Specific comments to Authors

Title: Planform river channel pertubations resulting from active landsliding in the High Himalaya of Bhutan
Journal: Earth Surface Dynamics
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Abstract

L1: What do you mean with persistent features? They are numerous and abundant? Or one landslide stays active a long time?

L1: Evolution is meant to be stability?

L2: Why is it difficult to assess hazard? Features are difficult to detect? They occur in inaccessible areas? Maybe add a half-sentence about the reasons.

L3 ff: Rather explain the reasons for using Fourier transform first and then succeeding explain the results

L3/4: Why is it important to mention that the wavelength is consistent with a fractal distribution (pink noise with a specific exponent)? How does it help us to distinguish areas with creeping landslide?

L4/5: Maybe it would help the reader to first mention that river wavelength is disturbed by landslides.

L7: Exceptional amplitudes of what? Landslide activity? Or river movements?

L7: What other geomorphological processes can induce lateral channel migration as well or if it is just creeping landslides?

L8/9/10: This sentence is hard to read. Maybe splitting the sentence? Or switch “range” to ”ranging”

L10: What do you mean with “early period”? How early is early and how long is a long period? Quantify the words with numbers.

L10: Are the rates an interpretation of your normalized channel offsets? If so are they really “consistent” or are they rather supporting the interpretation of phases of different landslide activity?

Introduction

L19: Why only “parasitic” failures? And not just slope failures in general?

L20: What would be sensitive mountain infrastructure? Isn´t all infrastructure human-made by definition?

L21: What do you mean with “lessen dam stability requirements”?

L21/22: What are other “driving geomorphological changes” that can affect dams than landslides? Either define it as landslides or mention examples.

L23: Maybe not just construction workers? Do not all humans depend on the functionality of the dam?

L25: Channel displacement due to landslide activity is quite well known (e.g. Korup, 2005, Earth Surf. Process. Landforms 30, 783– 800). However, it seems that your goal is rather to investigate whether channel displacement can be specifically linked to creeping landslides and how the channel is disturbed and adapts during longer time-spans. Be more precise in your usage of "landslides" and "creeping landslides" and try to specify your goals in these section.

Z25: Do you really "identify" zones of heightened erosional activity (creeping landslides?)? Or do you rather check whether landslides activity is reflected by lateral channel migration? You cannot do both at the same time.

L26: Evolutionary stage = Landslide activity?

L28: What are examples of modification of bedrock channels? What do you mean exactly?

L29: What do you mean with "those"? Fluvial processes? Uplift and erosional processes? It´s ambiguous here. And so you state that erosional processes (in general) are not influencing the hillslopes? However one sentence after it you mention landslide as erosional features.

L30: Are there other "Hillslope processes" that affect both bedrock strength and sediment transport? If not, leave out "such as".

L34: Evolution = migration?

L35: What do you mean with "cluster term"?

L35-L40: In this section it becomes clearer that you use specific terms without clarifying their meaning in the beginning. What is hillslope erosion (creeping landslides, landslides, slope failures, dry ravel?). What is erosional efficiency? Try to make the section easier to read and to follow your thoughts. So, erodibility depends on bedrock strength and erosional efficiency (also stream power?)? (Why use back-calculate?). State that you want to incorporate information about creeping landslides to study the lateral migration of channels. Again what do you specifically mean with "river evolution"? What do you focus on? Be clearer! Avoid using "evolution" so much, as it is a quite general term meaning nothing, everything, and all in between. What does it mean to "contextualize […] hillslope processes"? This sounds much like an empty phrase, specifically as you mention landslides right afterwards.

What do you mean with "engineering geological framework? You mentioned river dams in the beginning, maybe include as an example closing the circle?

L41-44: This section is so much easier to read! Use it and cooperate it into the section beforehand.

L47: Characteristic for… mountains? Plains? Alluvial fans? Be more precise!

L48: Again… evolution. Try to define it. What is your understanding of landscape evolution? Over what time frame? You mention relief production in the next sentence. Maybe it´s that?

