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Geoscientific Model Development Discussions

Interactive comment on "Ocean biogeochemistry in the Norwegian Earth System Model version 2 (NorESM2)" *by* Jerry F. Tjiputra et al.

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General comments:

This paper "Ocean biogeochemistry in the Norwegian Earth System Model version 2 (NorESM2)" is a description and evaluation of the Norwegian Earth system model that participates to the CMIP6 exercise. This kind of paper is extremely useful to the CMIP community that will use and compare the models taking part to the project, and who need to know the different model characteristics, mains results, biases. I appreciate the massive work needed to write this kind of paper, which are not the most exiting to write, but needs to be written. Although the paper would need some more polishing, the results are well described and clearly presented.

The paper mainly describes the improvements made to the model since the previous version used for the CMIP5 exercise, comparing both to observation, and showing that the new version is mainly better the its predecessor. Some difficulties come from this presentation choice as sometime the authors consider that some description being made in the NorESM1 description papers, the reader is assumed to know them. In results, some basic description are almost missing. For example, the ocean grid description of which we only know it is tripolar.

Apart some little corrections of that kind, listed bellow, which should hopefully help to improve the paper, i have one concern about the isotope run. The isotopes are run on an ocean-only run, with a lower resolution grid than the coupled run, and a different atmosphere to force the run. I don't think this run should be used to evaluate the coupled run, unless the authors show that both model DIC steady states are comparable, or mention in the isotope results paragraph that these results are only informative, because from a different run. This needs - at least - to be reminded to the reader. Written as it is, the isotope results are in the middle of historical and esm-hist results. The reader can easily misunderstand and think they all are from the same simulation.

Overall, i have positive feelings about this paper. Most comments are minor like rephrasing or asking for missing details, what should translate in minor revision.

List of specific remarks :

Being not native english speaking, i will not be the best one to correct the English formulation, if needed. Fortunately, from what i have seen, the paper looks well written.

1 Intro

P2 l1 : rephrasing : absorber of heat and the greenhouse gas CO2 to absorber of heat and of the greenhouse gas CO2 or absorber of heat and CO2 greenhouse gas ?? But the one in the paper sounds weird to my ears.

P2 l30 to P3 l3 : Is there an equivalent paper to this one for NorESM1 ? It seems

there is no reference description paper for the version 1 of the model. You list different papers of different development stages, but which one is the one that would describe the version of NorESM1 you use in this paper ?

P3 l3 : "which will contribute to CMIP6". You can probably write it at present tense.

P3 l24-33 : This can not replace having 2 separate runs. Which nutrient does the biology see ? How important could that be within the scenario ? (PI carbonate system evolves with biology that feels high CO2 world, pH,...) probably not important for historical runs. that's a problem we faced within OMIP, and we could not have a definite answer (should run both to be sure...).

P3 l34 to p4 l6 : 2 remarks : you say " The only external source [in NorESM1] is through atmospheric nitrogen fixation" you mean there is no dust (iron/Si/P) deposition in NorESM1 ? from this paragraph it sounds like you only add riverine nutrients, but you talk of dust somewhere else... could you clarify ? Also, what is included in riverine nutrients ? (actually you answer later on - maybe add a "see paragraph 2.4 for details")

2 Model changes and improvements

2.1 : you give several details in this paragraph but we miss some details of the ocean grid, like the basic ones: resolution, number of vertical levels,...

p7 l4-7 : i don't understand what you explain there to get the riverine fluxes of DOC and POC, maybe you could try to make it clearer ?

P9 paragraph 2.9 – So aerial dust deposition was already in NorESM1 - don't forget to add it P3.

P9 l11 - typo : strength *of* this

3 New tracers

P10 l12 : "during the spin-up" might be misleading. Maybe "for the spin-up" or "to start the spin-up" or just "initialized to zero" might be enough.

P12 l14 : "... and CaCO3 formation, but the latter is neglected in our implementation". Why ? any idea of the impact ?

