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Interactive comment on "Marine biogeochemical cycling and oceanic CO_2 uptake simulated by the NUIST Earth System Model version 3" *by* Yifei Dai et al.

Anonymous Referee #1

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Review of "Marine biogeochemical cycling and oceanic CO2 uptake simulated by the NUIST Earth System Model version 3" by Dai et al.

General comments

This paper provides a description and evaluation of marine biogeochemical simulation of the NESM v3. Given that this model is new to the CMIP community (participating in CMIP6), it is important to provide such description and evaluation paper to discuss the strengths and limitations of the model to help the end users of CMIP6 archives. Below I provide a few general comments, followed by specific comments and editorial corrections, to help improve the presentation of the paper. I believe that the authors

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can address these concerns.

The motivation of this paper is not clearly stated in the introduction section. I assume it is to evaluate the model performance of marine biogeochemical fields (e.g., P1, L10 and P3, L23), but the authors should describe why doing so is important for this particular model. I think this could be clearly stated by having a paragraph starting with a sentence like "The objective of this paper is to . . ." in the second last paragraph of the Introduction section, and by linking to CMIP6.

Restructure. I find that the flow of the paper could be improved if all the method stuff goes into the Method section. See my specific comments.

Concluding paragraph. The very last paragraph of the Discussion and Conclusion section is very weak (P25, L24). Also the two dots ".." at the very end indicates that it is unfinished. Please work on this last paragraph to provide the take-home message of the manuscript.

Model minus observation figures. Some figures can be improved by having a model-minus-observation difference subplots. This is done for Figures 1 and 9, but not for the others. Doing so makes it easy to show where the model has positive and negative biases and by how much, and helps understand the text (for example, it is hard to notice the negative biases mentioned in P24, L7 just by looking at Fig. 5).

Specific comments

Title. I think the acronym NESM v3 should be mentioned in the title if that's the preferred acronym for CMIP6 exercise.

Acronyms. All acronyms should be defined for the first time they appear in the text. For example, in the abstract, CO2, CMIP5, 1ptCO2. I suggest the authors to check throughout the manuscript.

P3, L8 to L24. I feel that the details of NESM v3 mentioned in these two paragraphs belong to the method section. Instead, provide the objective paragraph here with a very

brief introduction of NESM v3. At this point, the readers are not interested in knowing the details of NESM v3, but rather they want to know why NESM v3 is important and deserves an evaluation paper.

P5, L1. This sentence sounds to me that salinity of 4 PSU is added into the ocean when ice melting, but is this correct? I think the sea-ice salinity is fixed at 4PSU which is used to calculate the ice-ocean salt flux, which should actually result in dilution of seawater during ice melting (unless the ocean salinity is less than 4 PSU).

Sec. 2.2. Perhaps not so important for the interpretation of results, but to complete the description, mention the initial and boundary conditions for biogeochemical state variables. Were they initialized to the WOA18, GLODAP v2? Was the river discharge of biogeochemical state variables prescribed?

P7, L9 and L10. Briefly describe what it means by “offline”.

P7, L22. Why follow the protocol of CMIP5 for 1ptCO2 and not that of CMIP6 (one of the DECK experiments)?

P8, L16. Consider moving this paragraph earlier (at the beginning of the section) to give a broad picture up front.

P8, L24. WOA18 gives nutrient concentrations in units of umol/kg. Briefly mention how they were converted to mmol m-3 for model-obs comparison (e.g. Fig.1).

P9, L1. Briefly mention how these products compare or differ. I mean, do they not all incorporate SeaWiFS? Also, GlobColour and OCCCI are both merged products (and they look pretty much the same; Fig. 5), so the readers may be curious to know why these two similar products deserve comparison.

P9, L21. Suggest to remove this paragraph as it was already mentioned in P8, L20.

P10, L4. In addition to these physical processes, iron limitation is another main reason for high macronutrient levels in this region, which should be mentioned here.

P10, L10. Refer to the figure (Fig. 1 c,f,i) at the end of the first sentence.

P10, L22 to P11, L4. This paragraph belongs to the methods section.

P11, L2 to P12 L3. Again this paragraph belongs to the method section. Also, mention what the half-saturation constant is to set to in the model for each nutrient.

P12, L21. I don't think the chlorophyll levels are high for the equatorial Pacific and the Southern Ocean. They may be "relatively" high compared to the surrounding seas, but the absolute magnitudes are low.

P13, L7. I am not sure what it means by "the intermediate concentration regions". Maybe provide a number?

P13, L11. Instead of the International Date Line, refer to the longitude coordinate? Not every reader knows the exact location of the date line. This and the next sentence can be easily identified if the model-obs subplots are provided.

P13, L14. From 1998? Fig. 6 says from 2003.

P13, L25. PAR should be defined earlier in the text, and here just write as PAR.

Figure 6. Caption and the figure text do not match. Please check more carefully. In the caption, b = VGPM, c = Eppley-VGPM, d = CbPM, whereas in the figure, b = VGPM-MODIS, c = CbPM-MODIS, d = Eppley-MODIS.

P14, L25. Here and elsewhere, the term "deviation" is used to refer to the model-obs difference. This is a bit confusing because standard deviations are also used in the later analysis (e.g. P16, L2). Perhaps, use "difference" instead of "deviation".

