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Reply on RC1

Leicheng Guo et al.

Author comment on "River-enhanced non-linear overtide variations in long estuaries" by Leicheng Guo et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-75-AC1, 2021

Response to online comments from Xiao Hua Wang, UNSW

Review of 'River-enhanced non-linear overtide variations in river estuaries' by Guo et al (hess-2021-75)

This paper uses a 1D estuary model to explore the variability of overtide under varying river discharge. Model results show that significant M4 overtide is generated inside the estuary. Its amplitude decreases and increases in the upper and lower parts of the estuary, respectively, with increasing river discharge. More importantly, the paper shows that the total energy of the M4 tide integrated throughout the estuary reaches maximum when the river discharge to tidal mean discharge (R2T) ratio is close to unity. The paper is a good contribution to improve the understanding of non-linear overtides behaviors in river estuaries. A key result of this work is the two folds role of river discharge on tides. It appears that the paper does have something new to add to existing and recent literature of the topic (see below), namely, the authors have conducted analytical analysis of three non-linear terms and their relative contributions to the M4 generation. Further they have found spatial variability of maximum M4 along the river under various river discharges. Based on these two, I consider the paper to be published subject to major revision.

A: Thank you for the summary and the encouragement.

Major comments

However, they have missed one of key references below that let to an incomplete literature review in Introduction and incorrect discussion from line 493-503.

A: Thank you for suggesting the new article. We had included the new reference and related discussion in the Introduction and Discussion texts.

Specifically, in the second paragraph of the Introduction, we added that '*Elahi et al. (2020) documented the impact of river discharge in controlling the balance between the generation and dissipation of quarterdiurnal tides in the Ganges-Brahmaputra-Meghna*

Delta. They suggested the presence of a critical river discharge threshold as an optimal condition for overtide generation'.

The discussion paragraph in section 4.1 is rephrased as '*Note that the above-mentioned nonlinear overtide changes were predominantly reported in large, river- and tide-influenced estuaries and deltas, but less in many other tide-dominated estuaries with relatively smaller river discharge. We think that it maybe because the river discharge in tide-dominated estuaries is overall small and rarely reaches a magnitude that exceeds R2T=1. Therefore, the role of river discharge in stimulating tidal wave deformation and overtide generation has been widely observed and confirmed (when R2T<1), whereas further changing behaviors under R2T>1 are far less prevalent and hence less well documented. Another explanation is that most tide-dominated estuaries are relatively shorter in physical length compared with tidal wavelength, hence the distinction between tidal river and tidal estuary and the spatially nonlinear overtide variations are less apparent compared with that in long estuaries with profound river influences.*'

According to this paper, it seems to argue that it is the first time that this two-folds role is shown in literature. However, I would like to point out that we have recently demonstrated this phenomenon in our study on tidal propagation in the Ganges-Brahmaputra-Meghna river system, published in Journal of Geophysical Research Oceans last year (Elahi et al., 2020). As in the present study, a threshold river discharge dictates the generation and dissipation of overtides beyond the middle of the GBMR estuary.

A: Thank you again for pointing out this. We noticed the study and the findings in Elahi et al. (2020), and had changed the tone in this manuscript to get rid of the confusion. In the first paragraph of the Discussion section 4.1, we had added '*In the Ganges-Brahmaputra-Meghna Delta, numerical model results under varying constant river discharge also suggested enhanced quarterdiurnal tides in the lower delta and a transition from increase to decrease in the upper regions of the delta with increasing river discharge (Elahi et al., 2020).*'

We also investigated the non-linear terms related to bottom friction by applying a numerical model setup (Delft3d) and following the methods of Goddin (1999) and Buschman et al. (2009). Our results show that the threshold river discharge produces maximum amplitude of frictional coefficient in the non-linear term development, resulting in the maximum generation of overtides. The spatial variations of overtides with river discharge are also apparent in the short length of estuary in the Ganges-Brahmaputra-Meghna delta (< 300 km).

For this reason, I believe that it would be pertinent for the authors to cite our work (Elahi et al., 2020) in both the introduction and discussion of the present study, particularly in line between 493-503. That will enrich the discussion of results and increase the applicability of the study findings around the globe.

