Reviewer 1

General comments

The study provides insights on how CO_2 system in the ocean responds to CO_2 mitigation, and its interactions to ocean circulation in the near term. The results are needed for monitoring the climate-carbon feed back in different regions of the global ocean. The manuscript is clear and well written. However, as the authors identified the limitations of the work, I found it is necessary to look at those limitations more closely. In addition, I am wondering why only the short term effects, not the long term effects were studied.

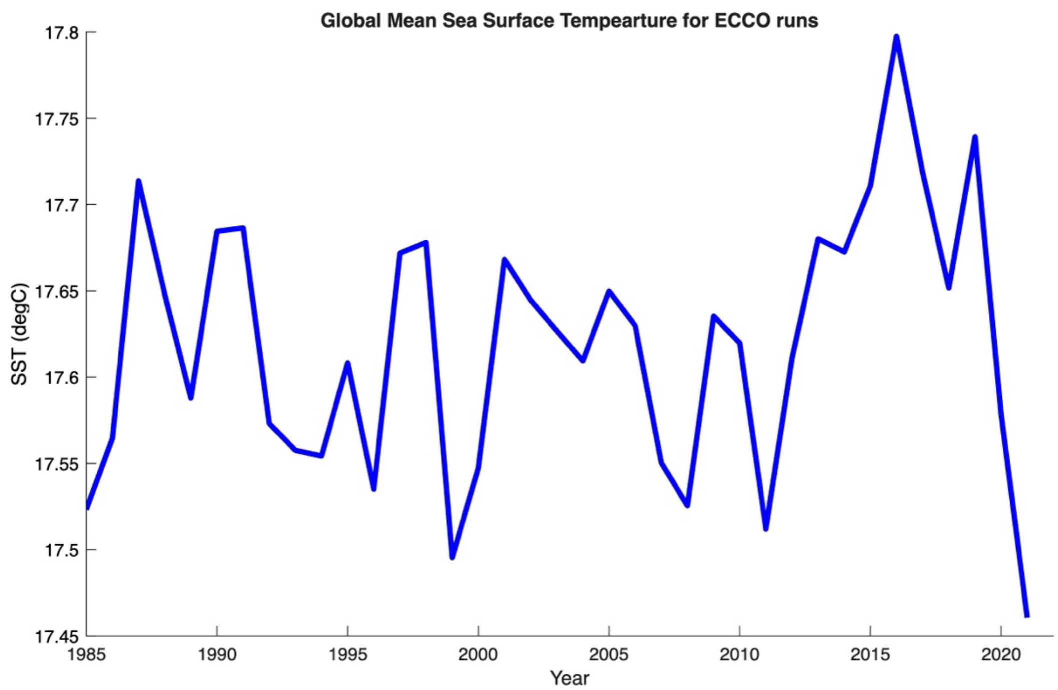
We thank the reviewer for these comments. Below we will respond to the specific question about our discussion of limitations of the results. Only the short-term effects of the response are analyzed and discussed in this paper because of the limitation of the model run length. ECCO can only be run out to recent years because it is a data-assimilative hindcast model. Thus, we were limited to a roughly 20-year period for our investigation. We chose to apply mitigation in the year 2000 because it followed along from the Montreal Protocol meetings where such efforts were pledged. Our motivating question was, what if those commitments were upheld and mitigation truly began soon after (i.e., the year 2000).

As an ecological modeler, my opinions maybe biased toward how planktonic systems play a role in it. This part is ignored due to the lack of feedback of mitigation to the ocean physics in this study. Ideally, mitigation would slow down warming, or even cool down the ocean over long term. That would increase mixing, and thus nutrient supply, primary production and biological CO_2 pump, and solubility pump at lower temperature. If you imagine increased primary production, and decreased respiration under cooling, CO_2 budget due to biological changes may not be trivial. Globally, the increase in CO_2 uptake due to increased primary production may not be high as the authors argued, but locally, in some normally low productivity areas, the increase could be significant.

We thank the reviewer for these detailed discussions of the biological feedback potentials in such mitigations. We have revised the manuscript to reflect this potential for large impact on primary production at local-scale.

I would recommend the publication of this manuscript after minor revisions. However, I would suggest the authors show how sea water temperature changes over time in baseline simulation, just like you displayed CO_2 flux and pCO_2 in baseline in Figure 1.

We thank the reviewer for this suggestion and here we show a timeseries of changing sea-surface temperature in the ECCO-Darwin model runs. We do not feel that this timeseries provides much additional interpretation information for the discussion in the manuscript so it will be added to the supplementary figures.



I would encourage the authors add another simulation of the mitigation scenarios using (downscaled, if needed) forcings derived from the output of Earth System Models. Without this, the scope of this work, and contribution to this area would be unfortunately limited.

The suggestion from the reviewer is an interesting idea, but unfortunately outside the scope of this work. We cannot apply output from the ESMs into the data-assimilative ECCO-Darwin model. Many other pieces of research look at mitigation in the ESM framework, and we have referenced these throughout our manuscript.

Specific comments

• Line 145: atmospheric CO2 forcing: better to use pCO2. We have changed the text as suggested.

• The paragraph between lines 286-293, and Figure 5: there are some mismatches between panels referenced and texts. Net diffusion is in Figure 5(e), not (d). Net advection is in Figure 5(d), not (e). We thank the reviewer for identifying this mix-up. We have revised and double checked all other figure references in the manuscript.

• Line 296: ”DIC gain and loss from circulation largely compensates when integrated globally”, but why is the globally integrated circulation value is positive: 0.132 Pg C year−1? This text refers to the 3 globally-integrated terms: -1.43, 0.132, and -1.56 Pg C year-1 for DIC tendency, circulation, and air-sea CO_2 flux. As compared to the other 2 terms (tendency and air-sea CO_2 flux) which are both an order of magnitude smaller, we summarized that the changes seen from the circulation component are being modulated because of the compensation between gain and loss. This is shown in Figure 5e where there are only a few spots on the map showing large magnitude changes. The value is positive because the gain of DIC is slightly larger than the loss and this is occurring predominantly in the boundary waters at the northern edge of the Southern Ocean, as well as along other frontal boundaries.

• Figure 5: The color scale is saturated. Maybe the color limit can be expanded to 1.5×10^{-5}. We thank the reviewer for this suggestion and adjusted the color scale on this figure.

• Figure 5d: DIC advection in the mitigation scenario increased comparing with baseline. I have to wonder why. As you used the same physics between baseline and mitigation, so the U, V, and W of the current should be the same between baseline and mitigation. Then the increased flux should be due to increased DIC concentration under mitigation. Mitigation under SSP1 should have reduced CO2 uptake and thus lower CO2 concentration than with baseline, rather than increase. Please clarify. We thank the reviewer for this comment. Yes, the ocean physics is the same in all our simulations. While lower atmospheric CO_2 results in less CO_2 uptake, in some places the DIC advection is increasing (example, equatorial pacific) because the difference in air-sea uptake of carbon is largest there and thus the advection term is redistributing gradients induced by these changes.

• Figure 5 legend: align the order of panels in the text with the figure. We have revised this section discussion to try to more clearly walk through the discussion in the order than the components are shown in the figure.

• Line 383: The reference should be Williams et al. (2024), not 2023. We thank the reviewer for this correction and have revised the manuscript.