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Reply on RC4

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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-AC4, 2021

RC4: 'Comment on hess-2021-75', Anonymous Referee #3, 29 Apr 2021

Finding M4 tide in the Changjiang and Amazon River estuaries, this manuscript discussed how the M4 is generated by different river discharges. This is an interesting work but the study of the mechanism seems not too stronge. I have few commons:

(1) If the morphology is schematized, the authors can also try other convergence ratios besides the prismatic model. Maybe Amazon model. Or how can the results relate to Amazon since the morphology comes from Changjiang?

A: Indeed the schematized model can be used to explore the sensitivity to other convergence rates. In this work, we mainly present results in a rectangular channel and a convergent channel, with dimension comparable to the Changjiang Estuary. Gallo and Vinzon (2005) have modeled the tides in the Amazon Estuary and their modeling results are cited and highlighted in this work (see Figure 6). Moreover, Elahi et al. (2020) also undertook a similar modeling study of the Ganges Delta and showed consistent results with this work. Instead of focusing on specific sites, we used schematic models to investigate the broad implications for similar estuaries. The main objective was to reveal the general pattern of the relative changes in the overtide amplitude in response to different magnitude of river discharge. We have not sought to reproduce tidal propagation changes in specific system, in which the absolute amplitude and longitudinal changes will very much depend on the regional changes in channel width, depth and bed slope etc. The channel pattern in the schematized model, e.g., reduced and increased M4 amplitude in the landward and seaward parts of estuaries, is overall consistent with the actual data analysis in Amazon, Changjiang, Columbia etc., justifying the model results in this work. As a response to this question and the following one, we have constructed more models with varying width convergence rates and preliminary simulations show similar patterns as found for the rectangular channel, although the absolute amplitude varies slightly. These extra model results will be included in the revised supporting information of the revised manuscript. We have added a sentence to note the similar pattern as convergence varies in section 2.2 '*Sensitivity tests examining the influence of the rate of convergence indicate that the patterns are similar to those for the rectangular channel case, with some small variations in the amplitudes of the various components*'.

(2) To what extent the R2T value (= 1) is appliable since morphology plays a role?

A: Morphology is indeed an important factor affecting tidal propagation and changes in estuaries. However, the difference in morphology will not alter the main findings in this work, because: 1) the model results in both rectangular and convergent channels show similar changing patterns of M_4 (see Figures 3 and 4), and 2) we use an equilibrium bed profile for tidal simulations, and have shown that the bed profile will not change the patterns of longitudinal change (see Figure R1 above). We will include more model results in Figure 6 to confirm the R2T threshold in the revised manuscript.

(3) Give more details about the benefits of maximal overtide amplitude.

A: In the first paragraph of Section 4.3 we discuss the relevance and implications of the maximal threshold conditions. The finding of a maximal overtide under intermediate river flow condition (or equal river and tidal forcing strength) has broad implications for estuary management. For example, one implication is for the residual sediment transport which tends to be the largest when the river flow velocity is equal to a tidal velocity. Such a residual sediment transport tends to lead to the largest seaward sediment flushing and consequently the deepest equilibrium depth (Guo et al., 2016).This threshold condition occurs because river discharge dissipates tides and the impact of river-tide interaction on creating residual sediment transport changes nonlinearly with rising river discharge. These arguments have been incorporated into the discussion section of the revised manuscript.

(4) How does the river discharge affect the effective friction? Is the location of the maximum overtide amplitude related to the morphology? where the friction is maximum?

A: River discharge affects the friction mainly via the velocity magnitude. River discharge enlarges the current velocity, and the friction the moving flow feels accordingly. The impact of river flow in inducing more dissipation of astronomical constituents was exerted via the effective friction term (Horrevoets et al., 2004).

Morphology affects the longitudinal variations of river flow velocity and landward decrease in tidal prism and tidal velocity. The morphology can therefore influence the location of maximum overtide, and this impact was reflected in the changing the strength balance between river and tidal forcing.

The location of maximal frication may have implications for the occurrence of maximal overtide amplitude. Elahi et al. (2020) explained that the place with equal river flow velocity and tidal velocity is an optimum condition for overtide amplitude in the case of Ganges Delta. Inspired by that, more general analysis will be added in the revised manuscript to further quantify the controlling impact of friction on the peak overtide amplitude.

(5) How is the M4 identified from the model? Or which term represents the M4 in the model?

A: M_4 tide was not imposed at the seaside boundary in the model simulations. However, M_4 was generated and detected inside the estuary owing to the river-enhanced nonlinear dynamics. The M_4 amplitude is analyzed by a harmonic method based on the modeled time series of water levels and currents. The M_4 component was not included in the Eqs. 3 and 4, because the equations were used to explain how overtide could be generated via the nonlinear terms (Eqs. 8 and 9).

(6) What is the role of the tide in this study?

A: In this work we focused on the impact of river forcing on the tides. Tides at the seaside boundary of the estuary are expected to influence the absolute overtide amplitude inside the estuary, but not on the non-dimensional results (M_4/M_2 ratio) presented in Figure 6. Including more tidal component, e.g., S_2, induces generation of other compound tide such as MS_4 that exhibit similar spatial variations as M_4 (see Figure 3c). To test the sensitivity to tides, we ran additional simulations by increasing the M_2 amplitude at the boundary. Model results show increased overtide amplitude inside the estuary, and larger river discharge is needed to meet the R2T=1 threshold, which is understandable. These extra simulations and discussions will be included in the revised manuscript.