Reply to Reviewers

Manuscript ID esurf-2021-46 entitled “The role of geological mouth islands on the morphodynamics of back-barrier tidal basins”

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Date of initial submission: 02-June-2021

Note to the Editor and Reviewers:

The comments and suggestions of the Editor and the reviewers are copied in *italic grey font*. The reply to each comment by the reviewers is written in normal font and appears just after the original comment or question.

We wish to thank the editor and reviewers for their valuable comments and suggestions that have resulted in a more insightful manuscript.

Reviewer No. 1

This paper from a very strong research group describes a study on the effects of the presence of the islands around the gorge of a tidal inlet on the morphodynamics of the tidal inlet systems using idealized numerical modelling. Basically, it is about the role of the geological constrains on the morphodynamics of tidal inlets, an interesting and important subject. The study already provides some useful insights and the paper is well written. Therefore, I support the eventual publication of the paper. Obviously, the subject dealt by the paper is a wide one. I would consider the study described by the paper as a start for studies on the subject. Many suggestions for extending and / or improving the study can be made. I would appreciate if the authors can consider the following suggestions for revising the manuscript. I would understand if not all suggestions can be implemented before finishing the present paper, but then please consider them in the discussion section of the paper.

Reply: We wish to thank the reviewer for providing very constructive and detailed comments. We have addressed the comments carefully and merged our responses into the revised manuscript.

1. In the introduction section two pairs of nearby tidal inlets have been presented for a comparison between tidal inlets with and without islands near the inlet gorge. Can this part be extended by elaborating more on what we learn from the comparison? What are exactly the different characteristics of the geomorphology of inlets with islands from those without islands? How are the results from the comparison linked to the present modelling study?

Reply: We fully agree with the reviewer that it is necessary to link the comparison more closely with this study. The relevant content has been added to the introduction section and discussion.

Two pairs of nearby tidal inlets have some similar characteristics: (1) They are both semi-enclosed bays characterized by a large area inside the bay and a narrow tidal inlet, which can effectively reduce waves; (2) Forced by similar tidal currents and small river discharge (Jiang and Meng, 2008).

However, some characteristics are still site-specific: (1) Sediment composition. Massachusetts Bay is a muddy environment, while Plymouth Bay is Sandy (Ford, 2010). The difference of sediment composition may be one of the reasons for the formation of different morphologies. (2) Local hydrodynamics. Sediment composition may also be the result of the long-term interaction between hydrodynamic and sediment transport (Zhou et al., 2016). Geomorphology is highly related to the local hydrodynamics (Van Der Wegen and Roelvink, 2008; Coco et al., 2013), which determines the

sediment transport and trigger morphological changes. By comparing two pairs of inlets, although they are close, the local hydrodynamic is somewhat different. Normally, a larger velocity is formed at the narrower tidal inlet. The inlet of Massachusetts Bay is wider, but the current near the inlet is still stronger (Knebel et al., 1991). In addition to the varying width of tidal inlets, there is also an obvious geomorphic difference driven by the presence of islands and its effect on morphodynamic processes has not been studied systematically. From this point of view, cases of different numbers of islands are designed to investigate the effect of varying inlet widths narrowed by mouth islands on morphological evolution.

2. Can you present something about the morphology of the Dongshan Bay, the reference tidal inlet system for the idealized modelling? Would it be possible to make a comparison between the model results and the real morphology of this bay? Even for idealized modelling study I think it is important to present some validation of the used model.

Reply: To start with, we think it is useful to recall the objectives of this present study as already introduced in the initial submission. This is a schematised modelling study with the Dongshan Bay as a reference site, aiming to provide some physical insights into the effect of mouth islands on morphodynamic evolution. Our modelling study focuses on the physical mechanisms underlying a phenomenon rather than exactly trying to reproduce a set of observations. Choosing Dongshan Bay as the reference site is useful because there are some basic data (e.g., tidal range, river discharge and major sediment type) that allow us to model.

For the interest of the reviewer, we have made a general comparison between the model results and the real morphology of Dongshan Bay (Figure R1). Model results show that the morphology is overall consistent in terms of pattern formation, and the trend of morphological evolution is also consistent with the real configuration (Liang et al., 2016), even though our model predicts a more intricate network. However, there are a number of model simplifications (e.g., our simplified tidal forcing or uniform grain size for the whole domain) and local factors (e.g., human activities) that directly affect the morphological changes. Therefore, it is difficult to really reproduce the channel-shoal morphology based on this idealized model, which is not the focus of this study and this figure would not add to the paper.

