Thank you very much for your effort and time to read our paper and help us improve it. The comments are very insightful and constructive for us. We have revised the manuscript point by point to the comments as listed below.

Review1 General comments:

This work designs a series of numerical experiments using FVCOM model to investigate the drivers of Qingdao cold water mass. The study finds that both tidal forcing and winds are important in the formation of cold water. However, the manuscript is not well organized and include the information not directly related to this work. The objectives of this study are not very clear. Figure 12 is not even mentioned in the manuscript. In Conclusions, the authors confused "anti-clockwise" with "anti-cyclonic". Therefore, I would recommend the publication of the manuscript after major revision. Below are my detailed comments and suggestions.

Response to the comment:

Many thanks for your helpful review, perspectives, and comments. We have removed the content that is not strongly related to the work. To express the objective of this study more clearly, we have also rewritten the scientific questions based on your suggestions. We apologize for the confusion regarding Figure 12; we have corrected it and added a description. Additionally, we have made the necessary modifications to ensure consistency regarding the "anti-clockwise" and "anti-cyclonic" terms. Please see the detailed response below.

Minor Comments:

1. Lines 35 and 47: line 35 states that the cold water is featured by moderate salinity, while line 47 says it is a low salinity water mass. Please be consistent.

Response to the comment:

Thanks for the correction. We have corrected and changed the low salinity to moderate salinity.

2. Lines 39-40 and Lines 47-49: information duplication.

Response to the comment:

Thanks. We have deleted that "It forms from March to April, reaches its peak in May" in lines 47-49 (in old version).

3. Lines 59-70: I would recommend the authors to rewrite this portion. First, other cold water masses are not directly related to this work, so it is unnecessary to include so many details. Please be concise and remove those examples. Second, the question need to be answered in a study should be very specific. Why you still use an example to express the question?

Response to the comment:

We have removed the examples and rewritten this part to make it concise. Please see lines 62-66:

Bohai Sea (Liu et al., 2003; Wan et al., 2004; Zhou et al., 2017) and the Yellow Sea cold water mass (Ho et al., 1959; Hur et al., 2000; Wei et al., 2010; Yuan et al., 2013). The special circulation structures around the Bohai cold water mass and Yellow Sea cold water mass have been well described in previous research (Wang et al., 2014; Xia et al., 2006; Zhou et al., 2017; Zhu and Wu, 2018), but the anticyclone current field analysis near the Qingdao cold water mass still needs to be investigated.

4. Lines 71-77: This portion is poorly organized. In question one, why you say it is a special cold pool structure? Question two is too vague. Influence what features of the anti-cyclonic gyre? Morphology, Duration, Magnitude, Timing, or something else? There is no need to list only two questions using one paragraph.

Response to the comment:

Regarding scientific question 1, we have deleted the "it is a special cold pool structure" and rewritten the scientific question to "Is the Qingdao cold water mass causing the local seasonal anticyclonic structure?" (lines 66-67). For scientific question 2, we have added "the morphology, magnitude, and position of" to make it more specific. Additionally, we have combined this paragraph with the previous paragraph.

Lines 66-68: In this work, we investigate the following questions: (1) Is the Qingdao cold water mass causing the local seasonal anticyclonic structure? Does such a seasonal

anticyclonic circulation fit the geostrophic balance? (2) What factors influence the morphology, magnitude, and position of seasonal anticyclonic circulation horizontally and vertically?

5. Line 82: cite the wrong paper. It should be Chen's 2003 or 2006 paper. Also there are a lot of citation format issues in this work. Please double check your citations.

Chen, C., Liu, H. and Beardsley, R.C., 2003. An unstructured grid, finite-volume, three-dimensional, primitive equations ocean model: application to coastal ocean and estuaries. Journal of atmospheric and oceanic technology, 20(1), pp.159-186.

Chen, C., Beardsley, R. and Cowles, G., 2006. An unstructured grid, finite-volume coastal ocean model (FVCOM) system. Oceanography, 19(1), pp.78-89.

Response to the comment:

Sorry, we have corrected it.

6. Line 82: remove "while".

Corrected.

7. Line 89: provide citation of CFSv2 dataset.

Corrected.

8. Lines 93-94: why only one sentence in this paragraph? Is it necessary to use one paragraph to state tidal forcing?

Corrected.

