

Interactive comment on “Variable phytoplankton size distributions reduce the sensitivity of global export flux to climate change” by Shirley W. Leung et al.

Anonymous Referee #1

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Review of Leung et al. “ Variable phytoplankton size distributions reduce the sensitivity of global export flux to climate change”

This manuscript examines the influence of incorporating information on phytoplankton size into a biogeochemical model alters predicted carbon export in response to climate change. The overall result that the influence of climate change is damped by incorporating size information is intriguing and worthy of publication. Generally, the manuscript is clear and well-written., and represents a useful addition to the literature.

Abstract: Line 20: the altered export values are reported without any reference to what the baseline simulation is, i.e. report what is the predicted decline in export without

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the size considerations, and what is it with the size included Line 22: “more robust predictions” – How do you know these predictions are more robust than the baseline? There is no model validation presented (which I don't mind for this manuscript, but “more robust” can't be asserted in this case).

Introduction: Line 41: how do the models cited here handle size or sinking speed (if they do at all)? i.e. do these models also already include a size-based parameterisation which means that the predictions are \sim equivalent to yours? Line 86-87: a fundamental assumption in this study is that small phytoplankton = small particles. A critical assessment from observational data of whether this is true, and when this assumption might break down, should be included. For example, how might TEP production or fragmentation affect the size structure of particles? Line 91-92: references needed for the assertion that small picophytoplankton = small particles, and same for large. Line 97: there's a dawning realisation that Stokes law rarely holds for marine particles e.g. <https://aslopubs.onlinelibrary.wiley.com/doi/abs/10.1002/lno.11388> This should be acknowledged here. Line 127: but wouldn't a shift to smaller particles also result in less C sequestration at depth as the C just goes round and round in the upper mesopelagic being readily recycled and re-entrained to surface? Also, Figure 2d – the caption acknowledges that smaller particles leads to greater recycled nutrient supply. This wouldn't increase C sequestration (or CO₂ drawdown) as that depends on the re-supply of preformed nutrients which isn't affected by the size considerations used here, at least on the timescales considered.

Methods: Line 217: just curious to know why Laws and Dunne estimates of export ratio, rather than others such as Henson et al. 2012 or Siegel et al. 2014 were used Line 227: I couldn't find where the in situ observations mentioned here had come from Line 238-240: is temporal autocorrelation accounted for here? I guess the seasonal cycle in beta and En are similar which will affect the linear regression. Also, are beta and En independent? How are pixels/regions with non statistically significant regressions dealt with? Line 266: in reality I suspect $\frac{d\beta}{\beta} / \frac{dE_n}{E_n}$ could vary seasonally. Might be

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worth a caveat on that point in the discussion? Actually, I suspect that some of the strange behaviour in the SAZ might be due to a seasonal effect or a time lag between changes in phytoplankton size and particle export. It would be helpful to the reader to include some example annual time series of a region showing the PP, export and beta to illustrate how they interact. It would also inform on potential time lags between PP, export and beta.

Results and Discussion: A point that should be acknowledged somewhere is that the results presented here are of course still dependent on the details of the model parameterisation and choices. Line 301-303: references needed here Line 322: isn't this 21% rather than 18%? I found the use of the word "visually" here and on line 307 confusing. It made me think that you had estimated the values by eye rather than calculating them. I suggest just dropping 'visually'. Line 346: some C:P ratio must be used here too? Couldn't find where that was mentioned. Does this formulation also assume that all nutrients supplied are regenerated? I think it assumes that all nutrients supplied are turned into PP (which is fine in nutrient limited regions), and then are all exported i.e. and e-ratio of 1? Line 376-378: I'm not sure this "visually" statement helps the reader's understanding here Line 415-426: specify the direction of +ve/-ve changes in the caption. At the moment it's a bit confusing as +ve indicates a reduction

Figure 1a: specify in the caption that higher beta values = smaller plankton (or mark with arrows on the colour bar) Figure 6a: rather than having the right y-axis in $\text{remin depth} \times 100$, just write out the numbers in full – it's clearer Figure S1: specify in the caption or legend that higher beta values = smaller plankton Figure S2: add the key to the PP and e-ratio model abbreviations into the caption here Table S1: Define the parameter names in this table.

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