9th November 2021.

Biogeosciences.

Dear Peter Landschützer,

Thank you for your and the reviewer's comments on our revised manuscript entitled 'Derivation of seawater pCO_2 from net community production identifies the South Atlantic Ocean as a CO_2 source' by Ford, Tilstone, Shutler and Kitidis. We have addressed all of the comments raised and implemented the necessary changes to the updated version of the manuscript. We provide detailed responses to your and Reviewer #1 comments below and hope you find these changes satisfactory. In the responses, we refer to page and line numbers in the tracked changed document.

We look forward to hearing from you
Yours sincerely,

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Response to Peter Landschützer (Editor)

Dear authors,

I have now received the 2nd review of both referees and I agree with their judgement, that the manuscript has improved and is almost ready for publication. One referee has raised a number of additional comments that I would like you to consider. Therefore, I have decided that minor revisions are necessary before the manuscript can be considered for publication. However, once you have considered these final comments and resubmit your manuscript, I will proceed with my final decision (without consulting the referees again).

Best regards
Peter Landschützer

Response: *Thank you for your decision and providing the reviewers comments. We have addressed the additional comments by the reviewers below, which have improved the manuscript further.*

Response to anonymous reviewer (Reviewer #2)

No additional comments provided

Response: *Thank you for your second review of our manuscript.*

Response to Jonathan Sharp (Reviewer #1)

General Comments:

Daniel Ford and coauthors describe a study in which three different biological parameters — chlorophyll a (Chl a), net primary production (NPP), and net community production (NCP) — were tested as predictors in neural networks to estimate the partial pressure of CO2 in the surface ocean (pCO2(sw)) in the South Atlantic Ocean. Fields of pCO2(sw) generated by these three neural networks were compared to each other, as well as to fields generated by two additional neural networks that did not include biological predictors, a recently published global surface pCO2(sw) product (Watson et al., 2020), and in situ literature values of pCO2(sw). Also, a perturbation study was carried out to quantify the potential for improvements to pCO2(sw) predictions from each of the three neural networks with biological predictor parameters.

The authors conclude that the approach that includes NCP as a biological predictor provides the most accurate values of pCO2(sw) in equatorial upwelling regions and in the Amazon plume region. They demonstrate this result by comparing climatologies generated by the neural networks to in situ buoy measurements, values of pCO2(sw) reported in the literature, and climatologies generated by separate neural networks without biological predictors. They also conclude that the approach that includes NCP as a biological predictor has the greatest capacity for improvement to its performance as uncertainties are reduced.

The authors have responded well to the reviewers' comments, resulting in improvements to the presentation and discussion of their results. The modifications made to Figs. 1, 3, and 5 are especially helpful to the manuscript. I do support the publication of this work, as the implications are both important and interesting. Nevertheless, additional comments and editorial corrections are listed in the following section, which I hope will lead to further improvement to the manuscript.

Response: *Thank you for your second appraisal of the manuscript, and the additional comments provided which have improved the manuscript further. Responses to the specific comments are given below.*

Specific Comments and Technical Corrections:

Lines 9–10: Recommend revising to "As a part of this process…"

Response: *We have revised the start of this sentence as suggested on Page 1, Lines 9-10.*

Line 14 (and elsewhere): Recommend revising to "…which biological proxy produces the most accurate fields of pCO2(sw)."

Response: *We have revised this as suggested at Page 1, Line 14, and revised text at Page 3, Line 69 and Page 20, Line 477-478.*

Line 18: Add missing period after "parameters"

Response: *We have added the missing period on Page 1, Line 18.*

Line 20: Recommend revising to "…this region appears to be a sink for CO2"

Response: *This has been revised as suggested; see Page 1, Line 20.*

Line 45: Recommend revising to "Where NCP is positive…" to match the structure of the following sentence.

Response: *This has been revised as suggested; see Page 2, Lines 46-48.*

Line 64: Recommend revising to "This dynamic biogeochemical variability in conjunction with…" or something more descriptive than just "This"

Response: *We have revised the start of this sentence as suggested; see Page 3, Lines 65-67.*

Line 69: eliminate errant "a" between "alongside" and "two"

Response: *We have removed the "a"; see Page 3, Line 70.*

Lines 97–100: This paragraph seems unnecessary until reading in section 2.6 that the PIRATA buoy data are flagged E. I'd either mention the PIRATA data here, or just remove this paragraph. There is no mention of dataset quality flags in the preceding paragraph, so there is not necessarily a reason for the reader to assume that flag E data weren't also downloaded along with the core SOCAT data.