9. Line 101: Very confusing. Please rewrite this sentence.

Response to the comment:

Sorry about this confusion. We have rewritten this sentence, please see lines 103-104:

Ensemble simulations are conducted for the control run, no-tide run, and no-wind run. Each ensemble simulation consists of four numerical simulation members.

10. Lines 103-104: why you choose these four time frames? Also there is no information regarding your 9-year climatological simulation.

Response to the comment:

This is a good question, which reminds us to address the motivation of 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. In short, we would like to seed a perturbation in the ensemble simulation, so we used four slightly different initial conditions, namely shift in model start time. 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 the same model configurations conducted in the different clusters (Geyer et al. 2021). We have addressed the motivation for 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 taken from the same climatological simulation, even though the time shifts a bit. The model starting time of the 9-year climatological simulation is 1st Nov. 2008, and the model ending time is 31st Dec. 2019. The climatological forcing for the climatological run is a smooth annual cycle without weather variations based on National Centers for Environmental Prediction (NCEP) Climate Forecast System Version 2 (CFSv2) data. We have added the description of the climatological simulation in lines 106-110:

Note that we conducted an independent 9-year simulation to generate slightly different but generally consistent initial conditions for the ensemble simulation. The model starting time of the 9-year climatological simulation was 1st Nov. 2008, and the model ending time was 31st Dec. 2019. The climatological forcing for the climatological run is a smooth annual cycle

without weather variations based on National Centers for Environmental Prediction (NCEP) Climate Forecast System Version 2 (CFSv2) data.

11. Line 105: why you choose year 2019? If the cold water mass has strong interannual variability, can 2019 scenario represent the normal year condition?

Response to the comment:

Thanks for your question. 2019 was chosen as an example for analysis. If we choose to simulate the results of other years (for example, we have simulated the result of 2010 discussing the characteristics of the seasonal variation of Qingdao cold water mass, published in a Chinese journal (Huang et al., 2019)), the basic characteristics will be similar, and the simulation of this anticyclonic circulation in other years is currently running, which will be the next step of work and the focus of the next step, namely, discuss the interannual variation characteristics and mechanisms of the interannual variation this anticyclonic circulation. We have mentioned this limitation and next step work in the paper.

Lines 375-379: In this paper, we use the model result of 2019 as an example. Huang et al. reported similar basic characteristics of the temperature and salinity of the Qingdao cold water mass in 2010 (2019). Currently, we limit ourselves to the simulation of 2019; in the future, we plan to discuss the interannual variation characteristics and mechanisms of the interannual variation in this anticyclonic circulation.

12. Lines 115-116: why you say "these results are not different if we consider the mean T …"? In your example the benchmark's mean T is around 5 while the sensitivity test's mean T is ~7.5. The rationale behind this setup is very tricky.

Response to the comment:

Sorry about this confusion, we have deleted this sentence and rewritten why we do a t-test for the control run, no-wind, and no-tide simulation. Hope it can express more clearly in the new version. Please see lines 122-134.

Because the deviations exist between ensemble members caused by the randomness, we need to test whether the differences between the ensemble mean of the control run and the no-tide run (/no-wind run) may be caused by external forcings (tidal or wind forcings) or could only because of 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 done for the ensemble monthly mean for May. The results (Figs. 2 and 3) show the sensitivity of the forming of the spring cold water mass to the presence of tidal forcing and wind forcing. Those grid points, at which a t-test indicated 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 intra-ensemble deviations are larger.

