Reply to Reviewer #1

Dear Reviewer,

We thank you very much for your very insightful and constructive comments to improve our manuscript. According to your comments, we have carefully revised the manuscript. Please see the detailed responses to each comment below. The comments are cited in black. The response to each comment is set out in blue. The revised manuscript will be submitted at the stage of revision.

Lei Lin

Using transport pathway, time scale and the concentration as indicators, this study examined the influence of tides on the river water behaviours over the shelf of the marginal sea. The results are important to understand and improve the climate model in the global water and biogeochemical cycles. The methods are solid, and the results are reasonable. Several points can be further clarified at this stage.

1. Several indicators including the pathway, time scales, tracer concentrations were used in this study. (1) The links and discrepancies among those indicators can be further explained, thus give better illustration on the influence of tide. (2) Such as there is high water age in the region of YSCWM, which trapped the river waters, while the emergence possibility there is relatively low.

   Response: (1) Following your instruction, we have added an extra paragraph to explain the physical meanings of the different indicators and their links and discrepancies. The emerging probability of the particles reflects the proportion of river water that passes through the region, which is mainly related to the shelf currents. The regions with higher emerging probability indicate a greater amount of river water passing through them and thus are the main pathway of river water transport. The transit area can be an approximate representation of the area through which the river flows. Water age reflects how long the river water has been on the shelf after leaving the estuary, while the transit time reflects the total time the river water takes from entering to leaving the shelf. The tracer concentration reflects the stock of the river water over the shelf, which can influence the salinity field. It should be noted that the magnitudes of the emerging probability, water age, and tracer concentration may not be directly related. For instance, a small proportion of one river water may stay in region A for a long time while the most proportion of the river water may quickly leave the shelf through region B. Then, region A would obtain a relatively large water age but a relatively small emerging probability compared with region B. However, the tracer concentration in region A could be either high or low which is determined by the accumulated amount of river water in this region.

(2) The high age of river water in the central Yellow Sea actually reflects the slow water exchange of the Yellow Sea. Once a particle goes into this region, it needs a long time to leave. However, only a small proportion of the river water stayed in the region of the YSCWM, and most of the river waters were transported along the west coast of the Korean peninsula. Meanwhile, the area of the central Yellow Sea is large. Thus, in spite of a high water age, the emerging probability at the region of the YSCWM was low. We have added this comment to the revised manuscript.

2. The transit time shows high STD, which is comparable to the mean values. There is also remarkable seasonal variability. While those variabilities were not well discussed or explained.

   Response: The high STD could be related to the water mixing and the high spatial variation in the water residence time. As shown by Lin et al. (2022), there is significant spatial variation in the water residence time (WRT) on the eastern shelf of China. The WRT can reach 15 years in the Bohai Sea, 4-10 years in the Yellow Sea, and about 1 year in the East China Sea. The particles released at the estuaries were continuously dispersed as they move under the effect of mixing. Dispersed particles can go into different seas and get different residence times over the shelf, which can explain the high STD of the transit time. The seasonal variability of the transit time could be related to the seasonal variation in the shelf currents. For instance, the part of the Changjiang River water in spring is prone to be transported into the Yellow Sea under the effect of the southerly wind and thus obtained a longer retention time over the shelf than in other seasons. Meanwhile, the large range of the residence time of the Yellow Sea induced the large STD in spring. We have added this comment to the revised manuscript.

3. How the emergence possibility represents the "pathway" of the river water? The emergence possibility is discontinuous spatially, should give a better explanation.

Response: The discontinuity of the emerging probability of the river particles could be due to the spatial variation in the area through which the river water flows, which can be understood using a schematic diagram as below (Figure S1). Because the total number of particles is constant, the emerging probability of the particles should be relatively large when they go through a small-area region, and vice versa. The area is relatively small in the regions of the inlet and outlet and is relatively large in the middle of the shelf sea. Thus, the emerging probability seems to be discontinued at the middle of the river water transport pathway, e.g., in the case of the Changjiang River. We have added this comment to the revised manuscript.

