Revised and Combined Reply to Reviewers

April 18, 2019

In this document, we list the reviewers' comments in black, and our response in blue. Line numbers correspond to lines in the manuscript with highlighted changes, where P#L# denotes the page and line numbers.

Response to Reviewer #1

We wish to thank Reviewer #1 (John Shaw) for his insightful and helpful comments. This response is a slight modification of our previous reply. The specific points raised by the reviewer are addressed below:

The main point of improvement is that the applications chosen to illustrate the theory are somewhat cursory compared to the theory. I find the application to Atchafalaya Bay in particular to be too simplified. The 6 km long transects showing gradual shallowing are very focused in a small part of the bay, and might not be characteristic of the slopes that a delta progrades over.

Our purpose is not to model the growth of the Atchafalaya Bay deltas per se. We agree that the adverse slopes we measured are not characteristic of the slopes that the deltas prograde over – the pre-delta bathymetry is fairly uniform in the areas where the deltas are growing. Rather, the purpose of this section is to obtain realistic values of our model parameters based on a field setting, and thereby constrain the wavelengths that we could realistically expect to find in the field.

Then, the prediction of the stable wavelength is given for $x = 10$ and 16 km, which is far longer than the adverse bedslope measurements. Also, the S_F is roughly -0.00024 for the Wax Lake Delta, as reported by Shaw et al. (2016) and cannot be reasonably estimated as $S_F = -1$. This would increase the neutral wavelength and instability as described in Eq. 17 and 14.

Note in revised text Eq. 14 is now 13 and Eq. 17 is now 16. We have reworked our paragraph on Wax Lake Delta, starting at P9L30. We have removed the reference to the x coordinate, since our model is independent of the definition of the x coordinate. Our finding that the neutral wavelength is larger than the distance over which we measure the adverse slope, reinforces our conclusion that the shoreline instability would probably not be observed, at least for this system. We have corrected our value of S_F, and find that this indeed increases the value of the neutral wavelength. We have also added a sentence to emphasize our conclusion that, under the parameters we obtained from this field setting, unstable shoreline growth would not be observable (p10L12).

Ultimately, I would consider trying to find more or better examples of deltas prograding across adversely sloping beds. Leva Lopez et al. (2014) provide a good discussion that might yield another geological case study. Deltas forming near or underneath glaciers are a potentially great place to look (Carlson et al., 1999; Dowdeswell and Vásquez, 2013; Lønne and Nemec, 2011. . . these are not perfect but show potential). This effort might really broaden the appeal of this paper beyond theoreticians (like me).

We agree that adverse basement slopes should be relatively common in proglacial deltas, for example if the delta reaches a moraine, the wall of a fjord, or perhaps progradation reaching the flexural bulge. However, we were not able to find any clearly documented examples of proglacial deltas from which we could estimate an adverse bed slope. Ultimately, we chose Houseknecht et al. (2001), which was also cited by Lopez et al. (2014), as an additional example. We have added a new paragraph based on this example starting at P10L14.

Additionally, based on our new calculations of the neutral wavelength, we have modified our conclusions (P11L7, P11L10) to emphasize that the wavelength of the predicted instability is large.

P4L16: I initially thought that this equation was incorrect because $\dot{\ell}$ was on both sides of the equation. I am now sure that it is correct, but it may be good to show this equation solved for $\dot{\ell}$.

Done (P5L5).

P7L13: I do not understand how a wavenumber k = 1 is chosen from the XES10 conditons.

The stated purpose of section 4.1 is to illustrate the nature of the evolution of the stability region. To put this in context we have chosen to do this using the XES data. The choice of wave number is somewhat arbitrary in such illustrative calculations and here, for convenience we have chosen $k = 1$. We have added this clarification to P7L19.

P9L11: shouldn't S_B always be positive? This looks like S_B must be negative.

Our convention is that S_B should be negative for an adverse basement slope. We now clarify this at P3L22. We also found multiple instances in the text where we incorrectly stated the sign of S_B, and these have been corrected.

Response to Reviewer # 2

We thank Reviewer #2 (Jorge Lorenzo-Trueba) for providing helpful comments and for spotting the error in our geometric model.

My main question is regarding the relationship presented in line 18, page 3 (i.e., $dL/d\ell = S_B/sin(\alpha)$). When $\alpha = 90$ degrees, the equation provides a relationship I believe to be correct. However, when $tan(\alpha) = S_B$ I believe the symmetry in the geometry should result in $dL/d\ell = S_B/2$. Additionally, when $\alpha \ll$, this equation suggests that $dL/dl \gg$. I am not sure I understand why this is the case. My guess would have been that when $\alpha \ll$ a change in ℓ would result in a small change in L. My derivation results in $dL/d\ell = 1/(1/tan(\alpha)+1/S_B)$. I might be wrong, but this solution seems to get the right answer in the scenarios presented above. Although I believe this equation would not change the overall results significantly, it would affect equations (10), (12), and (13), which are part of the perturbation analysis. Thus, the equations that describe the criteria for unstable shoreline progradation would also change.

We are very grateful to JLT for spotting this error. We have modified our geometric model, now correctly associating the water depth with the delta toe, not the shoreline. We have now incorporated this modification into our analysis and adjusted the calculations throughout the paper as appropriate. JLT is correct that this adjustment does not change the main result or finding of the paper; essentially, as we note in the revised paper, it simply modifies the definition of the effective basement slope used in our geometric and stability treatments. We note, however, that this modification is more pleasing, from a physical point of view, since it now, in addition to the topset and basement slopes, includes a dependence on the foreset slope into the analysis. Our correction is given at P3L15, and carried into equation 2 and P3L17. We then introduce an "effective" basement slope in equation 3, which allows the rest of the analysis to remain the same as before, after substituting in the effective basement slope in place of S_B. This correction slightly changes the stability criterion, as seen in the new equation 13 (equivalent to eq. 14 in original submission) , as well as the neutral wavelength (equation 16—eq.17 in original submission). We have updated the calculations throughout the paper in light of this correction, and we find that the neutral wavelengths are slightly larger than before.

Page1: Line 6: . . . autoacceleration is required for unstable to occur. . . In revised text this line now reads—autoacceleration is a necessary condition for unstable growth.

Page 4: I suggest the authors clarify in Figure 1 the sign of the basement slope S_B, which is negative in this case. I would do the same for the topset slope S_T. This is similar to the issues raided by John Shaw— as noted in the reply to that review-we have taken care to ensure that the signs of the slopes are now well defined. In particular we note slope signs in both the graphic and caption of Figure 1.

Page 6: Line 7: . . . to emphasize. . . Line 12: Nevertheless Correction made

Page 8: Line 8: . . . linear prediction is in excellent agreement. . . Correction made

Author changes

In addition to the corrections in response to reviewers, in order to streamline the revised manuscript we have also removed eq 13 and the text around it from the original manuscript