

Interactive comment on “Mechanisms of the Sea–Air CO₂ Flux Seasonal Cycle biases in CMIP5 Earth Systems Models in the Southern Ocean” by N. Precious Mongwe

Anonymous Referee #3

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Overall Statements:

The manuscript “Mechanisms of the Air-Sea CO₂ Flux Seasonal Cycle biases in CMIP5 Earth Systems Models in the in the Southern Ocean” by N.P. Mongwe, M. Vichi, and P.M.S Monteiro is a valuable contribution to the inspection of regional and seasonal carbon related fluxes in global CMIP5 models. The authors show that even when annual carbon fluxes accord to data-derived fluxes, model results can differ substantially and show biases compared to data-derived fluxes on the seasonal and regional scale. The authors use diagnostic tools to attribute model result characteristics regarding the efficiency of the simulated biological- and solubility-carbon pump. These diagnostic

C1

tools are based on empirical relations. The author’s approach is thus not fully based on model results and leaves me not fully convinced. Are simulated strong DIC variations really due to high biological activities, and is the subsequent respiration really the cause for outgassing? This appears highly speculative.

On the other hand model characteristics which may imply a strong or even overestimated simulated biological pump are not shown or discussed. But this would help to understand the basic differences between the models.

For these two reasons it is necessary

to give more information on model characteristics (Tab. 1), and

to study additional model results (e.g., export production) which are available for CMIP5 models.

This manuscript is written very sloppily. This has to be improved substantially.

Detailed remarks:

Line 1: better “Earth System Models”

Line 24 -31: This part appears as repetition of the preceding part. You can highlight here some specific results (from Table 2).

Line 37: Define here the extent of the Southern Ocean as you use it within the manuscript and give the ratio of Southern Ocean to Global Ocean surface area.

Line 42: Ref missing

Line 44: Leung et al., 2015 Ref missing

Line 44: Roy et al., 2011 Ref missing

Line 45: Segsneider and Bendtsen, 2013 Ref missing

Line 45: Sarmiento Ref missing

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Line 47: Le Quere et al 2007 Ref missing
Line 47: Son and Gerber 2010 Ref missing
Line 47: Thompson et al., 2011 Ref missing
Line 48: Landschutzer et al., 2015 Ref missing
Line 48: Zickfeld et al., 2008 Ref missing
Line 52: Please say once that all seasons you mention correspond to the Australian annual cycle.
Line 55: Taylor et al., 2012 Ref missing
Line 57: "almost all agree ..". Table 2 shows one exception.
Line 58: Anav et al., 2013 Ref missing
Line 60: Thomalla et al., 2011 Ref missing
Line 62 and Line 69 should be adapted
Line 62 ff: don't use different writings: in-gassing, outgassing, in gassing.
Line 63: "Ref" ???
Line 73: Sabine et al., 2004 Ref missing
Line 76: cooler than ?
Line 77: Marinov et al., 2006 Ref missing
Line 77: Metzl, 2009 Ref missing
Line 79: Matear and Lenton, 2008 Ref missing
Line 88: Rodgers et al., 2014 Ref missing
Line 88: Visineli et al., 2016 Ref missing

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Line 99: Reference missing
Line 101: There are large differences between FCO₂ used in this manuscript and values in Mongwe et al. (2016). Explain why you changed the data source. Why is it better than the former one?
Line 102: Landschützer et al (2014) Ref missing
Line 114: Pierrot and Wallace (2006) Ref missing
Line 115: Which equilibrium constants are used?
Line 129-130: Dunne et al (2013) Ref missing
Line 129-130: The hor. resolution of the MPI model is not correct
Line 129-130: Give additional information on model characteristics:
Parametrization of air-sea heat fluxes (e.g., dz(1); which layers are treated? ..)
Parametrization of air-sea flux of CO₂ (e.g., Wanninkhof, 1992; etc)
Is an ice model included?
Which nutrients are included?
Line 136: Wanninkhof et al. (2009) Ref missing
Line 140: Ref missing
Line 150: Ref missing
Line 169: Does delta MLD(T+1) refer to delta MLD within line 168?
Line 184: Ref missing
Line 184-187 could be shifted into the introduction
Line 186: Give mean latitudinal extent of the two zones

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Line 192-193 adapt PF and PFZ
Line 194: Four models do not broadly capture these features.
Line 218: Discuss also the RMSE
Line 220: $PCC(\text{CESM1-BGC}) = 0.47$
Line 224: Adapt units to Tab. 2
Line 237: You mean annual standard deviation?
Line 237: Is the standard deviation also applied over the ensemble members?
Line 243: The letters a-f are missing
Line 244 “weakening of uptake or an increase of outgassing”
Line 249: There are more zonal differences in the model results than in the observations
Line 260: it’s rather May
Line 268: I see an overestimation of group A, but no underestimation of group B
Line 273-275: Say it more straightforward: positive (red) – flux too high due to an overestimation of oceanic pCO₂ and negative (blue) – flux too low due to an underestimation of oceanic pCO₂
P277: Only Pacific basin shown (compare headlines in Fig 4)
L285: “are relatively better” this important statement should be made more precisely. Could you evaluate Fig 4 numerically to do so?
Line 333 What’s about the entrainment of alkalinity? This would damp the DIC effect on pCO₂
Line 346: The simulated entrainment is much larger.

C5

Line 386: “biological ..” also other reasons for deltaDIC could exist
Line 390: Why should group B models do so? Maybe some additional characteristics (Tab. 1) could help to explain this.
Line 405: “Fig. 9d-f”
Line 406: The wording “anticipated” shows the high degree of speculation. By the way, I see only two type A models doing so.
Line 488: Ref missing
Line 457: Also other models show similar deltaT values
Line 515: It is not the pCO₂ which is soluble
Line 584-585: New extra line
Line 654: really 2009? In the text it’s 2007
Line 667: really 1995? In the text it’s 2004
Line 697 ff: align the Saltee references according to the year of publishing
Line 734: Vichi et al., 2007 or 2009?
Line 744: Figures and inscriptions too small
Line 759: It would help when the legend also provides the membership (group A – group B)
Line 792: Letter a-f missing.
Line 792: Only Pacific Ocean appears displayed
Line 860-861: Headings of the sub figures incorrect
Line 862: You mean “mol kg⁻¹ month⁻¹”?

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Line 862 ff: Use “a”-“f”

Line 868-869: The y-axis for Chl is logarithmic, not the units

Line 870: You mean “ $\mu\text{mol kg}^{-1} \text{ month}^{-1}$ ”?

Line 891: Give units

Line 891: Indicate group A and group B members

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