## Response to Reviewer #2

We want to thank you for carefully reading and the constructive comments on our manuscript. Please find below our responses (in black) to all your comments (in blue) point by point, with new text added in the manuscript highlighted in *Italic*.

This paper describes the set up and validation of a coupled ocean-ice model over the Bohai Sea, with a focus on sea ice. The analysis was done using a 22-year hindcast simulation, and the intention is to use this model for long term and climate change studies - which a feature that makes it different to the other models developed for this area.

The presence of sea ice in the Bohai Sea, with it being at such a low latitude is interesting and it would be nice to include an explanation as to why it occurs.

Indeed, the Bohai Sea is the southernmost seasonal frozen sea in the Northern Hemisphere. The shallow water depth, low sea surface salinity, and geographical location are the main reasons for the formation of sea ice in the Bohai Sea. We have detailed this part to the introduction for clarity in the following.

*The formation of sea ice in the Bohai Sea mainly depends on the geographical environment and hydrometeorological characteristics (Ding, 1999). Specifically, the Bohai Sea is located in the continental shelf area, and the average water depth is only 18 m (Su and Wang, 2012), which indicates low oceanic heat content in winter. Following a northern continental climate, the Bohai Sea is affected by the cold Siberian air every winter, which causes the sea surface temperature of the Bohai Sea to be significantly lower than that at the same latitude (Zhang et al., 2016; Donlon et al., 2012). In addition, the sea surface salinity of the Bohai Sea is about 30 PSU, which is the lowest in the entire coastal waters in China (Yan et al., 2020). It means that the Bohai seawater freezes before reaching the maximum density. Therefore, it even more easily convects and loses heat just before freezing.*

Sea ice is the main focus of this paper however the underlying ocean dynamics of the Bohai Sea are not presented. I think that this article is lacking in the presentation of what is happening in the ocean and this needs to be addressed before publication.

We agree that the presentation of the underlying ocean is very valuable. We have added the comparisons of ocean temperature and salinity stratification between NEMO-Bohai and the atlas in a new section 3.2.4, as well as ocean circulation in section 3.2.3. In addition, more explanations for model biases are further proposed for clarify in section 3.

**Specific points/questions:**

1. You state that "a regional model for the Bohai Sea based on NEMO has not yet been developed, until now" but unfortunately this is not correct, as Li et al. 2021 have also set up a coupled NEMO model in this area:

Li, R., Lu, Y., Hu, X. et al. Space–time variations of sea ice in Bohai Sea in the winter of 2009–2010 simulated with a coupled ocean and ice model. J Oceanogr 77, 243–258 (2021). https://doi.org/10.1007/s10872-020-00566-2

Thanks for pointing out the study (Li et al., 2021), which simulated sea ice variations in the severe winter of 2009–2010 in the Bohai Sea based on NEMO 3.6 and distinguished significantly with our model application for climate studies. We have added this reference in the introduction part. At the same time, we have revised the mentioned sentence:
*However, a NEMO-based regional model for the Bohai Sea has not been attempted for long-term climate studies until now.*

2. When using FRS boundary conditions, the number of cells over which the relaxation is applied (nn_rimwidth) is typically between 8 and 10. I am interested as to why you have chosen to set it to 1 here.

This is a long story. We did not succeed in producing our boundary files by SIREN. Instead, we used the script provided by our coauthor, which is developed for NEMO application in the Barents and Kara Seas. In the script, the relaxation zone is set to be 1 grid cell, and the same setting can also be found in other studies (Thompson et al., 2021). Yes, the width of the FRS zone is typically set to a referenced value between 8 and 10. So far, we have only used this option (nn_rimwidth=1), but we will try some sensitivity experiments in the future.

3. It would be good to include some background information on the circulation of the ocean. Ocean currents play a role in determining the position of ice floes, so it would be beneficial to show that this model is simulating this properly before then going on to show how the model performs in predicting details in sea ice.

Thanks for your comments. We have added a new section 3.2.3, within which a new figure is added to illustrate the ocean currents at the surface and 16 m depth in August and February. We have also discussed the water volume exchange between the Bohai Sea and the Yellow Sea.

4. Instead of solely concentrating on surface plots, it would be good to include some vertical profiles of temperature compared to observations in the validation section. Perhaps also some transects of salinity and temperature across key areas in the results section, which would show the presence of any stratification of the ocean in different seasons.

Thanks for your suggestion, and we have added the figure and text in a new section (see section 3.2.4) accordingly to compare S/T vertical profiles:

*NEMO-Bohai and observed water temperature and salinity profiles along the transect AB (see Fig.1) are shown in Fig. 6 and Fig. 7, respectively. Observations are from the atlas by Chen (1992), which is based on data from the 1950s to 1990s. The temporally closest 5-year period from 1995 to 2000 of NEMO-Bohai simulations was selected for model-observation comparisons. Common features are found both in the model and observations. The Bohai Sea waters are vertically well-mixed in autumn and winter, and they have a remarkable homogeneous vertical distribution for both temperature and salinity. In spring and summer, thermal stratification occurs with a significant cold-water core at depth, eventually eroded in autumn. As apparent in Fig. 6 and Fig. 7, the stratification in shallow coastal waters is generally homogeneous. Similar features were reported by Wang et al. (2008), who analyzed the seasonal variations of the vertical profiles in the Bohai Sea.*