A: We have read very carefully the suggested article and included the citation and discussion of it in the Introduction and Discussion sections. Modeling results in terms of the longitudinal amplitude variations of the quarterdiurnal tides (D4, in Figure 7d in Elahi et al. 2020) are similar with Figure 3b in this work, other than the large D4 amplitude at the mouth of the GBMD. The results and findings in this work with a case of the Changjiang River estuary are thus overall in line with that in Elahi et al. (2020) in GBMD, which also justify the findings from the schematized modeling. We are happy to see the

two works output consistent results thus provide more confidence on the findings. Beyond that, this work moves a little bit forward in terms of identifying the maximal threshold (R2T=1) and the contribution of the three nonlinear terms in the tidal dynamic equations. The decomposition method proposed in Buschman et al. (2009) and used in Elahi et al (2020) refers to the subtidal friction term which is used to explain the (low-frequency) subtidal water level variations. It is different from methods in this work that is used to quantify the contribution of the friction, advection, and discharge gradient terms on the high-frequency overtide behaviors. Discussion and citation to Elahi et al. (2020) are included in the revision. For example, we added that '*Elahi et al. (2020) documented the impact of river discharge in controlling the balance between the generation and dissipation of quarterdiurnal tides in the Ganges-Brahmaputra-Meghna Delta. They suggested the presence of a critical river discharge threshold as an optimal condition for overtide generation*' and '*Bushman et al. (2009) and Elahi et al. (2020) employed similar decomposition method of the subtidal friction term to quantify the relative importance of river, tide, and river-tide interaction on subtidal water level variations*.' in the Introduction section.

Other comments

Line 178: Not true. Although conventional harmonic analysis may not accurately resolve tidal constituents, a non-stationary harmonic analysis based on the Complex Demodulation method (Bloomfield, 2004) can be applied here to water level time series.

A: We have modified the sentence as '*Conventional harmonic analysis may not accurately resolve tidal properties for a given river discharge magnitude owing to the nonstationary variations (Jay and Flinchem, 1997), although there were attempts to use continuous wavelet transform (Jay et al., 2014; Guo et al., 2015) and complex demodulation method (Bloomfield, 2013) as complementary approaches to resolve tidal species instead of individual constituents. In addition, modeling is another method to examine tidal dynamics (Elahi et al., 2020)*' to better clarify the meaning.

Line 458-459: Can you use your model results to explain why R2T ratio close to unity (not other values), benefits maximal M4 overtide generation?

A: In the first paragraph of the discussion section 4.2 Role of river discharge, we have argued that the river discharge has two-fold impact on the incident tides, i.e., enhancing tidal energy dissipation (damping) and transferring to higher frequencies (deformation). Hence quantitatively we conclude that an intermediate river discharge would benefit maximal overtide generation because it will not dissipate the astronomical tides too much and enhance the nonlinear friction effect in stimulating tidal energy transfer to overtide frequencies. Qualitatively, the model results suggest that the maximum threshold is around R2T=1 (Figure 6). However, it is technically challenging to explain why the threshold R2T ration is 1, but not other values like 0.5 or 2. In studying tide-averaged sediment transport, we had also detected that the tide-averaged sediment transport flux (induced by river flow, tidal asymmetry, and river-tide interactions) tends to be maximal when the river-enhanced residual current velocity equals to the magnitude of the tide-induced current velocity (e.g., the velocity amplitude of M_2 tide) (Guo et al., 2014, 2016, JGR:Earth Surface). We think a R2T ratio equal to unit (or similarly identical mean current velocity and tidal velocity) reflects a delicate balance between river and tidal forcing, while larger river discharge (R2T>1) or stronger tidal discharge (R2T<1) leads to deviation from the threshold.

Line 493-504: This is not correct. See the above major comments.

A: The texts in this paragraph has been thoroughly rephrased as '*Note that the above-mentioned nonlinear overtide changes were predominantly reported in large, river- and tide-influenced estuaries and deltas, but less in many other tide-dominated estuaries with relatively smaller river discharge. We think that it maybe because the river discharge in tide-dominated estuaries is overall small and rarely reaches a magnitude that exceeds R2T=1. Therefore, the role of river discharge in stimulating tidal wave deformation and overtide generation has been widely observed and confirmed (when R2T<1), whereas further changing behaviors under R2T>1 are far less prevalent and hence less well documented. Another explanation is that most tide-dominated estuaries are relatively shorter in physical length compared with tidal wavelength, hence the tidal river-tidal estuary distinction and the spatially nonlinear overtide variations are less apparent compared with that in long estuaries with profound river influences.*'

Line 538: maybe -> may be

Line 556: SI?

A: Changes are made as suggested. SI is the abbreviation of Supporting Information.

Reference:

Elahi, M.W.E., Jalón-Rojas, I., Wang, X.H., Ritchie, E.A., 2020. Influence of Seasonal River Discharge on Tidal Propagation in the Ganges-Brahmaputra-Meghna Delta, Bangladesh. J. Geophys. Res. Ocean. 125, 1–19. https://doi.org/10.1029/2020JC016417

A: The suggested reference is included and cited in the revised work.