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

Anonymous Referee #1

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This is a great paper, and I will be thinking about it, reading it, and citing it for a long time. It tackles some important questions in geomorphology that will be of very broad interest. I love the derivation of the width-discharge scaling relationship – wonderful! Also, I love that they tackled how to deal with the problem that power-law scaling in transport-limited 2D LEM models doesn't lead to concave channels – their solution seems spot on to me. Beyond the science, this paper is also very well written. I fully support publishing it, and it could be published in its current form.

Here I offer some general ideas and share where I got confused so that the authors can potentially add text here and there to answer some of my questions and minimize confusion. This is a very dense paper, so any reader is not going to get everything the first time. That's why I will be reading it for a long time to come. But that said, maybe

a few things can be clarified. I recognize that the authors know this work better than I do, so if they disagree with my suggestions it's fine. I don't think anything is technically wrong in the paper.

One of my big pet peeves, although I may be the only geomorphologist who thinks this, is calling slope the absolute value of the gradient. This can lead to sediment moving uphill. You use a few absolute values in your equations and then take care of the sediment moving uphill part by adding the signum function to your qs equation. But then eventually you get rid of it. I didn't understand why you did this. Looking at equation 3, (qs equation), I spent more time figuring out the sgn function, than if you had just changed your if statement. Why not just change the if statement that is already in the equation if to be if tb* <= tc*, then qs = zero? I went around and around on this, and I think you get to the same place by taking out the -sgn term and the absolute value on tau_b* by changing the if statement which to me is much simpler. Seeing the absolute value of bed shear stress was weird for me. And it took me a while to work out why that was needed when you also had sgn. It seemed overly complicated, but maybe I am missing something.

I know this seems like a micro-detail to bring up in my big comments, but when I have to go through 50+ equations, I don't want to be struggling on equation 3. And sgn is in other equations too. Why not just make the assumption that you are calculating in the downslope direction, as you are modeling 1D profiles anyway?

I also had a hard time going between general 2D network evolution and 1D channel evolution. I think the dz/dt equations should be general, and apply to a network, right? But the analytical solutions, which make the assumption that the channel is conveying sediment through, and not eroding or depositing, is for only 1D? Further confusing me, I think, is that when you bring up the Whipple and Tucker 2002, you are making an assumption that Qs is increasing downstream, so different from the earlier analytical solution. The W&T slope-area relationship – equation 51, and the 1D channel-only-conveying-what-is-sent-in-from-upstream slope-area relationship – equation 55, look similar, but the idea that in one, only sediment is coming in from the top of the profile, and in the other there is a network producing sediment – seems like it should make a huge difference. I wonder if by adding the area exponent on the steady-state Qs relationship (eq. 50) but with such a low exponent – e.g. 0.2 – it basically shows that inputs of sediment from tributaries are less important for channel profile form than we thought? This is really hard for me to wrap my head around. I'm not sure I have fully appreciated this or if I am following. But possibly it is worth more discussion, or I missed the links in this study of your paper.

I know that you relaxed the assumption of only upstream sediment supply a bit in section 5.4.3, however this is very brief. I'm not sure what the answer is, and I hate to tell you to lengthen the paper, however, I did get confused moving among the different assumptions.

Details:

Page 2, Line 5: "However, such a ... " - Perfectly stated. I was hooked.

EQ 1 : Many people (I think) might be used to thinking of this equation only in terms of the first term in parentheses, and not the second one. Is it worth explaining each term?

P 8, First paragraph : Very nicely written and explained.

Eq 17 : It's not intuitive that channel width increases with slope. Is the explanation for that coming up? I immediately thought of Finnegan, Roe, Montgomery & Hallet, Geology, 2005. Might need some discussion.

P 10, L 1 : It finally dawned on me, should sediment discharge really be termed sediment transport capacity? Isn't qs what the channel can transport, but it will only transport if that sediment is available?

P 12, L 23 : I'm not sure you should cite Whipple and Tucker here. I don't think they show any data on the discharge-area relationship or Hack's law, they just use them.

P 14, L 12 : Do you mean constant? Or uniform? I think uniform as you say "a short reach ... with no significant tributaries"

Eq 44 : In the context of W&T 2002, I think what you have derived above is Qc, not Qs. It might be worth stating that. Maybe some people will get confused. Even in the appendix you call Qs sediment discharge, and Qc sediment discharge capacity. But it seems to me your equation 3, which your Qs equations comes from, is really a capacity, and in a sediment starved system this would not be the sediment discharge. Help me out please.

P 16, L 12 : I know one can't cite everything, but I particularly like the study by Huang and Niemann, 2014 to show this point. GSA Reviews in Engineering Geology, 2014 Simulating the impacts of small convective storms and channel transmission losses on gully evolution

P 17, L 6 – 10 : Is this discussion of P_beta actually beta? If P_beta equals zero, I think that means that the sediment flux is the same everywhere, or beta * U, and not that all material weathers on the hillslopes. Similarly, if P_beta = 1, but beta = 0, then no materialÂă reaches the stream as gravel. I'm confused.

Eq 50: Maybe also state bounds on Beta. Maybe obvious, maybe not?

P 18, Last paragraph : I'm a little lost in this paragraph... Are you talking about spatial variation in rock uplift? I don't think so, but "reduce the concavity in the downstream direction and "increases the fraction of the eroded landscape that acts to produce gravel" imply spatial variations to me. I think you mean that where rock uplift rate is lower, residence time is probably higher, so less gravel makes it to the channel. I guess this was also shown in Sklar et al, 2017?

Figure 6 : In this figure, is sediment input at the headwaters and sediment output at the outlet? I'm confused as to why these values assymptote to one when the sediment input varies or the base-level drops out for a period, but in the case of an uplift

rate change, it evolves to a new steady state in which sediment flux is increasing or decreasing downstream. Is this something related to Qs_in is fixed?

P 23, L 2,3 : This confuses me. Isn't P_beta in the concavity, and if that changes, wouldn't that change the input sediment-to-water discharge ratio?

P 24, L 12, 13 : I'm confused. I thought the first sentence of this section said that the sediment-to-water discharge ratio does impact long-profile concavity.

P 25 : "ÂăAs this ratio becomes more positive, concavity decreases; as it becomes more negative, the concavity decreases." Should the last word be increases?

P 28, L 18: Is this supposed to be P_DQ, not P_BQ?

P 28, L 21 : Am I following this correctly? I think you are saying that P_DQ needs to be -2/9, but that is outside the range that you predicted in the previous paragraph. If I'm right about that, then does that have implications for theta values and/or exponent values in the width-discharge relationship? If I'm wrong about this, I think I've gotten a bit lost.

P 29, L 26 : Not to be a pain in the ass, but this isn't strictly true. They had a coefficient on sediment production, but they didn't have the area-to-a-power scaling.

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