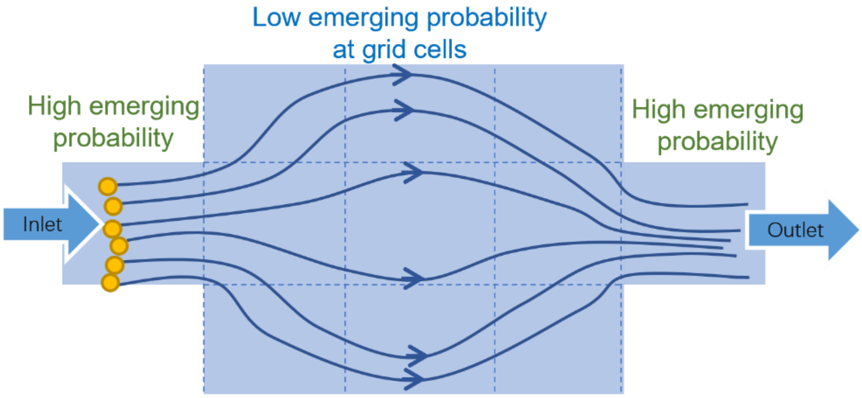

Figure S1. Schematic diagram for the spatial variation in the emerging probability. The area in the middle shelf is relatively large, resulting in a relatively low emerging probability at grid cells than in the regions of the inlet and outlet.

4. Why the tidal effect induced more dispersed transport for the Yellow and Yalujiang Rivers' waters but more concentrated transport for the Changjiang River water?

Response: The different tidal effects could be related to the different water transport patterns of the rivers. For the Yellow and Yalujiang Rivers water, the west coast of the Korea Peninsula with strong tides and cross-shelf tidal currents (Figure S2) is their main transport pathway (Figure 2 in the manuscript). As shown in Figure S3, without considering tides, the southward coastal current along the west coast of the Korean Peninsula was intensified, especially in winter, which accelerated the river water export and reduced the transport timescales of the Yellow and Yalujiang Rivers' waters. When considering the tides, on one hand, the cross-shelf tidal currents along the coast can increase the cross-shelf water dispersion as the magnitude of tidal dispersion is proportional to the tidal velocity (Geyer & Signell, 1992). On the other hand, the weakened coast current slowed down the along-shore transport of the river waters and further promoted the cross-shelf water dispersion. Thus, compared to the NoTide case, the Control run obtained a more dispersed transport for the Yellow and Yalujiang Rivers' waters. For the Changjiang River, there are three major branches for the river water transport, i.e., the northeastward branch to Cheju Island, the northward branches to the Jiangsu coast, and the southward branch to the Zhejiang coast (Wu et al., 2014). The northeastward branch to Cheju Island is the dominant one for the Changjiang River water transport. In the NoTide case, the intensified coastal currents could increase the river water transport to the Yellow Sea along the Jiangsu coast in summer and to the East China Sea along the Zhejiang coast in winter, which intensified the northward and southward branches of the Changjiang River water transport. Thus, the water particles of the Changjiang River in the NoTide case were more dispersed than those in the Control run. We have added this discussion to the revised manuscript.

