Reply to Reviewer #3

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

In this paper, the authors use POM with an offline particle-tracking model to reveal the behaviors of the fluvial fresh water discharged from three major rivers in the eastern shelf seas of China. This is an important study that may serve to better understand influences of tides on transit time, water ages, and pathways of the fluvial fresh water on the shelf seas, and could further help in calibration/validation of the tidal parameterizations for the Earth system models. The results of the particle-tracking model clearly demonstrate that the tides change the behaviors of river water. But I struggled to interpret some of these behaviors shown with different types of tracers. With additional clarifications in the hydrodynamic processes on which the spatial distributions of tracers rely, and more details in model setups and methodology, the readability of this paper could be largely improved. For this reason, I would recommend returning this manuscript to the authors for revision.

Response: Following your instruction, we have added an extra paragraph to explain oceanographic processes or properties that different types of tracers represent and more details on model setups and methodology to increase the readability of this paper.

The following are detailed comments:

1. Line 77: "… from the perspectives of transport pathways, transport timescales, and water concentration distribution". This is a general comment about these river water behaviors. The authors represent details in each behavior with tracer results, but do not explain well what oceanographic processes or properties they are presented. For example, as RC1 commented, why the water ages are high in the Yellow Sea, but the emerging probabilities are low? It may help to have an extra paragraph to explain oceanographic processes or properties that different types of

tracer represent, such as the water age reflects the residence time, emerging probability depends probably on both buoyancy and atmospheric forcings, and the tracer concentrations could show the effects in salinity field, etc. Then the effects of tides can be rooted through differences in tracer fields for physical reasons.

Response: Following your instruction, we have added an extra paragraph to explain oceanographic processes or properties that different types of tracers represent. 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 but 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. Line 91: In general, it would improve the readability with some level of detail in model setups. The authors provide a list of references containing very detailed information about the model they used, but I must stop reading and search for them.

   Response: We have added more details to model setups in the revised manuscript, including the tidal constituents, the vertical layers, the external forcings, etc.

3. Line 94: What are these tidal constituents?

   Response: The major four tidal constituents considered in the model were M_2, S_2, K_1, and O_1. We have added this information to the revised manuscript.

4. Line 95: How many vertical layers does POM have?

Response: The model had 21 non-uniform sigma layers in the vertical direction with finer resolution in the upper layer. We have added this information to the revised manuscript.

5. Line 96: What forcings are used in the POM; are wind, radiation, and evaporation considered?

   Response: The forcings used in the model included winds, heat fluxes, precipitation, and evaporation. We have added this information to the revised manuscript.

6. Line 125-126: "… by dividing the number of particles emerging in the grid cell by the total number of particles released." Is the denominator the total tracer released per day, or for the entire simulation of 30 years?

   Response: The denominator is the total tracer released per day, i.e., one thousand. We have added this information to the revised manuscript.

7. Line 148: Does reenter account on the shelf boundary, or is t1 accounted for the first leave?

   Response: The t_1 was accounted for the first leave. The re-entry process was not considered in both the transit time and water age. We have added this information to the revised manuscript.

8. Line 152-153: (1) This should be mentioned earlier in 2.1, and emphasize the tracer model is decoupled from the hydrodynamic model, as I thought the tracer module was running with POM. (2) Are three years long enough for POM to get equilibrium of the water exchanges along the shelf boundary? (3) If the hydrodynamic fields are not in a steady state, would it affect the results of particle-tracking model? (4) Which outputs of POM are used to force the particle-tracking model? (5) Does POM consider evaporation? (6) Does tracer-tracking model consider surface sink?

   Response: (1) Following your suggestion, we have added this information in Section 2.1. (2) Yes, it was long enough for the model to get equilibrium of water exchanges as the initial field used in the model was derived from the model that has reached equilibrium provided by Wang et al. (2008). The results of the total kinetic energy of the model are shown in Figure S1, demonstrating that the model quickly entered steady seasonal cycles. (3) Yes, it will affect the results to some extent. (4) The sea level, water depth, velocity, and diffusivity coefficients outputted from POM were used to force the particle-tracking and tracer models. (5) Yes, POM has considered evaporation. (6) But the surface sink was not considered in the particle-tracking and tracer models. We have added these revisions and information in the revised manuscript.