L49: Avoid mentioning of the same word in one sentence ("limited"). Suggestions: Controlled

L51: Try to keep it simple "Sediment evacuation from active hillslopes" = erosion

L51: How does sediment comminution affect spatial and temporal erosion patterns? If you state something like this you should definitely put in a reference and explain further 1) the principle behind 2) Why is it important for your work?

L52: Help the reader to understand your work by mentioning the most important principles. What are erosion products? How does it influence tectonic orogens specifically? Concentrate on the

principles important for your hypothesis. If it is not important, delete it, otherwise explain why it is helpful to understand the kind of erosional product.

L56: “Drainage area is therefore regularly used as a proxy for river discharge”. You referenced Wobus et al. (2006). However he only mentioned the typical power-law function that slope depends on drainage area (what you also mention later).

$$S = k_s A^{-\theta},$$

S represents local channel slope, A is the upstream drainage area, and ks and θ are referred to as the steepness and concavity indices.

Please, check again the sources or review the statement.

L56: What are *exponential* profiles? You mean longitudinal profile or river profile? Or you mean exponentially increasing slope?

L62: How long are “timescales relevant to relief production in alpine regions”?

L82 ff: Here you could try to keep it simpler as well. State that knickpoints lower base-level, increase local relief and reducing stability of adjacent slopes increasing the probability of failures.

However these failures would seem to be catastrophic. So we are probably not talking specifically about creeping landslides?

L86: Landslides are always driven by gravitation. However triggers usually include high and long rainfall duration as well as seismic activity (and anthropogenic triggers like road cuts). Be careful and distinguish between drivers, triggers and causes!

L87: I do not understand what you mean with “External support” when mentioning resisting forces. Resisting forces are usually a function of shear strength aka. cohesion and internal friction and depends on the rock type.

L88/89: Fluvial incision (in my experience) just affects the driving forces. It would interest me how resisting forces are changed (see comment above that resisting force is depend on rock type). Even when you mention that support at the slope toe is removed this affects only driving forces as it does not change material properties.

L90: Why is it a relative increase? Relative to what?

L90: How much is markedly?

L91: What do you mean with damage propagation? Joints, fissure and joints? Or just activity?

L92: How do you define compound landslides? What are with other types of slope failures?

93: The example you mention for increased landslide activity has a complete other setting and the reason for increased landslide activity is rather due to fluvio-glacial valley deepening and seismic activity than due to knickpoint propagation (Prager et al. (2008) did not mention knickpoints once in the paper). I would highly recommend to pick an example suited for your setting.

L94 ff: Why is it important for your work to calculate excess topography? You mention the method without explaining the advantage for your specific study.

L114 ff: Why not put the whole section in the Methods?

L118: Are there any other processes disturbing channel walls?

L148: The last part of the sentence already sound like a discussion/conclusion. This should be written there and not in the Introduction.

L151: What do you mean with “the manner”? Timing, velocity, phases of activity of the creeping landslide?

L151: What do you mean with evolution? Rather morphology, right?

L153: How many hydro-power dams are already built how many more are planned in your study area?

L155: What are geomorphic domains? River vs. Hillslopes? Either add the types or remove it.

L157: I would argue that there is no such thing as a “convergent tectonic setting”. However, one of the three plate-tectonic settings is “convergent boundaries”. Keep those definitions distinguished. The boundary would then be E-W striking.

L165: Magnitude 8 is a very big earthquake! Please check if there is really no seismic activity in the area. If so, that´s fine.

L172: Mention shortly what the five domains are before discussing them in detail.

L189: Every precipitation value should including a unit with year (e.g. 3500 mm/yr)

L200: What is the definition of “medium active” how many centimeters do the landslide have to move per year?

L200: Please revise whether the categories are either “Likelihood of activity” (as stated in figure 4 in the legend) or the “likelihood to be classified correctly as landslides”. There is a huge difference between the statement that the landslide is “probably a landslide” or if the landslide is “probable active”.