P15, L10. Again, this is where having the model-obs difference subplot would be helpful to support this sentence.

P16, L9. "due to the 3-dimensional correction . . .", unclear what this means. Add one or two sentences to explain.

P16, L12. Provide a reference for the observation value quoted here.

Table 1. As noted in the caption, the pre-industrial years between NESM v3 and IPCC AR5 differ by 100 years. Does this explain why the IPCC AR5 value is higher than NESM v3 because the former incorporates additional 100 years for the cumulative quantity? Also, in the caption, describe what the plus/minus values represent.

P17, L25. Should this paragraph have its own section? It is beyond oceanic co2 uptake (Sec 3.4).

P18, L21. ", which is associated ... deep ocean," this middle block of sentence is not supported by any figure or reference, and also is unnecessary. It can just be removed and simply be stated as "The reduction of mixed layer depth indicates a more stratified upper ocean ...".

Sec 3.5.1. This section only discusses the results of the FC simulation. Maybe provide some comments on the different simulations (e.g. BC vs RC simulations).

P19, L11. This first paragraph is already mentioned in the previous section, so why repeat here?

P21, L21 to P22, L8. This block of paragraphs belongs to the Method section. Having this much of methodological details in the results section breaks the flow of the paper. Please consider moving it to the Method section.

P22, L16. "Therefore, ..." this sentence is unclear to me. Especially for the carbon-climate parameter, which can be both positive and negative as shown in Figure 16d. Do the authors mean that it is negative in the year 2100?

P23, L3. This paragraph could move into the Method section and be combined with the block of paragraphs describing the sensitivity parameter derivation. Also, "4xCO2" is unclear.

P24, L12. "Our results suggest ..." How does your result support that temperature-

dependence is necessary?

P25, L1. "The strong . . .", but why does NESM v3 overestimate nutrients? The iron limitation is too strong? Too strong vertical mixing? A few speculations can be helpful.

P25, L10. Why do the results of IPSL-CM5A-LR appear here and not in the results section? Also, why choose this particular CMIP ensemble member over others? I don't really see the point of adding the comparison with IPSL-CM5A-LR.

Editorial corrections

P1, L15. "total CO2 uptake" –> Use subscript for "2"

P3, L2. "; 2)" –> "; and 2)"

P3, L4. "the effect of CO2 concentration" –> "the effect of increasing atmospheric CO2 concentration"

P4, L7. Should "NUIST-CSM-2.0.1" be "NESM v3"?

P4, L16 (and elsewhere). Add a space between 10 and m (10 m instead of 10m).

P5, L18-19. ": nanophytoplankton and diatoms," –> "(nanophytoplankton and diatoms)" and similarly for zooplankton.

P5, L22. "photosynthetic" –> "photosynthetically"

P6, L9. POM is already defined in P5, L25.

P6, L9. "diatoms silicate", should this be "biogenic silica"?

P6, L9. "described by . . . corresponding to" –> "is partitioned into"

P12, L2. "when all nutrients . . . than 0.9." –> "when the annual mean nutrient coefficients are greater than 0.9 for all nutrients."

P12, L14. SeaWiFS should be defined in P9, L1. OCCCI was already defined in P9, L2.

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P12, L19. “plankton” –> “phytoplankton”

P14, L23 Add a space between alkalinity and are.

Fig. 7. Superscript for alkalinity units. Also add a space between from and 1985.

P14, L23. Add a space between alkalinity and are.

P15, L9. Add a space between ocean and means.

P16, L2. I don’t think SD has been defined previously. If so, define here.

Figure 10. In the figure, the last subplot is labelled as “c) GLODAP v1”, which should be “d) GLODAP v1”.

P16, L24. “receptively” –> “respectively”.

Figure 12. Caption: “statistical patterns” –> “spatial patterns”(?); “carbon-related” –> “biogeochemical”; “upper ocean” –> “upper 100-m ocean”. Provide the information on observations for nutrients, DIC, and alkalinity, such as done for NPP and chlorophyll.

P18, L3. “to atmospheric” –>“to increasing atmospheric”.

P18, L5-L8. “presented” –> “present” and “compared” –> “compare”.

P18, L20. “and acting to mitigate” –> “and”.

P18, L21. “MLD is seen decreasing” –> “Modeled MLD decreases”.

P18, L24. “is seen in” –> “is projected for”.

Figure 15. In the caption “FC-RC-BC” –> “FC-RC+BC”?

Figure 16. Caption “cumulated” –> “cumulative”. “atmospheric co2 (c) and . . .” –> “(c) atmospheric co2 and (d) . . .”

P21, L25. “. The” –> “, the”. Similarly for P22, L4.

P23, L11. “estimated by CMIP5 models range” –> “estimated for CMIP5 models rang-

ing”

P24, L3. “Mid-Eastern” –> “Eastern”

P24, L14. The numbers quoted in this paragraph is inconsistent with the ones appeared in the Results section. Specifically, year 2016 (should this be 2011? Table 1), 149, 150 +/- 20, and 0.8. Please check these numbers with the Results section.

P24, L20. “nonlinear of “ –> “nonlinear response of oceanic” P25, L16. “precipitation in” –> “precipitation simulated in”

P25, L18. “which would lead” –> “which leads”

P25, L21. “NUIST-CSM”, should this be “NESM v3”?

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