Reviewer 1

We would like to thank Reviewer 1 for their thoughtful and helpful review. We have replicated the Reviewer's comments below in blue and italics. Our responses to each of the comments are in black and changes to the text in the manuscript are in red and bold. Thank you for your time and expertise!

*The study focuses on oxygenation during past interglacial periods, showing clear results on oxygenation patterns and differences between MIS 5e and MIS 9e in terms of ocean oxygenation. I recommend that the paper be accepted for publication with minor revisions.*

*1 When comparing the PI and global distributions of dissolved O2 concentration, did you account for the influence of greenhouse gases increase? Maybe this comparison can further elucidate the effects of greenhouse gases. Is there any simulation conducted with modern atmospheric concentrations?*

Thank you for this suggestion. We have indeed a transient historical simulation from 1850 to 2015. The WOA data is a compilation of observations spanning 1965-2022. Below we show the vertical mean $O_2$ concentration for our PI simulation in (a); for our historical run, averaged between 1965 and 2015, in (b); and the WOA data (1965-2022) in (c).

The difference between the PI simulation and the historical run is very small; the change in greenhouse gases in this transient simulation therefore does not change the fit with observations significantly.

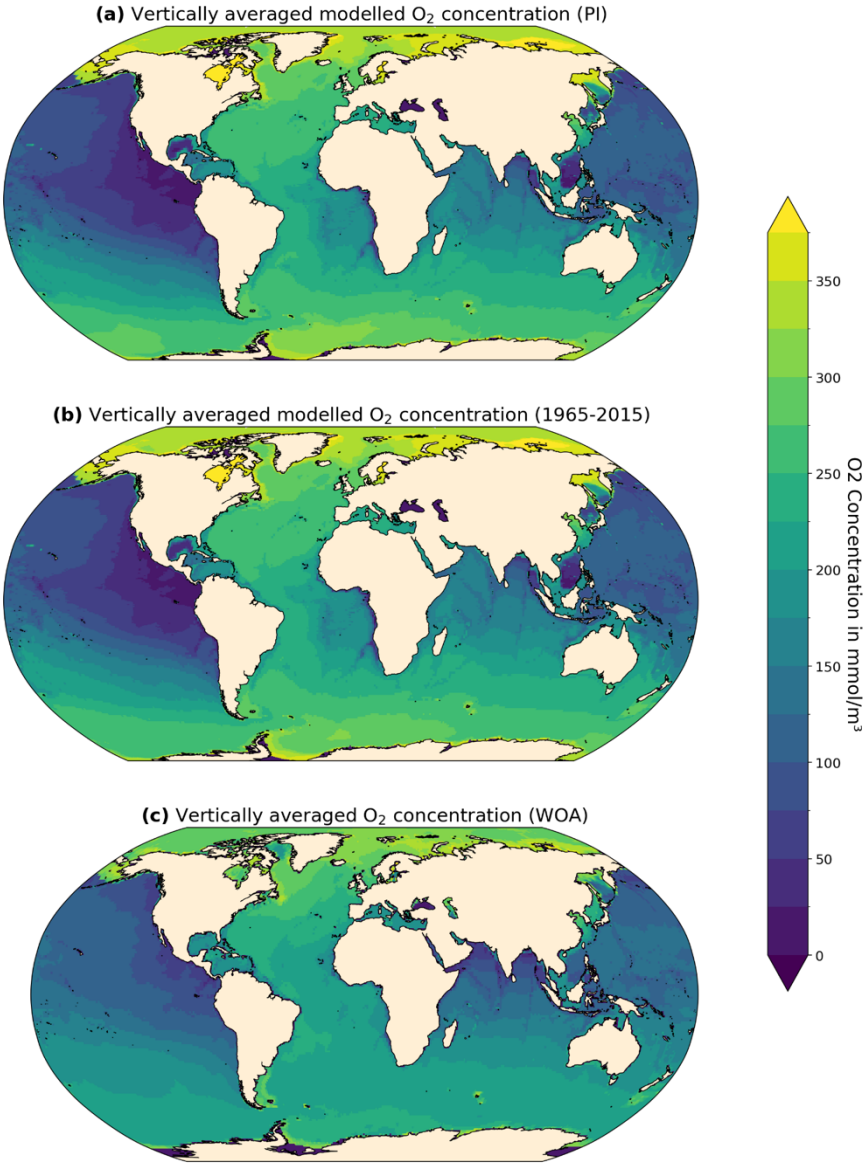


*Fig R1.1 Vertically averaged dissolved $O_2$ concentrations (mmol/m$^3$). (a) PI simulation ; (b) historical simulation, averaged over 1965-2015; (c) WOA data (1965-2022).*

We therefore decided not to change Figure 1 (new Figure 3) in the paper.

We have amended the sentence discussing the impact of changes in greenhouse gas concentrations in the first paragraph of the discussion as follows:

"**The large-scale ocean circulation patterns, including AABW, NADW and the ventilation of the North Pacific Ocean are therefore very sensitive to the latitudinal and seasonal distribution of incoming solar radiation in the ACCESS ESM1.5, and less sensitive to changes in greenhouse gas concentrations within the range of these three interglacials.**"

*2 The article does not perform a significance test when calculating anomalies, which should be included.*

We would like to thank the Reviewer for this suggestion (also mentioned by Reviewer 2). We have now performed significance tests on all results. All figures that show anomalies now clearly indicate regions that are not statistically significant.

*3 Some of the text in the figures is too small to read clearly (e.g. titles in Fig. 2,3,4..). Please increase the font size to improve readability.*

This comment was mirrored by Reviewers 2 and 3. We have now changed all the figures. In particular we have:

- Removed the titles of the subplots;
- Made the legend colour bars thinner where appropriate;
- Increased the font size for all remaining text in the figures;
- Reduced the white space between subpanels where possible.

*4 Certain figures appear unnecessary. I suggest the authors to reduce the number of figures in appendix.*

Reviewer 3 suggested moving a few key figures from the Appendix to the main text. We have now moved A2, A3 and A5 to the main text. This has reduced the number of figures in the Appendix to ten.

*5 More discussion about how ocean oxygen may change in the context of increasing carbon dioxide concentrations in the future and the potential impacts of such changes. I hope these suggestions assist the authors in revising the manuscript.*

Following paragraph has been added to Section 4:

**"Our study shows that even relatively small changes in boundary conditions can lead to large changes in ocean circulation, upwelling systems, export production, and ocean oxygenation. While our results cannot directly inform on future changes in ocean oxygenation, there might be some similarities. Ocean temperatures and ocean stratification are projected to continue to increase until atmospheric $CO_2$ concentrations finally plateau. Current ocean deoxygenation is therefore not easily reversible and will persist for centuries (Oschlies, 2021). There will be physiological and morphological impacts on organisms, including reduced growth for a vast range of taxonomic groups (Sampaio et al., 2021). Exposure to low oxygen conditions has also been associated with a delay when fish produce eggs, a reduction of the number of eggs fish produce and blindness (Landry et al., 2007; McCormick andLevin,**

**2077). The metabolic demand of oxygen increases with water temperature, and when combined with deoxygenation, this can lead to respiratory distress, followed by respiratory failure and death (Clarke et al., 2021). Over 50 mass mortality events due to hypoxia have been recorded in the tropics to date (Altieri et al., 2017). The consequences of deoxygenation for fisheries and the world's future food supply could thus be serious (Oschlies et al., 2018; Rose et al., 2019)."**

Thank you again for the very helpful review that helped us improve the paper.