L206: You mean that the scar or the toe is maximal 0.5 km away?

L208: What does it tell us about the age of the landslides if there are no deposits?

Methods

L211: What do you consider as apparent? How much displacement would it be? Same question goes for “atypical”. What do you consider “atypical”?

L214: What are “strong” variations? Until what number or percentage (or any other metric) do you consider any variations “as strong”.

L218: What is your definition of a “flow network evolution”? How does it differ from increases (or changes in general) in sinuosity? If it is the same take one term.

L222-224: Why did you set those parameters as they are? 2.8 km² seems a rather arbitrary number.

L224: Why didn´t you use the just the 5 m ALOS?

L228: Why did you choose exactly 500 as stiffness? What happen when you try other values?

L234: What is the advancement of only using half-wavelength? Does it affect results of full wavelength are used? You could explain this further in detail.

L245: “Minimum value” of what?

L246: Name what D_{ch} and D_{va} since you do not mention the abbreviations beforehand.

L243 ff: In line 234 you mention that you focus just on the lower 1/3 of the landslide. However in figure 6 the whole landslides are marked and their distance from the channel axis and river are calculated for every pixel. This needs to be clarified.

When you calculate a distance it has to have a reference point. Do you calculate the distances within the landslide to a certain number of points on the river and the valley axis or just one?

Concerning figure 6: I also noticed that the red line (apparently the channel axis) is crossing the hillslope on both figures. This might show that the results are flawed. The channel axis has to be in the middle of the channel rather than on top of the slope. This might explain why the distributions are going into a negative area towards the left.

The distributions in general are just odd. In the left one the red line goes up to 800 m (~2/3 of the landslide), however in the DEM figure both lines are not too far separated. So the differences in the maximum value are quite striking. In the right figure both lines for the distribution have a maximum value of 400 (which is ~20 % of the landslide). Do they belong together at all?
Furthermore, the median values do not make sense. The median should be where the peak of the distribution is. It is especially visible in the left lower panel. I´m not sure why the red line is so much farther to the left. Please clarify!

However, I foremost have trouble understanding the concept of those two distributions in general. Why do you not just take the difference between river and the channel axis? Why involve the landslides at all? Especially considering that you than would just have one value for every landslide.

One side question: In this section I just remembered that you talked in line 208-211 about the fact those slope instabilities do not show any deposits. So how can they change channel morphology if they do not have deposits?

So the planform channel offset DL is the amplitude of your frequency?

L252: This sentence do not make sense to me. Please clarify.

L255: So it is a landslide-induced offset you want to calculate? This should be stated somewhere.

L255: What is a half-wavelength of a landslide? Please describe why you need this parameter.

L256: I wouldn´t call it “flow distance”. This is regularly used for the length of flows (like debris, earth or mud flows). Maybe something like “extension of the landslide along the stream”.

L265-268: This section can be mentioned in the discussion but not in the methods. Start with “We can use…”

L279: I haven´t found the value for K in both of the references. The first one doesn´t mention the parameter and the second is an AGU talk, with only an abstract available. Please consider updating the references.

L288: So, do you assume that the landslide caused the knickpoints or the knickpoints caused the landslide? If the latter is the case, what caused the knickpoint in the first place?

L292: You also have to consider time! Not only stream power but also with more time, the channel will adapt and straiten again. How do you involve this in your concept?

<u>Results</u>

L299-303: You can put this section either into the methods or in the introduction

L314ff: So do all knickpoints have their origin in landslides or do they develop due to different lithological units? It would be easier to understand if in one map the lithology would be included.

L318: You have never defined ksn before (you defined ks). Please explain what it is.

L319-324: You say that the domain with the highest knickpoint concentration the ksn is also highest (8.1 $m^{0.9}$). Than you say that in the High Himalaya the ksn is lower. However you mention a higher value for Paro (14.7 $m^{0.9}$).

L334: Why do you suddenly make the distinction that you only take landslides which have a certain distance to the channel? You have to explain why! Also consider shifting that sentence to the Methods.