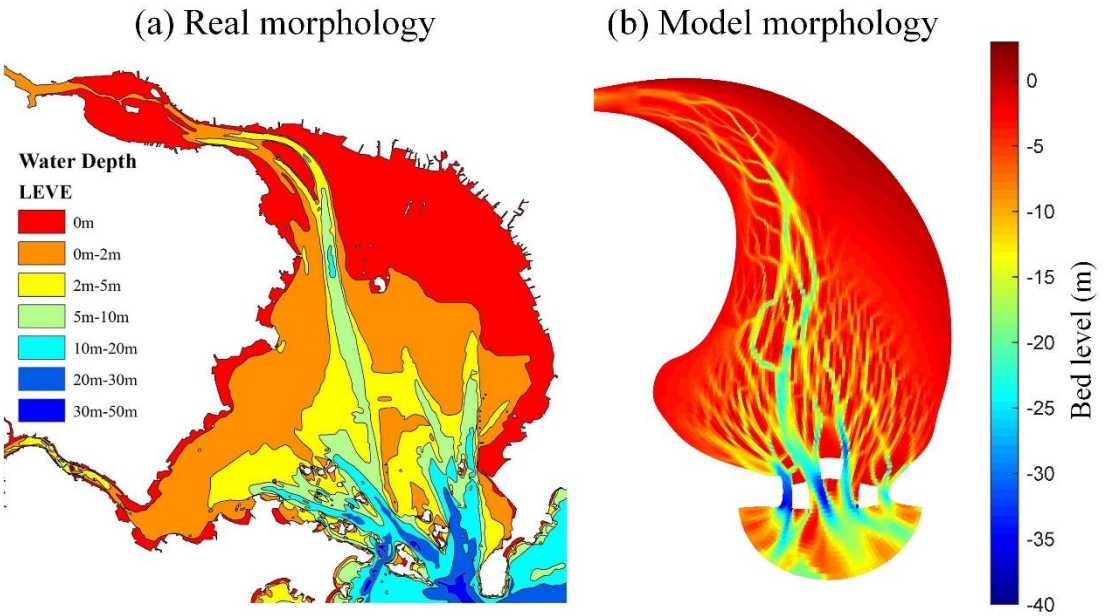

Figure R1 Comparison of real morphology of Dongshan Bay and model results

3. It seems to me that the major effect of the islands in the idealized model is narrowing the gorge of the inlet. Therefore, please discuss on what really matters, the varying width at the inlet gorge or the number of islands?

Reply: The reviewer is correct that the effects of varying widths and different numbers of islands play similar roles in term of converging flow and enhancing flow velocity.

However, the existence of islands can also exert additional influences on local tidal hydrodynamic when they are formed in different locations. Due to the obstruction of the island and the fast velocity on both sides of the island, a velocity gradient is formed between the channels and behind the island, resulting in the formation of eddies. The eddies generated by strong tidal flow past islands, have an important role in natural coastal protection, since they cause waves to refract and dissipate tidal energy (Neill et al., 2012). This provides a sedimentary environment behind the island, forming a back-barrier deposition and obviously affecting the local channel-shoal morphology of tidal basin.

Furthermore, different from a single inlet system, the existence of different numbers of islands can divide one tidal inlet into several tidal channels of varying width and velocities, affecting the local tidal asymmetry. We analyse tidal asymmetry at four locations near the tidal inlet under different cases. Model results show that a different tidal asymmetry occurs in two tidal channels of different width (Figure R2 b). The narrower tidal channel is flood-dominated while the wider one is ebb-dominated. The possible reason may be that the velocity gradient between two tidal channels leads to the tidal currents in the narrower tidal inlet flow into the wider tidal inlet, weakening its flood tide. Overall, we think the role of islands is broader than just narrowing the width of tidal inlet, since the whole hydrodynamic field can be affected.

