Reply to reviewer #1:

Dear reviewer,

We would like to thank you for the time you spent on the second review. Please find our point-by-point responses below:

** I think it needs to better emphasized that *surface* phytoplankton concentration increases, while total (depth-integrated) phytoplankton concentrations remain constant or slightly decrease. This is critical for understanding Figure 5b and Figure6a. Also, the title of Section 3.2 should include the word "surface", otherwise it's contradicting what was just shown in Figure 6a. Same for the section titles of 3.3 & 3.3.1. Also please add "surface" around line 15 of the Abstract in the revised manuscript.*

R: Thank you for pointing this out. We have modified the manuscript accordingly. Specifically, we added the word "surface" in the abstract (lines 14 and 15), as well as in the method section (lines 99, 105, and 132). Furthermore, we updated the titles of Section 3.2 and Section 3.3 & 3.3.1. Additionally, the word "surface" has been included in lines 239, 241, 243, 248, 251, 258, 339, and 344.

Reply to reviewer #2:

Dear reviewer,

We appreciate your second review and your supportive, constructive feedback. Below, please find our point-by-point responses:

**I commend the authors on a fairly thorough addressing of the reviewer comments. Overall, I found their revisions satisfactory. However, I remain confused on the modifications that they made to their emergent constraint analyses. It is not clear to me how they justified using an observable contemporary sensitivity between chlorophyll and MLD to then constrain future projections between phytoplankton biomass and MLD. In the response to reviewers they just cite Terhaar et al. 2021, but I think it would benefit the readers of this manuscript to have a more thorough justification in the text. A positive correlation with chlorophyll and phytoplankton biomass is implied here, but how strong of a relationship do you need to have in order to justify such an approach?*

R: Thank you for highlighting the need for additional clarification regarding the utilisation of different variables for our emergent constraints. Accordingly, we have included further elucidation on past instances where emergent constraints were employed with both identical and diverse variables, as added in L90-96.

"Emergent constraints are often built upon relationships between the same variable at different times, e.g., Kwiatkowski et al. [2017] establish a link between the change in tropical primary production in response to temperature changes on interannual timescales and the change in tropical primary production in response to temperature changes over the 21st century. However, emergent constraints can also be built on relationships between different variables if these are mechanistically related, e.g., Terhaar et al. [2021a] used Southern Ocean sea surface salinity to constrain future uptake of anthropogenic carbon in that region because sea surface salinity determines sea surface density and hence the amount of mode and intermediate water formation."

Additionally, we have provided a more detailed explanation of why we chose different variables for our emergent constraint, as described now in L101-L104:

"The emergent constraint we utilised here, incorporating distinct observable and constraint variables, hinges on the relationship between surface chlorophyll concentration and surface phytoplankton biomass concentration across individual models (Fig. A2). Benefiting from its comprehensive spatial-temporal coverage, chlorophyll provides an ideal balance by offering a strong linear correlation, easy observational access, and comparatively low observational uncertainties."