L338: Why not take the hand measurements in the first place?

L339: Why would it be expected?

L341: There are two options which haven´t really been clarified for causing a landslide. a) A knickpoint created by a seismic event, slowly migrates through the stream network, steepening walls and causing a landslide b) a landslide which was caused by rainfall or a seismic event created a knickpoint. If you assume a) than how did the knickpoints develop if there was nearly no seismic activity (lithological knickpoints do not migrate). If b) is the case, how can you be so sure that, considering you are speaking about creeping landslides, one landslides hasn´t produced multiple knickpoints?

L346: A rate, same as frequency, is something that always considers time. So your unit seems odd. This should be something like m/yr. If you want to have a normalization then there is no unit at all.

Discussion

In this section you tend to include information that can be put into the Introduction, Methods, and Results. The main objective, to discuss your results, is barely done. Furthermore, it is obvious that references are missing here (there are none in the discussion). Part of the discussion is to compare and integrate you research into previous work. This needs to be reassessed in detail.

L358: So three geomorphic domains? Not five as explained in line 172?

L359-361: The description of the domains can be put in the Study Area/Introduction.

L361: What are those glacial feature? Moraines? Glacial-fluvial terraces? And what does it signify that the “correlation of fluvial and hillslope activity is less clear” for your study? This might be an interesting point, but you have to discuss it in detail and compare with previous work.

L363-364: You are speaking again about catastrophic failures and not creeping landslides. How do knickpoints affect creeping landslides in general? That would be interesting to discuss. Also, a reference for that statement would be nice.

L364-366: “We calculated…” is a typical beginning for a paragraph in the Method section.

L366-373: “We find…” is a typical beginning for a paragraph in the Result section. Why not put it there? What is your goal in the first place to calculate the density of knickpoints and landslide? Explain (in the Method).

L373-376: You haven´t shown that landslides were just triggered by knickpoint retreat (what about other factors?). It is quite a bold assumption. However, this might be an interesting point which can be discussed further in detail (maybe checking excess topography, lithology influences or climatic changes?).

377: What is AV?

L380-382: You have data about the activity of landslides. It would be interesting to know, not only assume, how the data reflect your statement.

L384-390: Again this section reflect results. You are not discussing anything here.

L390: What do you consider as "characteristic processes within the domain"?

L396-397: Again, how can you assume that knickpoints caused landslides without checking other trigger mechanisms? Fluvial undercutting might be an explanation, as well as strong rainfall.

L397: Why not mention that you take "landslides with a minimum distance of 50 to the river channel" in the Methods? You mention it in the Introduction as well as in the Discussion where it does not belong.

L399: How can you decouple natural fluctuations of the river with an induced channel offset? Are the offsets larger with landslides nearby? This might be something to discuss.

L403: How can the Northern Valleys be a younger domain? What do you mean exactly with this statement? I would assume that uplift started earlier in the Northern Domains. You also mentioned that excess topography as well as knickpoint density are higher in the Northern Valleys. Especially you mention that it has "more time" – so it must be older?! Please explain.

L411: How much more additional time?

L412: What kind of displacement? Channel? Landslide?

L416: I think you "methodological artifacts" are produced by your channel axis crossing hillslope (as visible in Figure 6). This needs to be reevaluated! And also discussed more in detail.

L419-421: The landslide is not a thing that moved during your analysis. So the landside protrudes the same for both the axis as well as for the river channel. Like I said, negative values are produced by axis not following the river channel but crossing the adjacent hillslopes.

L426: Why normalized time?

L426-430: Again you describe your methods.

L438: What "plot"? A figure?

L442: What can be reasons for "Increased differential stresses"?

L445 ff: This sounds like a conclusion and you already have the first sentence in the conclusion (line 470)! Please remove this paragraph.

<u>Conclusion</u>

L451: "Potentially" creeping. This is new. You have never mentioned it before. So they are not all creeping?

L461-463: What do you mean with “make a case”? Also this sentence is in general hard to understand. What is your point you want to make? Also what are “well-connected domains”? Which domains exactly?

