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Interactive comment on “Optimality-Based Non-Redfield Plankton-Ecosystem Model (OPEMv1.0) in the UVic-ESCM 2.9. Part II: Sensitivity Analysis and Model Calibration” *by* Chia-Te Chien et al.

Anonymous Referee #2

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This paper aims to optimize and calibrate important parameters used in the lower trophic marine ecosystem component of UVic-ESM and is a companion paper to the model description paper (Pahlow et al., 2019). In this study, authors set up cost functions to minimize the misfit between model outputs and observations for nitrate, phosphate, dissolved oxygen, and surface chlorophyll-a. Of the 13 parameters they have chosen to calibrate, the subsistence N quota of phytoplankton and remineralization rate have the highest sensitivity.

Overall, the paper is nicely written and organized. Optimization schemes are well described and the parameters are calibrated rigorously. However, I do have some important points that need to be clarified before I am ready to recommend publications of this paper in the GMD.

General Comments:

1. What is the "best" model choice? The authors state in line 7 – "For identifying the "best" model we therefore also consider… water-column denitrification". I was not ultimately clear after reading this paper, what the "best" model choice is. Is it OPEM/OPEM-H with the lowest overall total cost function or "trade-off" model which does not necessarily have the lowest cost function (7th best) but does best at representing N cycle? I may have missed this but if water-column denitrification and N2 fixation are indeed very important, why did you not include these in your cost function?

2. What is the selling point of this "optimized" flexible C:N:P model? Authors state that most NPZD models do not adequately describe the behavior of plankton physiology such as non-Redfieldian plankton stoichiometry. However, outside the UVic framework, there are quite a few ESMs in the market already with flexible C:N:P including those in CMIP5 (see Bopp et al., 2013) and CMIP6 (see Arora et al., 2019). There are also some studies that utilize Pahlow's phytoplankton model (Kwiatkowski et al., 2018, 2019). My question then is what is the selling point of this model over other existing models out there? Is it the computational efficiency and how useful is this model for studying climatic conditions such as the last glacial maximum or future projections (lines 39)? I think some discussions on model comparisons would be useful.

3. How sensitive is "sensitive"? Authors discuss the sensitivity of each parameter in Section 3.1 but one thing I find problematic is that all the graphs in Figure 1 – 3 have different y-scale increments. Since sensitivity is non-dimensional, they should ideally all have the same axis for a fair comparison since authors frequently say things like "Sensitivity of XXX is low" (e.g., line 196) or "No single parameter dominates sensitivity" (line 217). Although such rigorous statistical treatments may not be expected for this

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kind of modeling work, I want some general clarifications on how authors interpreted whether something is very sensitive or not.

4. The highest sensitivity of C:N over C:P and N:P? Regarding the sensitivity, I was quite surprised looking at Figure 3 that C:N has much larger sensitivity compared to C:P and N:P. The current understanding in the scientific community is that C:N is more homeostatic compared to C(N):P for autotrophs, heterotrophs, and for detritus (Galbraith and Martiny, 2015; Geider and La Roche, 2002; Martiny et al., 2013; Sterner and Elser, 2002). Looking at the companion paper by Pahlow et al. (2019), steady-state C:N also seems to overestimate observation (Table 3 and Figure 7). I think this is an important point to address given that C:N (and therefore QoN) affects all aspects of the model output and that the whole point of this model is incorporating flexible C:N:P.

Specific comments:

Equations: Diazotrophy rate increases indefinitely with temperature with this formulation. But the growth rate of diazotrophs should hit the limit at some optimal value (e,g., 28 degrees Celsius for Trichodesmium; Breitbarth, E., A. Oschlies, and J. LaRoche (2007), Physiological constraints on the global distribution of Trichodesmium-effect of temperature on diazotrophy, Biogeosciences (BG), 4(1), 53–61). What is the justification of this temperature formulation? I feel like Eppley (1972) is not quite up to date.

Line 85: The temperature dependence of nitrogenase activity in the terrestrial system was used. Are there not any data from marine ecosystem literature?

Table 1: How are the “Range” chosen for these parameters?

Table 2: Maybe it would be nice to have some “target” values for comparison from WOA 2013 or other datasets.

Line 202: What are the sinks for DFe?

Figure 2: Phytoplankton (1st column) and diazotrophs (2nd column) have different y-axis range. For a fair comparison, they should have the same y range (at least for the

same given row).

Line 246: “their biomass is higher”. What is “biomass”? Is it C quota or C+N+P or Chl? I do not see “biomass” in Figure 2.

Line 254-257: The logical behind explaining C:P pattern is not clear. Why does NO3:PO4 supply stoichiometry only affect low latitudes? Why that fact P-limitation is not present in S. Ocean explain the negative correlation between C:P and QoN?

L282: The description of “trade-off solutions”. I went to Pahlow et al. (2019) but I could not easily locate where the discussion is. Could you direct me specifically to where it is?

Figures 6 and 7: What does “low nitrate” and “high nitrate” mean? I may have missed it but are they different model configurations or are they taken from different oceanographic regions?

Also Figures 6 and 7: It would be nice to have a zonal average from WOA 2013 for comparison.

Line 381: N:P of diazotrophs is critically important for determining the outcome of competition between diazotrophs and non-diazotrophs so it should be discussed in more depths here (e.g., Weber and Deutsch, 2012).

Line 407: I think authors should also mention the fact that physical component/ocean circulation is very important for the global distribution of oxygen and nitrate.

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