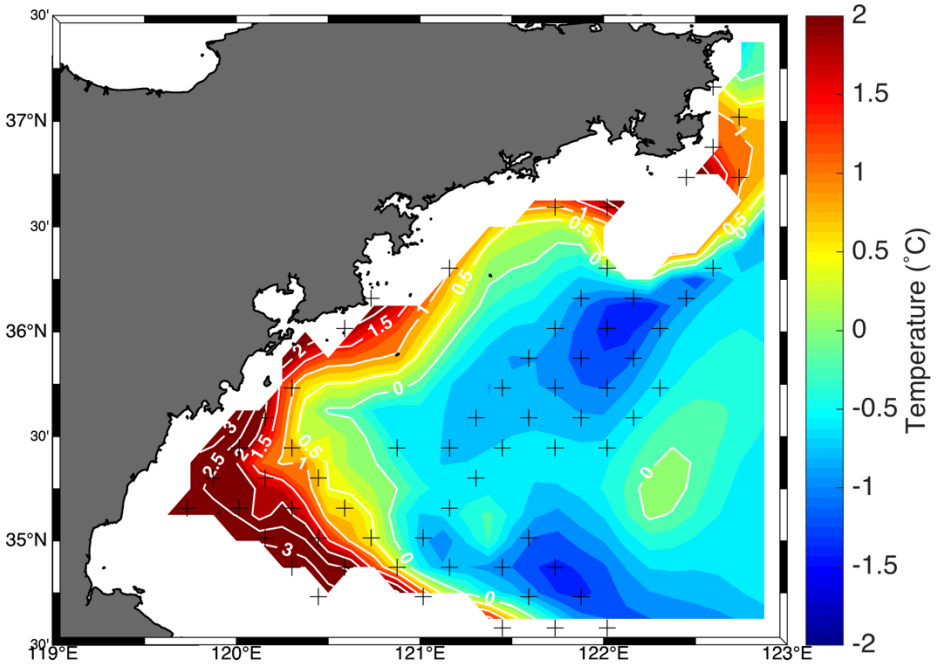

Figure 2. The difference in temperature between the ensemble means of the control runs and those of the runs without tidal forcing. The crosses represent the areas where the difference between the control run and the run without tidal forcing was significant at the 5% level.

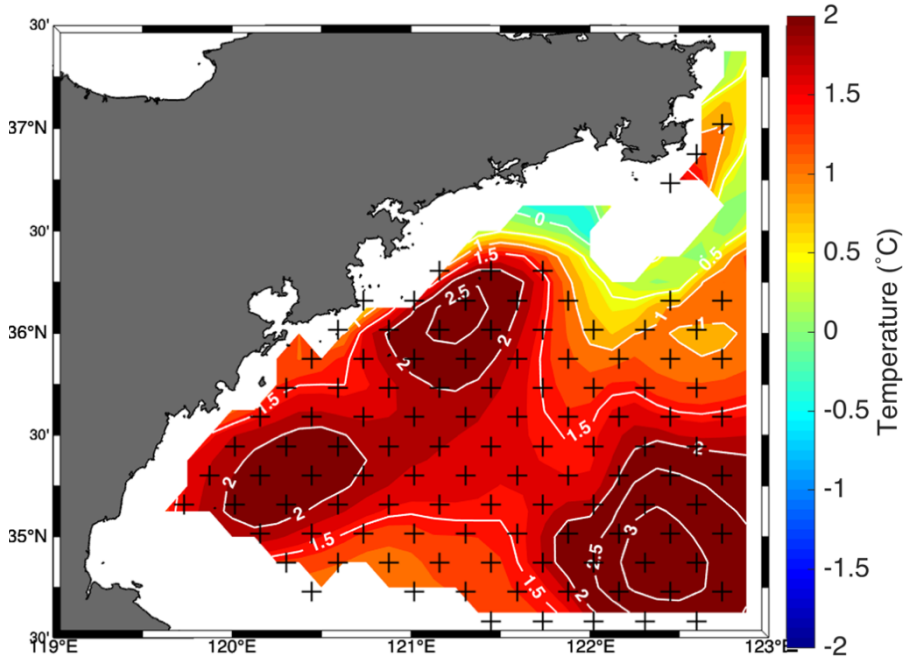

Figure 3. The difference in temperature between the ensemble means of the control runs and those of the runs without wind forcings. The crosses represent the areas where the difference between the control run and the run without tidal forcing was significant at the 5% level.

Additionally, the explicit logic behind the significance of the statistical test under review (the preprint: https://www.preprints.org/manuscript/202407.2261/v1; section5.2). As the main topic of this paper is the seasonal anticyclonic circulation around the Qingdao cold water mass, so we only briefly describe the ocean's internal variability related to the definition and understanding in the paper.

13. Line 122: Results.

Corrected.

14. Lines 124-126: the structure of this part is weird. There is no need to have this portion as a paragraph, especially when it does not provide too much detailed information.

Response to the comment:

We have deleted this portion, and have rewritten the model validations can be found in the previous publication in one sentence in section 2.1.

