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Interactive comment on "Fluvial response to changes in the magnitude and frequency of sediment supply in a 1D model" *by* Tobias Müller and Marwan Hassan

Tobias Müller and Marwan Hassan

tobias.mueller@geog.ubc.ca

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We thank the Referee for the helpful comments provided. Following the comments, we intend to change the manuscript in the following way: We accept the suggestions for restructuring the manuscript and will revise the paper accordingly.

Validation and calibration of the model

The manuscript currently uses prior flume results to 'validate' the model behavior and then uses this connection to place the model results into context with field systems. This to me feels like a broken chain of logic though, as the connection between the

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flume and field is never established therefore the connection between the model and the field is never properly established or verified.

- We agree that we conducted a model calibration rather than a validation and will explain this in the revised manuscript. The application of the developed time scales to field data was done as an illustration of how our findings can be used to interpret field cases. We see this insight as valuable even if the model is not validated. We apply the time scales to East Creek, which is a small creek in the Fraser watershed close to Vancouver in BC, Canada. This is the same creek that the flume experiments were designed from as a 1 to 6 model. We will clarify this in the manuscript and will add to the discussion to establish the connection between field, flume, and model.

Additionally, I would encourage a very brief discussion of (1) how higher or lower shear velocities would impact the results in figure 6, particularly through the modulation of the fluvial evacuation time and mobility of the grain size mixture, and (2) how these results would change for a partially mobile mixture. This discussion would add value to the conclusions of manuscript as it is insight that the authors likely have into this problem that is challenging to parse at the moment.

- We conducted a few additional simulations with 25% higher and 25% lower total sediment feed which collapsed onto the presented data after the non-dimensionalization. We left this material out to shorten the manuscript. Similarly, we expect an increase or decrease in shear velocities to be analogous to a change in the grain size distribution. We expect this also to be the case when adding large grain sizes that are initially immobile. The slope would increase to a point where these grain sizes become mobile leading to a very high (potentially unrealistic) equilibrium slope. As we compare all results to the corresponding constant feed equilibrium slope of the same grain size distribution, these conditions might collapse on the existing data as well. But it is likely that the conditions

become unrealistic in a way that the empirically derived transport function by Wilcock and Crowe is not realistically applicable any more. We will add a discussion along this line to the manuscript. We will add a figure showing the collapse of simulation results with 25% increased and 25% decreased sediment supply in the supplement.

Specific comments

As stated above, we accept the suggestions for restructuring the manuscript and will revise the paper accordingly. We also accept all minor/editorial suggestions. In the following, we will not respond to them explicitly if they do not contain questions.

Minor Comments. In the model are all sediment types mobile for the given flow?

- Initially yes, but armouring might make the larger grain sizes immobile.

pg 2 ln 1 - Do you mean 'concentrated activity'?

- Yes, we will change this sentence.

pg 2 ln 2-4 - It is not clear that this statement is necessarily true. At this point it would seem that the number of papers are fairly equally split between large fine-grained lowland rivers and coarse-grained rivers in or near the mountains. [...]

- We refer to streams with steep gradients and will clarify this in the manuscript.

pg 2 ln 22-31 - There a quite a few articles (Cui et al., 2003 a b; Cui and Parker, 2005; Lisle et al., 1997; and especially Lisle et al., 2001) some of which are cited above in the intro that deserve a bit more discussion in the opening paragraphs. [...]

- We will add to this section as suggested.

pg 2-3 ln33-3 - Please provide a working definition of an equilibrium channel. It is not clear from the text what constitutes a transient form or an equilibrium form in a river channel or what level of adjustment is still considered to be no longer equilibrium. [...] These paragraphs would carry more weight if the mechanistic studies cited earlier on page 2 lines 10-21 were worked into them to demonstrate what has been tested or explored. [...] There is a lot of information on river adjustment to perturbations within those works and the sorting literature that provides firmer footing for the current study (especially because the current manuscript models a flume and those are flume studies by and large while the cited examples here pertain to field studies for the most part).

- We will rework this section to be less about speculative about phenomena and better describe equilibrium and transient conditions by adding insight from the mechanistic studies cited.

pg 4 ln 28 - first 'water depth' followed by Q should be discharge. Assuming all of the units here are SI?

