

## ***Interactive comment on “Light absorption by marine cyanobacteria affects tropical climate mean state and variability” by Hanna Paulsen et al.***

**Anonymous Referee #1**

Received and published: 11 October 2018

Summary: This manuscript presents a sensitivity study of the effects of including a biophysical feedback of general phytoplankton and cyanobacteria light attenuation in an earth system model. With respect to cyanobacteria, the authors find a significant effect on tropical general circulation that opposes the prevailing understanding based on observations and regional modelling. Biophysical feedbacks are typically ignored in ocean modelling, thus this manuscript advances our understanding of potential deficits in the state of the science. The science is of a high quality and is suitable for publication in ESD. The language needs editing but I have no major concerns about this study.

General Comments:

The positive buoyancy of cyanobacteria in the model is novel, as far as I am aware, and deserves more discussion. If a high concentration of cyanobacteria warms the

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local water (or produces a cooling via advection), this should also change the surface density. I assume the cyanobacteria buoyancy then adjusts, but are there upper or lower limits to this? If limits are imposed, is there an implication for the model results?

Specific Comments:

Abstract: Please add a sentence explaining the reason for the apparent disagreement between your model results (cooling effect) and observations (heating effect).

Page 2, line 14-16. Not quite true, see Dutkiewicz et al. (2015) Biogeosciences and references contained within. I'm not sure how many of these include bio-physical feedback however.

Page 18 line 16. The model has short time steps. Does it produce temporary local heating? And please mention whether there has been observed subsurface cooling associated with the localized warming.

Technical Corrections:

Abstract line 4: remove "as of yet".

Abstract line 5: Please specify whether these previous studies are model studies or observation-based.

Abstract lines 10-11: This sentence is awkward. I recommend removing "the specific phytoplankton group of" to make the subject more clear.

Abstract line 12: remove "the" from before "phytoplankton-dependent"

Page 2 line 2-3: remove either "over" or "up to", and change to: "several million square kilometres"

Page 2 line 13: remove "indeed"

Page 2 line 14: "at the best" should be "or at best"

Page 2 line 19: edit to "to particularly affect", and insert the relevant regions associated

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with each study for clarity.

Page 2 line 22: insert a comma after "circulation"

Page 2 line 23: remove "identified to be relevant"

Page 2 line 24: insert "also" before "play" and remove extra "e" in "globale"

Page 2 lines 27-28: insert commas after "cyanobacteria" and "phytoplankton"

Page 2 line 29: insert comma after "phytoplankton" and "the" after "address"

Page 2 lines 29-33: Please add numbers to the questions to separate them more clearly. The first 2 questions should be made more specific. Question 4: "What are the positive/negative..."

Page 3 line 18: So there is a single shortwave radiation value at each latitude per day? This should be made clearer.

Page 3 line 22: remove "which"

Page 3 line 23: insert "and" before "includes"

Page 3 line 24: remove "the compartments" and parentheses

Page 3 line 25: add "two" and remove the contents of the parentheses- this is repeated in the next paragraph.

Page 3 line 31-32. This sentence is repetitive and not needed.

Page 3 line 32: remove "and, on the other hand," and replace with "but can also". The next sentence is also repetitive and not needed.

Page 4 line 1: What other models include positive buoyancy in some phytoplankton types? This should be addressed by one sentence in the Introduction.

Page 4 Equation 1: There is no light attenuation by sea ice? Are the parameter values also adopted from Zielinski et al (2002) or were they tuned for MPI-ESM according to

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some criteria?

Page 5 Table 1 and line 12: replace "set to" in PHY\_ONLY with "made"

Page 6 line 1: "contents" should be singular

Page 6 line 11: remove "anymore"

Page 6 line 12: commas after "cyanobacteria" and "phytoplankton"

Page 6 line 14: "consulted" is the wrong word. Perhaps "... years and represents an estimate of the internal..."

Page 6 line 20: "optimum temperature" for what?

Page 6 line 25: replace "thereby" with "therefore"

Page 6 line 26: edit to "The order of magnitude of both biomass and N<sub>2</sub> fixation rates, as well as the large scale spatiotemporal patterns, ..."

Page 6 line 29: remove "probably somewhat"

Page 7 Figure 1 caption: spelling error in "physical"

Page 7 line 11: "set to" should be "made"

Page 8 line 7: really? My impression from Page 6 line 25 and Page 7 is the top layer is 22 m thick.

Page 8 line 9: "refer" is the wrong word- "convert" instead?

Page 8 line 11: replace "in" with "of"

Page 8 line 14: reverse order of "reach now" and delete everything after 1.6 mg Chl m<sup>-3</sup>.

Page 8 line 20: Change sentence to: "In contrast, a cooling effect on SST dominates larger areas."

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Page 8 line 22: insert comma after "PHY\_CYA"  
Page 10 line 1: replace "an" with "the"  
Page 10 line 6: insert "physical" before "regimes"  
Page 10 line 9: I think you mean "west of" not "western"  
Page 10 line 13: remove "and" after "gyres"  
Page 10 line 15: edit to "...dominates large parts..."  
Page 10 line 16: remove "as mentioned above"  
Page 11 line 4: edit to "Here it is not the local effect of high light absorption causing the anomalies, but changes..."  
Page 11 line 6: remove comma after "experiment"  
Page 11 line 8: edit to "are, enlarged by roughly..."  
Page 11 line 11: remove second "which"  
Page 11 line 13: change "which" to "that"  
Page 13 lines 30 and 32 and Page 15: change "dampens" to "damps"  
Page 13 line 32: edit to "by causing less transport of cold subsurface..."  
Page 14 lines 4-5: edit to "... strength, but damps it in the ..."  
Page 15 line 15: remove "rather"  
Page 15 line 17: replace "different" with "variable"  
Page 16 line 7: remove "exemplarily"  
Page 17 line 4: move "also" to before "affected"  
Page 18 line 5 and line 13: "let expect" is awkward. One solution: "Interestingly, a

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stronger cooling ... PHY\_CYA does not lead to a stronger..." And then remove "however" from the next sentence. Line 13: remove "would let expect" and replace with "suggest" and change "to" to "would"  
Page 18 line 7 and 12: "which" should be "that"  
Page 18 line 16: "episodic"  
Page 18 line 18: "larger", "local surface heating effect", remove "acting"  
Page 19 line 8: remove "especially the" and replace with "explicitly accounting for"  
Page 19 line 11: "Agreement on the sensitivity"..."circulation, as well as precipitation patterns,"...  
Page 19 line 17: insert "and" before 3)  
Page 19 line 20: replace "which" with "that"  
Page 19 line 25: replace "which" with "that" and "underpin with numbers" with "quantify"  
Page 20 line 1: "retroaction" is a strange word. Perhaps "effect of light attenuation"?  
Page 20 line 6: "which" should be "that"  
Page 20 line 18: remove "rather"  
Page 20 line 19: "diverging"  
Page 20 line 22: "linearly"  
Page 21 line 4: remove "seems to", change to "overestimates"  
Page 21 line 17: remove "Especially,"  
Page 21 line 19: third "the" should not be capitalized  
Page 22 line 1: replace "roughly refers" with "approximates"

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Page 22 line 4: "..that results.."

Page 22 line 6: move "also" to before "compared"

Page 22 line 15: remove "as described in the beginning of this paragraph"

Page 22 line 31: remove "possibly"

Page 23 line 2: move "also" to before "improved"

Page 24 line 10: remove "locally"

Page 24 line 20: change "which" to "that"

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