Response letter to Reviewer#2

We thank Reviewer#2 for the careful consideration of our work. We agree with her constructive and thoughtful comments and suggestions, which led to a much improved and complete manuscript. In this response letter, we have replied (in blue) to all the comments formulated by the Reviewer (in black).

Comments:

In this study, the authors investigated the spatial-temporal water level dynamics along the main stream of the Yangtze River estuary by means of a triple linear regression model accounting for both the upstream and downstream boundary conditions. The model was subsequently used to quantify the influence of the Three Gorge Dam's operation on the water level dynamics. Results showed that the alteration in water level dynamics are mainly controlled by the variation in freshwater discharge owing to the Three Gorge Dam's operation, while the influence by geometric changes are minor when compared with that of the river discharge alteration. The first reviewer already provided many constructive comments on the manuscript, which I mostly agreed, especially concerning the validity of the proposed triple linear regression model. Generally, the paper is well organized and written. However, there are still some concerns which should be properly addressed before the paper can be accepted in the Ocean Science.

Our reply: We very much appreciate all the comments and suggestions raised by the reviewer. In the revised manuscript, we shall completely address all the comments.

Major concerns:

1. The authors assumed that the alteration in water level dynamics can be primarily attributed to the geometric change (caused by the combined influences of both natural and anthropogenic modifications) and the boundary effects (induced by the changes in upstream and downstream conditions, primarily due to the TGD's freshwater regulation). Since the authors proposed a triple linear regression model to quantify the impacts of the Three Gorges Dam (representing the intensive human intervention) on the water level dynamics, how did the authors account for the potential impacts due to the climate change (such as intensifying precipitation, global sea level rise, etc.)?

Our reply: We thank the reviewer for pointing this out. Indeed, for the time being, we assumed that the largest contribution to the alteration of river discharge before and after the TGD can be primarily attributed to the TGD's freshwater regulation, which is not completely true due to the influences of other dams (such as Gezhouba dam) and the climate change (such as intensifying precipitation over the river basin). Similarly, the potential influence of climate change (such as global sea level rise) may slightly alter the water level at the downstream boundary. Consequently, in the revised manuscript, we shall clarify that: "*It is worth noting that the quantity Δ_{BOU} (including both the upstream and downstream boundary conditions) should be interpreted as the water* *level alteration owing to the overall influences driven by both human interventions and climate change. However, in this study the largest contribution to the alteration in upstream boundary condition (i.e., river discharge) can be primarily attributed to the TGD's operation, since the TGD alone accounts for more than 30% of the total storage capacity of the dams constructed between 1987 and 2014 along the Yangtze River (Li et al., 2016). In addition, we note that the only other dam (Gezhouba, abbreviated by GZB, see Figure 1a) along the main course of the Yangtze River was constructed in 1981 (before the TGD). With regard to the downstream boundary condition, the adopted water levels observed at TSG station implicitly account for the potential impacts induced by both anthropogenic (such as channel dredging) and climate (such as global sea level rise) changes.*"

2. It was mentioned by the authors that the proposed model is particularly useful for determining scientific strategies for sustainable water resources management in dam-controlled estuaries worldwide. Actually, as far as I see, the proposed method can also be used to quantify the influence of climate change on spatial-temporal water level dynamics since both the upstream and downstream boundary conditions are closely related to the climate change even without the construction of large dams. Further comments with regard to the applicability of the proposed method can be clarified.
Our reply: We agree with the reviewer's comment. In the revised manuscript, we shall clarify that: "*Such a novel approach should be particularly helpful for determining scientific guidelines for sustainable water resources management (e.g., dredging for navigation, flood control, salt intrusion prevention etc.) in estuaries worldwide, especially for dam-controlled estuaries. In addition, the proposed method can also be used to quantify the potential impacts of changes in boundary conditions induced by climate change (such as intensifying precipitation, global sea level rise, etc.) in natural estuaries without considerable human interventions*".
In addition, we shall slightly modify the last sentence in the abstract part: "*The presented method to quantify the separate contributions made by changes in boundary conditions and geometry on spatial-temporal water level dynamics is particularly useful for determining scientific strategies for sustainable water resources management in dam-controlled or climate-driven estuaries worldwide*".

3. The geometric effect in this paper is mainly referred to the bathymetric changes in the estuarine system, which should be the primary factor dominating the geomorphological changes in the Yangtze river estuary. However, for other estuarine systems, the geometric effect could also due to the lateral boundary changes. Could the authors give some comments on the applicability of the proposed method to such cases?
Our reply: In the revised manuscript, we shall clarify that: "*Meanwhile, it is also worth noting that the quantity Δ_{GEO} should be interpreted as the water level alteration due to the overall impacts caused by both the bathymetric change and the storage area change.*"

