

Dear Dr. Marcello Vichi,

Thank you very much for the time you took to review our manuscript and for your comments. In the following text we will address your comments and explain how they were incorporated into the revised manuscript or used to clarify the points you addressed. When referring to line numbers we consider the reviewed manuscript without tracked changes.

With my best regards,

21 December 2021

(Pedro Manuel da Silva Duarte, on behalf of all co-authors)

Comments and answers

Comment

“At line 87-89 the authors should make explicit that this testing is specifically applied to the CICE model and its technical features. The implementation may be different in another model, and not even be appropriate in certain cases. This is necessary because the theory is presented as grounded on the specific configuration and parameters chosen by CICE and ICEPACK (e.g. line 109).”

Answer

Done as suggested. Please refer lines 76-77 of the revised manuscript.

Comment

“1. I think the comparison with and reference to the heat flux is misleading and should be removed. It can be done in the introduction and brought back in the discussion, but in the conceptualization phase is confusing and not entirely justified. Starting from the case of salinity is more adequate since nutrients are solutes just like salt. Like at line 99, the authors could say: "When this quantity is salt in seawater, the formulation is:" Heat is also mentioned at lines 105-106 while only salinity has been presented in the previous sentences. This also also applies to the turbulent exchange coefficients α . I would suggest the authors to just refer to α_s and its range of variability, and not to α_h and how it relates to salt exchange.

In particular, I would kindly request the author to revise their statement that the material exchange fluxes should be made equivalent to the treatment of the heat fluxes, because they are actually resolved in different ways in the CICE implementation, and moreover, such a statement is not of general applicability to all models.”

Answer

Done as suggested. We also removed the equation for the heat flux and the text about the relationship between the heat and the salt transfer coefficients, from section 2.1.

Comment

“2. The most important change is to add the explicit parameterization of the bottom boundary condition before explaining the time scales (L116-L137). I would recommend the authors to first present eq. 7 and then the boundary condition that is resolved by CICE (eq. 40 in Jeffery et al. 2016). At this point, they should clarify their proposed parameterization of the boundary flux and how they modified the implementation of the diffusivity at this boundary grid point. Please make sure to indicate that this point is an interface grid point representing ocean conditions, with porosity equal to 1.

Finally, I would kindly request the authors in their discussion to clarify that this proposed parameterization is based on an approximation of the molecular sublayer and the related physical processes. That specific measurements are required to further improve its description and generalization for applications to other model formulations.”

Answer

Section 2.1 was reformulated. We reordered the equations, following the recommendations from the referee. Please refer lines 92-117. Moreover, we added a new paragraph to the end of the Discussion section (lines 442-459) where we addressed some of the concerns expressed by the referee.

We also added a few sentences to the Introduction (lines 63-67) to better emphasize comparable approaches carried out in previous studies.