

Review of the paper by Li et al:

Inter-annual global carbon cycle variations linked to atmospheric circulation variability

General Comments:

Na Li and co-authors relate the inter-annual variability (IAV) of de-trended global observed atmospheric CO₂ growth rates and the modelled global land sink from 1959 to 2017 with spatio-temporal sea level pressure (SLP) anomaly fields. They use a regularised linear regression method (Ridge Regression, RR) combined with a statistical learning technique to predict the IAV of the observed and model-simulated global CO₂ growth rates. They compare these results with a similar regression that is based on 15 classical global and hemispheric teleconnection indices, as well as with a regression that is solely based on Southern Oscillation index (SOI). They find very good predictability (Pearson R > 0.7) with boreal winter SLP anomalies, that is comparable or even better than with classical teleconnection indices. They show that CO₂ IAV is most sensitive to tropical and southern hemisphere SLP anomalies (a finding, which was already observed by Bacastow in 1976 and attributed to the influence of ENSO on the land biosphere sink by Keeling et al. in 1995).

This is an interesting and careful analysis, with the results being well presented in the manuscript. However, I would have appreciated some more discussions of the results. For example, it would be nice to gain some direct insight, which land regions dominate the globally observed atmospheric CO₂ growth rates. The biosphere models obviously reproduce the IAV very well so that this information should be available from these models.

Specific comments:

Abstract

Line 6: Please add “global” in “...from the **global** de-trended ...”

“... and from different datasets ...”: Please be more specific which datasets have been evaluated.

1. Introduction

Line 23: “Quantifying and understanding the patterns of variability in the C-cycle and their drivers is crucial to better understand the drivers of C-cycle dynamics and better constrain future climate projections.” I fully agree to this statement, however, in the current study solely the SLP anomaly is correlated with the CO₂ IAV, which, at least to my understanding, serves as a place-holder for the real drivers, which are e.g. temperature, water and radiation availability, for CO₂ exchange with the land biosphere (as correctly stated in line 39). Do the correlations presented here really help “process understanding of C-cycle dynamics”? This needs to be explained to the reader or, alternatively, such rather strong statements should be a bit de-emphasised throughout the manuscript.

Line 30: “(e.g., carbon uptakes by photosynthesis)” Isn’t heterotrophic respiration even less well observable?

Line 72: Please add again “... **global** atmospheric CO₂ ...”

Line 74: “We additionally compare results with...” which results?

Line 77: Please make sure that the reader understands this sentence correctly, i.e. that the latitudinal domains only refer to SLP, not to the biosphere land sink. See my general remark above.

2. Data and methods

2.1 CO₂ data sets:

As an “atmospheric observations person”, I was a bit confused that not only the AGR but also the modelled land sinks etc. were named “CO₂ data sets” (see my comment on lines 225ff below). Also, please have a look at Le Quéré et al. (2018) how the different components of the carbon budget listed in Eq. (1) shall be cited (see their Table 2).

Lines 135-136: What are the consequences that “dynamic vegetation” is not included?

2.2 Data pre-treatment:

Line 145: “grid points”? Do you mean “months”?

Line 146: “... LOESS as for the SLP fields.” Do you mean “as for the CO₂ time series”? There is no mentioning of a smoothing of the SLP fields.

2.4 Experimental design:

Line 206: “... from 1 to 53 years”. Do you mean “1 to 35 years”.

Lines 221-222: Verb is missing in the last sentence.

3. Results and discussion

3.1 Global IAV patterns:

Lines 225-227: See my earlier comment on the confusion about “observed” CO₂ time series (sec. 2.1). It would be easier for the reader if only the AGR is called an observed CO₂ time series and the biosphere model based IAV records are called differently. In this manuscript I had a hard time to get used to the many different terms and abbreviations. A few more explanatory words here and there may help to digest the text.

Line 233: include “... LOO correlation of **SLP**-predicted and observed/**modelled** CO₂ time series ...”

Figure 2: It is a bit confusing that the y-axis title is called ρ_{SLP} . I guess simply ρ would be correct.

Figure 2 caption Line 1: insert “... annual **measured and modelled** CO₂ time-series...”

Line 4: insert “...de-trended **data** basedpredicted vs. observed **and modelled** CO₂ time ...”

Line 5: “Additionally ...” Verb is missing in this sentence.

Lines 258-259: “2) SL_{Resid} implicitly includes the variability from land use changes as well as ocean sink variations” Any idea which one contributed more?

Line 293: insert “...number **of** predictors ...”

3.2 Sensitivity to the SLP domains:

Lines 299-300 and 304-306: If I read the heat maps in Fig. 4 correctly, the predictability is largest if the domain includes high latitudes of the SH, i.e. not only the tropics.

Lines 311-315: This explanation would be more convincing with some spatial information on the biosphere fluxes (see my general comment).

Lines 316-317: "... is likely due to strong ..." here a more detailed inspection of the model results may give insight (see my general comment).

3.3 Sensitivity to the temporal domains:

Lines 345-346 and Fig. 6: When increasing the time interval there are less possibilities to obtain different ρ_{SLP} and the correlated data become more and more similar. Doesn't this automatically decrease the variability of ρ_{SLP} ?

Lines 360 and 364: Perhaps better use the word "interval" instead of "scale".

An explanation of Figure 6b is missing in the text.

Line 395: please include "... different **atmospheric** driving ..."

Lines 392-396: Please refer here to my comment that SLP is only a place-holder for atmospheric drivers influencing the C-cycle.

Figure A1: The x-axis scale and title should be degrees.

Figure A3: What are the light blue shaded areas?

Figure A6 caption line 2: delete "extending" at the end of the line.