

Interactive comment on “Will open ocean oxygen stress intensify under climate change?” by A. Gnanadesikan et al.

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The paper describes trends in oxygen concentrations and in the extent of hypoxic regions in an Earth System Model forced with increasing atmospheric CO₂. The focus of the paper is on the region near the Chilean coast. I think the paper is interesting because it presents one scenario of what might happen under global warming. The paper shows how changes in ventilation due to convective changes driven primarily by the hydrological cycle produces younger and more oxygenated waters in the hypoxic regions in the South Eastern Pacific. The authors do a good job of diagnosing what is going on in the model. What is not so clear is the robustness of the results. The biggest changes in the buoyancy budget responsible for the changes in the ventilation are localized in a few grid points. To what extent are the results reproducible in other

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Earth System Models is not at all clear to me. Of course one has to start somewhere so it is important for climate modeling groups to report their results. I am therefore supportive of publishing the paper. A change in the title to something along the line "Will open ocean oxygen stress intensify under climate change? Suggestions from a simulation using an Earth System Model" seems appropriate unless the authors can do additional work that could establish the robustness of their results.

I have a list of minor changes to suggest, which, I hope, will make the paper more clear:

page 7008 line 25: "did not necessarily increase under global warming." should be changed to "does not necessarily increase under global worming." or "did not increase in their global warming simulation." Global warming is not a thing of the past for the real world!

page 7012 lines 7-8: "a linear decrease in emissions ...resulting in a further increase in greenhouse forcing over this time period" is unclear. I'm not sure if this is a typo or if the sentence means something else. A decrease in emissions should lead to a decrease in greenhouse forcing. Or is the sentence meant to say that there is an increase in the greenhouse forcing in the ESM2.1 run relative to the simulation done by Schmittner et al. (2008)? Please clarify.

page 7014 paragraph starting on line 22 and Fig 3c. For the water represented by the red "dots" in Fig 3c, there are both positive and negative changes in O₂ and age and while it is certainly true that the largest changes are associated with increases in O₂ and decreases in age, it appears that the many (a majority?) of the points have shifted to lower O₂ and larger ages. Is this true? It's hard to tell for sure because of the overlying blue points. Also the contour plot in Fig 3b shows decreases of more than 100 (units? please add the units in the caption or beside the colorbar) in the Arabian Sea and in the Indonesian through flow that don't appear in the red dots shown in Fig 3c even though they lie between 40 S and 40 N. Why is that?

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page 7015 line 10: Need to refer to Fig 3d when discussing the "solid black line"

page 7015 line 24: change "so that biological cycling is..." to "so that the change in biological cycling is...".

page 7016 line 6: the sentence does not parse, there is a word missing

page 7016 line 7-12: There is a sentence that starts "This trend arises because..." and another that starts "This increase arises because there is ..." Only the second of these sentences actually explains why there is a trend.

page 7016 line 11-12: Is the increase in the advective supply due to a change in the strength (or direction) of the currents or due to a change in the O₂ gradients? In other words, are the changes in the resolved circulation significant?

page 7016 lines 24-25 and Table 1: How sensitive are the results to the size of the box? Isopycnal diffusive fluxes of O₂ will depend on the O₂ gradient so that the relative importance of Advection relative to small-scale mixing might be sensitive to the position and size of the control volume. Some sensitivity tests would be appropriate.

page 7016: line 17 insert "of" to get "...higher values of nutrients..."

page 7016 line 21: the word "accounts" should really be "balances" because eddies don't consume oxygen.

page 7016 line 23: insert "shadow zone" after stagnant and before regions to make it more evident why Luyten et al. 1983 is referenced.

page 7016 line 28: I believe the discussion should point to Eq. (1) instead of Eq. (2).

page 7017: line 2-3: change to "results in excessive spreading of the oxygen minimum zones in the vertical."

page 7017 line 5: the word "jump" makes it sound like there is an abrupt transition (i.e. bifurcation) to a larger eddy-driven supply of oxygen. Is that really what happens?

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page 7017 lines 9-18: should anything be said about the model resolution and the extent to which the authors think the features captured by the model are sufficiently resolved for the results to be robust?

page 7017 line 26-27: "associated with" should be changed to "that parameterizes the mixing due to"

page 7020 line 11: I'm not sure how to parse "climate change linked to circulation". Deleting "linked to circulation" or perhaps replacing "response to climate change" with "response to changes in circulation."

page 7021 line 14: change "that the much" to "that much", i.e. delete "the"

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