15. Lines 129-130: you already included the similar information in Introduction, no need to repeat it here.

Response to the comment:

We have deleted this part.

16. Lines 131-133: the figure should be included in the supplementary material to help readers better understand your work.

Response to the comment:

We have added the figure as suggested.

17. Line 137: remove "moreover". "the shape of ... has a ... direction"? Rephrase this sentence.

Response to the comment:

We have deleted this sentence.

18. Line 138: it should be Shandong coastal current, not Bohai coastal current or Bohai coast current.

Corrected.

19. Line 139: In Fig. 2, why not show data in June?

Response to the comment:

We have added a panel showing the salinity data in June. Please see the Fig. 4 in the revised manuscript.

20. Line 141: "Diao et al" citation issue.

Corrected.

21. Line 144: the figures directly jump from Fig. 2 to Fig. 15?

Response to the comment:

Sorry, we have moved Fig. 15 in the old version to Fig. 5 in the revised version and adjusted the figure number correspondingly.

22. Line 147: Additionally?

We have deleted the "Additionally".

23. The color gradient of colorbar and the x axis labels are not well matched.

Thanks. We have replotted the figures. Please see Figs. 9 and 10. And we have avoided this kind of problem in the revised paper.

24. Line 161: to July?

Corrected.

25. Line 163: it is hard to tell the anticyclonic structure is closed from the figure.

Response to the comment:

Sorry for the confusion, it should be the anticyclonic structure closes in May, rather than "in May and June". To be more accurate, we have rewritten the sentence, and the sentence in the revised version is "In May, the anticyclonic structure almost closes".

26. Lines 199: In Figs. 5d and 6d, I don't think the statement in the manuscript "vertical fricition term plays a role, especially east of 122E" match the figure.

Response to the comment:

Ok. The significance of the vertical friction terms is mostly described in section 3.4, so we decided to delete the "vertical friction term plays a role, especially east of 122E" in section 3.3 and address the importance of the vertical friction later in section 3.4.

27. Line 210: the subtopic is too long. Please be concise.

Response to the comment:

We have changed the subtopic to "Relation between the seasonal anticyclone circulation pattern and the Qingdao cold water mass".

28. Line 216: why you choose 35.5 N transect? If you look at Fig. 1 this transect does not cross the center of the cold water mass.

Response to the comment:

35.5 ºN was chosen because it is around the center of the anticyclonic structure. The center of the Qingdao cold water mass is not exactly the same as the center of the anticyclonic structure. Additionally, we have examined the results if we shift the transect 0.5º northward or southward. It does not change the conclusion that the geostrophic balance is not satisfied because the topography of the Qingdao cold water mass is shallow, thus inducing strong vertical friction.

29. Line 280: I don't think the authors discussed Fig. 12 in the manuscript.

Response to the comment:

Sorry for this. The Fig. 12 in the old version manuscript is now Fig. 14 in the revised version. This figure is used to show that the center temperature of the Qingdao cold water mass decrease by 2°C when the wind forcing is turned off, so I have the description of it in the manuscript.

Lines 314-317: On the other hand, in the absence of mixing caused by surface winds, the temperature of the Qingdao cold water mass decreased by 2°C (Fig. 14), resulting in an increase in the baroclinic pressure gradient force around the location of the Qingdao cold water mass in the no-wind experiment. The vertical friction somewhat decreases because of the lack of wind stress in the no-wind experiment.

30. Lines 310-311: rephrase this sentence "for the eastern portion,....but for the eastern portion,..."

Response to the comment:

Thanks for the correction. The correct sentence should be "For the western portion (122.625-123°E), the wind forcing still plays a role, but for the eastern portion, tidal forcing contributes more to upwelling". We have corrected it in the manuscript.

31. The two transects show very similar results. I think one transect is enough.

Response to the comment:

We have modified it as suggested, please see Fig. 5 in the manuscript.

32. Line 353: be concise. I feel this section does not relate to the topic of this research. I would recommend to remove it.

Response to the comment:

Deleted as suggested.

33. Line 369: Conclusions

Corrected.

34. Lines 372, 373, 378: anti-clockwise or anti-cyclonic?

Response to the comment:

Sorry about this. It should be anticyclonic. We have corrected and double-checked it in the whole manuscript.