L467: Where do the 300 ka come from? You never mention them before.

L470: “Perhaps” quantify? Either you did it or you don´t.

L474: How could your method support hazard assessment? Might be something to discuss.

Figures

Figure 1: Add small letters on top of the drawings

Figure 2: Why did you add excess topography to the map? What is the additional value? Could you maybe add the geology to the map or the geomorphic domains (Line 166 ff and line 173 ff)? Longitude values should be put underneath or above the corresponding line (It´s therefore hard to read if the lower line is 60°N or 80°N)

Figure 3: Check that no numbers are overlapping with any lines. You can also make the little map bigger.

Figure 4: Mark the exemplary tributary with another color. It is nearly not visible. Also try to stretch the legend more. There is a lot of white space in between.

Figure 6: I would recommend making both the lines and the text thicker and bigger. Furthermore, in the figure description the source is missing (“hillshade derived from….”)

Figure 9: The bubbles for “area” in the legend are overlapping each other. Also the colors for “unlikely” and “likely” are hard to distinguish.

Figure 13: The bubble sizes within the plot do not correspond to the bubble size of the legend. Also the bubbles in the legend are overlapping each other.

Technical corrections

1. Remove unnecessary little words such as: “Regularly”, “Likely” “in order”

(Examples: L32: “typical”, L34: “likely”, L35: “in this context”, L46: “in order”, L52: “ultimately”,

L55: “consistently”, L38: “this provides additional insight”, L390: “the fact that” – it either is or is not. You do not have to specify it as “a fact” (…))

2. Keep it simple

(Examples: L36: Remove “by Incorporating information regarding”, L53: Remove “many of the aspects regarding”, L59: Replace “have been shown to be capable of broadly reproducing” with “show”, L97: Just say that landslides are more likely in excess topography, L255-260: This is a very complicated way to say that the extension of the landslide is called the width.)

3. Remove words (grammar)

(L205: Remove “ranges”, L206: Remove “as”, L365: remove “for the”)

4. Typos

L82: and/or (“and / or”)

L86: occur (“occurs”)

L95: Quantifies (“Quantify”)

L217: ~10 km (“~ 10 km”)

L222 + L224: 11.9 m DEM ; 5 m ALOS DEM („11.9m“ + „5m“)

L443: were (“were were”)

5. Other technical comments

L53/54: You mention that erosion has an influence on river morphology twice. You can either delete the first section until “evaluated by”. Starting the sentence with “Studying” or integrate your “regional” into the first half of the section and delete everything after “profile”.

L57: Knickpoints are waterfalls. Again: keep it simple. You are mentioning the same thing twice. Locally increased profile slopes are basically knickpoints or waterfalls. Why is it important to mention “increase in turbulent flow”?

L97: By definition topography “in excess” in termed “excess topography”. You made it very clear the section before. You are just repeating yourself here. Start with “Excess erosion is assumed to be…”

L166/167: Why put “Miocene to Pliocene synorogenic deposits” in ‘…’? Do you quote here? However, there is no reference added.

L170: If you say “metamorphosed” than you do not need the “meta” in metasedimentary rocks or vice versa.

L171: Replace “located” with “delineate”

L206. Set a point after the parenthesis and start a new sentence with “Almost”.

L211-220: I´m not sure if this section is really necessary. Because you repeat every step in the following chapters. This could be removed.

L211: Something like “Between” is missing in the first sentence “between creeping landslides and river channels”

L216-220: Split the last sentence of the first paragraph.

L243: You do not just quantify the offset of valley axis but also the local channel offset, since you describe it two lines further. Maybe delete the first part of the sentence until the first comma.

L256-259: There is something wrong with this sentence. The first part until the comma does not fit well. Please check again!

L334: Insert a “is” between “that” and “less”

References: Korup, O. (2005). Geomorphic imprint of landslides on alpine river systems, southwest New Zealand. *Earth Surface Processes and Landforms*, *30*(7), 783-800.