Response: *We agree and have now removed this paragraph; see Page 4, Lines 98 – 101.*

Line 115: Recommend revising to "These satellite algorithms were shown to be the most accurate…"

Response: *We have revised the sentence as suggested on Pages 4-5, Lines 116 - 117.*

Line 116: Change "accounting" to "accounted"

Response: *We have changed accounting to accounted on Page 5 Line 117.*

Lines 151–158: Although it is explained here, I was initially confused as to exactly which parameters are used in training each of the NNs. A table may be helpful in clarifying this. Most importantly, that SA-FNNNO-BIO-2 and Watson et al. (2020) are the only NNs that use salinity and mixed layer depth as predictors.

Response: *We agree with your suggestion and have added a new table (Table 2; Page 7, Lines 152 – 155) which displays the input parameters used in training the respective neural network approaches. Table 2 is referred to in the text at Page 7 Lines 156, 159 and 160, where the SA-FNN variants are described. Table 2 and caption can be seen below:*

Table 2: The input parameters of the neural network variants described in section 2.3. and 2.6. xCO_2 is the atmospheric mixing ratio of CO_2.

Neural Network Variant	*Input parameters*
SA-FNN$_{NCP}$	*$pCO_{2\,(atm)}$, SST and NCP*
SA-FNN$_{NPP}$	*$pCO_{2\,(atm)}$, SST and NPP*
SA-FNN$_{CHLA}$	*$pCO_{2\,(atm)}$, SST and Chl a*
SA-FNN$_{NO-BIO-1}$	*$pCO_{2\,(atm)}$ and SST*
SA-FNN$_{NO-BIO-2}$	*$pCO_{2\,(atm)}$, SST, salinity, and mixed layer depth*
W2020 (Watson et al., 2020a)	*$xCO_{2\,(atm)}$, SST, salinity, and mixed layer depth*

Lines 268–270: This sentence is a bit confusing at the moment. One suggested revision here: "This showed that a reduction in pCO2(sw) RMSD of 36% was achieved by eliminating satellite NCP uncertainties, 34% by eliminating satellite NPP uncertainties, and 19% by eliminating satellite Chl a uncertainties."

Response: *We have revised this sentence as suggested; see Page 12, Lines 274-276.*

Figure 3: Unfortunately, with the helpful addition of new data to these plots, this figure has become very difficult to interpret (at least given the quality of image I have). This could perhaps be remedied by simply reshaping the panels: an elongated y-axis might help emphasize the distinctions between individual lines. Another option may be to adjust the color palette selection. Or, to split this into two separate figures, showing the climatology from SA-FNNNCP in both.

Response: *We have revised Figure 3 by changing the y-axis limits for each plot as suggested. The figure caption has been updated to highlight the different y-axis limits. The updated Figure 3 and caption can be seen below:*