4. Finally, I would suggest the authors to clarify the implications of this contribution.

Our reply: We very much appreciate this suggestion raised by the reviewer. In the revised manuscript, we shall explicitly mention that: " *There exists a long tradition of statistical, analytical and numerical studies on tide-river interactions in estuaries worldwide, such as the Columbia River estuary in the USA (e.g., Kukulka and Jay, 2003; Jay et al., 2015; Pan et al., 2018b), the St. Lawrence River estuary in Canada (e.g., Godin,1999; Matte et al., 2013, 2014), the Mahakam River estuary in Indonesia (e.g., Buschman et al., 2009; Sassi and Hoitink, 2013), the Yangtze River estuary in eastern China (e.g., Guo et al., 2015, 2020; Yu et al., 2020) and the Pearl River estuary in southern China (e.g., Zhang et al., 2018; Cai et al., 2018b, 2019b). These studies showed that as tides propagate along the estuary the tidal amplitude, phase and shape were influenced by the bottom friction, channel geometry and river discharge. In this study, with the proposed simple yet effective triple linear regression model, we are able to isolate and to quantify the impacts of the boundary (such as freshwater regulation due to dam's operation) and geometric (such as channel dredging) effects on the tide-river dynamics. Such a novel approach should be particularly helpful for determining scientific guidelines for sustainable water resources management (e.g., dredging for navigation, flood control, salt intrusion prevention etc.) in estuaries worldwide, especially for dam-controlled estuaries. In addition, the proposed method can also be used to quantify the potential impacts of changes in boundary conditions induced by climate change (such as intensifying precipitation, global sea level rise, etc.) in natural estuaries without considerable human interventions.*".

References:

Buschman, J. F., van der Vegt, M., and Hoekstra, P.: Subtidal water level variation controlled by river flow and tides, Water Resour. Res., 45, W10 420, https://doi.org/Artn W1042010.1029/2009wr008167, 2009.

Cai, H., Yang, Q., Zhang, Z., Guo, X., Liu, F., Ou, S.: Impact of river-tide dynamics on the temporal-spatial distribution of residual water levels in the Pearl River channel networks, Estuar. Coasts, 41, 1885-1903, https://doi.org/10.1007/s12237-018-0399-2, 2018.

Cai, H., Yang, H., Liu, J., Niu, L., Ren, L., Liu, F., Ou, S., Yang, Q.: Quantifying the impacts of human interventions on relative mean sea level change in the Pearl River Delta, China, Ocean Coast. Manage., 173, 52-64, https://doi.org/10.1016/j.ocecoaman.2019.02.007, 2019.

Godin, G.: The propagation of tides up rivers with special considerations on the upper Saint Lawrence river, Estuar. Coast. Shelf S., 48, 307 – 324. https://doi.org/10.1006/ecss.1998.0422, 1999.

Guo, L.C., van der Wegen, M., Jay, D.A., Matte, P., Wang, Z.B., Roelvink, D., He, Q.: River-tide dynamics: Exploration of nonstationary and nonlinear tidal behavior in the Yangtze River estuary, J. Geophys. Res. -Oceans, 120, 3499 – 3521. https://doi.org/10.1002/2014jc010491, 2015.

Guo, L. C., Zhu, C. Y., Wu, X. F., Wan, Y. Y., Jay, D. A., Townend, I., Wang, Z. B., and He, Q.: Strong inland propagation of low-frequency long waves in river estuaries, Geophys. Res. Lett., 47, e2020GL089112, https://doi.org/10.1029/2020GL089112, 2020.
Jay, D.A., Leffler, K., Diefenderfer, H.L., Borde, A.B.: Tidal-fluvial and estuarine processes in the lower Columbia River: I. along-channel water level variations, Pacific Ocean to Bonneville Dam, Estuar. Coast., 38, 415-433, https://doi.org/10.1007/s12237-014-9819-0, 2015.
Li, Z., Zhang, Z. Y., Lin, C. X., Chen, Y. B., Wen, A. B. and Fang, F.: Soil-air greenhouse gas fluxes influenced by farming practices in reservoir drawdown area: a case at the three Gorges Reservoir in China, J. Environ. Manage., 181, 64–73, https://doi.org/10.1016/j.jenvman.2016.05.080, 2016.
Kukulka, T., and D. A. Jay, Impacts of Columbia River discharge on salmonid habitat: I. A nonstationary fluvial tide model, J. Geophys. Res., 108(C9), 3293, https://doi.org/10.1029/2002JC001382, 2003.
Matte, P., Jay, D. A., and Zaron, E. D.: Adaptation of classical tidal harmonic analysis to nonstationary tides, with application to river tides, J. Atmos. Ocean. Tech., 30, 569–589, https://doi.org/10.1175/Jtech-D-12-00016.1, 2013.
Matte, P., Secretan, Y., and Morin, J.: Temporal and spatial variability of tidal-fluvial dynamics in the St. Lawrence fluvial estuary: An application of nonstationary tidal harmonic analysis, J. Geophys. Res.-Oceans, 119, 5724–5744, https://doi.org/10.1002/2014jc009791, 2014.
Pan, H. D., Lv, X. Q., Wang, Y. Y., Matte, P., Chen, H. B., and Jin, G. Z.: Exploration of tidal-fluvial interaction in the Columbia River estuary using S TIDE, J. Geophys. Res.-Oceans, 123, 6598–6619, https://doi.org/10.1029/2018jc014146, 2018b.
Sassi, M. G. and Hoitink, A. J. F.: River flow controls on tides and tide-mean water level profiles in a tidal freshwater river, J. Geophys. Res.-Oceans, 118, 4139–4151, https://doi.org/10.1002/jgrc.20297, 2013.
Yu, X., Zhang, W., Hoitink, A.J.F.: Impact of river discharge seasonality change on tidal duration asymmetry in the Yangtze river estuary, Sci. Rep., 10, 6304, https://doi.org/10.1038/s41598-020-62432-x, 2020.
Zhang, W., Cao, Y., Zhu, Y.L., Zheng, J.H., Ji, X.M., Xu, Y.W., Wu, Y., Hoitink, A.J.F.: Unravelling the causes of tidal asymmetry in deltas, J. Hydrol., 564, 588 – 604. https://doi.org/10.1016/j.jhydrol.2018.07.023, 2018.