Comment on gmd-2021-361

Timothée Bourgeois (Referee)

Referee comment on "FOCI-MOPS v1 – integration of marine biogeochemistry within the Flexible Ocean and Climate Infrastructure version 1 (FOCI 1) Earth system model" by Chia-Te Chien et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-361-RC2, 2022

General comments:

In their study, Chien et al. present the results of the integration of the marine biogeochemistry model "Model of Oceanic Pelagic Stoichiometry" (MOPS) into the Earth system model "Flexible Ocean and Climate Infrastructure" (FOCI). A sufficient description of MOPS is given along with the references formerly presenting the two models. The simulated biogeochemical tracers and fluxes as well as their response to increasing atmospheric CO2 are extensively evaluated using observation-based datasets, models, and multiple statistical metrics. The manuscript is well written, well structured, well illustrated, and fits the scope of the GMD journal. FOCI-MOPS is a valuable input to the collection of already existing Earth system models including marine biogeochemistry. It will contribute to the model diversity of future climate model intercomparison projects.

Specific comments:

The 3-member ensemble approach using varying initial conditions is very valuable, but the ensemble variability is barely presented and not discussed at all despite the promise done line 51. The resulting variability should be discussed, not only for tracers, but also for fluxes regarding to their spatial distribution, seasonality, globally-integrated values and their response to increasing CO2. The standard deviation of the ensemble mean (std) should be given with ensemble mean values. The resulting std should also be illustrated in figures using ensemble mean values.

Several model weaknesses are identified such as sluggish ventilation of deep waters, too long remineralisation timescale, excessive remineralisation, excessive denitrification and shortcomings due to the absence of iron limitation. It would be interesting to inform the reader of any future development plans providing solutions to these model weaknesses.

Minor comments:

L28: For a comprehensive

L32: feedbacks and variations

L45: "MOPS has the advantage that its biogeochemical parameters have been calibrated": isn't it supposed to be the case for all models?

L76: "e-folding length scale"?

L82-84: suggest rephrasing the sentence "Together with…" in 2 sentences.

L85: "matter. If"

L87-88: "Water column denitrification occurs during anaerobic remineralisation" is already stated 2 sentences before: "if oxygen falls below a threshold, denitrification sets in". Suggest merging the 2 explanations.

L88: "remineralisation and leads"

L103: "computing time for FOCI-MOPS increases 26% compared to a physics-only FOCI version": a comparison with other models would be welcome since the computational efficiency of this model is argued as an advantage in the introduction (L44).

L106: What is the "Estimating the Circulation and Climate of the Ocean (ECCO)"? A model, an observation dataset, a reanalysis dataset?

L127: Why did you use the 480th year of the FOCI-MOPS spin-up instead of the 500th to initialize the ESM-spinup?

Recommend ensuring that the full spin-up outputs are provided in the Data availability section following Séférian et al. (2016).

L150: "The loss of O2 indicates that, in the model,"

L162-163, L165-166, L183-184, L321-322: Theses sentences seems unnecessary. More engaging prose (like the one in L196-197) would be to use the points you make (like the one in L166-168) and then link it to the figure(s), e.g., "(Fig. 3)", instead of sentences like "X is shown in Fig. Y."

L201: Duteil et al. (2012)

L304: "2000 m depth"

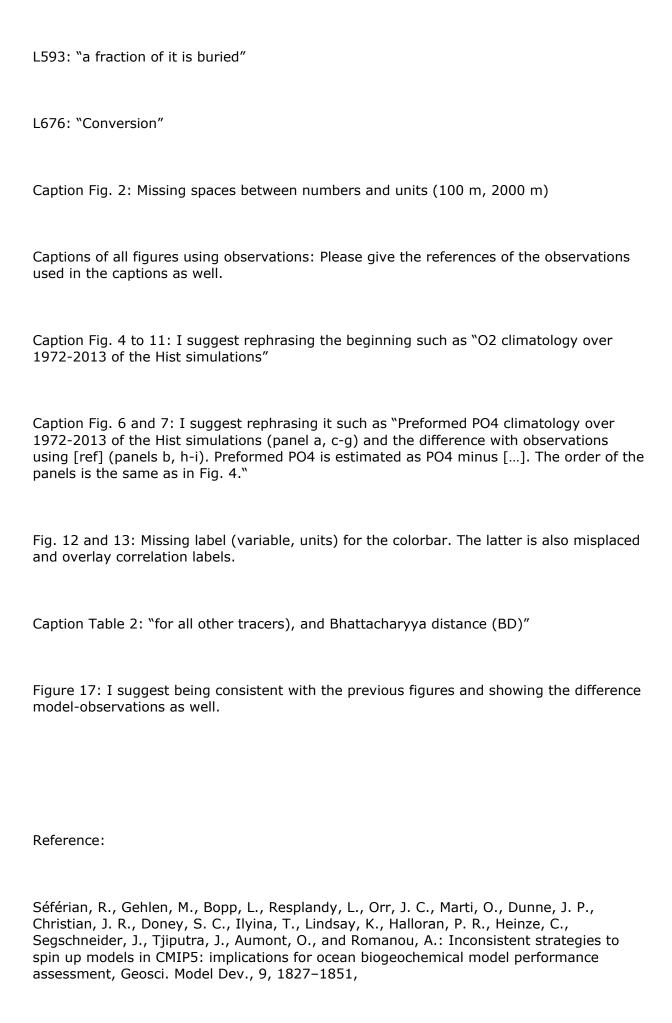L316-317: Explanation on the reasons why such mismatches occur are welcome.

L436: It does not seem to be dimensionless.

L464: Symbol "a" is already used in L438.

L575: "carried as active tracers"

L581: "Orr et al. (1999)"

L590: "in Weiss (1974))."

L593: "a fraction of it is buried"

L676: "Conversion"

Caption Fig. 2: Missing spaces between numbers and units (100 m, 2000 m)

Captions of all figures using observations: Please give the references of the observations used in the captions as well.

Caption Fig. 4 to 11: I suggest rephrasing the beginning such as "O2 climatology over 1972-2013 of the Hist simulations"

Caption Fig. 6 and 7: I suggest rephrasing it such as "Preformed PO4 climatology over 1972-2013 of the Hist simulations (panel a, c-g) and the difference with observations using [ref] (panels b, h-i). Preformed PO4 is estimated as PO4 minus […]. The order of the panels is the same as in Fig. 4."

Fig. 12 and 13: Missing label (variable, units) for the colorbar. The latter is also misplaced and overlay correlation labels.

Caption Table 2: "for all other tracers), and Bhattacharyya distance (BD)"

Figure 17: I suggest being consistent with the previous figures and showing the difference model-observations as well.

Reference:

Séférian, R., Gehlen, M., Bopp, L., Resplandy, L., Orr, J. C., Marti, O., Dunne, J. P., Christian, J. R., Doney, S. C., Ilyina, T., Lindsay, K., Halloran, P. R., Heinze, C., Segschneider, J., Tjiputra, J., Aumont, O., and Romanou, A.: Inconsistent strategies to spin up models in CMIP5: implications for ocean biogeochemical model performance assessment, Geosci. Model Dev., 9, 1827–1851,

https://doi.org/10.5194/gmd-9-1827-2016, 2016.