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Comment on esurf-2021-50

Anonymous Referee #1

Referee comment on "Generation of autogenic knickpoints in laboratory landscape experiments evolving under constant forcing" by Léopold de Lavaissière et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-50-RC1, 2021

Review of Generation of autogenic knickpoints in laboratory landscape experiments evolving under constant forcing

In the submitted manuscript Lavaissière and colleagues present new laboratory experiments documenting the generation and retreat of autogenic knickpoints. Overall I am supportive of this manuscript (the experiments are really cool!) and believe that it should be eventually published in ESurf. Autogenic knickpoints are seeing increasing study in our field, and experiments, like those detailed in the submitted manuscript, are important for advancing our knowledge of how these features form, what controls their retreat rate, and how we might separate autogenic dynamics from climate/tectonic forcing in natural landscapes. The submitted manuscript has potential to address all these issues. I believe that with some moderate revisions, the authors can revise the manuscript to be both more impactful in our community, and easier for readers to digest. I've outlined my comments below, and offer the comments as constructive criticism for a manuscript that I think is cool, an important contribution, and which I look forward to seeing eventually published.

- **Mechanism of knickpoint formation and retreat**

I found the manuscript to be very detailed on observations, which is good, as the authors did an excellent job of relating the results of their experiments. However, I believe the manuscript could be more impactful if the authors expanded their discussion of the mechanisms that control both autogenic knickpoint formation and knickpoint retreat.

For knickpoint formation, the abstract stresses channel narrowing as the initiation mechanism, but it seems to me after reading the manuscript that knickpoint formation may actually cause channel narrowing (i.e., the narrowing occurs after knickpoint initiation) in the experiments. Can the authors use their experimental data to separate the role of channel narrowing and channel steepening in knickpoint creation? Based on my reading of the manuscript and looking at the data, I think that, after the initial autogenic knickpoint has been created, spatially variable erosion caused by the initial knickpoint formation leads to channel steepening, which then allows additional knickpoint formation

and channel narrowing. Is this correct? If so, it would be helpful to make this clear in the manuscript. If not, it would be helpful to document that channel narrowing occurs before knickpoint creation if it is indeed the change in channel width that controls knickpoint formation. I recommend the authors create a schematic diagram/cartoon to include in the manuscript that shows the steps leading to knickpoint formation.

I think I understand the authors' mechanism for how autogenic knickpoints continue to be created once the initial one forms (spatially-variable erosion due to changing channel width result in changes in river profile concavity). However, what creates the initial knickpoint? Can this be determined from the experimental data? A discussion of this would be helpful.

Sedimentation was mentioned briefly in the manuscript, and sedimentation has been shown to play an important role in knickpoint formation and retreat in previous studies (e.g., Grimaud et al 2016; Scheingross et al., 2019). It was unclear to me if sedimentation and cover of the bed contributed to the formation of knickpoints in these experiments. Discussing this in more detail would be helpful.

For knickpoint retreat, what is the mechanism that drives this retreat? Are knickpoints discrete steps that are undercut (e.g., Baynes et al., 2018)? Or is it simply the steeper slope of the knickpoint leads to increased erosion rate relative to the surrounding?

I also had questions about the controls on knickpoint retreat rate. The authors argue that knickpoint retreat rates follow a 'bell shaped curve' where retreat rates are initially slow, rates increase up until the knickpoint has gone approximately half way to the divide, and then rates slow. I have two questions about this:

First, I think this pattern seems clear in experiment MBV06; however, the pattern is less clear to me in experiments MBV07 and MBV09. If the authors want to argue for this pattern in their experiments, I would encourage them to perform some statistical tests to show that the quadratic they fit to the data in Fig. 8C is indeed the most appropriate description of the data. For example, can the authors show that the observed patterns of retreat rate vs. time are statistically distinct from a constant retreat rate? My guess (from looking at Fig. 8C) is that the retreat rate vs. time data for experiment MBV09 might be equally well described by a constant retreat rate. If this is the case, this raises a new an important observation that base level drop rate can play an important role in setting how retreat rate varies with distance upstream.