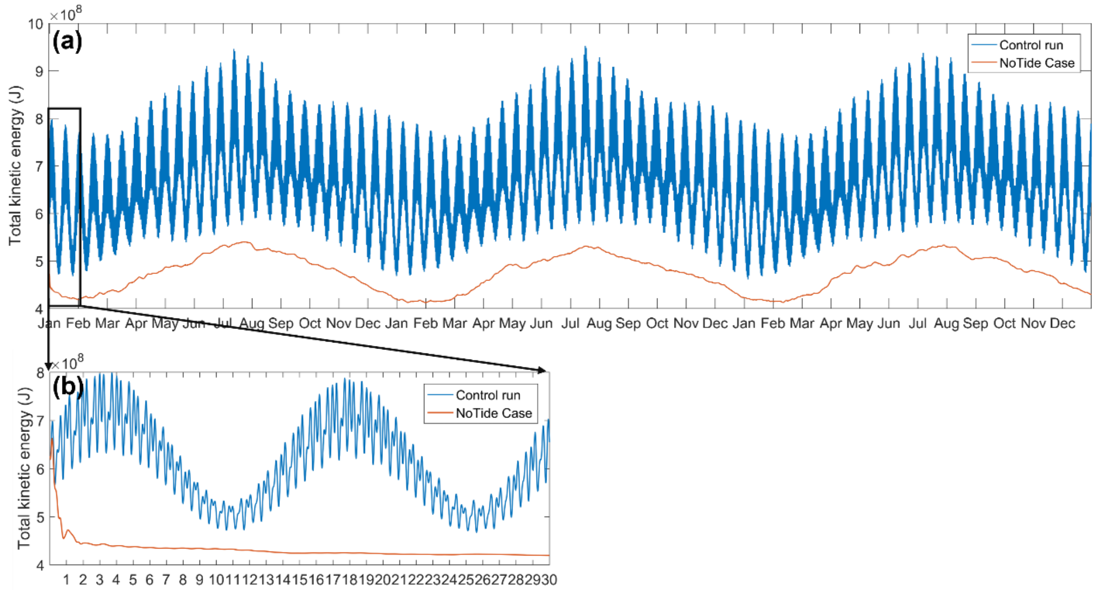

Figure S1. (a) The 3-year variation in the total kinetic energy of the models for the Control run and NoTide case, respectively. (b) The variation in the total kinetic energy in the first month.

9. Line 170: “Figure 2 …” (1) Is the emerging probability calculated only for surface layer, or integrated vertically? (2) Why is the spatial pattern of emerging probability discontinued at Yellow Sea trough for Changjiang River?

Response: (1) The emerging probability calculated for integrated vertically. We have added this information in Section Methods of the revised manuscript.

(2) The discontinuity of the emerging probability of the Changjiang River particles could be due to the spatial variation in the area through which the river water flows, which can be understood using a diagram below (Figure S2). 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 central Yellow Sea. The dynamic mechanism of the discontinuity of the emerging probability could be related to the Yellow Sea Warm Current (YSWC) along the Yellow Sea trough. The northward YSWC brings some Changjiang River water into the Yellow Sea and induced a more dispersed transport over the shelf, thus the rapid reduction probability at the Yellow Sea trough. We have added this comment to the revised manuscript.

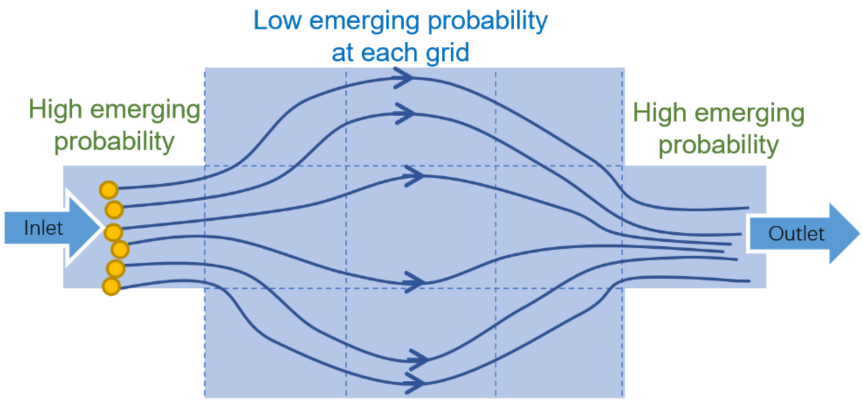

Figure S2. Schematic diagram for the spatial variation in the emerging probability. The area in the middle shelf is relatively large, resulting in a relatively low emerging probability at grid cells than in the regions of the inlet and outlet.

