Reviewer 2 General comments:

This study presents the results of a local anticyclonic gyre around Qingdao cold water based on 3D numerical simulations. In short, the authors found that wind and tide are major factors influencing the anticyclonic structure, not the temperature and salinity gradients caused by the cold-water mass. The manuscript is generally well written but clarifications or more explanations and rearrangements of figures are suggested. There are also some typos. Please see below the detailed comments.

Response to the comment:

We appreciate the reviewer for the time and effort in reviewing the manuscript. Thanks for the confirmation of the paper and suggestions which help us to improve the manuscript significantly.

1. A large bathymetry map identifying locations (e.g., Shandong Peninsula, Korean Peninsula), coastal seas (e.g., Yellow Sea, South Yellow Sea, Bohai Sea), and coastal currents (e.g., Bohai coast current, Yellow Sea warm current) mentioned in the paper are suggested to provide a big picture for readers who are not familiar with this region.

Response to the comment:

We have added a map which identifies the locations, please see Fig.1.

2. Please supplement explanations on why ensemble experiments are needed. Why not directly using the realistic simulation but initializing the model for four times to get the ensemble?

Response to the comment:

Thanks for your question, which reminds us to address the motivation for ensemble simulation. We have added a paragraph to describe why we need the ensemble simulation and why we conduct ensemble simulation in such a way. Essentially, we conduct the ensemble simulation to reduce the randomness caused by a single numerical simulation; and initializing the model four times a way to generate an ensemble simulation, such a way follows the tradition of previous research (Büchmann and Söderkvist, 2016; Geyer et al., 2021; Penduff et al., 2019). Additionally, the details of how the perturbations are seeded do not matter, they can be seeded by slightly different model start times or by the simulations with exactly the same model configurations conducted in the different clusters (Geyer et al. 2021). We have addressed the motivation of ensemble simulation in lines 113-121 in the manuscript.

The motivation for using ensemble simulations is based on the observation (Lin et al., 2022, 2023; Penduff et al., 2019) that deviations form within the ensemble members if the ensemble simulations are conducted with the same model configuration except for slight perturbations in the initial conditions. In other words, if we have only one numerical simulation, the model output will be a mix of "signal" (external forcing) and random effects. Some spatial features are not repeatable in other ensemble members, even though the model configurations are the same. Averaging across ensemble simulations efficiently reduces the random impacts of randomness. Therefore, in Sections 3 and 4, we consider the ensemble means for further analysis. An ensemble simulation with slightly different initial conditions is one way to analyze ocean internal variability. For the ensemble simulation configuration in this study, we follow the tradition of generating an ensemble simulation with slightly different initial conditions (Penduff et al., 2019).

We used the 9-year climatological simulation to provide slightly different but consistent initial conditions. All the initial conditions for the ensemble simulation members are took from the same climatological simulation, even though the time shifts a bit.

3. is the anticyclonic structure formed at depth shallower than 25 m?

Response to the comment:

We have plotted the current pattern at the depth 5m and 15m, please see below (Figs. 1* and 2*). The shape of the anticyclonic structure at the depth of 15m can still be visible, but the center is not very clear compared to that at 25m. The anticyclonic structure disappears completely at 5m depth. Thus, we choose a 25m layer for detailed analysis because the boundary and center of the anticyclonic are much clearer.

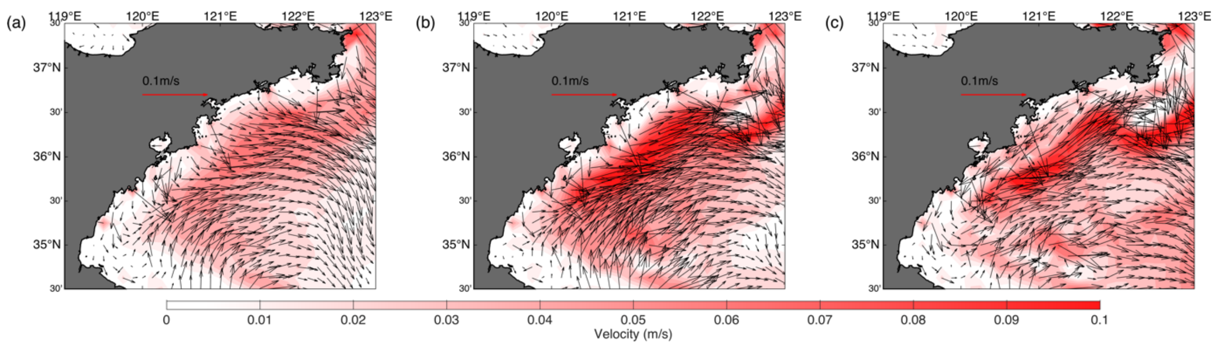

Figure 1*. The horizontal circulation distribution around the Qingdao cold water mass (5 m layer) in April (a), May (b), and June (c).