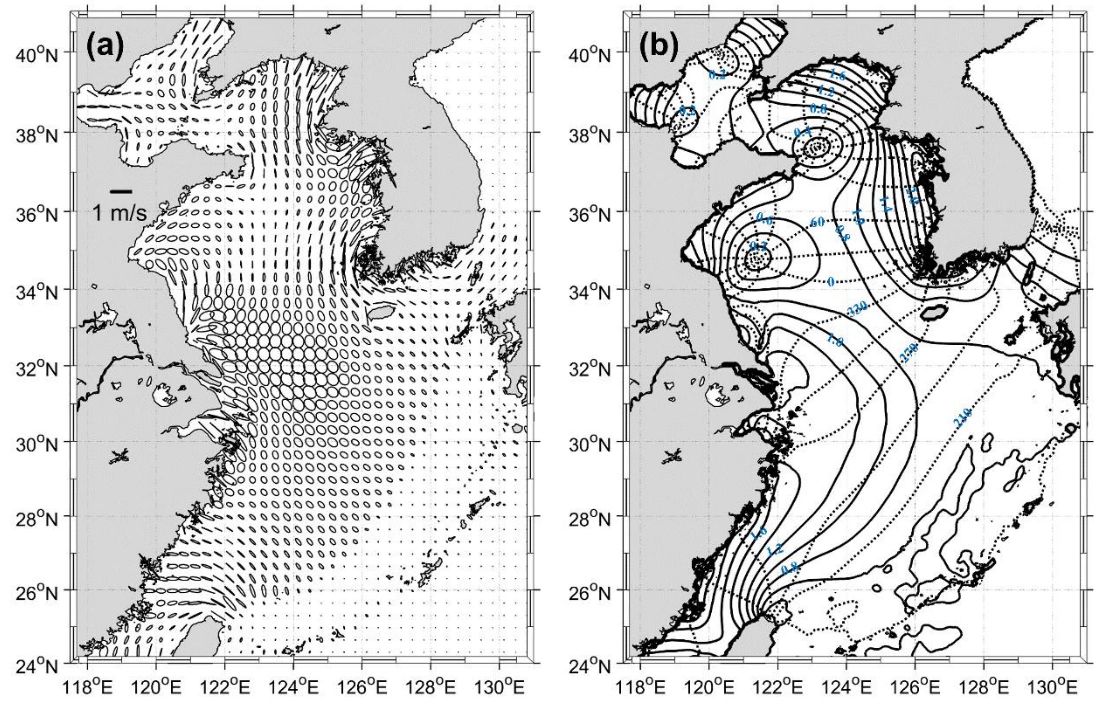

Fig. S2. (a) Tidal ellipses for M_2 tide. (b) Contour lines of coamplitude (solid lines, with an interval of 0.2 m) and cophase (dashed lines, with an interval of 30°) for M_2 tide.

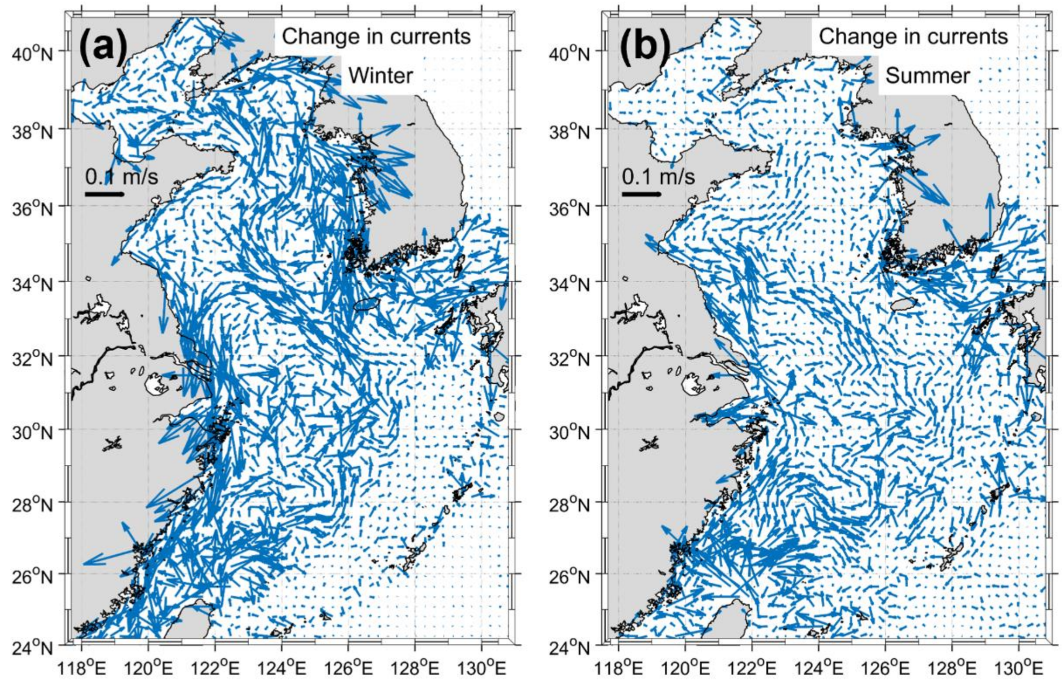

Figure S3. The changes in shelf currents in February (a) and August (b) after removing tides in the model.

