Comment on bg-2021-285
Anonymous Referee #1

Referee comment on "Observed and projected global warming pressure on coastal hypoxia" by Michael M. Whitney, Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-285-RC1, 2022

Review of "Observed and forecasted global warming pressure on coastal hypoxia" by Michael Whitney.

Summary

This manuscript analyzed the long-term trend of SST and surface oxygen capacity from 40-year global gridded climate data record from a satellite platform compared it with CMIP5 CESM Large Ensemble mean on the simulated trend. The forecasted median trend under RCP 8.5 forcing along the global coast are 0.39deg, -1.6 mmol m-3, and 1.2 mmol m-3 per decade for SST, surface oxygen capacity and vertical-minimum oxygen concentration, respectively. The trends in the forecasted global coastal region are much faster than the median rate for the entire ocean, and they are also much faster than the corresponding observed rates. This study also highlighted that warming and oxygen decline rate are larger at high latitude that it may cause new emerging hypoxic areas.

The manuscript will benefit the field of research in global deoxygenation due to warming by providing an estimate of expected changes in SST, sea surface oxygen solubility and vertical oxygen minimum in the global context in the future. However, this paper is a little thin on content and present numbers like a report. It lacks of more advanced understanding, deeper analysis on this topic, and comparison with previous similar study. Although I see the value of this work, I perceive that the publication is premature at this time. My major and detailed comments are listed as below.
Major comments:

(1) This manuscript missed a more in-depth discussion and insight of causes on the observation/model simulation comparison and global/coastal/hypoxic region comparison. Some interpretations of data are debatable. For example, the median trend of vertical oxygen minimum concentration decline in hypoxic areas is faster than all the global points (Table1, L275 and L282). Why is it due to little coverage of high latitude? Based on Figure 6(a), there are regions nearly the north pole with a large increase in oxygen concentration, which also missed further discussion in the manuscript. From the review’s perspective, there are potential questions that could be further explored and discussed. For example, why the forecasted hypoxic region has a faster vertical minimum oxygen decline rate than the coastal region, while the forecasted oxygen capacity decreases at slower rate in the hypoxic region? Why the forecasted SST increases faster in the hypoxic region than the coastal zone, which is the opposite from the observation???

(2) Second, this manuscript lacks further analysis regarding the discrepancy/disagreement with the previous study and discussion about the possible causes. It also didn’t include any uncertainty analysis, like what are the pro and cons of using CESM large ensemble rather than using multiple different GCMs? What is new about this study compared to previous similar papers (i.e. Gilbert et al.,2010; Bopp et al., 2013)? For the disagreement in estimated rate, the observed global median oxygen capacity trend is -0.9 mmol m-3 per decade, several times faster than Gilbert et al. (2010) for 1976-2000. What are the primary causes for the difference? The different time periods covered? The different data sources? Or other reasons? Similarly, for the forecasted trend, there are also discrepancies from Bopp et al. (2013). From the author’s perspective, which one is more credible?

(3) Except for the hypoxia in larger coastal systems like the Northern Gulf of Mexico, Baltic Sea, East China Sea, etc., the majority of coastal hypoxia occurs in small scale estuarine systems, which are not able to be covered, or could not be represented by the Global Earth System models. The CESM model with resolution at 1deg could not accurately represent both the physical and biogeochemical dynamics. Therefore, I am much concerned about the results on the forecasted vertical oxygen minimum in the hypoxic region. For example, I am suspicious about the result in Table 1 on the forecasted change rate of surface oxygen capacity and vertical oxygen minimum in the hypoxic region. In the coastal hypoxic system like the Chesapeake Bay and the Gulf of Mexico, the bottom minimum oxygen concentration region was generally much smaller than 62.5 mmol m-3 and the anoxia existed. In this case, there should be barely room for further oxygen decline due to warming. Thus, the decrease of surface oxygen capacity could be greater.
One big component missing in the discussion of the entire manuscript is nutrients. Unlike the open ocean oxygen minimum zone, the nutrient load into the coastal waters is the determining factor for hypoxia development. Although the rising temperature will reduce the oxygen solubility in the water and cause oxygen concentration decline, the hypoxia formation is also subjected to the local hydrodynamics (e.g. stratification), riverine nutrient loading and larger-scale ocean circulation. The ecological system (e.g. phytoplankton-zooplankton-bacteria coupling) may also shift with changing temperature. Thus, the rising temperature might not necessarily lead to the expansion of hypoxic water. The above points are worthy to discuss in the manuscript.

The oxygen loss from ocean with rising temperature and getting more severe towards higher latitude is pretty much predictable according to the nature of oxygen gas. From this point, this paper did not provide any innovative insight on the topic of global warming pressure on coastal hypoxia. More intriguing questions should be like: how was the impact of the warming pressure compared to the nutrient management strategies to reduce hypoxia? Will it completely overturn the mitigation of coastal hypoxia from nutrient load reduction? Another suggestion is to add regional case studies in some large coastal hypoxic system (e.g. Baltic Sea, Northern Gulf of Mexico, Gulf of St. Lawrence on the high latitude, etc.) combined with the analysis of this study might help to prove

Detailed comments:

Introduction

Warming induced change in oxygen capacity, metabolic rates, stratification

L36: Here the authors noted that this paper aimed to update the analysis with more recent climate modeling. However, it didn’t provide any discussion on the model reliability/uncertainty analysis among different GCMs and RCP/A1B emission scenarios, or an explanation on the discrepancy with the previous study.

L57: The linear trend analysis was applied throughout the manuscript, but the trend/long-
term change is not necessarily linear (i.e. quadratic or exponential, etc.)

L58: how does the satellite-derived SST compare to in-situ measurement? Is there any bias?

L60-61: using one GCM (CESM) may lead to bias in the projection

Method

L78: using constant 35 salinity will lose the impact of changes in salinity due to circulation and freshwater flow discharge. Any justifications?

L104-107: large ensemble mean of climate projection is not suitable for short-term point-to-point comparison since it loses decadal variability in the observation

L111-112: compare the seasonal average should be better since the annual mean might conceal the Tmax/Omin information

L131: In an opposite opinion, those areas should be included and highly possible to become hypoxic with future warming temperature since nutrient is a big part of coastal hypoxia

Result

L170, 173-174: why the global rate is much faster than other literature?

L165, 172: there is an issue in rounding from Table 1
L184-185: why the differences in scatters reach up to 5deg, while RMSE is just 0.03?

L210-212: why this study generates greater warming forecast than previous study?

L224-225: P>0.1?? I don't understand this sentence

Figure 4c, 5c: why the distribution of hypoxic SST/capacity trend is similar to coastal SST/capacity in the forecast, which is different from observation?

Table 1: forecasted oxygen capacity rate is larger than forecasted oxygen concentration rate in the global and coastal ocean, what are the reasons?

Figure 6b: what lead to the oxygen increase in some coastal regions when the oxygen capacity decrease?