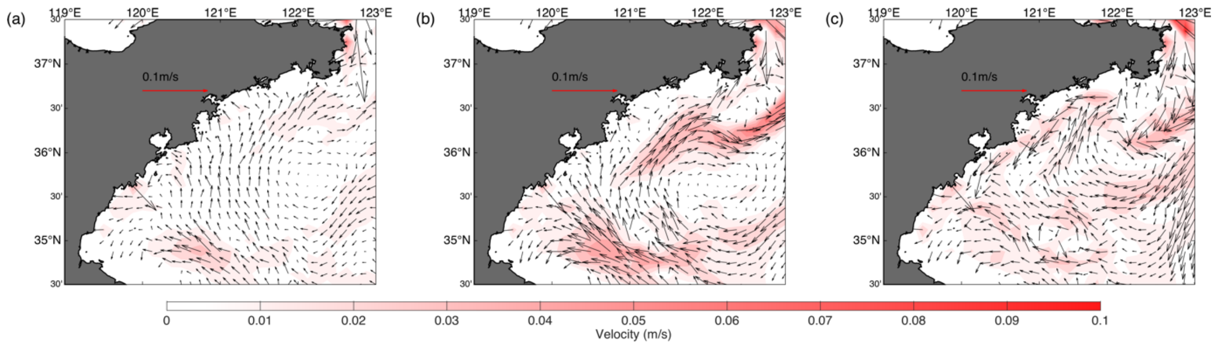

Figure 2*. The horizontal circulation distribution around the Qingdao cold water mass (15 m layer) in April (a), May (b), and June (c).

4. "temperature or salinity gradient" was used several times, are these horizontal or vertical temperature/salinity gradient?

Response to the comment:

Sorry about this. We have clarified the horizontal or vertical temperature/salinity gradient accordingly in the manuscript.

5. The short Section 3.1 Model validation could be merged into Section 2.1.

Response to the comment:

We have merged the brief model validation into Section 2.1 as suggested.

*6. '-fu' in Equation (2) should be '+fu'. The expression of the barotropic pressure gradient force should be g*dζ/dx in Line 190.*

Response to the comment:

Corrected. Thank you for the correction.

7. the identified different roles of wind and tide on upwelling that occurred east or west of the cold water mass is interesting. Yet, what leads to the different roles of wind and tide on different sides of the cold water mass seems lacking. The tide-induced front was mentioned. Could you add a plot showing where the tide-induced front is?

Response to the comment:

We have added a summary of how the wind and tide affect the upwelling at the end of section 4.3. The model results show that the western portion of upwelling is contributed by wind forcing and the eastern portion of upwelling is contributed mostly by the tidal forcing, but wind forcing plays a role as well. The upwelling caused by the wind force can be explained by the Ekman theory because of the predominant southeasterly monsoon; and the upwelling contributed by the tidal forcing is because of the tide-induced front (Fig. 3*), which affects the horizontal (Fig. 3*) and vertical (Figs. 5a and 5b) temperature distribution. The temperature variation will change the density distribution. The density redistribution will further influence the baroclinic pressure gradient force change accordingly around the front zone, which further triggers upwelling (when the tidal forcing is considered). The mechanism of how tidal forcing changes the baroclinic pressure gradient force and in the end triggers the upwelling is explained in previous research (Lü et al., 2010), in this paper, we found that such explanation can interpret the upwelling around the Qingdao cold water mass as well.