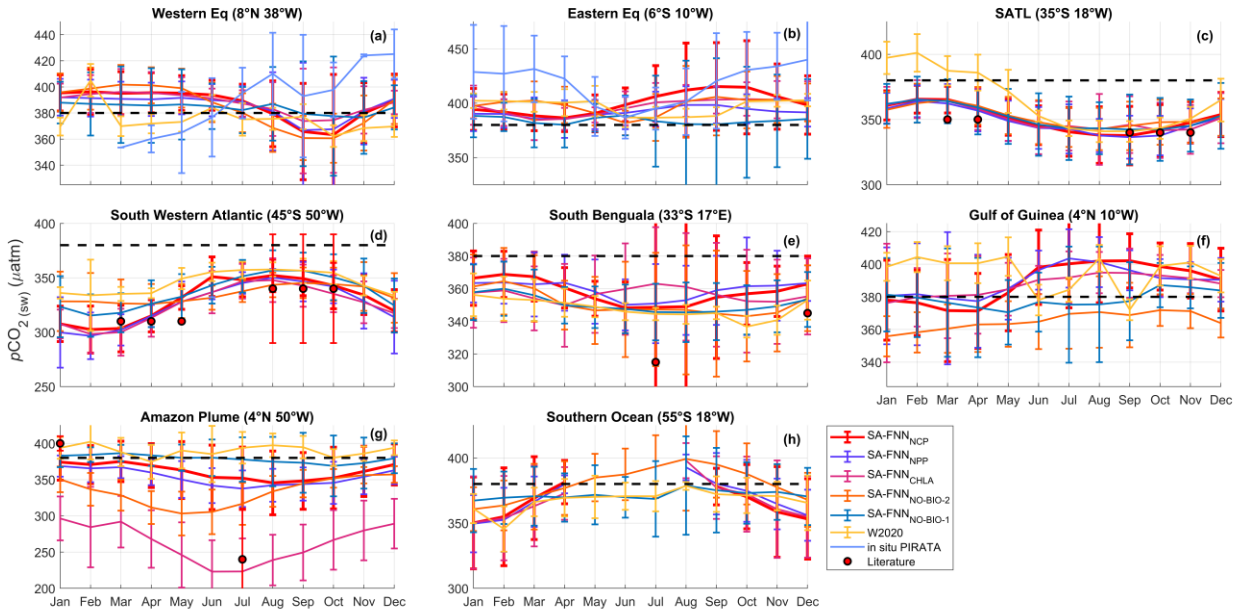

Fig. 3: Monthly climatologies of $pCO_{2\,(sw)}$ referenced to the year 2010 for the 8 stations marked in Fig. 1 from the SA-FNN_{NCP}, SA-FNN_{NPP}, SA-FNN_{CHLA}, SA-$FNN_{NO\text{-}BIO\text{-}1}$, SA-$FNN_{NO\text{-}BIO\text{-}2}$ and W2020 (Watson et al., 2020b). Light blue lines in Fig. 3a, b indicate the in situ $pCO_{2\,(sw)}$ observations from PIRATA buoys. The atmospheric CO_2 increase was set as 1.5 µatm yr^{-1}. Black dashed line indicates the atmospheric pCO_2 (~380 µatm). Error bars indicate the 2 standard deviation of the climatology (~95% interval), where larger error bars indicate a larger interannual variability. Red circles indicate the literature values of $pCO_{2\,(sw)}$ described in section 4.2. Note the different y-axis limits in each plot.

Line 286: Change "climatology" to "climatologies"

Response: *We have made this suggested change, see Page 14, Line 296.*

Line 363: "…indicated however, that elevated pCO2(sw) at ~430 uatm exist…" During what time of the year is this elevated pCO2(sw) occurring? Year-round?

Response: *The elevated $pCO_{2\,(sw)}$ observed by Bruto et al. (2017) referred to was measured in September for 2008 to 2011, which contrasted with Lefèvre et al. (2020) who reported lower $pCO_{2\,(sw)}$ at ~360 µatm in 2013. We have included the month within the sentence, see Page 17 Lines 372-373, which now reads: "Bruto et al. (2017) indicated however, that elevated $pCO_{2\,(sw)}$ at ~430 µatm was observed in September for 2008 to 2011."*

Line 364: "The PIRATA buoy pCO2(sw) observations (Fig. 3a) clear highlight the difference between these years…" It's not clear to me how the monthly climatology in Fig. 3a highlights a difference between the years. Are PIRATA observations only available from 2008 to 2011, during which time Bruto et al. indicate higher pCO2(sw)?

Response: *The size of the errorbars indicate the interannual variability of the climatology as described in the methods section 2.6., and Figure 3's caption. For September (Fig. 3a), larger errorbars were observed consistent with the differences between Lefèvre et al. (2020) and Bruto et al. (2017). We have updated the sentence to make this clearer, see Page 17 Lines 373 – 375, which now reads: "The errorbars on the PIRATA buoy* $pCO_{2\ (sw)}$ *observations (Fig. 3a) clearly highlight the differences between Lefèvre et al. (2020) and Bruto et al. (2017), but there are less than 4 years of monthly observations available, which do not resolve the full seasonal cycle."*

In SOCATv2020, data available from the PIRATA buoy at 8 °N 38 °W correspond to the data presented in Lefèvre et al. (2020) and Bruto et al. (2017), which covers 2013 and 2008 to 2011 respectively, but do not provide full annual coverage.

Line 472: Change "reduced" to "eliminated" or "reduced to zero"

Response: *We have changed this to "reduced to ~0", see Page 21, Line 483, to be consistent with the sentence on Page 16, Line 341.*

Line 475: Recommend revising to "…and two neural networks that do not use…"

Response: *We have revised the sentence as suggested; see Page 21, Lines 484 – 485.*

Line 478–479: Add to the end of this sentence "occurred" or "was observed"

Response: *We have added "occurred" to the end of the sentence as suggested; see Page 21, Lines 488 – 489.*