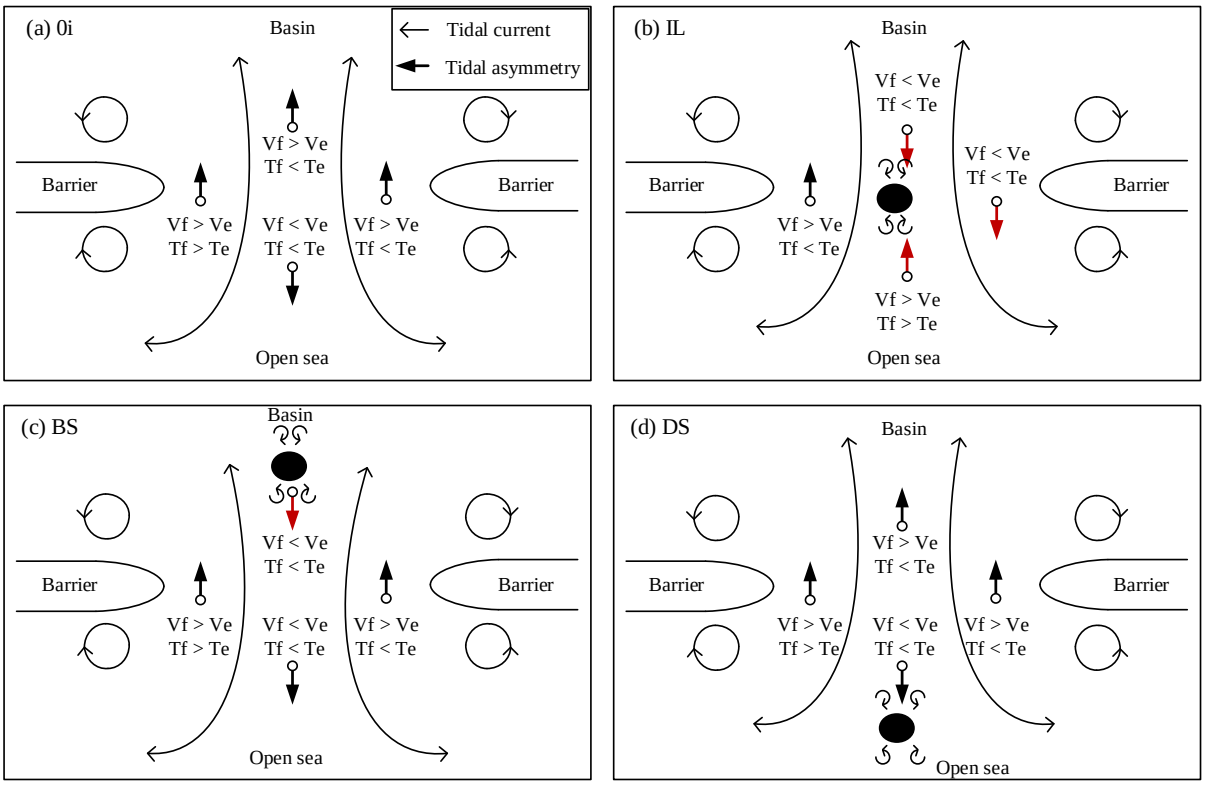

Figure R2 Initial tidal asymmetry of different observation points near tidal inlet of different cases: (a) 0i-case; (b) IL-case; (c) BS-case; and (d) DS-case. In each figure, small arrows represent the direction of tidal currents, while solid arrows represent tidal asymmetry.

4. The model results show that sediment export takes place in all cases. Can you please discuss on the mechanism(s) causing this seaward residual sediment transport? Is this due to the residual flow velocity caused by the river discharge and the flow compensating Stoke's drift?

Reply: Yes, the reviewer is correct that the export of sediment is probably due to the Stokes return flow. In this study, the river discharge is relatively small (50 m^3/s), so its impact on residual current and residual sediment transport is limited. A phase lag between the water levels and velocities induces a landward Stokes drift that causes a landward accumulation of water and momentum, resulting in a water level gradient (negative seaward) (Van Der Wegen et al., 2008; Van Der Wegen and Roelvink, 2008). This water level gradient induces a seaward return flow (Stokes return flow), enhancing the ebb dominant and exporting character of the basin. In this study, it is worth noting that the residual currents are landward in the initial bathymetry, while the net residual sediment is seaward (Fig. 7). A possible explanation can be provided in terms of the Stokes return flow that interacts with the tidal current generating larger residual sediment transport than residual current (Guo et al., 2014).

5. More detailed, at what time are the flow velocity and sediment transport presented in Fig.14? Please consider changing the scales of the vertical axes of pictures a and c. Picture a does not show any differences between the four cases seemingly in in contradiction with the results presented in e.g. Fig.13. The relative differences in sediment transport between the cases should be much larger than those in flow velocity because of the non-linear relationship between sediment transport and velocity. However, picture c does not show this, most likely because of the used scale of the vertical axis.