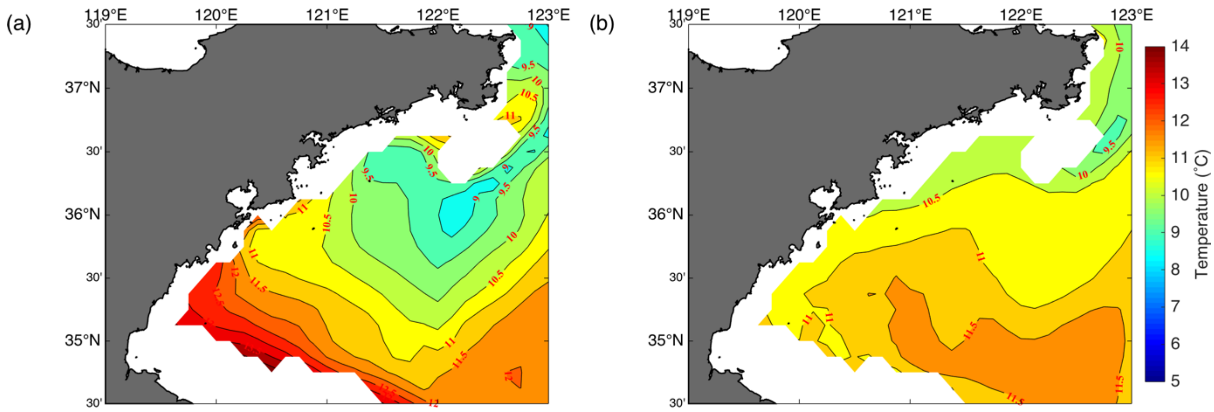

Figure 3* The temperature distribution in the control run (a) and no-tide experiment(b). In the control run(a), there is a front around the cold water mass. When the tidal forcing is turned off, such front disappears (b).

8. All "anti-clockwise" in Conclusion should be "anti-cyclonic" or "clockwise".

Response to the comment:

Sorry, we have corrected it.

9. Line 35: the cold pool is characterized by "moderate salinity" but later, it was described as "low salinity" (Lines 47, 53). Please check it.

Response to the comment:

Corrected. To be consistent, we have changed to "moderate salinity".

10. Line 41: "emergence" to "mergence".

Corrected. Thanks!

11. Line 56: add reference(s) after "...the Qingdao cold water mass forms".

Response to the comment:

We have added the reference as suggested.

12. Line 57: "Yellow Sea cold water mass" should be "Qingdao cold water mass"?

Corrected.

13. Line 70: "anticyclone" to "anticyclonic"

Corrected. Thanks!

14. Line 115: "However, these results are not different…" seems to be not correct. In the example, the mean temperature of this grid node's ensemble is 4.875 ˚C for the control run and 7.375 ˚C for the no-tide run. Their difference is 2.5 ˚C, which is different from the "3 ˚C".

Response to the comment:

Sorry for the confusing sentence. We have deleted it and rewritten the significance of the statistical test in lines 122-134. Additionally, we have an explicit version of why we need statistical test in another under-review paper with the topic of "Significance of Internal Variability for Numerical Experimentation and Analysis" (section 5.2; preprint: https://www.preprints.org/manuscript/202407.2261/v1). To explain more clearly, we would like to show part of the content in the reply to the review comments.

Lines 122-134: Because deviations exist between ensemble members because of randomness, we need to test whether the differences between the ensemble means of the control run and the no-tide run (/no-wind run) may be caused by external forcings (tidal or wind forcings) or could be caused only by randomness. A proper way to do so is statistical hypothesis testing with the null hypothesis: "external forcing has no effect". If this null hypothesis is rejected with a sufficiently small risk, then a valid conclusion is that an external factor has an effect and plays an active role. Here, a t test is performed for the ensemble monthly mean for May. The results (Figs. 2 and 3) show the sensitivity of the formation of the spring cold water mass to the presence of tidal forcing and wind forcing. Those grid points, at which a t test indicates that the effect of external forcing is significant, are marked with a cross. Figs. 2 and 3 demonstrate that the difference between the control run and the no-tide ensemble (or the /no-wind ensemble) is significant, especially where the intraensemble deviations are large.

When such local tests are conducted, one has to expect that even if the null hypothesis is valid, at approximately 5% of grid points, the null hypothesis is rejected (multiplicity of tests, cf. von Storch, and Zwiers, 1999). Since the rejection rate is itself a random variable, the false *rejection rate can be much larger, but more than 20% is very unlikely. Here, the rate is considerably greater in both cases.*

15. Line 141: (Diao, 2015) to (2015)

Corrected. Thanks!

16. Line 144: Figures should be mentioned in ordered sequence in the text.

Response to the comment:

We have corrected it and avoided this problem in the revised manuscript.

