Dear Editor,

We are grateful to the reviewers and to you for your constructive feedback. Below, we provide detailed responses (in red) to each of the comments raised.

Reviewer 1

My first feeling after reading the whole Intro is that the authors wanted to build a model that can overcome the limitations mentioned in paragraphs from line 22 to line 53. But to prove that, the new model must have better performance than previous models. However, the model performance is actually worse than simple Eulerian models. This is totally okay, but the Intro should be modified to better express the authors true focus, that is to serve as a tool to better study phytoplankton diversity and productivity in a more realistic turbulent ocean.

[Response] We thank the reviewer for this helpful comment. We have revised the Introduction to clarify that the objective of our study is not to improve the performance of phytoplankton models in reproducing bulk properties, but rather to provide a new tool to explore phytoplankton diversity, acclimation, and productivity in a dynamically variable environment.

Specific Comments
Line 24: This is not true. To my understanding, the change of phytoplankton concentration in Eulerian models actually means the cells are moving.

[Response] We have revised the text to better explain the distinction between the Eulerian and Lagrangian frameworks, specifically focusing on how they represent the movement and environmental experience of phytoplankton (see lines 46-47).

Line 59: increasingly what? popular?

[Response] Yes, popular. Thank you.

Eq3. I still don't think respiration cost Chla. Actually, I read Geider et al. 1997 again to double check if I'm wrong. Geider used a Eulerian framework, so the degradation of Chla is actually caused by mortality, but Chla doesn't degrade within the cell. That's the difference.

[Response] That is correct, Geider et al. (1997) present a population-level model in which chlorophyll loss is attributed to cell-specific mortality. However, our formulation follows the intracellular framework developed in Geider et al. (1998), where their Eq. 3 includes a first-

order degradation term for intracellular Chl-a. This term represents a physiological pigment loss process occurring within the cell, and is not associated with mortality or population turnover.

Nevertheless, the reviewer is right in highlighting the fact that R_C, R_N, and R_{Chl} are degradation rate constants, not respiration rates. We thank the reviewer for drawing attention to this and have clarified the terminology in the manuscript (see lines 125-128).

Line 656: DCM is actually not captured. The patterns are quite different (Fig.4, middle panels). DCM is better simulated in the other two models (Fig.13). It would be interesting if the authors can explain why this happens. This is actually more meaningful.

[Response] Thank you for the note. The original explanation didn't describe the model differences clearly enough. We've now expanded the text to explain this variability in more detail, focusing on the effects of trait selection, acclimation, photoinhibition, and self-shading in PIBM. The main reason for this to occur is because trait selection favour types with elevated growth rates at higher light levels.

We hope the above responses and revisions are satisfactory. Thanks again for your input.

Best regards,

Iria Sala,

Bingzhang Chen