- Yes, all units are SI. It is correct that Q should be discharge.

sec. 2.2 Model Validation - How was sediment flux measured in the experiments and at what frequency? I did not see this mentioned in the section

- Sediment flux was measured with a light table and validated by total weight after each experiment. The light table data is presented as a 10-minute average. We will clarify this in the revised manuscript.

pg 8 ln 18 - Is a value of t*rm not available from the flume experiments? It seems odd that a factor of 2 increase is required. This should be explained as it suggests that we might be missing a parameter in the equations that treating the threshold as a fitting parameter hides (sidewall corrections?)

- Wilcock (2001) suggests taking the same approach of increasing the threshold shear stress to match a sediment transport calculation to field data. In personal communication Gary Parker also supported this approach. Other authors apply a similar factor 2 adjustment as well (Chartrand et al.,2015). We also want to note that a sidewall correction would increase the shear stress in the center of the channel, which we would have to counteract by increasing t*rm further.
  Citation:
  Chartrand, S. M., M. A. Hassan, and V. Radic ′ (2015), Pool-riffle sedimentation and surface texture trends in a gravel bed stream, Water Resour. Res., 51, doi:10.1002/ 2015WR017840.
  Wilcock, P.R. (2001), Toward a practical method for estimating sediment-transport rates in gravel-bed rivers, Earth Surf. Process. Landforms, 26(13), 1395-1408, doi:10.1002/2015WR017840

pg 8 ln 19-20 - Overall the model provides a good approximation of the flume data, however there appear to be additional consistent differences between the model and the flume that may not be just sampling related and it would be nice for the authors to comment on this as it directly relates to the relaxation and response time of the system. See comments to figure 3 below for specific differences.

- We will add a discussion of discrepancies between the flume experiments and our numerical modelling.

Figure 6 - (a) what is the numbering scheme for the Tpp axis? (b) can this be put into hours so as to match 6a? In 6a the distributions seem strongly skewed, in that the mean may not be the best statistic to represent the distributions especially from about 80 hours onward. (c) is the xlabel supposed to be Tfe instead of Tfc?

- The numbering scheme for the x-axis in Figure 6a is irregular, as each Tpp chosen for this study must match the condition that the total simulation time of 20,000

hours divided by Tpp gives a whole number of pulse events. This achieves that the same total mass was fed over the same amount of time at the end of the last pulse for each simulation.

- We will add hour markers in Figure 6b that make a comparison with Figure 6a easier.

It is correct that the distributions are strongly skewed. We also tested using the median of the distributions, but this did not change the numbers significantly. As visible in Figure 5a and 5b, the strongly armoured runs show little adjustment after a pulse was introduced. Here, the mean slope is visualized and can be seen to be at the lower end of slope values.

- Yes, the x-axis in Figure 6c should read Tpp/Tfe

pg 20 ln 2-4 - This might be a bit of a stretch as the total difference in slope ranges (6a) from 0.8 to 1.2 from an equilibrium profile and the armor ratio compared to equilibrium only differs by a factor of 1.2 for these simulations. These are pretty small differences to pick up in the field with parameters that sometimes have at least factor 2 to order of magnitude variability. To be fair this section is a reasonable idea to pursue but it feels underdeveloped here to the point that it may not yet be practical given field data sparcity and error. pg 20 ln 5-17 - This section and Table 4 feels like a non-sequitur and seems underdeveloped compared to the rest of the paper. I recommend removing it and extending these ideas into a different manuscript. Substantiated with more data from different field sites these ideas could be expanded into a short format paper.

- We see the most value in our approach in estimating sediment supply conditions for which constant feed assumptions are valid in simulations of sediment transport. For this, we give a quantifiable condition and an example of applying it to a field case. We see this as a valuable addition to the manuscript, especially as the

defined time scales can be applied in cases with sparse data availability. Further, we see the differences of 20% between some of the model runs as significant, as we previously would have assumed that a constant feed assumption would be adequate for a wider range of pulse conditions and these cases would consequently produce very similar slopes. We agree that this magnitude of difference would be hard to measure in the field, especially as other factors might hide the differences caused by different sediment pulse frequencies.

Data availability - Nothing mentioned that I could see. No mention of model code or data from the model runs that were presented in the figures. Lab data used for validation from Elgueta-Astaburuaga and Hassan (2017) is available upon request from M. Hassan. I do not know Earth Surface Dynamics data availability policies, however as it currently stands the data used in this paper is not available and the flume data used to calibrate the model is only marginally available

- The model code and simulation results are available on request. We will clarify this in the revised manuscript.

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