

This is a very interesting paper addressing the decadal variability of carbon fluxes. I enjoyed reading it and support its publication in Biogeosciences, subject to minor revisions.

**Minor comments:**

Throughout the text: the authors use the abbreviation “fCO<sub>2</sub>” for ocean carbon fluxes. This can be misleading since fCO<sub>2</sub> is often utilized as an abbreviation for surface water fugacity of CO<sub>2</sub>. I recommend choosing another abbreviation.

p. 1348, lines 4-6: The sentence is ambiguous. Consider reformulating (e.g. “...can really be attributed to anthropogenic climate change or if they have to be attributed to natural climate variability”).

p. 1348, line 17: remove “But” at the beginning of the sentence

p. 1350, line 13: replace “have been” with “has been” and “fields of research” with “field of research”

pp. 1350-1351, line 25-line 1: consider reformulating the sentence as it is ambiguous (e.g. “This limitation can be illustrated by considering the North Atlantic for investigating.....Here, ocean reanalysis...”).

p. 1351, lines 4-8: consider reformulating the sentence as it is ambiguous (e.g. “or merely considered in the terms of individual long-term stations ...”).

p. 1351, lines 10-11: replace “be the minimum amount of data” with “include the minimum years of data”

p. 1352, line 16: does “their” refer to “macronutrients and iron”? If so, the second part of the sentence is unclear. Consider reformulating.

p. 1352, line 25: replace “assessment of IPSL-CM5A-LR’s marine biogeochemistry modern-state” with “assessment of IPSL-CM5A-LR’s modern state of marine biogeochemistry”

p. 1353, line 7: add comma after “Secondly”

p. 1353, lines 3/ 7/ 14: no comma after “here”

p. 1353, line 12: replace “the” with “a”

Table 1: consider replacing “of solely one drivers (i.e. T/SST, S/SSS, DIC or Alk) compared to the fully-driven ocean carbon fluxes” with “different combinations of temperature (T), salinity (S), dissolved inorganic carbon (DIC), and alkalinity (Alk)”

p. 1353, line 23: replace “shows” with “show”

p. 1353, line 24: replace “compares” with “compare” and “term” with “terms”

p. 1353, line 24: add “with a correlation of” in front of “R”

p. 1353, line 26: the abbreviation “fCO<sub>2</sub>” is not introduced in the text

p. 1354, line 3: please add a short description of the approach

p. 1354, lines 15/ 16: replace “in average” with “on average”

p. 1354, line 14: please specify what is illustrated in Figure 1a (the inverse modeling estimate? The simulated carbon fluxes?)

p. 1354, line 19: add “simulated” in front of “ocean carbon fluxes”

Figure 1: please specify in the caption where the ocean carbon fluxes in Figure 1a) originate from (the inverse modeling estimate? the simulated carbon fluxes?) and enlarge the labeling

Figure 1b: parts of the labeling are cut off

p. 1354, lines 23-24: compared to Figure 1b, it looks like there is stronger outgassing of carbon in the southern sub-polar Atlantic than in the polar southern Pacific (and not in the southern sub-polar Pacific)

p. 1354, line 27: please state shortly how the variances were time-filtered

Figure 3: please correct the caption (the second reference to Figure 3a is incorrect and the reference to Figure 3b is missing “...and (b) the area-weighted carbon fluxes...”)

Figure 3: please replace “a) Ocean carbon uptake Variance” with “a) Ocean carbon fluxes Variance” and “b) Variance of ocean carbon fluxes” with “b) Variance of area-weighted ocean carbon fluxes”

Figure 3: please enlarge the labeling

p. 1355, line 24: clarify in the caption that the tracking is regional (e.g. “Tracking the decadal mode of variability of regional ocean carbon fluxes”)

p. 1356, lines 3-4: Figure 3a doesn't justify this statement. In the Pacific, the variances of the low latitude North West Pacific are stronger than those found in high latitude regions. And what about the variances of the Arctic?

p. 1356, line 4: Is  $0.01 \text{ Pg C yr}^{-1}$  the mean difference between variances of high latitude oceans and mid/low-latitude oceans?

p. 1356, line 4: replace “low-latitudes” with “low-latitude”

p. 1356, line 8: add “which are” in front of “much larger”

p. 1356, line 26: replace “amounts” with “accounts”

p. 1357, line 18: add “the” in front of “North Pacific”

Figure 4a: there is no title

Figure 4: the x-axis is not labeled

Figure 4: replace “is indicated by vertical bars” with “are indicated by vertical bars”

Figures 5/ 6/ 7: replace “into brackets” with “in brackets”

Figures 5/ 6/ 7, caption: do “spatial correlations” refer to correlations of spatial EOF patterns? Do “temporal correlations” refer to correlations of PCs? Please specify.

p. 1359, line 10: add “the” in front of “North Pacific”

p. 1359, line 11: replace “correlation” with “correlations”

p. 1359, lines 15-16: consider reformulating the sentence (e.g. "AMO and PDO have been estimated from the leading EOF and PC of SST, while NAM and SAM are calculated from those of SLP.")

p. 1359, lines 20-24: I am not sure if a correlation of .42 is a good approximation. Please include as well the correlations for NAM and SAM.

