Reviewer 2

The manuscript tests the effect of changes in atmospheric CO2 on oceanic carbon uptake using a model, while keeping other parameters such as circulation, temperature, and sea ice identical. The broad conclusions are physically sensible: lower atmospheric CO_2 reduces the air–sea gradient, uptake declines rapidly, and the resulting DIC anomaly is redistributed along upper-ocean ventilation pathways. I suggest some revisions to improve clarity.

The manuscript should explicitly define "mitigation", as this word can be misleading. As implemented here, mitigation is not an emissions intervention but a prescribed atmospheric CO_2 concentration trajectory. The model does not simulate emissions, policy actions, carbon-dioxide removal, enhanced marine productivity, or the coupled feedback of altered ocean uptake on atmospheric CO_2. This distinction is essential because different mitigation strategies could produce different ocean responses. Please define the term consistently in the abstract, introduction, and methods and consider modifying the title to describe the imposed concentration forcing accurately. We thank the reviewer for this comment and have edited the text to clarify that the "mitigation" that is causing changes in these experiments is simply a reduced atmospheric carbon level and therefore specific responses to various potential mitigation methods that would result in these reductions are not considered. We have also edited the title from "Quantifying the Near-term Response of the Ocean CO_2 Sink to Emissions Mitigation" to "Quantifying the Near-term Response of the Ocean CO_2 Sink to Reduced Atmospheric Carbon Concentrations"

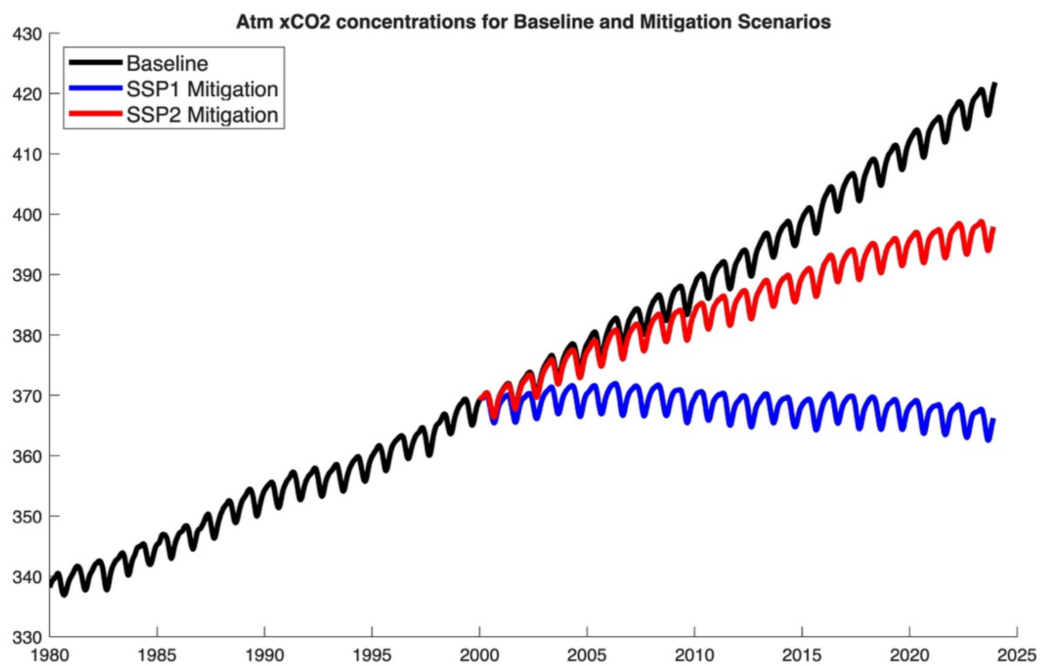
Please show the biological DIC-budget terms rather than asserting that biological differences are negligible. Enhanced biological consumption and export could lower surface-ocean pCO_2, partially restore the air–sea gradient, and modify the inferred response. We thank the reviewer for this comment and have added text in the manuscript to discuss how local impacts of biological impacts from changing DIC could be significant but that on a global scale they are negligible as compared to the other components discussed.