Reply: Very good suggestion. The time in the Fig. 14 is the result at high tide of the initial year. We have deleted figure a in Fig. 14 since they have little difference. We have also adjusted the vertical axis of Fig. 14 and zoom in locally, as shown in the following figure. It can be seen from the enlarged figure that the relative difference in sediment transport is indeed greater than those in flow velocity.

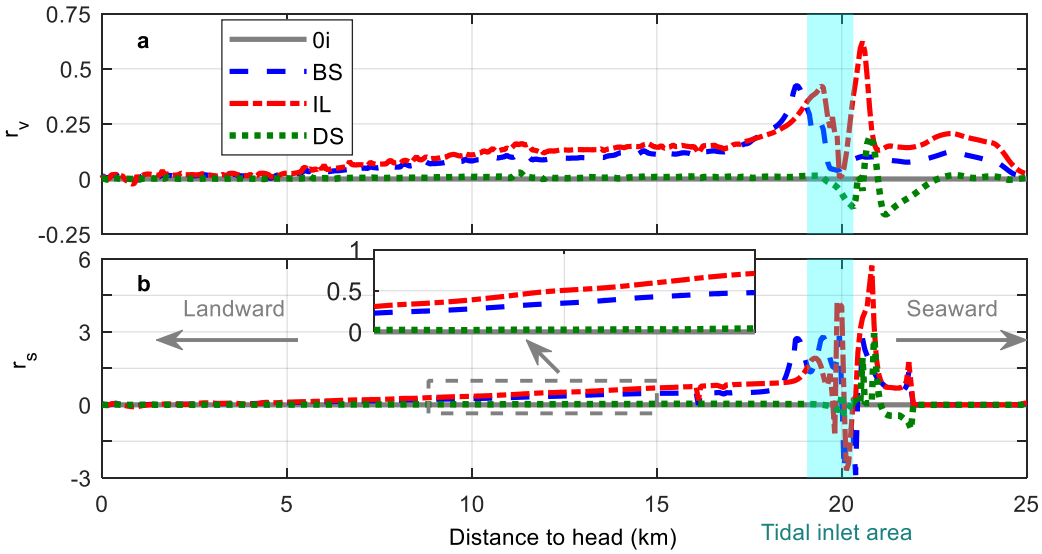

Figure 14 Longitudinal variations of cross-sectionally averaged flow velocity (a) and sediment transport (b) compared to the case of zero island at high tide of the first year.

Line 27 – I would remove "empirical"

Reply: Agreed.

Line 39 – I think that you mean "anthropogenic" instead of "anthropologic"

Reply: Agreed and modified accordingly.

Line 93 – Replace "under" by "with"?

Reply: Agreed and changed.

Line 138-139 – Is it not prescribed that the bed level is not changing?

Reply: Yes, in this way to ensure that the boundary bed level remains unchanged.

Line 143-145 – "which suggests"? I cannot follow the reasoning.

Reply: Following the comment, we think the reason is really a bit of a stretch, so we remove it all.

Line 151 – "the shape of rectangular prism"?

Reply: Sorry, "prism" should be removed. What I want to indicate is a rectangle shape.

Line 188 – Replace "higher" by "stronger"?

Reply: Agreed and changed.

Line 189 – Replace "show" by "shown".

Reply: Agreed and changed.

Line 195 – "continue"?

Reply: Sorry, I don't understand this comment.

Line 380-381 – What do you mean by "horizontal" and "vertical" redistribution? In the model only horizontal sediment transport (from one grid cell to another) is simulated.

Reply: Sorry, this may be a wrong expression. What I want to indicate is that "horizontal" means the sediment moves from one grid to another, and "vertical" means that the tidal channel is gradually deepening, but the shape and size of channel network change little.

Line 393 – Remove "as"?

Reply: Agreed and modified accordingly.

Line 410 – "integrated averaged"? Consider removing "integrated".

Reply: Agreed and changed.

Line 468-469 – I am not quite sure if you can claim "hence providing … systems". No discussion is on this is provided in the manuscript.

Reply: Agreed. We have revised it to the following sentence:

Overall, this study shed lights on the influence of mouth islands (which may be submerged under future sea level rise) on the long-term morphodynamic evolution of tidal basins, hence providing new insights into the evolution of these systems.

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