I commend the authors for their careful consideration of the reviewers' comments. I feel the argumentation is more robust in the revised manuscript, yet I feel some (relatively minor) aspects still need to be clarified.

We thank the reviewer for their very insightful comments and are now clarifying our response further.

L. 375-386. I welcome the newly added paragraph, yet I feel the discussion developed in this section remains largely descriptive. The supply of dissolved Fe (and more generally, macronutrients) to the ocean surface in the AZ is to a large extent determined by vertical mixing/upwelling (e.g. Lefevre and Watson, 1999; Tagliabue et al., 2017), possibly explaining why EP decreased in the AZ during past ice ages, if one considers palaeoceanographic reconstructions. Indeed, several authors have argued that EP decreased in the AZ as a result of increased water column stratification as global climate cooled (e.g. Francois et al., 1997; Jaccard et al., 2013; Sigman et al., 2021). How does vertical mixing/upwelling change in the glacial simulations, when compared to the PI timeslice?

We agree that physical mechanisms are important in controlling the magnitude of export production in the AZ. In our simulations, we have kept surface winds prescribed to present day conditions in both the 70ka-control and PI-control simulations, making it difficult to address changes in upwelling due to potential changes in magnitude or latitudinal shifts in westerly winds. With our constant wind forcing, the winter mixed layer in the 70ka-control experiment is slightly deeper compared to the PI-control. This leads to a slight increase in macronutrients in the AZ. Without changes in iron supply (70ka-control experiment), there is an increase in EP in the SAZ and a decrease in EP in the AZ compared to PI (as mentioned in Section 3.1), in agreement with paleo proxy records. When iron supply is increased within this diatom-dominated region, it results in higher utilisation of available nutrients, leading to greater EP within the AZ. We are now including this information in the manuscript as below.

Lines 321- 335:

"In our 70 ka simulations with enhanced iron input, EP increases in the AZ and polar frontal zone (between SAF and APF) and decreases in the SAZ, in contrast with most paleo-proxy records (Figure A5b). Existing $\delta^{15}N$ records suggest higher nutrient consumption at the MIS4/MIS5 transition in the AZ (Studer et al., 2015; Ai et al., 2020), a region where the supply of macronutrients to the surface is determined by ocean upwelling and mixing (Lefevre and Watson, 1999; Tagliabue et al., 2017). Studer et al., (2015) argues that the relative increase in nutrient utilisation in the AZ during MIS4 is due to the general decrease in the nitrate supply, resulting from greater isolation of the deep ocean during glacial periods (Francois et al., 1997; Jaccard et al., 2013; Sigman et al., 2021), rather than iron fertilisation.

This is in contradiction to our results, where we find a deepening of the winter mixed layer in the 70ka simulations compared to the PI-control, which leads to a slight increase in macronutrients in the AZ. Higher iron supply within this diatom-dominated seasonal sea ice zone then leads to a greater utilisation of available nutrients, in agreement with previous studies (Abelmann et al., 2006, 2015), resulting in greater EP within the AZ. With higher nutrient utilisation in the AZ, the nutrient advection into the SAZ is reduced, leading to a decrease in EP in the SAZ. The disagreement between the modelling results and paleo-proxy records thus suggests that the AZ is not stratified enough in our 70ka simulations. This could be due to a weakening and/or more equatorward position of the SH westerly winds during glacial times (e.g., Toggweiler et al., (2006), Gray et al., (2023)), which are not included in our simulations as present-day surface winds are prescribed."

The discussion related to the d15N records Is Insightful, yet, the reasons put forth in the referenced studies are different than the arguments developed here. Indeed, Studer et al., 2015 have argued that the increase in relative nitrate utilization during MIS4, was due to a general decrease in the supply of nitrate via upwelling (and not Fe fertilization). I certainly agree that the cross-frontal (surface) transport of nitrate decreased as a result, yet palaeoceanographic records show no sign of a decrease across MIS4 in the SAZ in all sectors of the SO. Taken together, the palaeoceanographic evidence is consistent with a strengthening of the biological carbon pump, enhancing the storage of remineralised carbon in the ocean interior.

We have now revised our argument concerning the $\delta^{15}N$ records as in the response above and made it clear that the EP response in the SAZ and AZ in our results is inconsistent with most paleo records. As stated in the revised manuscript (Lines 321-324), there is evidence of a greater iron flux in the AZ (Lambert et al., 2015) and evidence of a higher iron flux within the seasonal sea ice zone resulting in increased diatom concentrations (Abelmann et al., 2006, 2015) and likely enhanced EP in this region during glacial periods. Therefore, our results are somewhat consistent with a few of the paleo records.

As such, I would encourage the authors to develop this discussion further. I mean, taken at face value, the model outputs are at odds with palaeoceanographic reconstructions in the entire SO (i.e. both AZ and SAZ) and the North Pacific (which I agree does not warrant more detailed discussions). I do not necessarily argue that palaeoceanographic records are to be taken at face value, yet the fundamental discrepancy between model outputs and paleoproductivity records should be discussed in more details before the manuscript can be accepted for publication.

We agree and have stated the inconsistency in our results with paleo data in the response above. We have also added the following paragraph in addition to the above response.

Lines 336-343:

"However, our simulated EP increase in the AZ during MIS4 compared to PI, and thus the increase in regenerated carbon storage in the deep ocean, aligns with some proxy records suggesting a decrease in deep ocean oxygenation in the AZ (Jaccard et al., 2016; Amsler et al., 2022). Our EP increase is also consistent with the increase in opal flux north of the APF (Amsler et al., 2022) at the MIS4 onset (Figure A5b). In summary, while our EP responses in the SAZ and AZ are inconsistent with most of the paleo records, the strengthening of the biological pump leading to greater storage of deep ocean organic carbon is consistent with palaeoceanographic evidence. Since proxy data for dust flux and EP is limited to only a few marine sites and ice cores, additional paleo-proxy records covering a larger area in the Southern Ocean during MIS4 are needed to better quantify the impact of iron fertilization during the glaciation."