6: "pseudo-random realizations of a-priory errors and model-data mismatch errors" Please give a bit more detail on how these errors have been obtained.

Page 3175 line 1-5: I can not follow your logic why IAV in the drivers should be "over-written"? Would you not expect that the pCO2 IAV reflects the driver IAV? Please clarify.

Page 3175 line 20 – page 3176 line 7 (section 2.3.4): Which source of uncertainty has large and which one has small effects? There is information on page 3182 line 3-6 regarding the sensitivity of the ocean internal DIC sources/sinks and MLD, but not on the others.

Page 3176 line 10 - referenced supplement section 3.1, figure S5 and S6: The Pacific 90S-45S (bottom left in figure S5 and S6) appears to have both bias and scatter increasing in time. Particularly the strong increase in the annual mean scatter is striking. Is this due to data sparsity/heterogeneity and how does this effect trends and IAV results for the global ocean?

Page 3180 line 24-25: "...almost reverse the a-priory anomalies ..." - looking at Figure 5 it appears that the SFC run and the gray a-priori line are shifted ($\sim$1-2 years) rather than reversed.

Page 3181 line 12: Again, (same as on Page 3174 line 5-6) please provide some more information regarding the uncertainty setting.

Page 3182 line 7-8: "... this range has been chosen to account for the missing interannual variations in MLD values used, ..." - How did you change the MLD values? E.g. did you change MLD for all years by a factor 2 and 0.5? It seems more plausible to create random variations for each year/month/day in order to test the effect of interannual variations in MLD.

Page 3184 line 3-4: "Sea-air CO2 flux (...) and ocean interior carbon sinks are constrained from SOCAT" - This is a repeat and can be removed.

Page 3185 line 7: "Both estimates are of roughly similar amplitudes". I am not convinced that you can say that looking at figure 7. Please provide numbers here to underline this statement.

Page 3185 line 10-11: "Both the SOCAT and the APO constraints suffer from incomplete spatial coverage, where the regions of good coverage do not necessarily coincide." - Figure 7 shows the APO comparison in the tropical Pacific. Since SOCAT coverage is good in this area (reference to Figure 4) does that mean the atmospheric inversion based APO suffers from poor data coverage, or is this a region where "regions of good coverage coincide"?

Page 3185 line 28: "the partial agreement in the interannual APO flux variation is remarkable" - Looking at figure 7, I think the term "remarkable" might be a bit overconfident, or does this statement refer to regions that are not shown?

Page 3186 line 17-18: "... using the same gas exchange parametrization . . . " - What about the wind product? Was the model output created with the same winds?

Page 3186 line 20-23: Why is this model used in particular and not one of the others (or several) mentioned in Wanninkhof et al. (2013)? You might give a false impression that there is actually a better model estimate - observation estimate agreement, considering that this model "agrees by far best with the SOCAT-based estimate".

Page 3187 line 13: "... agree that the 1990-1999 period saw a negligible or even reversed trend ..." - I do not think that you can say that trend estimates (plotted in figure 8) are in agreement, considering $\sim$ -0.1 PgC/yr/decade trend of the model and the $\sim$ +0.3PgC/yr/decade trend of the SFC run, even if these trends are not statistically significant.

Page 3202 Figure 4: It would be interesting in terms of % (or absolute area) how many 4x5 pixels actually show an RoU>0.2. It is very difficult to see in Figure 4.

Page 3203 Figure 5: Please expand the y-axis of the bottom figure, as part of the gray uncertainty band is cut off.

Page 3207 Figure 9 Bottom: One conclusion drawn in this study is that the pCO2-based estimate can improve atmospheric inversion land flux estimates, hence it would be interesting to compare both standard inversion and inversion using the SFC results to other land flux estimates (e.g. from the Global Carbon Project).

Interactive comment on Biogeosciences Discuss., 11, 3167, 2014.