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Biogeosciences Discussions

Interactive comment on "Unique role of jellyfish in the plankton ecosystem revealed using a global ocean biogeochemical model" *by* Rebecca Mary Wright et al.

Anonymous Referee #1

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General Comments

The paper addressed relevant scientific questions within the scope of Biogeosciences by examining marine biogeochemistry and planktonic ecosystem function. It presents a novel global model of ocean physics and biogeochemistry that adds a jellyfish plankton functional type (PFT) to the typically represented phytoplankton and crustacean zooplankton. Additionally, its use of 11 PFTs resolves the planktonic ecosystem more finely than most coupled physical-biogeochemical ocean models. The scientific methods and assumptions of the paper are valid but need to be more clearly outlined. Specifically, all new parameter values must be given to allow reproduction (traceability

of results). The results are sufficient to support the authors' interpretations and conclusions, but neither the results nor their interpretations/conclusions are very substantial. Similarly, the Tables and Figures illustrate the results well, but lack some of the detailed methodology and analysis. The title reflects the contents of the paper, though "unique" may not be the most accurate word and requires substantiation. Overall, the paper is well-structured with a clear flow. With a deeper analysis and discussion of mechanisms, this paper would be an unparalleled contribution ocean biogeochemical modeling.

Specific Comments

1.

The words "unique" and "role" are vague in the title and not well defined throughout the paper.

1a. "Unique" may not be the most accurate word. Other organisms could play a similar ecological role as jellyfish as predators on and competitors with macrozooplankton. For example, fish larvae, squids, and benthic filter feeders. If the authors wish to use this term they should substantiate the uniqueness of the jellyfish role in the Discussion. I have the same issue with its use in the abstract.

1b. L91-92: Vague what is meant by the "role of jellyfish." What quantitative metrics are used to assess this?

2.

Lacking sufficient methodological detail for reproducibility.

2a. L86-89: If the macrozooplankton only represent crustaceans here, then they should not eat picoplankton. The salps and pteropods that were included in the group as described in Le Quéré et al. (2016) can do this, but euphausiids do not.

2b. L103-104: This is not true; many parameters have been modified. e.g. L260-266.

2c. L129-143: Please mention here that the $g_{F_k}^{Z_j}$ term is a temperature-dependent Michaelis-Menten form that includes the prey preference and a half saturation coefficient. Otherwise, please provide the full equations.

2d. Eq 1: The authors mention in the Introduction that jellyfish are part of the biological pump and may be a significant vector for carbon export. How does the jellyfish PFT contribute to the 3 detrital pools? Are the parameters the same as or different than the other zooplankton groups?

2e. L165-166: What is the GGE value for the jellyfish?

2f. L181-183 and Table 3: The preferences are a ratio of what to what? What are the numerator and denominator? It is unclear how preference enters into the grazing equation and how preferences can be greater than one. I had to refer back to the Le Quéré et al. 2016 paper (LQ16). I think that this information is essential and the reader should not have to look at the original paper.

2g. L259-260: These new parameters should be given for transparency and reproducibility. A table in the Appendix would be acceptable.

2h. L279-290: This description lacks some necessary details. For example, it says that PlankTOM10 is the same as PlankTOM11 except that the top predator mortality terms for mesozooplankton and macrozooplankton were returned to pre-jellyfish values. One, I assume that pre-jellyfish values are those from Le Quéré et al. 2016 (but Table 5 does not support this). Two, did the mesozooplankton respiration rate also return to pre-jellyfish values? (Yes, as evidenced in Table 5, but not mentioned in the text) Three, all of the changes to phytoplankton and bacteria made to PlankTOM11 remained? Does PlankTOM10.5 just have two identical macrozooplankton groups? I would suggest a table that outlines the differences between all 3 simulations. The authors attempted to do this with Table 5, but it lacks a column for PlankTOM10.5 and there are discrepancies between the text here and the values in the table. If PlankTOM10 mortality rates were returned to pre-jellyfish values, then why are there different MAC mortality rates for PlankTOM10 (LQ16) and PlankTOM10 (this study) in the table? And are macrozooplankton mortality and mesozooplankton respiration the only 2 parameters that varied across the 3 simulations?

2i. Table 4: Please show all parameters for jellyfish and macrozooplankton. e.g. grazing rate temperature-dependence, half saturation coefficients, MGE, GGE, etc.

2j. Table 6: What is adapted from Le Quéré et al. 2016? Is the PlankTOM10 in this table PlankTOM10-LQ16 or PlankTOM10-here? That needs to be noted in the table caption.

2k. Figure 8: The black boxes that denote the North, Tropic, and South regions used in Figures 4 and 9 are only in the Pacific. If this analysis was only carried out for the Pacific, then that should be mentioned in the main text as well.

3.

The analysis is rather superficial. It only described changes in plankton biomasses. I expected Section 3.3 to also compare differences in net primary production, carbon export, nutrient cycling, etc. with and without jellyfish. More detail should be given on how rates and fluxes change across the three simulations as well as on the mechanisms and processes involved. e.g. What are the grazing mortality rates of each PFT by each predator with and without jellyfish? How does the productivity of each PFT change? What are the flows of mass/energy from one PFT to another in the three simulations? These types of analyses would better elucidate food web structure and function with and without jellyfish.

3a. L421-422: Why merely suggest that the decrease in predation of protozooplankton by macrozooplankton may be compensated for by the increase in predation by jellyfish? Why not use the model output to verify this? This is one example of how this manuscript would be improved by a more thorough analysis. For example, the mortality of each PFT could be partitioned by each grazer in the 3 simulations.