*The model results, however, show some discrepancies compared to the atlas. Although the model reproduces the summer saline stratification, it is weaker than in the atlas. Nonetheless, Li et al. (2015) reported that the summer salinity stratification in the Bohai Sea is possibly weaker than in the atlas, with an observed top-to-bottom salinity difference of 0.6 PSU. The modeled salinity distribution along with transect AB during summer is possibly affected by the high vertical diffusivity. In the north part of the transect, which corresponds to the northern Liaodong Bay, a negative salinity bias is visible compared to the atlas. In addition to the reasons mentioned in section 3.2.2, inaccuracies in the ETOPO1 bathymetry, especially in the low water depth region seen from Fig. 6 and Fig. 7, may also cause these underestimations.*

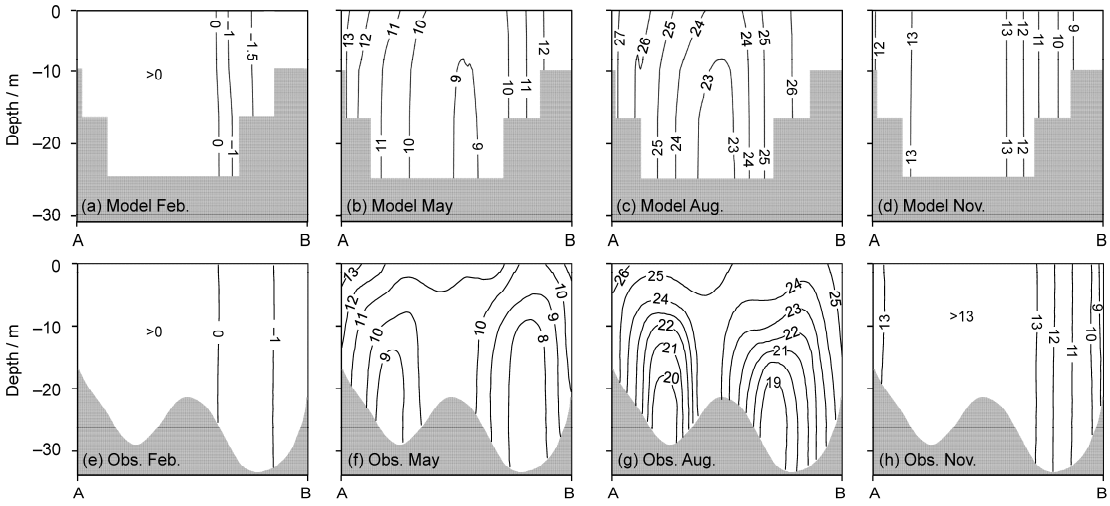


***Figure 6: Comparison of vertical profiles of water temperature (°C) along with transect AB (locations shown in figure 1) between NEMO-Bohai (a-d) and the atlas (Chen, 1992) (e-h) in February, May, August, and November.***

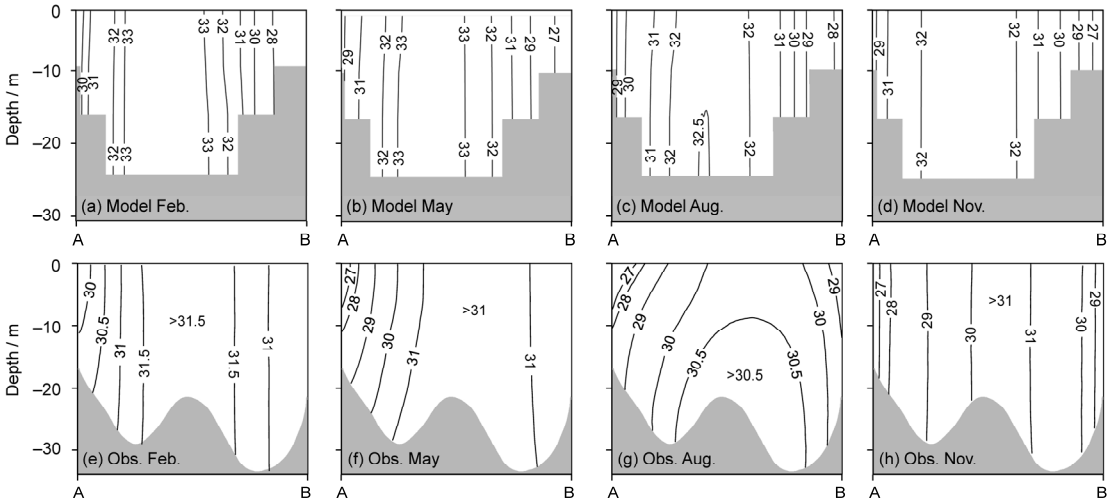


***Figure 7: Similar to figure 6 but for salinity (PSU).***

**Technical:**

*There are quite a few mistakes in the language throughout the manuscript (too many to list here) and these need be corrected before publication.

We have followed you and checked grammar throughout the manuscript. We also have finished the English Language Editing service to improve English presentation accordingly.

*On pages 6 – 10, the odd symbols made it quite hard to read whilst reviewing. This should also be corrected in the manuscript before publication.

Yes, there are some glitches on pages 6-10. The certain terms in Nimbus Mono L Font are garbled, and we have clarified in Author Comment (https://doi.org/10.5194/gmd-2021-100-AC1). We have revised these odd symbols in the revised manuscript.

*Salinity units should be in PSU.

Changed.

*Figure 4. Ensure that the number of ticks on the y axis is the same (c, f, h have more).

Thank you for noting this. The number of ticks in Fig. 4 has been unified for all subfigures.

*Page 16, line 342: "Sea ice volume is defined as the total ice over the whole Bohai Sea, which is calculated through sea ice concentration times ice thickness in all grids."
This should be replaced by: "…sea ice concentration multiplied by ice thickness in all grids."

The sentence has been revised accordingly.

**Reference**


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