Response to comments by John Armitage

We are grateful for the constructive comments by John Armitage (hereafter: reviewer) on our manuscript. Below we respond to all points raised in his review and outline how we changed our manuscript accordingly.

General Comments:
In this contribution the authors present a numerical model of sediment transport built on Deflt3d. They then design and run a set of experiments where the upper boundary condition of water flow is varied, the channel boundaries are altered, partial barriers are inserted to the flow, channel bars are removed, or barriers are imposed upon the channel bars. This contribution is basically a list of, to me, a set of numerical experiments that the authors try to baggage together as an exploration of system response to perturbations. The individual experiments are interesting in their own right, but this manuscript as presented is quite a tough read, and is a long description of various model scenarios.
Reply: We acknowledge that the large number of model simulations might make it difficult to extract and understand the main message of the paper. Therefore, we made a new grouping and numbering of the scenarios: scenario 1 is the reference (without disturbances); scenarios 2-4 show that the simplifications in scenario 1 (constant Q, non-erodible banks) are valid; scenarios 5-9 are similar to the reference but with disturbances; scenarios 10-14 are idealized scenarios starting from a perfectly regular bar pattern and with perturbations. Thus, effects of inflow and erodible banks are still used, but not part of the main message and therefore removed from the title and research questions.

I would recommend that the authors reconsider what they consider to be a ’perturbation’ and try to find some generic message or insight on river networks and how they evolve. The manuscript would also be enhanced if a more thorough exploration of the model space was made, rather than a set of individual experiments where various initial conditions or boundary conditions are changed.
Reply: We believe that this recommendation arises from the need to explain better why we did what is in our view a concise and systematic set of experiments. Figure 2 gives a complete overview of the simulation scenarios and the different boundary conditions and disturbances applied. Scenarios 2-4 are now solely be used to demonstrate that we can use constant discharge and non-erodible banks for our purposes (used in runs 5-14). For clarity, the word ‘perturbation’ is replaced by ‘disturbance’.

My biggest problem with this paper is that the model scenarios presented are not all perturbations. A perturbation is a change to the system state, yet here we are presented to different initial conditions, different boundary conditions and only one or two true perturbations. Furthermore, the model conditions explored are rarely justified: why would a dam be built across only one channel? Would it not be futile to try and protect a bar in a large braided river? Is this a realistic scenario? If it is, then explain why.
Reply: See above for the different sets of model scenarios. We now explain our taxonomy of disturbances on the basis of field examples, of which we made a new figure. In brief, we

distinguish dredging of sediment, and addition of dams to fix bars and dams to close off channels in the braid plain. All of these have downstream effects in the sense of flow and sediment blockage in the near-field and a change of direction in the far-field. Our scenarios with dams should be loosely compared with real cases, and our goal is to show the effects of generic perturbations rather than evaluating specific training works. Closure of branches in a braided river is a river training measure that has been considered in multiple cases, but is not common, among others due to the uncertainties of the morphological effects and sustainability. Also, protection of populated islands in large braided rivers has been done and is part of ongoing engineering projects.
Above all, we study how dams, bar protection and sand mining provoke non-uniformity of flow and sediment transport, developing a network response that is found to be much larger in the far-field than expected.

I think that there is very good science within this manuscript, but the structure of the text is poor, with simple mistakes like the model descriptions not following the numbering in Table 2. In its present form it is an unyielding list of model scenarios and so the simple scientific messages that are contained within are lost. In summary, this paper poses relevant scientific questions within the scope of Esurf, using a sound numerical model based on valid assumptions. The aspects in which this manuscript falls down are: (1) the contents do not reflect the title and (2) the structure is a mess.
Reply: Point taken and we did a thorough rewrite. Also, the scientific messages are highlighted. We changed the title, as our focus is on the network response of bars and branches in sand-bed braided rivers to disturbances within the study reach.

