Responses to comments by Reviewer#2

We thank the Reviewer for the careful consideration of our work. In this rebuttal, we have addressed all the comments formulated by the Reviewer by replying (in black) to your remarks (in blue).

General comments:

The paper presented a new analytical 1D approach to estimate the changes of morphological characteristics such as the tidally average depth, wave celerity and tidal amplification in an estuary. Despite of the assumptions made with the absence of river flow and a constant depth in the inverse model, this finding provides a useful and yet simple tool to obtain a first estimation of the morphological changes. Furthermore, it is applicable to be applied in region where minimal data is available.

The manuscript is well-organized, and the data and results are well-presented. There are few typos and grammatical error spotted but they are only minor. Nevertheless, there are some unclear sections that I would like to address in my comments below:

Our reply: We thank the reviewer for his/her overall positive assessment of our work.

Major comments:

1. Page 8, paragraph 1, Figure 3: Authors mentioned with $r_S = 1$, Equation (25) indicates that the tidally averaged depth varies proportionally with the tidal damping rate δ_H. However, in Figure 3 the different colours shades representing the changes in averaged depth only varies with the celerity (vertically) and not the tidal damping rate (horizontally). Also, there is no indication on which point or region the depth is minimum and tidal damping is at critical condition. Authors are recommended to revised on this section.

Our reply: We very much appreciate the reviewer's comment and advice. Generally, the storage width ratio r_S ranges between 1 and 2 (Savenije, 2005). In Figure 3, for illustration, we assume that r_S=1. Actually, it can be seen from Equation (25) that the relationship between tidally averaged depth $\bar{h}$ and the tidal damping (or amplification) rate δ_H is nonlinear. To highlight such a kind of nonlinear relationship, in the revised manuscript, we shall provide the derivatives of the tidally averaged depth with respect to two variables (i.e., the tidal damping or amplification rate and the wave celerity):

$$\frac{\partial \bar{h}}{\partial \delta_H} = \frac{r_S b c^4 \left(2\delta_H b - 1\right)}{g\left(\delta_H c^2 - \delta_H^2 c^2 b + b\omega^2\right)^2} \qquad \text{(R1)}$$

$$\frac{\partial \bar{h}}{\partial c} = \frac{2 r_S b^2 c \omega^4}{g\left(\delta_H c^2 - \delta_H^2 c^2 b + b\omega^2\right)^2} \tag{R2}$$

It can be seen from Equation (R1) that the depth $\bar{h}$ is decreased with the tidal damping (or amplification) rate δ_H until a minimum value is reached at a critical δ_H corresponding to the condition $\partial\bar{h}/\partial\delta_H = 0$, i.e., δ_H=1/(2b). A further increase of the δ_H yields an increase of $\bar{h}$. On the other hand, it can be seen from Equation (R2) that the depth $\bar{h}$ tends to increase with the celerity c since the value of $\partial\bar{h}/\partial c$ is positive. In the revised manuscript, we shall update the original Figure 3 by including the critical value of δ_H=1/(2b) (see Figure R1 below).