3b. L389-395: The partitioning of phytoplankton biomass by PFT differs between the PlankTOM11 and observations. Is the PlankTOM10 in Table 6 PlankTOM10-LQ16 or PlankTOM10-here? Was the partitioning of different phytoplankton PFTs in PlankTOM10-LQ16 the same as here with PlankTOM11? Or did the partitioning change? If it stayed the same, it suggests that the jellyfish had no effect on phyto-

plankton community composition. If it changed, did it become more or less aligned with observations and how did the jellyfish affect it?

3c. L413-414: It is very unclear why the biomass of macrozooplankton drops from PlankTOM10-here to PlankTOM10.5 and this needs to be described in further detail. As far as I can tell, PlankTOM10-here and PlankTOM10.5 are nearly identical, except that macrozooplankton mortality and mesozooplankton respiration are lower in PlankTOM10.5 and there are two identical macrozooplankton groups. Without any parameter changes, I expect the sum of the two macrozooplankton groups in PlankTOM10.5 to equal the biomass of the macrozooplankton in PlankTOM10-here. But the decrease in macrozooplankton mortality would lead me to expect an increase in macrozooplankton biomass in PlankTOM10.5. Why does it decrease? Did the drop in mesozooplankton respiration allow them to outcompete macrozooplankton for shared resources? And what accounts for the change in latitudinal distribution of the mesozooplankton and macrozooplankton in PlankTOM10.5?

3d. The Discussion does a thorough job addressing the assumptions and limitations of the model. However, it is lacking a section that describes the hypothesized mechanisms involved in the differences between PlankTOM10-LQ16, PlankTOM10-here, PlankTOM10.5, and PlankTOM11.

3e. The Discussion also lacks a section on how the lower temperature sensitivity of jellyfish (lower Q_{10}) compared to macrozooplankton might affect spatial distributions and how this is balanced or offset by disparities in their respiration and mortality rates.

3f. L509-511: More detail should be added here to describe where regionally, when seasonally, and which phytoplankton PFTs.

4.

The model really only characterizes the pelagic phase of the complex jellyfish life cycle. The authors cited much variability in this life cycle, but do not provide enough information on how representative this model is without the life cycle and dependence on benthic substrate? Some useful details include how much time is spent the pelagic medusa stage and how much biomass is present in this stage in comparison to the other stages.

Other scientific questions/issues:

L152-155: Please add a statistical skill metric for the exponential fit and the 3-parameter fit to observations so that the reader may compare. Showing both in Figure 2 for the jellyfish could also help support the claim that the exponential fit is poor.

L228: How was the adjusted mortality of $\mu = 0.12$ chosen from the sensitivity analysis? What skill metric was used?

L251-254: Jellyfish had a higher preference for protists than microzooplankton. Why were changes unnecessary for the protist parameters?

L272: Why was 1948 not used for spin-up, since this would be the start year of meteorological forcing. Couldn't using 1980 to spin-up induce a shock to the system at 1948 that would then need to stabilize?

L307-308: Why were the MAREDAT observations binned to a different grid as the model? Why not use the same grid?

L338: Please add a global map of observations for visual comparison.

L348-349: Why not use the same type of mean to compare? Or if the authors are concerned about the underrepresentation of zeros in the observations, why not use the mean that is best for describing that type of distribution?

L352-361: This paragraph is missing a sentence that notes where the model disagrees with observations spatially. There is a prominent difference out the outer shelf of the Eastern Bering Sea where the model predicts some of the highest biomasses while observations show some of the lowest biomasses. A potential explanation for this discrepancy should also be added here or in the Discussion as appropriate. (Here if it is local to Alaska, in the Discussion if it is applicable to the model as a whole.)

L376-379: Is this ratio standard for validating model chlorophyll? i.e. Is it a meaningful metric?

L387: This underestimate of primary production by 10 PgC/y seems rather large. How does it compare to the Le Quéré et al. 2016 model and other biogeochemical models?

L395-398: These statements could be supported by mentioning that the light affinity and nutrient uptake parameters of mixed phytoplankton and Coccolithophores are very similar to those of picophytoplankton, with the exception of Fe uptake.

L406-407: But jellyfish have a much higher preferences for mesozooplankton and protozooplankton than macrozooplankton. How does this affect the results?

L432-433: This line is too vague. What was the largest direct influence of jellyfish? Predation? Competition? If competition, for which resources?

L434-437: Is a double peak in northern hemisphere phytoplankton seasonal biomass consistent with observations? Is the amplification more or less similar to observations? Is one of the simulations (PlankTOM10-LQ16, PlankTOM10-here, PlankTOM10.5, PlankTOM11) more similar to observations?

L486-488: The jellyfish may not need a coastal advantage, but a deep-water disadvantage, since their benthic polyps are filter feeders and dependent on pelagic plankton.

Figure 2: Using the same y-axis scale for all subplots hides the fit with observations for FIX, MAC, and JEL. Also, an R^2 and/or p-value for the fit would be appreciated.

Figure 4: Could observations of the observed PFT biomasses from MAREDAT be added to this plot similar to observed chlorophyll?

Figures 5, 6, 7, 8: I recommend a colormap that is perceptually ordered for spatial distributions. See cmocean, colorbrewer, and colormoves for examples.

Figure 7: The cyan color used in the time series is very difficult to see. Use a darker color or a dashed black line.

Figures 10, 11: I would not refer to the 2nd macrozooplankton group of PlankTOM10.5 as jellyfish in these figures. Instead, the biomass of the 2 macrozooplankton groups should be summed together and displayed that way. Keeping them distinct is misrepresentative.

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