Figure 8: replace "compenents" with "components" and "t-test" with "T-test"

Figure 8: add "and" in front of "sea-level pressure" and remove "carbon fluxes" after "Southern Ocean"

Table 2: Clarify in the caption how the correlations are calculated. Are the AMO-, PDO-, NAM-, and SAM-indexes correlated with the globally integrated carbon flux or with the regionally integrated carbon flux or with the corresponding leading PC of a specific region? If the table considers regional carbon fluxes, then please specify which region is considered for the displayed correlations. The high correlations between SST-fCO<sub>2</sub> and AMO / PDO are expectable if the AMO and PDA indexes estimated from the leading EOF and PC of SST are correlated to the leading PCs of SST-fCO<sub>2</sub>.

p. 1360, lines 5-6: the correlations between time variability of fCO<sub>2</sub> and fCO<sub>2</sub>-DIC/fCO<sub>2</sub>-Alk/fCO<sub>2</sub>-SSS show approximately the same order of agreement (with negative correlations between time variability of fCO<sub>2</sub> and fCO<sub>2</sub>-Alk/fCO<sub>2</sub>-SSS), while the text seems to suggest that the correlation between fCO<sub>2</sub> and fCO<sub>2</sub>-DIC is better than the correlation between fCO<sub>2</sub> and fCO<sub>2</sub>-Alk/fCO<sub>2</sub>-SSS. Please specify this. Furthermore, a correlation of  $R \sim 0.3$  is still considerable and does not justify the usage of the term "poorly correlated".

p. 1360, line 13: replace "index" with "indices"

p. 1360, line 18: add "a" before "strong correlation"

p. 1360, lines 18-19: replace "Correlation" with "Correlations"

p. 1360, lines 21: replace "several site" with "several sites"

p. 1360, line 27: add "as well" in front of "for fCO<sub>2</sub>-DIC"

pp. 1360-1361, line 28-line 3: The leading EOF of fCO<sub>2</sub>-SST has a spatial correlation of 0.07 and a temporal correlation of  $-1.e-5$  with the fully driven carbon fluxes. How can that imprint a low-frequency signature on the carbon fluxes?

p. 1361, line 20: Figure 7b exhibits a spatial correlation of 0.33, therefore it should be  $R \geq 0.33$ .

p. 1361, line 22: please mention the temporal variability of the other CO<sub>2</sub>-fluxes

p. 1362, line 4: add comma in front of "respectively"

p. 1362, lines 23-24: replace "long-term mean and variance concentration" with "long term mean concentrations and associated standard deviations"

Figure 9: add the unit to the labeling of the color scale

Figure 10: please enlarge the labeling

Figure 10: Does variability refer to standard deviation? Please specify.

Figure 10: remove “the” from “variance of the Alk, DIC, S and T”

Figure 10: please specify that the confidence intervals are marked by vertical error bars

Figure 10: please add vertical space between the panels

p. 1363, lines 13-14: the convention up to this point was to first name pCO<sub>2</sub> and then the driving variable, but here it is the other way around. Please correct this.

p. 1363, line 13: replace “profile” with “profiles”

p. 1363, line 13: add “The” in front of “statistical” and replace “each” with “a”

p. 1365, line 8: do the values (~30-40%) arise from Figure 3c? If so, ~20-40% seems to be more accurate for the North Atlantic.

p. 1365, line 14: in case of the Subpolar and Polar regions of the Antarctic sector, I would encourage the authors to include furthermore the lower boundaries (25%?)

p. 1365, line 18: replace “others” with “other”

p. 1365, line 25: add comma after “Interestingly”

p. 1366, line 6: add “and” in front of “not”

p. 1366, line 13: add “do” in front of “modes” and replace “a given Earth System Model” with “different Earth System Models”

p. 1366, line 19: add “the considered” in front of “ocean model”

p. 1366, line 21: replace “region” with “regions”

p. 1367, line 11: remove “Then,”

p. 1367, line 13-15: please specify how the study of Lenton et al. differs from this study

p. 1367, line 17: replace “usefull” with “useful” and “that” with “this”