Second, perhaps I missed it, but I didn't see a mechanistic explanation of why the retreat rate would follow a bell shaped curve. I would encourage the authors to provide a detailed mechanistic description of why this should occur.

Finally, for both knickpoint formation and retreat, I would encourage the authors to discuss if the material used in the experiments imparts any bias on the results. My understanding is that the silica paste used in these experiments erodes via clear water flow, unlike natural rock which (in many cases) erodes primarily via abrasion from sediment impacts. Would you expect different results in a natural landscape where erosion occurs primarily via abrasion? Some discussion of this would strengthen the manuscript.

- **Expand the discussion on the implications of the work**

The authors motivate their study with arguments that knickpoints are often used to read tectonic and climate history recorded in river profiles. While I think the authors do a nice job of showing how knickpoints can form autogenically, there's no discussion about what the implications of this are for inverting river profiles or for landscape evolution. In order to make their manuscript more impactful, I encourage the authors to expand their discussion of the implications of their work. For example, how can we use the experimental results to help separate autogenic versus tectonically (or climatically or lithologically) created knickpoints in the field? Do the autogenic knickpoints created in the experiment have any characteristic scales or morphology that one could look for in the field to identify them? Are there certain landscapes or lithologies that will be more prone to autogenic knickpoint formation than others?

- **Motivation of the problem and knowledge gap in the introduction**

The introduction did not seem to state a clear problem, question or knowledge gap which the authors were addressing in this study. Instead, this comes in the methods, when the authors describe how previous experiments used a fixed outlet while in this experiment the rivers are free to adjust their width at the outlet. This is an important point that shows how the contribution here is unique relative to previous work. I suggest the authors revise the introduction to add this information and further expand upon a statement of the overall question and knowledge gap would (in my opinion) strength the paper.

- **Writing style**

Throughout the results and discussion session, I found the authors spent significant time describing the figures with detail in the manuscript, instead of placing this information in figure captions. Especially when reading the results, it felt to me as if the authors were describing the figures, rather than trying to describe the results of the experiments and the processes that were observed. I think the length of the paper could be reduced, and the paper would be easier to read, if the authors tried to re-write these sections to focus more on the observations and results themselves, and saved the details of the figures for the figure caption. In practice, this could be accomplished by a switch in writing style. In place of text such as "In Fig. X, we show this and that, and these observations indicate this process" the authors could instead write "We observed this process (Fig. X)" and then include additional details of what's plotted in the figure caption. For example, L255-260 is all text that I think belongs in the figure caption and not in the main manuscript. This is just one example, but this occurs throughout the manuscript. I think that streamlining this text will free additional space for the authors to discuss some of the issues I've raised above as well as comments that may come from the other reviewers.

Related, there were a handful of English language errors throughout the manuscript. I've pointed out a few of them below, but not all. These errors did not affect my ability to read and comprehend the manuscript, and were rather minor, but should be fixed.

Minor and Line-by-line comments

Somewhere in the introduction or methods, it may be useful to distinguish a knickpoint from a step in the profile. Tectonic geomorphologists are often interested in knickpoints that extend hundreds of meters to kilometers across long profiles, whereas steps can form

at much smaller spatial scales in channels. Both steps and these longer length steepened channel reaches have been called knickpoints in the literature. Which features are the authors referring to in their use of the term 'knickpoint'? And are the knickpoints generated in the experiment better described as individual steps or steepened channel reaches that extend over a significant portion of the channel length? I think it's the latter, but this should be made clear for readers.

L16: Change these to this.

L20: Change rivers to river (singular).

L27: Remove their

L39-41: This is vague. It would be more insightful to the reader to explain what the limitation is and what the role of sediment supply is.

