

Interactive comment on “Marine biogeochemical cycling and oceanic CO₂ uptake simulated by the NUIST Earth System Model version 3” by Yifei Dai et al.

Anonymous Referee #2

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Marine biogeochemical cycling and oceanic CO₂ uptake simulated by the NUIST Earth System Model version 3

by Yifei Dai, Long Cao, Bin Wang

1) General comments

Dai and co-authors evaluate the ability of their earth system model NESM v3 to represent the carbon cycle (and, particularly, the CO₂ uptake) and the representation of several marine biogeochemical tracers (nutrients, alkalinity, DIC, chlorophyll and net primary production). NESM v3 performances are compared with observations and, occasionally, to CMIP5 models. As regional discrepancies are identified, the authors

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discussed their physical (e.g. weak upwelling in the Indian Ocean, strong convective mixing at high latitudes and more generally, shortcomings in simulated ocean circulation) or biogeochemical (iron limitation in the Southern Ocean, excessive remineralization in the deep Northern Pacific) origins.

2) Relevance of the subject

Such a paper evaluating the limits of a modelling platform can be very useful to the scientific community which is going to use and analyse NESM v3 outputs, especially if the model has contributed to the CMIP6 Intercomparison Project.

However I did not really understand from the text if the model described and used in this paper has really been a part of CMIP6: p.3, l.10: “as a registered model of CMIP6” but p.7, l.21: “following the protocol of CMIP5” Maybe the authors may explain why not using the protocol of CMIP6 (to be CMIP6 fully compliant) ?

3) General structure

The readability could be improved by a better structure. Please have a look at Séférian et al. (2019, <https://doi.org/10.1029/2019MS001791>) which provides an evaluation of CNRM earth system model for CMIP6 by comparing it to observations, as well as to CMIP5 multi-model ensemble, and to an earlier version of the same model.

Keeping the introduction in its actual state (i.e. focusing on carbon uptake), I suggest to move the description of NESM v3 found in the introduction (p.3, l11-16) to the dedicated section (2.1.1). But I would rather expect a more focused introduction, relaying previous/other model evaluations of the carbon cycle and uptake. As it is, the scope of the introduction is a bit too wide.

4) Results

I suggest to discuss the magnitude of the nutrient biases obtained in section 3.1 in regard of those obtained with other models like CMIP5 models (maybe a short summary of the published CMIP5 literature on these aspect will be enough). This would help

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the reader to know how NESM v3 places itself in the CMIP models diversity. This is also true for the section relative to the Taylor diagram (Fig. 12): please see my specific comment.

The section 3.5.2 discussing the coupling between the “radiative” (i.e. in this case only atmospheric radiation is affected by changing concentrations of atmospheric CO₂) and “biogeochemical” (i.e. in this case only the ocean carbon cycle is affected by changing atmospheric CO₂) sensitivity experiments is quite interesting. However if the motivation of this paper is to evaluate model skills in modeling carbon-related biogeochemical species, the study of the non-linearity of their sum appears a bit beyond the lines of the paper. I would recommend that either the authors restructure (a bit) the current draft or clarify the aim of their study.

5) Discussion

I would expect of a paper aiming at evaluating a model that the “Discussion and Conclusion section” would give more details of how this model behaves (in terms of modeled carbon cycle and CO₂ uptake here) in comparison with other models or in the context of the other CMIP models. If such comparisons are occasionally done in the current draft version, it would be valuable to systematise them.

6) Language

I would recommend a careful reading which may easily help to correct the typing errors.

7) Specific comments

p.3, l.19: modes -> models

p.4, l.4: includes -> that includes or including

p.4, l.15: tripole -> tripolar grid

p.7-8, l.27, l.1-4: “To separate the effect of atmospheric CO₂ and global warming on the ocean carbon cycle, we performed three types of experiments (biogeochemically

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coupled, radiatively coupled, and fully coupled). These types of simulations were also performed by previous studies that investigated the effect of CO₂ and global warming on the global carbon cycle (Friedlingstein et al., 2006; Arora et al., 2013; Schwinger et al., 2014).”

