Anonymous Referee #2
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Review of 'Gravel threshold of motion: A state function of sediment transport disequilibrium'
Earth Surface Dynamics (esurf-2015-52) Joel P. L. Johnson

This paper uses flume experiments and a morphodynamic model to assess the impact that sediment supply has on the evolution of thresholds of motion. The topic of the paper is of interest to readers with some interesting findings that are applicable to the wider discipline. However at present the paper is quite, long, 'dense' and difficult to read in parts meaning that the novelty of the paper is somewhat lost in places. The main comment I feel which needs addressing in this paper is the lack of emphasis on the physical underpinnings of how sediment supply affects the thresholds of motion. Whilst the author makes reference to the bed state conditions in the introduction he does not really follow those through in terms of the implications of his findings. This currently leaves the reader wanting more detail in this regard. There are many papers which talk about the effects of both bed state in terms of structure as well as sand content on entrainment thresholds. I think the latter is particularly important for this paper and the author could look at the following papers as a starting point.

I appreciate the comments, and have worked to address them by reorganizing and expanding on the physical explanations for why thresholds of motion can change over time. Following these comments, I have streamlined some sections and shortened the manuscript wherever I felt possible. However, because of additional clarifications and explanations requested by the reviewers the manuscript is slightly (~4.5%) longer as measured by text, but has 1 fewer figures. More importantly, I believe it is more clear and focused.

Following the recommendations of both Turowski and Reviewer2 that the physical processes causing changes to thresholds of motion be described in more detail and combined in one place, the biggest change I made to the manuscript is moving parts of two sections that discuss previous work on evolving thresholds of motion—part of previous section 3.2 that discussed the sand dependence of reference stresses in the Wilcock and Crowe (2003) model, and also most of previous section 4.1 ("Comparison to previous work"), which discussed Recking (2012) relations—into the introduction. These are now section 1.1. In this way I have one section that better describes the many various physical controls on thresholds of motion. This topic is presented in section 1.1, and also 2.1. While the effect of sand on thresholds of motion was addressed in the previous version, it is now discussed much more prominently near the beginning of the manuscript.

Because of concerns over length brought up by Reviewer2, I cut one figure (previous Figure 11) and the section of text that went along with it. I removed this part because, while interesting, I felt like it was less central to the science than the other parts of the work. The other 10 figures are essentially unchanged.

Curran, J.C. and Wilcock, P.R. (2005). Effect of sand supply on transport rates in gravel bed channels. Journal of Hydraulic Engineering. 131:961-967

Ikeda, H. and Iseya, F.(1988). Experimental study of heterogeneous sediment transport. Environmental Research Centre Paper 12. University of Tsukuba; Japan.

Jackson, W. L., and Beschta,R.L. (1984). Influences of increased sand delivery on the morphology of sand and gravel channels. Journal of the American Water Resources Association. 20; 527–533.

I now reference these papers in regards to sand supply and thresholds of motion.

I also feel the paper could benefit from being shortened as it is currently quite long and loses focus in places. Detailed comments are also given below.

I have tried hard to improve the paper by following the comments of all of the reviewers. This includes adding material to explain many points further, hopefully making the manuscript less dense. While I have also cut text (in particular Figure 11 and the text along with it), unfortunately the manuscript is now slightly longer as measured by text. However, I also believe that it is more clear and understandable. The revised manuscript better guides the reader and explains why certain things are being presented, hopefully helping it keep its focus (for example, new lines 79-82, 203-211, 386-389, and 545-548).

Because of how Word changes line numbers in the "track changes" version of the manuscript, I note that the line numbers refer to the revised manuscript that does not show all of the edits.

Line 83- I am not sure I agree with the statement that is still only believed to be controlled by grain parameters. There is an increasing recognition that, as the author alludes, bed state controls are also important. I think at the very least this should be recognised in the current text and references made to the large body of work relating to the impact of structure on bed stability. How does this also link to the concept of mobile armours? You go on to mention this in lines 153-157 so this section could be reorganised?

Section 1.1 now more clearly lays out the relations and overlap between what I am categorizing as grain controls and bed state controls (new lines 84-87). I now specifically address and reference armoring in relation to both of these categories (new lines 92-95). Because space is limited I do not expand on the differences between mobile and static armors.

Line 93- comma missing after vertical position
Added comma.

Lines 123- 131- this section is clumsy and needs re-writing
I edited this section to use active voice and to be less awkward. (new lines 203-211).

Line 141- 143- does this not assume that the bed state does not change? You could have the same overall flux of sediment but the surface structure may change and hence the distribution of threshold stress will thus change as the bed is more stable?
I rearranged this section to have the mention of steady state at the end of the section rather than at the beginning, to more clearly explain how the proposed feedbacks work. I also expanded specifically on the case of steady state threshold of motion based on this comment: Yes, the threshold could evolve under constant flux, but because sediment transport rate and the threshold of motion are directly linked, a change in threshold would change the transport rate (new lines 268-274).

Line 155- consider revision of little additional decrease
Changed wording.

Lines 158 – 167 – I think if you are using the terms interchangeably throughout the paper then there is no need for this paragraph at all.

I got rid of some of this paragraph, and shorted and moved part of it to elsewhere (new lines 52-57). I believe it is important to explicitly state what threshold stresses and reference stresses are, and to justify using them interchangeably.

Line 185- should be dimensional not dimensionally
Changed.

Line 189 – move 'Ar is an optional dimensionless armouring parameter, described further below' to line 198 where you talk about Ar. I think the Ar should be defined as it can have different definitions.

