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Interactive comment on "Improved representation of river runoff in Estimating the Circulation and Climate of the Ocean Version 4 (ECCOv4) simulations: implementation, evaluation and impacts to coastal plume regions" *by* Yang Feng et al.

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Response-to-reviewer 1:

We thank reviewer 1's encouraging words and constructive comments to improve the work. Please check out our point-by-point response below. The line numbers below are correspond to the revised manuscript.

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L28: “Sea-Surface Salinity”-> “Sea Surface Salinity” Response: Done. Please refer to line 28.

L45: add a comma after “products’ Response: The statement has been removed after response to the second reviewer’s comments, so the word no longer exist.

L54: “Sea Surface Salinity”-> “Sea Surface Salinity (SSS)” Response: Done. Please refer to Line 54.

L113:“locally isotropic”-> please make sure if they are really isotropic.

Response: We’ve checked with the ECCO community and found this and the the next statement may only hold for ECCOv4 LLC90. Please refer to Figure 1 in Forget et al. (2015) Geosci. Model Dev. https://doi.org/10.5194/gmd-8-3071-2015. We removed them accordingly.

L118: “The model has 50 vertical z-levels; vertical resolution is 10 m in the. . .”, the same for all the experiments that you run? Please clarify. Response: Yes, all experiments have the same configuration for the vertical grid setup. We have clarified this in the text by adding the sentence, “This setup was the same for all designed experiments”. Please refer to the revised manuscript Line 116.

L121: GGL should be defined. Response: This is short for Gaspar-Gregoris-Lefevre (Gaspar et al., 1990). Please refer to Line 118 to Line 119.

Gaspar, P., Grégoris, Y. & Lefevre, J.-M., A simple eddy kinetic energy model for simulations of the oceanic vertical mixing: Tests at station Papa and long-term upper ocean study site, 95(C9), 16179-16193, doi:10.1029/JC095iC09p16179, 1990

L127: “ECCOv4 uses natural boundary conditions” -> “ECCOv4 uses natural boundary conditions for the river discharge”? Response: Natural boundary condition is applied for both river discharge as well as Evaporation-Precipitation (E-P). Therefore, we changed it to “ECCOv4 used natural boundary conditions for both the river discharge and E-P (evaporation minus precipitation). Please refer to Line 125 to Line 126.

L143: Please provide details for the “iso-neutral mixing” and “residual mean velocity”. Response: The details have been provided as “D_(v,S) and D_(σ,S) are subgrid-scale processes parameterized as mixing diapycnal and along the isoneutral surface, which respect the highly adiabatic process of the oceanic interior (Griffies et al. 1998). The v_res and w_res are the horizontal and vertical residual mean velocity fields and hold the relationship (v_res,w_res)=(v,w)+(v_b,w_b), where (v_b,w_b) is the bolus velocity parameterize the effect of unresolved eddies (Gent and Mcwilliams, 1990).”

Please refer Line 139-143 for the details and two additional references

Gent, P. and Mcwilliams, J.: Isopycnal mixing in ocean circulation models, J. Phys. Oceanogr., 20, 150–155, 1990. Griffies, S. M., Gnanadesikan, A. Pacanowski, R. C., Larichev, V. D., Dukowicz, J. K. and Smith, R.D. Isoneutral Diffusion in a z-Coordinate Ocean Model, Journal of Physical Oceanography 28, 5 (1998): 805-830, doi:10.1175/1520-0485(1998)028<0805:IDIAZC>2.0.CO;2, 1998

L149: What are the initial conditions and surface forcings for the ECCOv4 here? The optimized or initial fields? Response: The initial condition of ECCOv4 was from optimized adjustment of Mapping Ocean Observations in a Dynamical Framework: A 2004-06 Ocean Atlas (OCAA) and surface forcing was from adjustment of ECMWF Re-Analysis (ERA) interim. Please see Line 149-Line 152 in the revised manuscript

L182: “in at”->”at”, “white boxes”->”black boxes” Response: Done. Please refer to Line 189.

L198: Is this equation applied to each grid point, or to an area? Response: This calculation is applied to an area, which has been recognized as the river-month region in Line 265-272 to recognize the river mouth region. Data was averaged within the river mouth to generate time series and then do a skill calculation using this formula. We have further clarified this in Line 197.

L217: Eq. 7 is not correct. Reformulate it or delete it- it does not influence the analysis.

Response: We have removed Eq. 7.

L237, L243: Is the integration in the formulas bounded by specific S? Response: Yes. This was introduced in Section 4.2 in Line 447. A series of S has been used as the threshold (from 28 to 36 PSU) for the plume area calculation. S = 30 PSU was specified for the plume volume calculation. We also have switched Figure 8 and Figure S6 in response to reviewer 2's comments.

L243: What is the effect of vertical resolution? Response: Reviewer 2 request us remove the transport calculation. We have do so accordingly. Therefore, there was no this line in the revised manuscript. We'll leave more plume analysis in future works.

L297: "grid resolution"->"river forcing"? Response: We thank the reviewer read this carefully. This should be runoff forcing as well as the model grid resolution. We have changed accordingly. Please refer to Line 325 in the revised manuscript.

