Earth Surf. Dynam. Discuss.,
https://doi.org/10.5194/esurf-2018-39-RC2, 2018

Earth Surface Dynamics Discussions
Open Access
EGU

Interactive comment on "Long-Profile Evolution of Transport-Limited Gravel-Bed Rivers" *by* Andrew D. Wickert and Taylor F. Schildgen

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Received and published: 24 August 2018

This paper presents a new approach to predicting the long-profile evolution of gravel-bed rivers. The authors couple a range of governing equations for different components of these channels, resulting in a predictive relationship for channel development. From analysis of this relationship the authors are able to explain a number of observations including width-discharge scaling, and channel response to changes in sediment input, discharge and external forcing. I think that this paper will be of interest to a broad audience, and support its publication.

Overall I found the paper to be clearly written, although like the other reviewer I also found that there were places where I needed some more explanation. There are nec-

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Discussion paper

essarily a lot of equations in the paper and I have taken the authors' word that where they have combined equations etc. that this has been carried out correctly. The list of definitions at the end is useful, but there are places in the paper where it would be helpful to remind the reader what various parameters are.

One question that I had at a number of points is what the impact of size-selective entrainment would be on the model results. The model uses a single grain size, and the grain size is found to have to decease downstream in order to produce realistic concavity values. This decrease is implied to be caused by grain abrasion. However, we know that grain size also decreases downstream because of size-selective entrainment (e.g. Hoey and Ferguson. 1994). If you attributed the decrease in grain size to entrainment processes instead, would this have any impact on the rest of the model formulation? For example, abrasion should only be a function of transport distance, whereas the extent of size-selective entrainment will depend on the rate of sediment deposition.

The paper often refers to concavity and steepness, and it would be useful to state explicitly the relationship between the two. I assumed that changing the profile concavity would also change the slope of the profile (by different amounts at different locations), so I wasn't sure how the two could be seen as being separate from each other.

One general comment about the discussion is that in some places the figures are more extensively referred to by a section that is later on that the section that they are presented in. It might be worth double checking that all figures are in the most appropriate section and/or whether any sections could be combined.

Comments by page/line:

1/17: topographic relief of rivers or mountains?

2/28: Suggest replacing 'modifies' with 'defines'.

2/29: So how is your approach different to/an improvement on Blom et al?

3/25: Isn't the high excess shear stress also necessary to enable the river to erode

the bedrock bed as well as transport all the sediment? Also, is this something that you should come back to later on when assessing your model results from scenarios with an increase in uplift rates, as it suggests that your model assumptions might not apply in those conditions?

4/10: I got a bit confused by this material about the valley, probably because I would tend to think of long-profiles models as just considering the channel bed. It makes sense that if you want to raise the channel bed you also need to raise the elevation of all the material in the valley, otherwise the river will just occupy the lowest parts of the valley. However, you could state this more explicitly. In line 5/8 I wasn't sure if you were referring to the channel or the valley. I also wasn't sure where the terms in the brackets on the RHS of eq.1 had come from.

5/8: I think that this sentence about sinuosity will be clearer if you clarify the earlier material, but check; it took me a few reads to clarify what you meant. Also, sinuosity is introduced as a term here, but doesn't seem to feature in any of the later analysis. Is the impact of sinuosity on channel form (or the other way around?) something that you could look at in future work?

6/4: I agree with reviewer 1 that the use of the signum function is not intuitive. I can see why it might be useful to relax the assumptions, but I don't think that it is necessary is any of your analysis?

7/26 and 8/10: Could re-emphasise here that you are considering the excess shear stress and depth at the channel forming discharge.

8/28: I wasn't sure what I was meant to take away from that sentence.

11/9: It took me a couple of reads to get this comment about valleys not having vertical walls.

14/4: Rephrase

14/6: This is one of the points where I was trying to remember what the various P

parameters were. You have defined them in a sensible way, but it might help early on just to spell out your definition (e.g. that in all cases P_xy is the power that relates x to y).

16/2: It's not clear what studies you are referring to here.

16/31: What should I take from this example?

17/30: If weathering can reduce the amount of gravel, presumably it also alters the size?

18/5: Couldn't the location of the gravel-sand transition be as much a size-selective transport phenomenon rather than an abrasion-of-gravel phenomenon? I thought that Dingle et al actually supported your idea by the observation that the amount of gravel leaving a basin didn't seem to depend on basin size, and therefore most of the gravel from the basin was abraded to sand before leaving the mountain front.

18/8: I wanted a bit more explanation as to how Fig 3 was produced. It wasn't clear to me whether the increase in P_beta was falling out of the equations, or was something that you were altering.

19/5: If this model is for transport-limited conditions, can it be applied to these upper parts of the network?

20/8: I think that Fig 4 shows that valley widening is likely, but there is still a solution when P_xB is zero.

20/25: Amplitude of what?

21/fig 5: Explain in the caption which of the thick black/grey lines is the start/end. Why is there a dashed line in a2?

22/fig 6: I initially read the caption as being the ratio of sediment input to water output discharge, so clarify this sentence. Also, why do b and c not get to a state where the input and output sediment fluxes are equal?

24/3: Another steepness/concavity confusion; looking at fig 3, different slopes seem to be associated with different concavities.

24/21: This first phrase was not clear to me.

24/22: Here and after equation 56 are the first explicit mention of tributaries. I think that their input is implied in many of the earlier relationships, so it might be useful to mention them when presenting the earlier sections.

24/25: Might be useful to state that this time is that taken to fill the valley floor to a depth of 1 m?

25/3: One of these decreases should be an increase.

26/19: I think that you have implied this point earlier, but this is the first time that it is spelt out. Move to earlier on?

27/fig 9: I needed a bit more explanation to understand how this figure supported the point made in the text.

29/14: Does whether bedrock rivers behave as transport limited depend on the timescales over which you are considering them? One of the main assumptions about bedrock rivers is that over long timescales they are supply limited.

29/28: Is there any field evidence that identifies the location of the detachment- to transport-limited transition? How does it agree with your finding?

Reference: Hoey, T. B. and Ferguson, R. I.: Numerical-simulation of downstream fining by selective transport in gravel-bed rivers - model development and illustration, Water Resour. Res., 30(7), 2251–2260, 1994.

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