Done; I moved text around and also expanded on this portion, to explain and justify this model parameter (new lines 307-316).

Line 202- this sentence does not make sense- do you mean large grains rather than large range?
That is exactly what I meant; I somehow put the wrong word. I'm glad the reviewer was able to figure out the intention of the sentence.

Line 205- although this paper is concentrating on step pool sequences perhaps something to consider later on in the paper is how applicable these results are to gravel bed rivers more broadly e.g. at lower slopes?
I have added a statement to the discussion that the model parameters were calibrated to these particular steep slopes, and that future work is required to validate the model over a broader range of parameter space. (new lines 635-639).

Line 207 – unit missing after flume length
Done, added m.

Line 226- can you be more specific- how much erosion?
In the interest of clarity and length, I edited the text to focus on the bed responses (coarsening and roughening and sediment transport rates) that matter more for my analysis; in doing so I cut the explicit mention of erosion. (new lines 343-344). Erosion amounts are less informative and somewhat different for the different experiments.

Line 227 – what does 'very low' mean? Can you quantify?
I have reworded the text to say that flux dropped by approximately 3 orders of magnitude, and also have a callout to Figure 2a that shows the transport rate changes through time. (new lines 341-344).

Line 228 – why was this feed rate chosen? What was this rate in comparison to the initial transport rates?
I added an explanation of why the feed rate was chosen—"this feed rate was chosen to be similar to the high initial transport rates (Fig. 2a), while not so high as to inhibit morphodynamic feedbacks by fully burying the stabilized bed surfaces." (new lines 347-349).

Lines 243- consider deleting to GSDs compared
Done

Lines 237- why was the Wilcock and Crowe model specifically used?
I now give the specific reasons that I used this model: because it can account for both surface grain size changes and also let me evaluate whether sand supply can explain the experimental transport trends. (new lines 359-365).

Lines 237- 265- can this section be shortened? Why not just reference the W&CM highlighting the changes you made to it?(lines 262-263)

I considered cutting some of the equations that are Wilcock and Crowe (2003) model, but in the end decided to leave them in. I believe that cutting Eq. 13 and 14 (previously 10 and 11), which show what nondimensional bedload transport rate means and how thresholds of motion actually go into the transport relation, would make the paper more difficult to understand for most readers, especially those not intimately familiar with W&CM. Also, since I made changes to equations 15 and 16 (previously 12 and 13) I would have to leave those equations in the manuscript; the length of writing actually cut would be pretty small.

Lines 313 -316 – what was your GSD? This is important if you are beginning to duscss sand content and the mechanisms by which sediment feed rate affects initiation of motion? Also in line 313 you mention that the % of grains smaller than 2mm was very small bu tin lines 316 you say 2.8mm was your smallest grain fraction?

I now clarify and describe more completely the full grain size distributions used in the flume experiments; relevant here is that the smallest size class used in the experiments had a D16 of 2.0 mm, D50=2.4 mm, and D84 of 2.8 mm (new lines 327-330). I clarify that this was the size class used for the calculations of sand fraction (new lines 414-422).

Lines 332 – define RMSD

Done (new line 433)

Lines 336 – 344 – this is an interesting finding but what are the implications of this in terms of bed state?

I now give a suggestion of why my model was seemingly insensitive to having combinations of D84, D50, D16 and bed roughness included as another parameter in the model—it may suggest that net erosion and deposition were more important over the range of parameter space explored in the experiments (new lines 440-442).

Line 352 – need full reference to Parker

Done, new line 451.

Line 473- change stresses to stress

Done

Line 474- I am not sure they are comparable are they? Again thinking in terms of the relative effects of bed structure and implications of grain size, structure and thresholds of motion would D50 and D84 be expected to behave the same?

I clarified the writing; I was not trying to suggest that D50 and D84 thresholds would necessarily be or should be expected to be interchangeable. I simply make the point that Recking's relation is not too far off from my thresholds of motion, although the R^2 value is still low (new lines 552-560).

Line 475- what do you mean by 'fairly comparable'?

Reworded to say I do not expect these different threshold measured to be equivalent (new lines 553-554).

Lines 503-506- I think this is one of the places where a better physical explanation behind the findings would be useful

Good point. I added a substantial amount of text. First, I now acknowledge that future work would be required to really determine specific process linkages explaining asymmetry in

aggradation vs degradation effects on thresholds of motion (new lines 587-589). Second, I present a hypothesis that could be tested with future work about the differences in deposition, erosion and roughness evolution (new lines 589-606).

Lines 530 – this section is supposed to be linked to system memory but I find it hard to distinguish this and a much more explicit link needs to be made.

While the section talked about system memory, it also covered other topics. In the interest of article length I removed the section (old section 4.3 in the previous manuscript, and also figure 11) and also cut most of the content. I did however keep and expand slightly on parts related to memory, these are now at new lines 628-639.

Lines 545-546 – I would re-write to avoid asking a rhetorical question

This sentence was cut during editing.

Lines 576 – whilst I find this section an interesting concept I think it could be shortened a lot given the paper is already quite long.

I shortened this section by roughly 23% through editing (new section 4.2). However, I feel like it is an important idea to explain thoroughly, and I really do not want to remove more of it. I did cut substantial portions of old section 4.3 in the previous manuscript, and also old figure 11, in order to keep the manuscript focused and not even longer.

Line 584- expand upon the work of Phillips (2007)

Done, new lines 649-652.

Line 625 - I would re-write to avoid asking a rhetorical question

Done. I also edited out some other rhetorical questions in the manuscript.