I suggest to slightly reorganize the above paragraph in order to properly introduce the list items that follows. I suggest something like that:

“Following Friedlingstein et al., 2006; Arora et al., 2013; Schwinger et al., 2014, we performed three types of experiments (biogeochemically coupled, radiatively coupled, and fully coupled) to separate the effect of atmospheric CO₂ and global warming on the ocean carbon cycle: 1) Biogeochemically coupled (BC)...”

p.9, l.18: the modeled result -> the modeled sea-air CO₂ fluxes to a 4°x5° grid.

p.10, l.3: Fig. 11 -> Fig. 1 ?

p.11, l.21-22: why is the ocean circulation so different in IPSL-CM5A-LR and NESM, as both models share the same oceanic model (NEMO) ?

p.14, l.23: alkalinityare -> alklinity are

p.16, l.11: “,” -> “.”

p.16, l.24: receptively -> respectively

p.17, l.4: stimulated -> simulated ?

p.17, l.23: Similar to the vertically integrated inventory (Fig. 10): I suggest to add the figure you are referring to, in order to facilitate the reading.

I also suggest to clarify (in the text or, at least, in the caption of Fig. 11) the period on which DIC has been averaged for computing these vertical sections: I guess that these vertical sections have been averaged between 1985 and 2014 as other vertical sections ? As it gives an indication of the temporal persistence of the bias, I would suggest to

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mention it. The vertically integrated inventory of Fig. 10 are not representative of the whole period but represent only few years around 2002 or 1994.

p.17, l.25 : it would be very helpful to add other models data or even CMIP5 ensemble mean on this Taylor diagram for all the biogeochemical fields in order to get an idea of how NESM v3 behaves in the current modeling landscape.

p.18, l.20: MLD is seen decreasing -> "MLD is seen to decrease" sounds to me more correct.

p.21, l.3: "some regions of the Northern Atlantic even appear CO2 outgassing". The formulation sounds weird to me, please check its grammatical correctness.

p.25, l.27: ". ." -> "."

p.26, l.15-16: please replace XXX and YYYY by providing publication numbers, or delete the sentence.

8) Figures

p.40, Figure 2: to improve the readability of this figure, I suggest to separate the 3 oceanic regions (Atlantic, Pacific, Global) and to increase the tick labels and titles. You can keep all the 3x6 subplots on the same figure, but at least try to increase the margin below the 6 subplots related to the Atlantic ocean, and also increase the margin below the 6 subplots related to the Pacific ocean following a pattern like:

a0 b0. c0

a1. b1. c1

<- increased margin

a2. b2 c2

a3. b3. c3

<- increased margin

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a4. b4. c4

a5 b5. c5

p.41, Figure 3: same recommendation than for Figure 2, please add an increased margin between the cluster of subplots for preformed PO4 and the cluster of subplots showing regenerated PO4. Increase all ticks labels and titles.

As the whole analysis of Fig. 3 is based on biases values, it would be very helpful to show these biases on Fig. 3. You could show a first line of vertical sections relative to observations and then a second line with biases (model-obs) rather than model means.

p.42, Figure 4: please mention the source of these nutrients limitation patterns. Are they diagnosed from NESM v3 model ?

P.44, Figure 6: be careful with the mismatch between subplots titles and their name in the legend.

p.46, Figure 8: see recommendations for Figures 2 and 3.

p. 51 and 53, Figures 13 and 15: please add units of analysed fields.

9) Bibliography

Séférián, R., Nabat, P., Michou, M., Saint-Martin, D., Voltaire, A., Colin, J., et al (2019). Evaluation of CNRM Earth-System model, CNRM-ESM2-1: role of Earth system processes in present-day and future climate. *Journal of Advances in Modeling Earth Systems*, 11. <https://doi.org/10.1029/2019MS001791>

Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2019-288>, 2019.

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