10. Line 199: "Figure 3 …" It would be helpful to (1) show the annual mean vertically averaged velocities, and to (2) explain why the water ages are high in Yellow Sea, but the emerging probability is low.

Response: (1) We have added a figure (Figure S3) to the revised manuscript to show the annual mean vertically averaged velocities of the Control run and NoTide case.

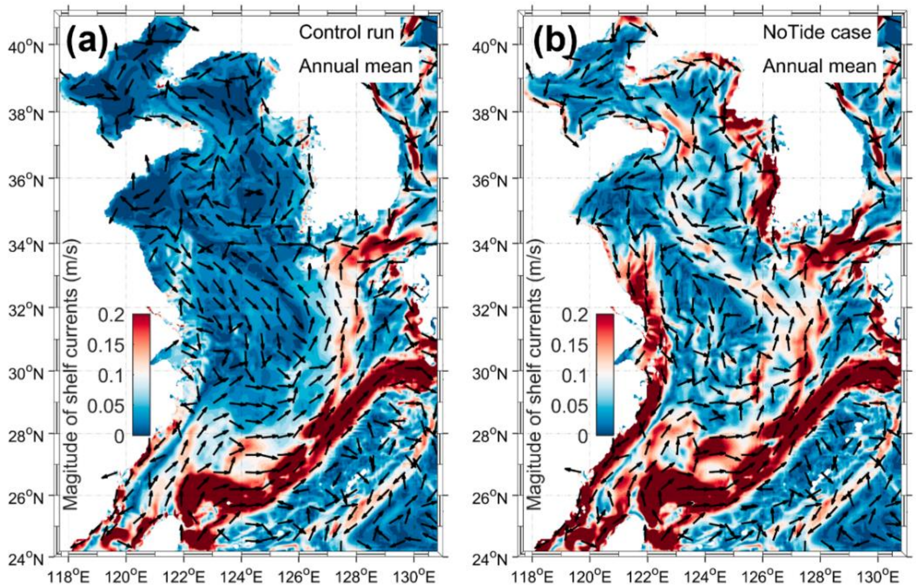

Figure S3. The annual mean and vertically averaged velocities for the Control run (a) and No-Tide case (b). The arrow and color denote the direction and magnitude of the velocity, respectively.

(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.

11. Line 213: Consider replacing Figure 4 with Figure 9, as both contain the transit time for "control" and "no-tide" cases.

    Response: Thanks for your suggestion. For the convenience of comparison, the means of the transit time for the Control run and NoTide case were plotted in Figure 9. However, their standard deviations were not included due to the space limitation of the figure. Thus, we consider that Figure 9 cannot completely replace Figure 4.

12. Line 225: "Figure 5 …" Why the tracer concentrations are low in Cheju Strait for all rivers, but their emerging probabilities are high?

    Response: Since the Cheju Strait is an important outlet for river water, most of the river particles would pass through the strait which induced the high emerging probabilities of the river water at the Cheju Strait. However, when the river water was transported to the Cheju Strait, it has been mixed with shelf seawater which decreased the river water concentration. Thus, we obtained high emerging probabilities but low tracer concentrations in Cheju Strait. We have added this comment to the revised manuscript.

13. Line 297: "Figure 10 …" (1) Please consider changing the color scheme to increase readability. (2) As all tracer fields are shown in annual mean, what are the net effects of these seasonal differences in shelf currents? Generally, a set of annual mean vertically integrated plots of velocities and/or tidal current ellipses would greatly help better understand the tracer patterns.

    Response: (1) Following your instruction, we have changed the color scheme of Figure 10 (Figure S4 below) to increase readability.

    (2) We also added figures (Figures S3 and S5) for the annual mean vertically integrated velocities and the tidal current ellipse (M_2 tidal constituent) to help understand the net effects of the seasonal differences in shelf currents on the tracer patterns. The change in vertically integrated velocity for the annual mean (Figure S3) is very close to that for the winter (Figure S4a and S4b), suggesting that the winter processes dominated the tracer pattern as the stronger shelf currents and water exchange occurred in winter.

