

Geosci. Model Dev. Discuss., referee comment RC3  
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## **Comment on gmd-2021-327**

Anh Pham (Referee)

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Referee comment on "Ocean biogeochemistry in the Canadian Earth System Model version 5.0.3: CanESM5 and CanESM5-CanOE" by James R. Christian et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-327-RC3>, 2021

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### **Summary**

The submitted manuscript by Christian and colleagues presents some major developments of the marine biogeochemistry component of the Canadian Earth System Model(s) v.5, focusing on representing a prognostic iron cycle and denitrification and including flexible phytoplankton elemental ratios and interactions between multiple food chains. These improvements are described in details and results of the Canadian Earth System model version (CanESM5-CanOE), which includes this newly improved marine biogeochemistry component, are presented and compared with results from two other CanESM versions (CanESM5- CMOC and CanESM2). While CanESM5-CMOC differs from CanESM5-CanOE in its ocean biogeochemistry component, CanESM2 is the older CanESM version, having different ocean circulation. The results show that CanESM5 versions are much better than CanESM2 when compared with available observations thanks to improvement in ocean circulation. The improvements in performance of CanESM5-CanOE over CanESM5- CMOC are not as clear due to sparsity in observations and uncertainties in historical trends. However, the inclusion of prognostic schemes for ocean Fe cycling and denitrification would be more suitable to address climate change problems.

### **Assessment**

In general, I think that this manuscript is suitable for publication in Geoscientific Model Development, serving as a documentation on the development of an important model member of Earth System Models participating in CMIP. However, I do have some comments and suggestions, which hopefully can improve the quality of the manuscript.

First, while I understand that the main purpose of this manuscript is to describe recent developments in the ocean biogeochemistry component of the CanESM and to compare performance of its different versions, having more explanations as to why there are improvements of CanESM5-CanOE over CanESM5-CMOC in some areas but not all would be helpful. In addition, given that the comparison is performed also with CanESM2, which uses different ocean circulation, I would expect more discussions on which improvements of CanESM5 over CanESM2 are due to physics and which are due to biogeochemistry.

Second, I find the naming convention throughout the manuscript is somewhat confusing since there are three model versions involved in the comparison, of which two are under the CanESM5 umbrella. Sometimes it is difficult to figure out which model version of the CanESM5 that the authors are referring to. In some places, the authors explicitly wrote CanESM5-CanOE and CanESM5-CMOC, but in others, they wrote only CanESM5 or just CanOE and CMOC. It would be better if the authors could keep the naming consistent throughout the manuscript.

Third, since the model developments focus on Fe and N cycles, I was thinking that the authors should do a more comprehensive comparison of the modeled Fe distribution with observations, taking advantage of the growing GEOTRACES data. I understand that there is no climatological Fe dataset yet, but comparison with observed Fe transects from GEOTRACES should give an indication of the model performance on ocean Fe cycling.

Fourth, while export production is an important biogeochemistry feature, using it as a metric to evaluate model performance is difficult because of the uncertainty in the observational estimates, as the authors already pointed out. Primary production/chlorophyll might be a better metric.

Finally, since the historical trends section forms an important part of the manuscript, I would suggest the authors give more details on how the historical model runs are performed (i.e., which CO<sub>2</sub> and atmospheric forcings are used...), how the results are analyzed, and why analyzing and comparing model historical trends is important.

Some specific comments:

Line 27: some areas? Which areas? Please be more specific if possible.

Line 30-32: Which CanESM version that shows these results?

Line 127-128: Do you mean CanESM5 uses the same carbon chemistry as CanESM2?

Line 500: Change can not to cannot.

Line 608-609: Which model version are you referring to here?

Line 648-650: it might be worth to mention the difference between CanESM2 and CanESM5 in the nitrate initialization field earlier in the text. Introduction or section 2, for example.

Thank you so much for including me in the reviewing process.

Best,

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