Abstract:
"physics-based" Drop this phase. The bank erosion is arbitrary and follows a heuristic law. What is wrong with it simply being a numerical model? I notice the authors like this phrase and have used it in past publications but let's be honest, the model is not based on first order physics.
Reply: We persist to use 'physics-based' and now clarify that we mean a reductionist model, based on momentum and continuity, rather than a cellular automat model which cannot predict far-field effects due to backwater effects. We agree that Delft3D also includes some non-physical rules and now put less emphasis on the 'physics-based' by removing some of the words 'physics-based'. However, the essential elements of the model for far-field effects both up- and downstream of the disturbances are physical.

"The results showed that the perturbations initiate an instability that propagates in downstream direction by means of a bifurcation instability" What is a bifurcation instability - please define this jargon. The way I read the manuscript was that the perturbations, those that were truly perturbations, modified the existing bifurcations. Bifurcation is the division of something into two branches, I guess it would follow that a bifurcation instability is an instability that leads to the splitting of a system - the formation of a bar. However, once the bars are made they are modified not sub-divided, no?

Reply: We added a definition of bifurcation (in)stability. A stable bifurcation indicates that the division of water and sediment over the two downstream branches around a channel bar is constant in time, which may be a symmetrical or asymmetrical division, but not more asymmetrical than, say, 90/10. Bifurcation instability thus indicates that the division of water and sediment changes over time, which is often related to sedimentation and bar shift. In practice all symmetrical bifurcations are unstable as also found in other studies (http://dx.doi.org/10.1002/esp.3268).

"...with a feedback to the upstream bifurcation" From all the model runs I only saw downstream changes due to perturbations. If there was some upstream propagation it was in the model run 9 where an unexplained initial condition was imposed. Is this therefore not the therefore the model evolving to steady state?

Reply: A dam or other kind of channel confinement results in water level rise upstream of the confinement: the backwater effect. A question is whether this backwater effect is sufficient to change the water and sediment division at a bifurcation. The dam in run 12, for example, had a morphological effect upstream of the dam (Figure 8B).

Page 203:

line 14: Delete "natural". line 16: Delete "how fast, and how far", I get the idea with a simple "how". line 26-27: Change "...and bifurcation become unstable" to "...and the bifurcation becomes unstable".

Reply: Done.

Page 204:

line 7: Change 'dataset' to parameter space or something better. These are simulations and no data is being created.

Reply: This is a matter of semantics. The models ran for weeks and produced large output datasets. We put the word dataset between inverted commas to indicate that it is not a classical field dataset. However, we used model simulations to produce a 'dataset', similar to if we would conduct field measurements or flume experiments.

Page 206:

line 23: Delete "so called" and "Thus".

Reply: Done.

Page 207 to 208:

I would argue that only the runs in group D represent perturbations, as the model has been run to a state and then perturbed. The rest are a series of model with different boundary conditions and/or initial conditions. This is in my opinion the central problem with this manuscript: 5 out of the 14 models are exploring a perturbation, and the remaining 9 models have nothing to do with a perturbation to the system and are very distracting from the central message of the paper.

Reply: We agree that groups A and B are not perturbations, and now describe them separately from the groups C and D. Nevertheless, group C does represent perturbations of a *symmetrical bar configuration. The asymmetrical bar growth and shift in group C is the direct effect or indirect network effect of the perturbations, without the influence of initial situation.*

page 213:
The sections describing the discharge attenuation and channel confinement are interesting but have nothing to do with the abstract of the paper or the title. Where is this going? These model runs explore different boundary conditions. Is this a paper on how braided rivers form under different forcing? Line 6: Non-erodible walls had a relatively small effect on the bar pattern statistics relative to what?
Reply: We now clarify this, see above responses.

page 214:
The section on inflow asymmetry bears no relation to a perturbation of the steady system developed in section 3.1, 3.2 or 3.3. Why is this initial condition been used? A perturbation would, for example, be a change in the flow direction during a model run. This experiment explores how an initial condition is altered, not how the system responds to the change in flow direction at the upper boundary. I don't understand how this model relates to parts 3.1 to 3.3.
Forgive me, but is it not also obvious that a different boundary condition will lead to a different bar morphology?
Reply: The purpose of run 9 is to show the downstream propagation of local non-uniform flow, in this case at the upstream entrance (and in other runs more towards the center of the model area). A skewed discharge distribution over the width occurs, for example, in case of an upstream valley bend, a large tributary or an anthropogenic disturbance of some kind, for which we here isolate only the directional flow effect. Run 9 therefore allows the analysis of the downstream propagation of the skewed inflow over the full 40 km of the channel.