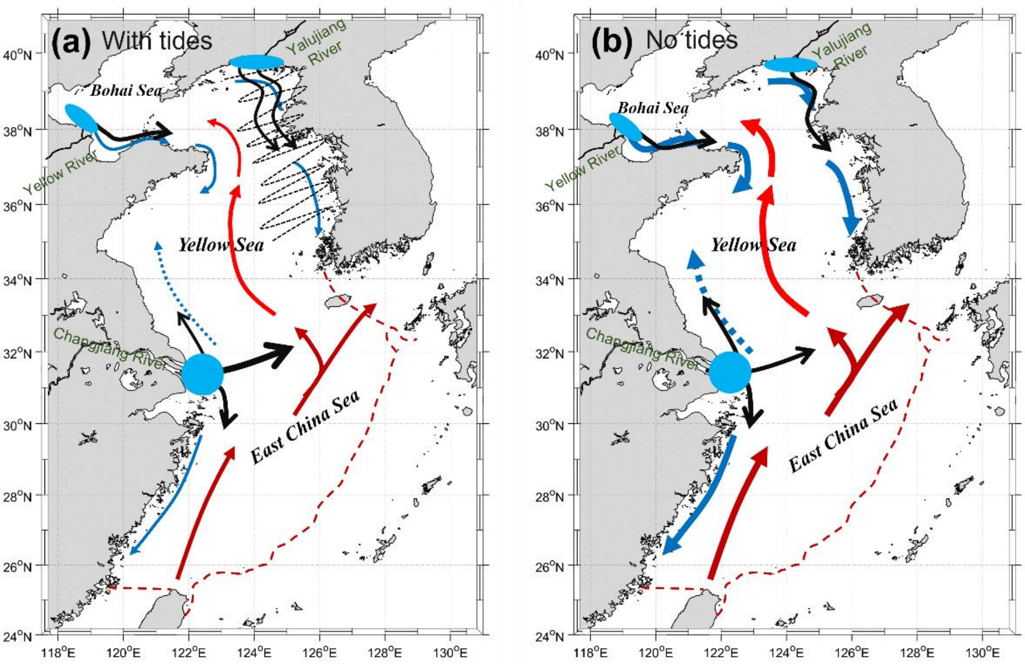

Figure S4. Schematic map of the shelf currents and the major pattern of the river water transport for the Control run (a) and NoTide case (b). The blue and red arrows denote the coastal currents and warm currents, respectively. The blue dashed arrow at the Jiangsu Coast denotes the coastal current in summer. The thickness of the arrows denotes the intensity of the shelf currents. The black dashed wavy line in (a) denotes the cross-shelf dispersion induced by tides. The black arrows denote the direction and the branches of the river water transport.

5. The tide has different effect on the river behaviour in Bohai& Yellow Seas and the East China Sea, due to the semi-enclosed geometry or the water depth?

Response: The different effects of tides on the river behaviour in the Bohai and Yellow Seas and the East China Sea could be related to both the geometry and the water depth, as both of them can influence the water exchange and the strength of the tidal current. The semi-enclosed geometry in the Bohai and Yellow Seas induced relatively weak water exchange compared to the relatively open East China Sea. Thus, the coastal currents are important dynamics for the water exchange in the Bohai and Yellow Seas and the tidal effect on the coastal currents significantly influenced the river water behaviour in the Bohai and Yellow Seas.