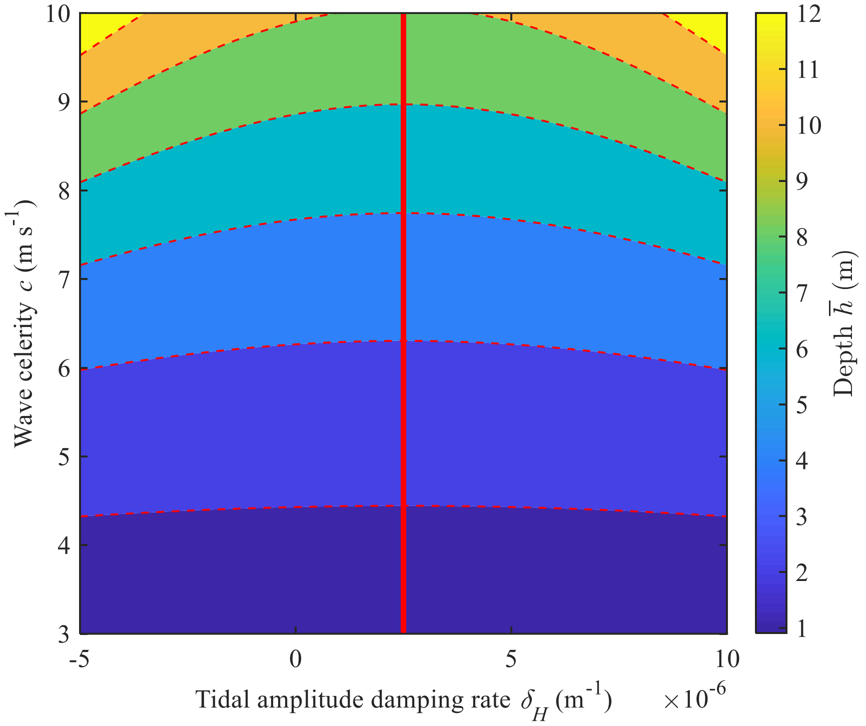

Figure R1. Contour plot of the estimated depth $\bar{h}$ as a function of the wave celerity c and tidal amplitude damping (or amplification) rate δ_H obtained from Equation (22). The drawn red line indicates the critical value of δ_H=1/(2b) corresponding to the minimum water depth for given a constant wave celerity.

2. Section 4.1: The definition of tidal damping/amplification rate is confusing. Does the (/) means "or" or ratio? In line 312, it is mentioned that the tidal damping/amplification rate can be compute with Equation (27) and has the symbol δ_H. But, in line 317 there is another symbol representing the tidal damping/amplification rate which is β. In Figure 7, both symbols are presented with different indication, and is the gradient of the regression between the tidal amplification and tidal amplitude. What does the gradient means in this context? The same issue also goes to the wave celerity. Also, it would be nice if the authors can explain more clearly on how the negative gradient indicating

stronger amplification and faster celerity during neap tide than spring tide.

Our reply: Here tidal damping/amplification rate means tidal damping rate (δ_H<0) or tidal amplification rate (δ_H≥0). In the revised manuscript, we shall reproduce "tidal damping/amplification" with "*tidal damping (or amplification)*". Actually, the gradient β indicates the change rate of the tidal damping/amplification rate δ_H with respect to the tidal amplitude at the estuary mouth η_0, where smaller values indicate the periods for the neap tide, while larger values indicate the periods for the spring tide. Hence the negative gradient (β<0) suggests that the value of δ_H is decreased with the increasing tidal amplitude, which means stronger tidal amplification for the neap tide (smaller η_0, larger δ_H) than that for the spring tide (larger η_0, smaller δ_H). Similarly, the negative gradient α for the wave celerity indicates a faster wave celerity for the neap tide (smaller η_0, larger c) than that for the spring tide (larger η_0, smaller c). In the revised manuscript, we shall clearly clarify that: "*In general, we observe that both wave celerity and the damping (or amplification) rate are decreased with increasing tidal amplitude at the estuary mouth with slightly different negative slopes (indicated by α and β representing the change rate of wave celerity and tidal damping or amplification rate with respect to the tidal amplitude, respectively), suggesting a more strongly amplified yet faster wave for the neap tide (smaller η_0, larger δ_H and c) than that for the spring tide (larger η_0, samaller δ_H and c).*"

3. Section 4.3: In Equation (25), r_S = 1 was used for analysis. In this section, the values used for r_S were calibrated against observed data using the shape preserving piecewise cubic interpolation in which the results are presented in Table 3. From the table, the values of r_S obtained is close unity. It would be more interesting if the calibration process in obtaining of the r_S values can be explained further showing in what sense the values are near to 1.

Our reply: In the revised manuscript, we shall explicitly clarify that the storage width ratio r_S generally ranges between 1 and 2 (Savenije, 2005). In Figure 3, we adopted a constant value of r_S = 1 for simplification. With regard to calibration, in the revised manuscript, we shall clarify the process of determining the value of r_S: "*We calibrated the analytical model by adjusting the Manning-Strickler friction coefficient K and the storage width ratio r_S, which are detailed in Table 3.* ***In particular, the calibrated r_S is relatively sensitive to the variation in phase of the elevation.*** *The model performance was evaluated by the root mean squared error (RMSE), where RMSE=0 corresponds to perfect agreement. In general, the correspondence between analytical results and observations is good, both for the tidal amplitude (with RMSE ranging between 0.015 and 0.020 m) and the phases (with RMSE ranging between 1.1° and 2.1°), suggesting that the analytical model can reproduce the main tidal hydrodynamics in Lingdingyang Bay well. The calibrated friction coefficient K ranges between 58 $m^{1/3}s^{-1}$ and 90 $m^{1/3}s^{-}$*