Some language incorrectly implies that circulation changes between runs. Physics is identical, so mitigation does not alter circulation in this experiment. Advection-budget differences arise because the same velocity field transports different DIC distributions. Statements about "the dynamic response of ocean circulation" (line 112) should instead refer to tracer redistribution by fixed circulation. We thank the reviewer for this insight and have adjusted the text according as: "Each simulation uses identical physical and biogeochemical initial conditions. Differences among scenarios and the baseline therefore reflect the dynamic response of carbonate chemistry to changes in atmospheric CO_2 concentration alone."

High-latitude and boundary-current systems show the largest modeled responses, but their strong natural variability and sparse observations may obscure the mitigation signal. Because the study does not perform a signal-to-noise or time-of-emergence analysis, it cannot conclude that these signals would be detected earliest in the real ocean. We appreciate the reviewer's comments here. The model performs well across the globe as compared to independent data (as well as other models). Therefore, sparse available observations in these high latitude regions would not cause the large response in the model — they are due solely to the perturbation response of the model's ocean carbon chemistry to changes in atmospheric CO_2 concentrations.

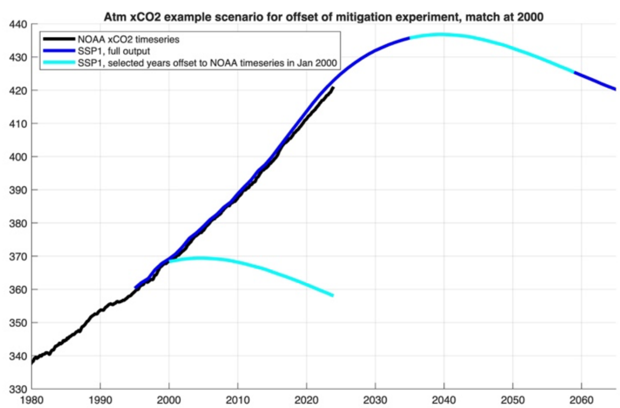
Explain exactly how the atmospheric CO_2 scenarios were constructed. The backward shifting of SSP1-1.9 and SSP1-2.6 concentration trajectories is insufficiently documented. Please provide the transformation, original and shifted years, treatment of the January 2000 transition, and complete atmospheric CO_2 time series. Clarify whether the scenarios represent lower concentrations, lower growth rates, or actual concentration declines. This information is necessary for reproducibility and interpretation.

We thank the reviewer for this suggestion. A supplementary figure has been added with the complete global mean atmospheric CO_2 timeseries for each scenario, and is shown here.



In order to create these timeseries, we start with the monthly global xCO_2 values downloaded from the Global Monitoring Lab website (https://gml.noaa.gov/ccgg/trends/gl_data.html, Lan, X., Tans, P. and K.W. Thoning: Trends in globally-averaged CO2 determined from NOAA Global Monitoring Laboratory measurements. Downloaded: May 20, 2024). This timeseries extends from 1979-2023. We utilize the "trend" column which does not include a seasonal cycle on the xCO_2 values. The monthly atmospheric CO_2 concentration values for each SSP scenarios are from the MAGICC7 live tool (available at https://live.magicc.org/, described in Meinshausen et al (2011), with updates in Meinshausen et al. (2020)).

To apply a simulated atmospheric CO_2 expected post mitigation, we selected the year 2035 from the SSP scenarios, which is when the reductions of atmospheric CO_2 are beginning to be observed in the global timeseries. We take values for Jan 2035 from each SSP scenario and subtract the NOAA global mean xCO_2 value for December 1999; this is now our offset value. We subtract this value for each SSP scenario and translate the resulting curve to begin in Jan 2000, concatenating it to the NOAA timeseries beginning in that year. See example figure here for SSP1.



Lastly, we utilize the latitudinally-varying seasonal cycle of xCO_2 available from the marine boundary layer file from NOAA (Lan, X., Tans, P., Thoning, K., & NOAA Global Monitoring Laboratory. (2024). NOAA Greenhouse Gas Marine Boundary Layer Reference – CO2. [Data set]. NOAA GML. https://doi.org/10.15138/DVNP-F961, Downloaded April 4, 2024, available at https://gml.noaa.gov/ccgg/mbl/data.php). We apply this spatially-varying seasonal cycle to the adjusted timeseries for Baseline and each Mitigation scenario timeseries to simulate observed seasonal variability on top of the declining xCO_2 trends at the timestep required for input to the ECCO-Darwin model.