17. Line 161: "July" should be "June" (?)

Corrected.

18. Lines 160, 168: "southeast monsoon" and "southward monsoon" are a bit confusing. Is it southeasterly monsoon or northward monsoon?

Response to the comment:

Sorry, we have changed to southeasterly monsoon. We would like to express that a southeasterly monsoon prevails around the Shandong Peninsula, and a northward current exists along the Shandong Peninsula.

19. Lines 178-179: please clarify "meaning that the Qingdao cold water mass is less affected by horizontal disturbances".

Response to the comment:

We have deleted this unclear sentence.

20. Lines 199-200: "east of 122 °E" should be "west of 122 °E"? change "southwest wind stress" to "southwesterly wind stress," "northern current" to "northward current".

Corrected. Thanks!

21. Line 299: please check "a decrease in the baroclinic pressure gradient force around the location of the Qingdao cold water mass in the no-wind experiment". Is it "increase"?

Response to the comment:

Thanks for your correction. We have corrected it.

22. Line 335: "west side" should be "east side"?

Corrected.

23. Add references in Section 4.4 for the Yellow Sea basin-scale cyclonic circulation.

Response to the comment:

As we consider that the description of the Yellow Sea basin-scale cyclonic circulation is not strongly related to the main topic of this paper, we decide to delete section 4.4 in the revised version.

24. Question about the terminology: the anticyclonic circulation studied here disappears as the seasonal Qingdao cold water mass disappear. It's not a permanent feature, maybe call it a 'seasonal anti-cyclonic gyre' is more accurate or just use 'anti-cyclonic circulation'?

Response to the comment:

Thanks for bringing this discussion to us. In our opinion, the gyre usually refers to a large-scale feature, such as the sub-tropical gyre. In our paper, maybe it is more appropriate to use seasonal anti-cyclonic circulation. Further discussion about this issue is warmly welcomed. Additionally, in the revised version, we have added seasonally in front of the anti-cyclonic circulation.

Specific comments about figures:

1. Some figures can be combined for better visualization and comparison of results, for example, the following figures can be put together: Figures 1 and 2, Figures 5 and 6 (those two can be re-formatted into two rows and each row shows four plots), Figures 10 and 11.

Response to the comment:

We have replotted the above diagrams as suggested.

2. the unit of the momentum term in several figures is wrong: Figures 5, 6, 10, 11. It should be m/s2.

Response to the comment:

Thanks for the correction. We have corrected it.

3. For those figures showing features at 25 m, some of them masked the nearshore region (I believe these are shallower than 25 m), like Figures 1-3, 5-6, but others have valid values in this shallow region, like Figure 10-11. Please check it.

Response to the comment:

Many thanks for your comments. We have checked this problem and found the visualization problem is caused by unsuitable color bar. We have replotted the above diagrams.

4. Figure 7: correct (e, f, g) to (d, e, f). Which direction does the positive value represent?

Response to the comment:

Corrected. Thank you!

The positive value represents northward direction. We have added this informatio in the manuscript in line 233.

5. Figure 8: there should be no unit for Ekman ratio.

Response to the comment:

Corrected.

6. Figure 11: why is "time average over two M2 tide cycle" used here, rather than using "monthly mean for may" as Figure 10?

Response to the comment:

Thank you for pointing out this problem. We have modified it and both diagrams are monthly mean.

7. Figure 12 is not cited in the main text. Figure 12a is the same plot as Figure 1b, keep one figure is fine.

Response to the comment:

Sorry about this mistake. We have added a description for Fig. 12 and removed Fig. 12a (now Fig. 14 in the revised version) as suggested.

8. Figure 14 is repeated with one of the plots in Figure 15. You may consider put Figure 15 into supplementary. It's also recommended to reduce the vector numbers in Figures 14-15 to make them easier to see.

Response to the comment:

We have removed Fig. 14 in the revised version.

*9. Figure A1: which period of the surface wind stress is shown in this figure? The caption indicates that this *constant* wind field was used in the control run (?)*

Response to the comment:

Sorry about this. It is the monthly mean of surface wind in May. We use the realistic wind forcing, not the constant, as we described in the model configuration part. Sorry for not expressing this clearly. Fig. A1 (now Fig. A2 in the revised version) is only used to provide a direct feeling for the readers of the wind stress direction.