Why is run 2 followed by run 9? What happened to runs 5, 6, 7 and 8?
Reply: We now clarify the meaning of the runs, but the numbering was arbitrary during the study and we keep it to allow future analysis and for the sake of making the data available to interested readers.

page 215:
Why would anyone dam only one bar of a braided river? Again, now run 12 is being described before any mention of runs 5, 6, 7, 8, 10 and 11.
Reply: See above responses. In general, the reviewer seems to interpret our study as a straight-forward impact analysis of a specific set of measures. However, this is not what we intend to demonstrate; instead with our modeling experiments we demonstrate the impacts of different kinds of typical disturbances, including narrowing or widening the channel, or fixation of parts of the channel bed. As river training measures essentially involve such types of disturbances as well, we express our disturbances in terms of 'training measures' to illustrate the analogue, not to claim that we evaluate meaningful or necessary engineering measures. We made this point more clear in the text to avoid confusion.

page 217:

Could you give an example of where engineers have tried to protect a channel bar in a braided river? Is this a likely prospect?

Reply: See above responses.

page 219:

Why is it surprising ("remarkable") that the structure does not have a large effect upstream of the structure? The structures modelled in section 3.6 likewise had only a minor effect.

Reply: Dams or other kinds of confinements have a backwater effect, and one would expect that this propagates in upstream direction if it changes upstream bifurcations and bar evolution.

page 220:

The sand mining section is nonsense and should be deleted. This is an arbitrary initial condition and how the model evolves has nothing to do with exploring how a braided river responds to a perturbation, for example the removal of a bar from an actual model run. Taking run 12 as a good example of a perturbation, I recommend the authors wind up a model to steady state and then remove a bar. This would be a perturbation.

Reply: See also our reply under p.215 above. Like the simulation runs 10-14, this is essentially a sensitivity test for the model output to removal of a bar. Of course we do not intend to predict the perturbation effect of sand mining as such, but used this run to explore the effect of locally enlarging the channel bed, as opposite to local confining it by a dam. Still, sand mining and its effect on channel morphology is a big issue in many braided rivers worldwide, and certainly not nonsense. Thus, we think run 12 is a valuable scenario.

page 221:

line 25: "The novelty in this study is the propagation of perturbations by means of bifurcation asymmetry, which is a consequence of bifurcation instability, and bar reshape." I don’t understand this sentence at all.

Reply: We clarified this sentence as a chain of events triggered by the disturbance and rapidly growing and propagating because of the inherent bifurcation instability. A change in sediment and water division over a bifurcation (‘bifurcation instability’) affects the shape of the bar downstream of this bifurcation (‘bar reshape’). Later, the bar shape affects the sediment and water division over the bifurcation downstream of this bar.

page 222:

line 2: "This way, even small perturbations, for example a relatively small dam on top of a bar, may cause major impact on bar and branch planimetry and dynamics..." I don’t see a major difference between Figures 5 and 12 for example. Could the major impacts be better explained?

Reply: Perhaps the reviewer is referring to Figures 11A (second panel, without dam after 15 months) compared to Figure 12 (with dams after 15 months). The main difference in bar and *branch morphology is in the downstream part, for example in km 55-60 in which the morphology after 15 months is completely different between the three scenarios.*

line 19: "According to theory..." What theory? Big bang theory?
Reply: Linear analyses and other theoretical studies, now clarified in the text.