On the other hand, the change in the bottom friction induced by the tides is an important mechanism for the tidal effect on the shelf currents. Due to the larger inertia and stronger stratification, the shelf currents in relatively deep water could be less influenced by changes in bottom friction than that in relatively shallow water (Figure S5). Thus, the effect of tides on river water behavior in the East China Sea was relatively smaller than those in the Yellow and Bohai seas. We have added this comment to the revised manuscript.

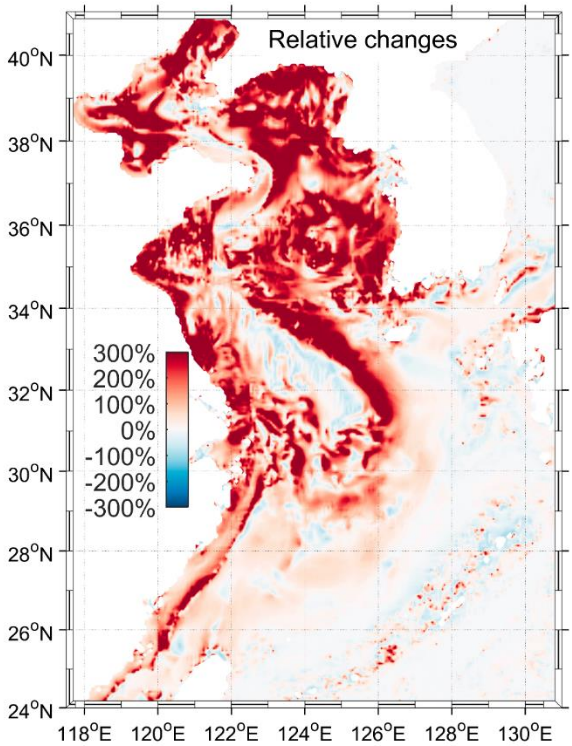

Figure S5. The relative changes in the annual mean magnitude of shelf currents after removing the tides in the model. Positive (negative) values indicate an increase (decrease) in the magnitude of the currents.

Some minor comments:

1. What's the frequency of the hydrodynamic model data used to drive the particle tracking and passive tracer model.

Response: The hydrodynamic model data with a time interval of 0.5 hours were used to drive the particle tracking and passive tracer models. We have added this information to the revised manuscript.

2. For the transit time and water age, did authors consider the re-entry processes?

   Response: The re-entry process was not considered in the calculation of the transit time and water age. Thus, the timescales in this study represent the time from leaving the estuaries to touching the shelf boundary for the first time. We have added this information to the revised manuscript.

3. The changes of mixing intensity can be shown

   Response: We have added a figure (Figure S6) to show the changes in the vertical turbulent diffusivity coefficients in the revised manuscript. Due to the space limitation, we put this figure in the supplementary material.

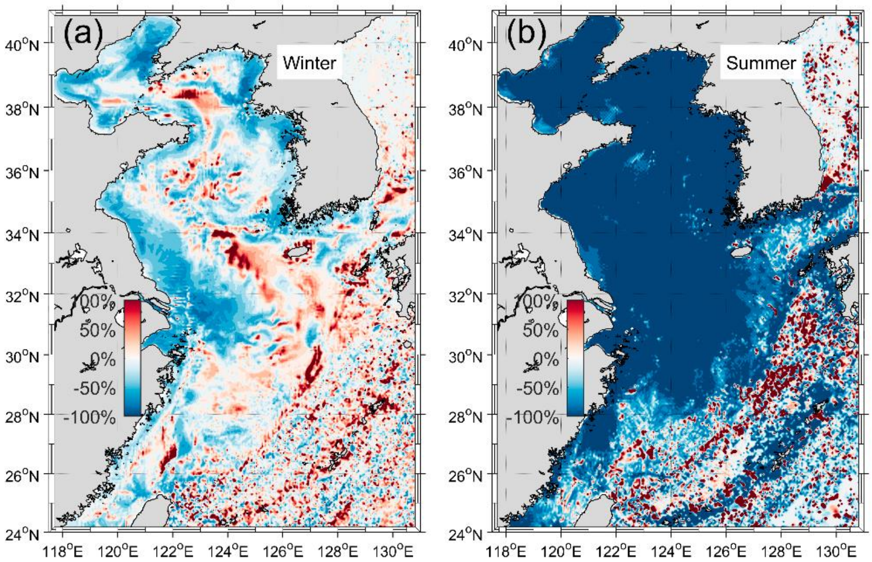

Figure S6. The relative change in the vertical turbulent diffusivity coefficients in February (a) and August (b) after removing tides in the model.