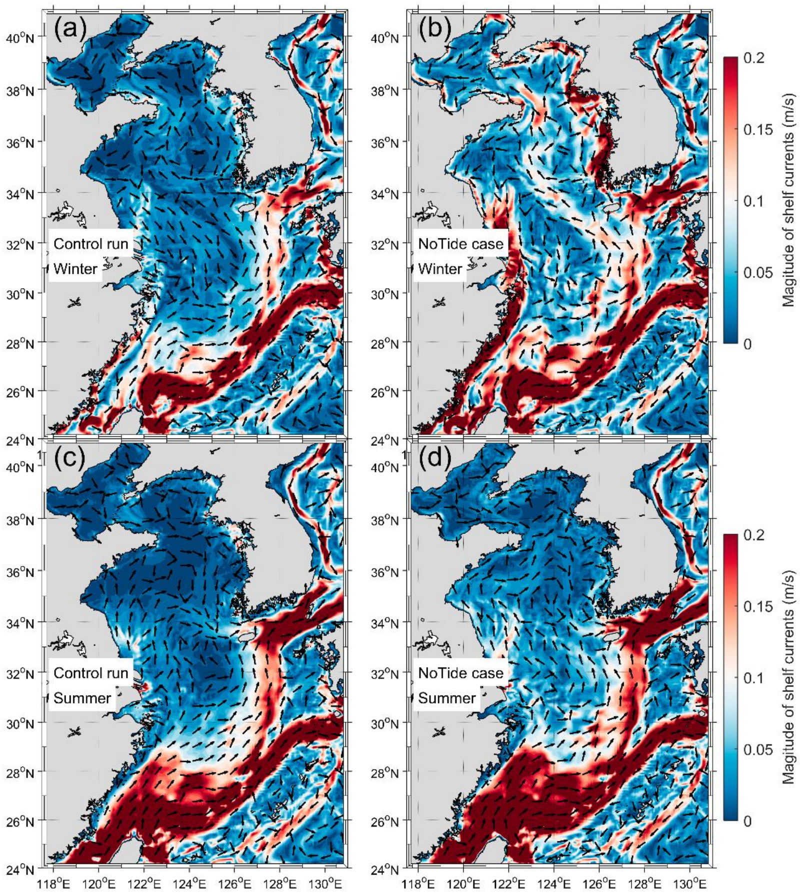

Figure S4. Monthly and vertically averaged velocity for the Control run (left panels) and No-Tide case (right panels), respectively. (a, c) for February and (b, d) for August.

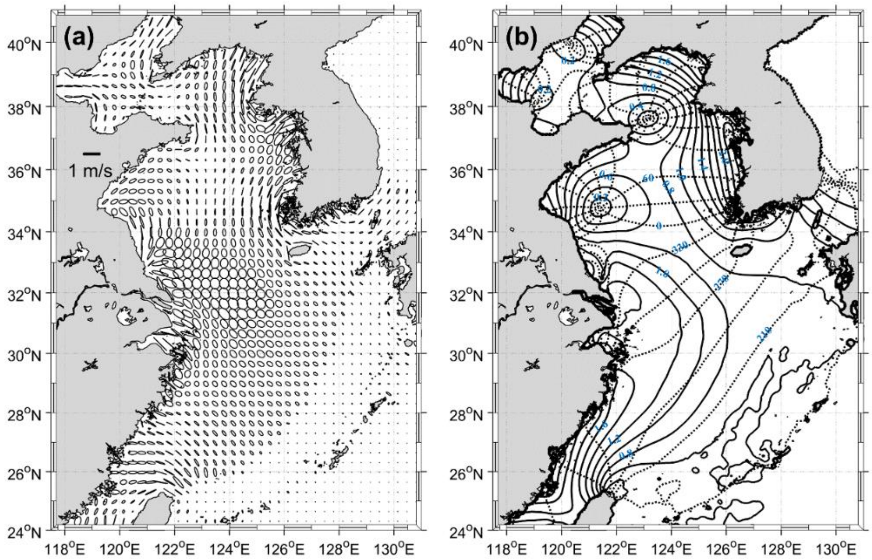

Fig. S5. (a) Tidal ellipses for M2 tide. (b) Contour lines of coamplitude (solid lines, with an interval of 0.2 m) and cophase (dashed lines, with an interval of 30°) for M2 tide.

14. Line 309-310: The seasonal velocities (Figure 10) also show differences in mesoscale eddies. Would they affect the river water behaviors?

Response: Insightful question. The flow field at the middle shelf in the Control run showed a pattern of a mesoscale eddy which might trap some river water and reduce the dispersion of the water. We have added this comment to the revised manuscript.