Earth Surf. Dynam. Discuss.,
doi:10.5194/esurf-2016-41-RC2, 2016

Earth Surface Dynamics Discussions Open Access EGU

ESurfD

Interactive comment

Interactive comment on "Steady state, continuity, and the erosion of layered rocks" *by* Matija Perne et al.

Anonymous Referee #2

Received and published: 13 September 2016

This manuscript on the influence of horizontally (or close to it) layered rocks and their influence on landscape evolution is very interesting. Some of the results are extremely counter-intuitive, and that always makes for a fun read. The math and modeling seem sound to me, and I'm generally supportive of this paper.

The paper is timely, as another paper on a similar topic recently came out – Forte et al., which is cited here. Forte et al., also discussed that steady state is not reached with horizontal layers. Where this paper falls a bit short, in my opinion, is a lack of much discussion and also some lack in details of the modeling. As for the discussion, I thought they might tie in more with the Forte paper at some point, but that never happened. But in general I did not find the discussion to be very deep. As for the modeling, it was not always clear to me why the models were set-up as they were.

My general comment is just to give a bit more detail, including around the figures, and some suggestions for this are laid out in my line-by-line comments.

Line by line comments:

After reading the abstract I'm still not sure what channel continuity means. Notably, the sentence starting on line 5 made no sense to me, and I think that made me stumble through the rest of the abstract. I went back and read it after reading the manuscript and then it made sense to me. I think it was hard for me to envision what retreat in the direction parallel to a contact meant without the schematics, but after seeing the schematics it seems obvious. I don't have a great suggestion for improving this sentence.

The caption in Figure 2 and main text around it confuse me. In A, is the upper layer steeper, or is it simply that the upper layer is overhanging the lower layer, creating an instability? Similarly, in B, isn't the problem that there was a dam created?

Equation 2: Is this vertical incision rate?

Page 4, first paragraph. I see the math, but this is confusing. A few things. I wonder if it would be helpful to remind people the relationship between K_w and K_s? As for equation 5 with n<1, the prediction is so counter to my 'gut', that I wonder if some discussion about whether n<1 is realistic, or about whether this counter intuitive relationship has been observed, would be useful. The n=1 case is also difficult for me to wrap my head around. Maybe more discussion is coming later.

Page 4, line 28: What does it mean that experiments with resolution suggest that the conclusions are not affected by numerics? Does that mean you changed the resolution and ran with different numerical schemes, and got the same answer? Or that your results are not dependent on the resolution for a given implementation of stream power? Please clarify.

Page 5, line 6, 7: Is layer thickness thought to vary with uplift? I don't think so. Why do you do this?

Page 5, L 14: What do you mean it holds if ‘slope is replaced with slope‘?

Figure 4 caption: What is meant by the ‘steady state profile predicted by the theory‘? Just the elev-chi plot for a channel with that erodibility in vertical layers? Or is it the theory that you present in this paper. I’m confused.

Page 7, summary in paragraph on line 25: I got a bit lost. I think a bit more description/hand holding for the reader would help. I recognize that lambda* is a way to show how large chi_s,+ is. But in the description with respect to figure 6, the damping is described in terms of cycles through rock layers. I don’t understand what this means, or how to get that from the equations. I must be missing something easy. How does chi_s,+ related to the depth of the rock layers? How do I know from lambda* how many layers the knickpoint has propagated through?

Figure 7 is difficult for me to interpret. I think I can see the knickpoint that is propagating up in elevation, but I can’t really make out the knickpoint that it is ‘catching‘. Can you tell us how you determined that there was a knickpoint at the red line that was caught? If I look at the dashed line (intermediate time) in C, it does not look like there is any significant change in the chi-elev relationship at the red line, but I think that there is supposed to be a knickpoint there, right? Or at least one close to it that will soon catch up? I only see one knickpoint downstream from there, but maybe I am interpreting incorrectly? Actually, after watching the movies, I may understand this. But I still think it is worthwhile to point out to readers exactly what you are calling knickpoints.

Fastscape runs: It is a bit unsatisfying that the n=2/3, 3/2 runs have channels that extend through 4+ layers of each rock type, but the n=1 run only just barely taps three week layers. I know this is a lot to ask, but it’d be more satisfying to see more of the n=1 profiles, i.e. just make the K values in this run smaller. I’m not adamant about this, as the 2D runs appear to be very similar to the 1D runs.

In the beginning of Section 4, the authors mention that they include hillslope processes. It seems like this needs a bit more description. How are the different rock types treated with the hillslope model? How do they model hillslopes?

Discussion and Conclusions: I liked that the authors brought in a real world example. However, this example confused me. I may be wrong, but my impression of Niagara Falls and the Niagara river is that the soft rocks underneath the hard caprock are indeed basically vertical at the waterfalls. But if you move any length downstream the channel is not so steep anymore. I might be wrong as I haven't studied the Niagara River, just visited it. But does the whole length of profile have the 'inverted' relationship (steeper in weak rocks) suggested by Figure 4D, or is it just 'inverted' around the waterfall? This may seem a picky point, but I would guess, as the authors brought up elsewhere, that the processes going on right at the knickpoint are not adequately modeled by stream power. So in some ways this comparison feels a bit odd to me.

I felt as though the discussion could be expanded a bit. The parameter n turns out to be extremely important in this study. Any thoughts beyond Niagara Falls on how your contribution plays in to the n debate? Have many studies suggested that $n<1$? Are there any other landscapes to call upon to illustrate the modeled behavior besides Niagara Falls?

I also generally prefer a separate conclusions section. I think it is better for authors because often times the only sections of the paper that get read are the abstract and conclusions. But this is stylistic.

Interactive comment on Earth Surf. Dynam. Discuss., doi:10.5194/esurf-2016-41, 2016.