4. Line 165: "The Yalujiang River water passes mainly through the western Yellow Sea", western or eastern?

   Response: It should be "eastern". We have revised this word in the revised manuscript.

5. Figure 10 should be improved to make the arrows more clear

Response: We have redrawn this figure (see Figure S7 below) in the revised manuscript to make the arrows clearer.

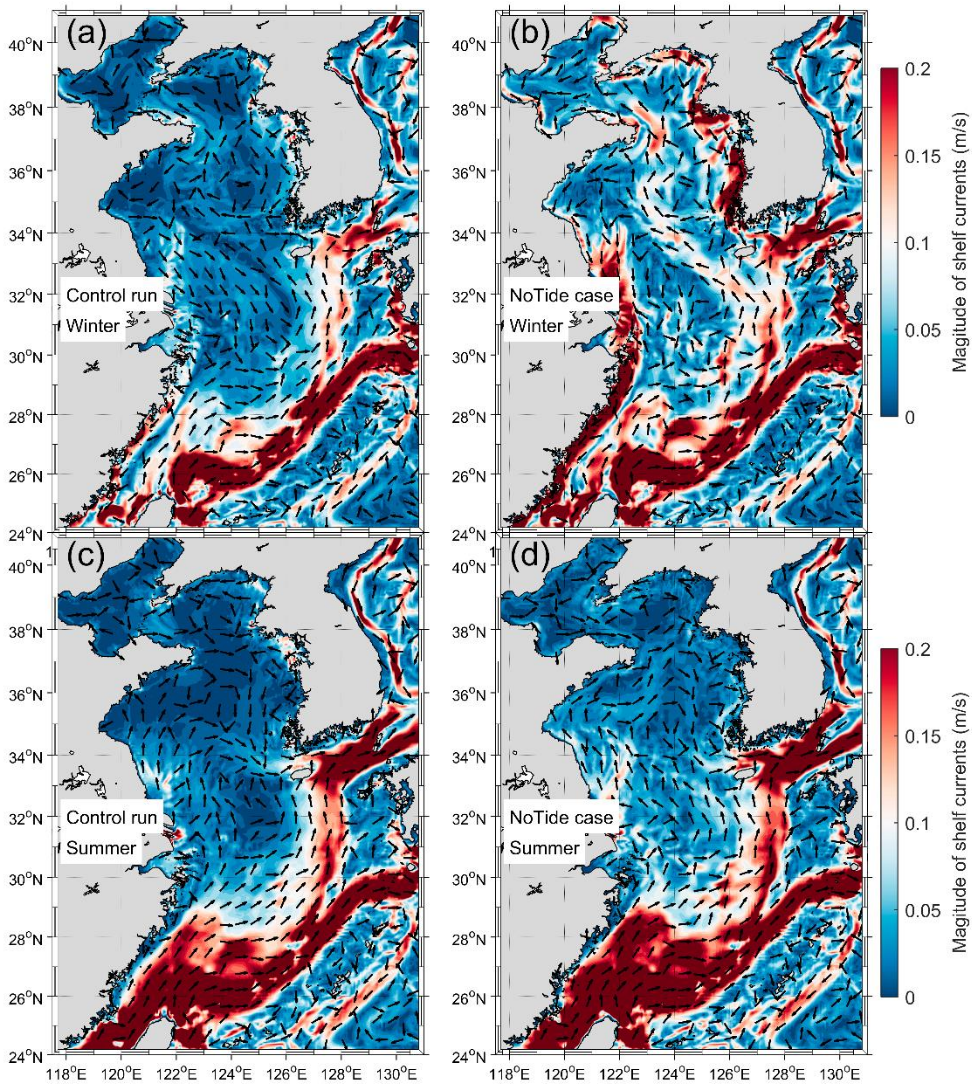

Figure S7. Monthly and vertically averaged velocity for the Control run (left panels) and No-Tide case (right panels), respectively. (a, c) for February and (b, d) for August.