L301: Figures 5? Figs. 4&5. Please add discussion on the reasons of the large bias over 1.5? Response: We thank the reviewer check our manuscript carefully. This should be Fig. 4 rather than Fig. 5. We have fixed it. The Mekong river had large normalized bias over 1.5 for LLC270R and LLC540R. A plot SMAP SSS timeseries in the MK river mouth area (see attached Figure) shows that the low salinity signal associated with riverine freshwater has not been well recognized. It also had a lot of sub-montnly variabilities (noise). This may be because SMAP SSS are contaminated by land signals near the Vietnam coast. Therefore, taking the SMAP is abnormal comparing to other river mouth regions. We have added a comment from Line 369 to Line 371.

Fig. S4: why the seasonal variations are different between R and C experiments? Response: The R and C experiments are distinct from each other not only for the way freshwater added to multiple grids or one-single grid, but also for the river forcing itself. The R experiment used JRA55DO forcing, which had both seasonal and inter-annual variability. The C experiment used Fekete et al. (2002), which is climatological, with

seasonal variability only. The are not exactly the same. This was also questioned by reviewer 2. To further check on how much variability brought by the river forcing temporal variability itself, we run two additional experiments: Exp. LLC270R_spread, which used diffusive surface forcing method, but daily JRA55DO runoff. Exp. LLC270R_clim, which used point-source surface forcing, but climatological runoff derived from 2015-2017 JRA55DO (Table 1). We updated Table 1-3, Figure 3 and 4, and placed a new figure in supplementary material (S8) for the new experiments. We updated the corresponding statement from Line 163 to Line 171; Line 278 to Line 291; Line 307 to Line 316; Line 341 to Line 352; Line 360 to Line 371. We now refer to adding runoff to multiple cells from the surface as the diffusive runoff; to a single grid cell as the point-source runoff.

L377-383: please explain EOF2. Response: The spatial pattern of the second EOF mode represents the low salinity Mississippi River plume water transport downcoast from Louisiana towards Texas, which was carried by the reversed shelf circulation from September to May (Cochrane and Kelly, 1986). We also added the following references Cochrane, J. D., Kelly, F. J., 1986. Low-frequency circulation on the Texas-Louisiana continental shelf. J. Geophys. Res. 91(C9), 10645-10659. Please refer to Line 420 to Line 422 in the revised manuscript.

L386: reference should not be italic. Response: Done. See Line 425.

L389: NBC should be defined in advance. Fig. 8. Caption. “Same as Fig. 7”, not. Response: Done, please refer to Line 437. Fig. 8 has been switched with Figure S6 in supplementary material.

L438: “experiments ability”->” experiments’ ability”? Response: Done. Please refer to Line 478.

L462, Fug11; what is “integrated freshwater transport”? Why does the transport of the 3 rivers show increasing trend over the 3 years? Why no annual cycle for Amazon? Please explain.

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Response: The integrated transport was calculated by taking the starting point as day 1; then day2 was the integration of day1 and day2 (day1 + day2); and day3 integrated day1, 2 and 3 (day 1 + day 2 + day 3). Reviewer 2 suggested we removed the fresh-water transport part in this manuscript, we have done so accordingly. So, there was no longer this part in the main text. We'll leave more plume analysis to our future works.

L484: 'stratification'-> 'stratification difference'? Response: Done. Please refer to Line 511 in the revised manuscript.

L591: VSF should be defined. Response: Done. Please refer to Line 617 in the revised manuscript.

Please also note the supplement to this comment:
https://gmd.copernicus.org/preprints/gmd-2020-321/gmd-2020-321-AC1-supplement.pdf

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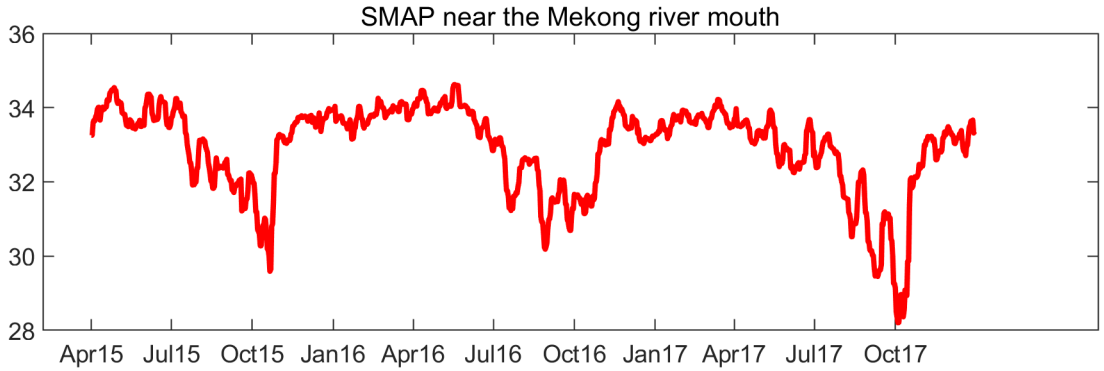

Fig. 1. SSS timeseries at the Mekong River from SMAP

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