L46: Unclear what 'their' refers to in this sentence.

L48: Change has to have

L52: The abbreviation BL should be defined as base level before first use. Furthermore, I suggest spelling out base level throughout the manuscript, as it's not a commonly abbreviated term.

L73: Replace 'to create' with 'creation of'

L87: Define the term DEM on first usage.

L94: Change 'most of channels being straight' to 'because most of channels are straight'

L98: Change 'verified manually' to 'manually verified'

L98: What is meant by 'define knickpoints correctly'? Do you mean against a geometric definition? This section is unclear because it seems there are two ways to define knickpoints. One is based on the erosion rate relative to base level fall, and the other is a manual way (presumably based on geometry and channel slope?) that is not well defined.

L127-128: I'm confused on what the threshold is. Is this the minimum water depth for an area to be classified as a channel? Can this be made more clear?

L168: When using the term 'non-linear relationship' please indicate between what variables this non-linear relationship is expected.

L176-177: Change "whatever regardless" to "independent of"

L231: See Mackey et al. (2014) for a field case showing constant retreat (https://doi.org/10.1130/B30930.1).

L240: The authors write "they do not show a clear tendency of increasing" – I think the data actually looks pretty good. I would encourage the authors not to sell themselves short. It could be worth quantifying this statistically to show that there is a statistically significant increase.

L260: Replace 'channel is in average' to 'channel is on average'

L249-299: This paragraph is quite long and hard to follow. Can this be simplified? See

my comments about writing style above. Also a discussion of the mechanism of knickpoint formation could be useful here.

L265: Change 'before to subsequently widens' to 'before subsequently widening'

L272: Change 'erosion rates value' to 'erosion rate values'

L382: I think defeat should be decrease instead?

L383: Change 'downstream the knickpoints' to 'downstream of…'

L384: Change 'downstream retreating knickpoints' to 'downstream of retreating…'

L390-410: This feels more like results than discussion to me, and I would incorporate it in the results section.

L425: Change 'downstream the' to 'downstream of the'

L436: Change 'before to decelerated' to 'before decelerating'

Figures

Figure 3: In panel B, the solid lines are model predictions I think? This should be made clear. It would also be helpful to plot the measured value in the experiments.

The purple line is hard to see in a panel A, why not plot both lines as red? Or choose a different high contrast color?

Figure 6: This looks like the jet colorbar? I suggest using color schemes that are colorblind friendly (see these for example: https://www.fabiocrameri.ch/colourmaps/).

Figure 7: Is the colorbar the same scale in all three panels? If so, please make the labels on the colorbar for knickpoint retreat rate the same (experiment 9 has a different label than experiments 6 and 7). Also, what's the difference between the dashed blue, red and yellow lines around ndd of ~0.5 relative to the gray lines?

Figure 8: Is panel A needed? Panel A & C show essentially the same information, but panel A is very difficult to read. What about color-coding the data in panel C and eliminating panel A?

Figure 10: The caption says blue and orange colors, but I think purple and green is meant instead?

Figure 11: Typo in caption, it says "shear stress (FD) for all pixels", but I think this should be 'shear stress (D) for all pixels"

Figure 12: Is distance on the x-axis flipped relative to fig. 6? I think it is. It would be helpful to change the x-axis label to "distance from the divide" or something else to indicate which direction the divide is in, and make sure the orientation of the x-axis is constant between figures.

Also in Figure 12, it would help to shade or add arrows specifying exactly where the knickpoint is. Simply putting the label K1, K2, etc on the panel is less useful than explicitly indicating where the knickpoint is.

Supplementary Information

- Please note that throughout the supplement most of the units have powers listed as subscripts when these should be superscripts.
- At the end of the first paragraph, please spell out "Table 1" instead of "Tab. 1"

Overall, the text of supplementary information has a lot of repetition from the main text (some of it is also repeated word for word). Please eliminate this redundancy.