P14 l24 to P15 l2 : The method to initialize the C isotopes is very clever, and must save a lot of computing time. But i wonder the impact of initializing them this way. Don't you introduce bias compare to a proper model integration? Do you note drifts in the isotopes concentration during the historical period ?

4 Model simulations

P15 l19-23 : might need a bit of rephrasing here. explanation about (3) are a bit confusing. i would suggest to call it emission-driven simulation as (1) and (2) are also "esm" runs. Or if you absolutely want to call it esm-... explain straight what it is like " (3) esm-experiments, the atmospheric CO2 is prognosticaly computed from ocean-atmosphere and land-atmosphere CO2 -fluxes, as well as from prescribed anthropogenic emissions (for the historical period). (3) is composed of a esm-piControl-spinup simulation (100 model years) which is then branched off into (3a) an esm-piControl simulation (for 250 years), and (3b) a transient esm-hist (years 1850-2014) simulation." But calling this experiment "esm" is confusing for the reader.

P15 l30 : "The atmospheric forcing of the spin-up is the CORE normal year forcing (Large and Yeager, 2004), which represents a climatological mean year with a smooth transition between end and start of the year" Why did you use the CORE climatology ? that's a surprising choice, it removes all substantial link between your C-isotope/ocean-only run and the esm. Using CORE remove all potential isotope insights on the esm runs... there are other ways that could provide this insight possibility: you could extract atm fields from the end of the spin-up and use them as forcing field for this experiment, for example. Using CORE, the ocean dynamics will be different from the coupled, the spin-up steady state will have nothing to do with the esm's steady state. Already changing the ocean resolution affect the dynamic, but resolution plus forcing completely change the ocean. I don't think you can use the isotopes to evaluate the esm run with

such a different set-up.

P15 l30 : Subsequent question concerning the isotope run. What happens after the spin-up ? Is there anything special to run the historical period ? Do you change the atm forcing field (i really wished you used atmospheric fields extracted from the coupled historical run)? or do you simply follow the historical atmospheric CO2 records for the last $\sim$150years ?

5 Results

5.3 Salinity - P17 - no ref to Fig. 4

5.6 Nutrients - P18 - No ref to Fig. 7 and 9 The fig 2 is understandably well discussed as it is a very instructive figure, but all following figures are almost forgotten, and sometimes not introduced at all.

P19 l3 - if you refer to NorESM1, you should point to fig 8h and 8i

5.7 Dissolved oxygen - P19 - No ref to Fig. 11 .

P19 l21 - Fig. 9 is the silicic acid ; AOU is Fig. 12

5.12 - P22 : The Analysis done here are really great, but coming from a stand alone run forced with a different forcing field, these results do not inform about the main NorESM2 MM and LM runs i am afraid.

5.12 and 5.13 - double-check the figure order, you switched both section figures .

6 Figures

Fig.1 some features are missing. For instance the riverine inputs (with the different materials they contain). Also the silicic acid is missing.

Fig. 10 : The modeled Diatoms are never Si limited ? You say biological productivity, how is that done ? as both phyto are not necessarily limited by the same nutrient. Might be good to say 2 words in the figure caption about how you calculate that.

Fig. 13 : I have difficulties to realize what's going on with contours superposed to colormaps and showing different things. It is OK-ish on vertical sections, but on global horizontal maps it is difficult to appreciate the differences, and spot what we should see. it is not straight forward. could you add a colored pictures for NorESM1 so it is not superposed as contour, for fig 13, 15, 18. I would ask to do that for all fig of that kind, but that would mean almost all pictures... i really find it difficult to interpret that way. it save space, but doesn't make it simpler for the reader, i think.

Fig 14. and all alike : what is the difference between the solid red and dotted red lines ? i guess the dotted one is NorESM-LM but it is not written in the caption. you probably can remove the dotted line as there is no reference to it at all.

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