6. In some figures, the STD is too larger. Refine the figure to make it clear

Response: We have redrawn these figures (see Figure S8 below) in the revised manuscript to make it clear.

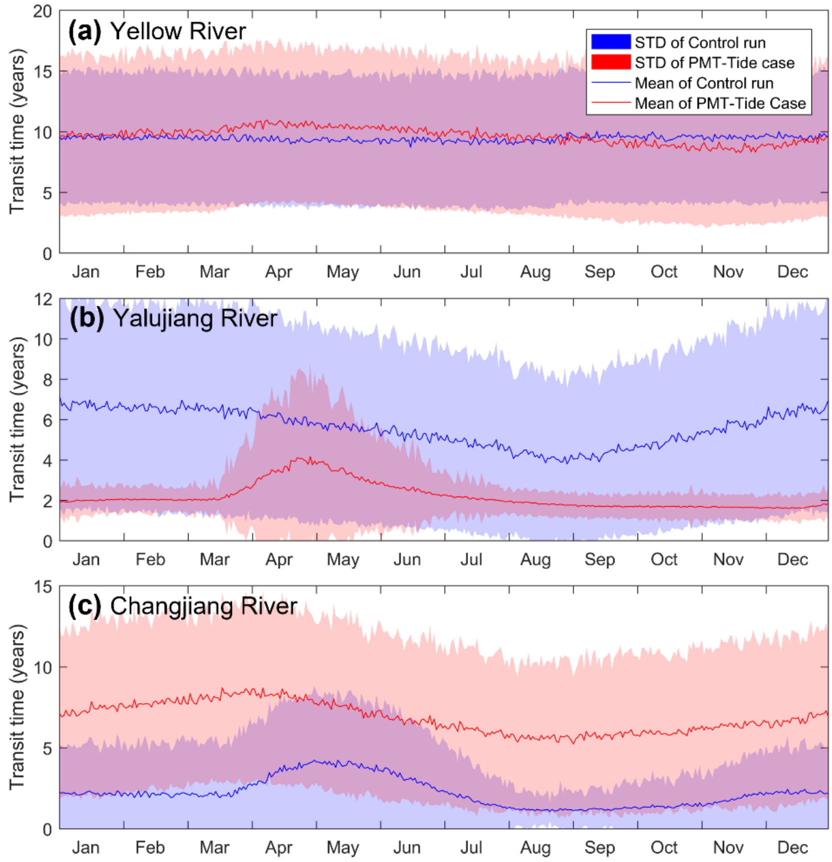

Figure S8. The daily mean water transit time over the shelf of the three rivers for the Control run (blue) and PMT-Tide case (red). STD in the figure label denotes the standard deviation of the transit time for particles released on the same day.

Reference:

Geyer, W. R., & Signell, R. P. (1992). A reassessment of the role of tidal dispersion in estuaries and bays. Estuaries, 15(2), 97-108.

Lin, L., Liu, D., Guo, X., Luo, C., Cheng, Y. (2020). Tidal Effect on Water Export Rate in the Eastern Shelf Seas of China. Journal of Geophysical Research: Oceans, 125(5).

Wu, H., Zhu, J., Shen, J., Wang, H. (2011). Tidal modulation on the Changjiang River plume in summer. Journal of Geophysical Research: Oceans, 116(C8).

Wu, H., Shen, J., Zhu, J., Zhang, J., Li, L. (2014). Characteristics of the Changjiang plume and its extension along the Jiangsu Coast. Continental Shelf Research, 76, 108-123.