^{1}, with the minimum value occurring in 2009 (indicating relatively strong friction) and the maximum in 1965 (indicating relatively weak friction). ***On the other hand, the calibrated storage width ratio r_S is approximately unit (ranging between 1.0 and 1.15), which suggests a minor impact from the storage area on the evolution of tidal hydrodynamics.***"

4. Figure 8: It would be nice if the authors can include the values of the geometry characteristics in this figure for each year. The lines could not show clear difference in the geometry changes over the years and look almost the same. With the geometry characteristics values included, it is easier to see how much the geometry has changed.

Our reply: We agree with the reviewer's comment. In the revised manuscript, we shall update the Figure 8 (see Figure R2 below).

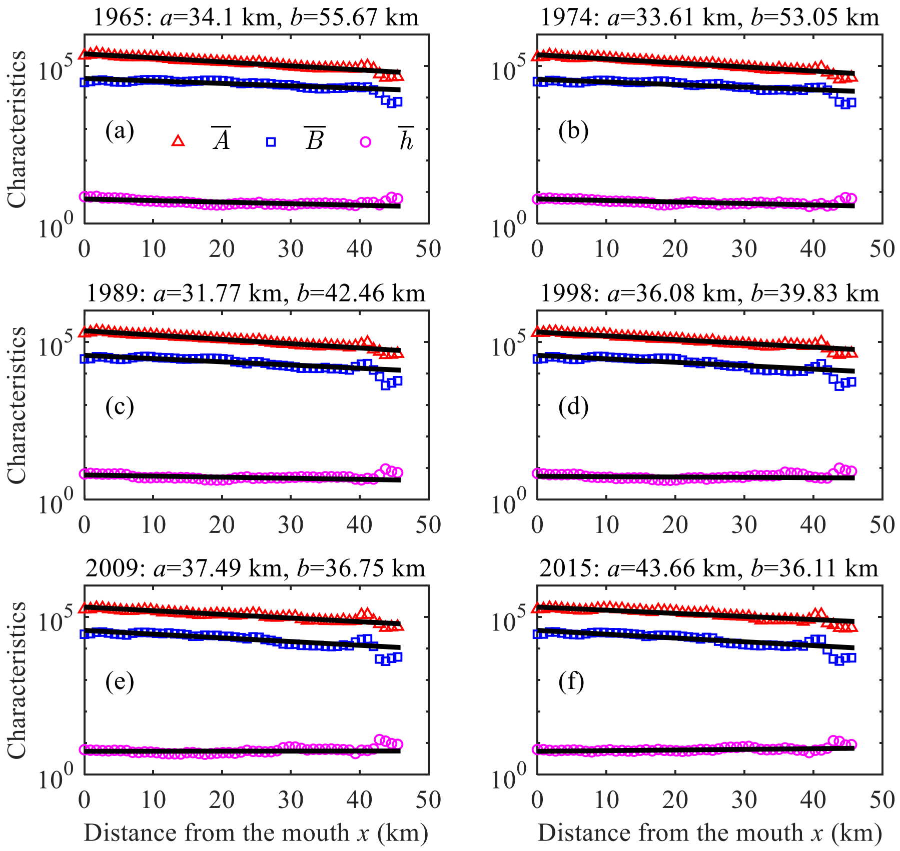

Fig. R2. Longitudinal variations of the geometric characteristics (the tidally averaged cross-sectional area $\bar{A}$, m^2, width $\bar{B}$, m, and depth $\bar{h}$, m) of Lingdingyang Bay for different years: a) 1965; b) 1974; c) 1989; d) 1998; e) 2009; and f) 2015, in which the black thin lines represent the best fitted curves according to the exponential functions (5)-(6).

Reference:

Savenije, H. H. G.: Salinity and Tides in Alluvial Estuaries, Elsevier, New York, 2005.