Response to Editor

Simon Mudd:

I have read both the responses to reviewers and the revised manuscript. Most of the issues raised by the reviewers have been addressed. The manuscript includes a new way to assess divide migration rates and has two interesting field sites. I think the paper will be well received by the community. However I think the paper could use one more round of revisions before it is accepted in ESURF. You can find my detailed comments in the annotated pdf.

RESPONSE and CHANGES:

Dear Editor,

Thank you very much for your handling our manuscript and the comments. In the revision, we have addressed each issue and modified associated texts and figures. We also check carefully the article to avoid the errors in the references. The line numbers in our response are from the manuscript with changes marked.

Simon Mudd:

The main issues are:

Some of the information on the methodology is distributed through the manuscript rather than collected in one place. It should be more clear that equations 4 and 8 are those used to calculate the divide migration rates. The methods should have these equations, and then an explanation of how each of the inputs into the equations are measured all located at the same place in the manuscript. At present this information is spread across a few sections so the reader has to do a lot of searching to find out how the numbers are calculated (everything readers need is there, it is just spread out over a number of sections). In the same place in the text, the authors should state the method of extracting the channel head (which is done with S-A plots), and explain how A is calculated (D8? D-infinity?). The gradient at the channel head should be described (in the text later it says the tangent to the profile is used: explain). For the chi-based gradient metric the authors should explain the start and end points of the segment used

to calculated the gradient (the upstream end is the channel head: where is the downstream end?) Finally, a bit more detail needs to be included about the calculation of the hillslope gradient (why is the hilltop ignored, why on the figures does the segment extend below the channel head)? I think clearing up these issues will help readers of the paper better understand the outcomes.

RESPONSE and CHANGES:

We have added a section (2.3 Parameter extraction) Lines 218-261.

In this new section, we make it more clear that in this study we use Eqs. 4 & 8 to calculate the divide migration rates, and how each of the inputs into the equations are measured: "Based on the high-resolution topography data, we first extract river channels and drainage divide, using a single-flow-direction algorithm (D8)." "According to the breaking point of the slope-area regression line, we obtain the value of the critical upstream drainage area (A_{cr}) of each river channel (Duvall et al., 2004)." "The slope of the channel head (S_{ch}) is calculated, according to the 100 m long channel on the river's long profiles around the channel head (50 m upstream and downstream)." "An elevation of the catchment outlet (z_b) can be assigned at the top part of the channel to make the elevation-χ profiles quasi-linear between the channel head and the outlet." "Topographic gradient (tanα or tanβ) is calculated through the average slope (in the normal-divide direction) of the hillslope segment (not including the hilltop part, because of its lower gradient)."

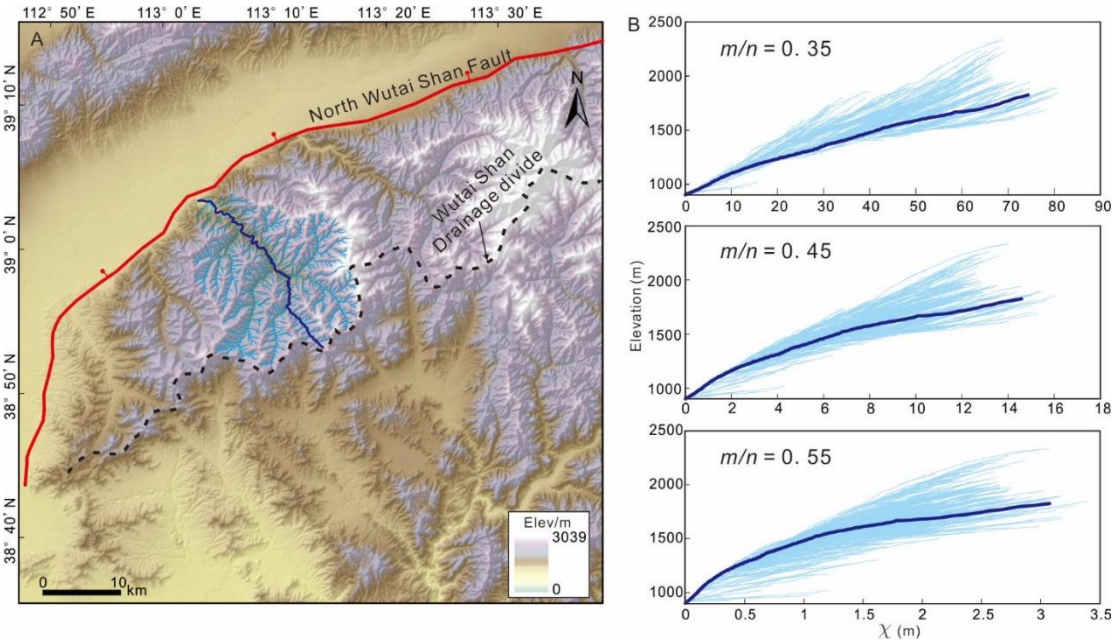
We have changed the Figures 4 DGJ & 5 DJG to reveal the topographic gradient (tanα or tanβ) is calculated above the channel heads.

Simon Mudd:

In addition, the results are quite contingent on the theta (or m/n) values, as highlighted by a reviewer. In the revision two new values are used (bringing those analysed to 0.35, 0.45, 0.55). There should be some text about how sensitive the results are to varying theta values, It would also help to show a chi-elevation plot of one of the larger basins with tributaries included so the reader can see if theta=0.45 is reasonable.

RESPONSE and CHANGES:

Thanks very much for this suggestion. According to this suggestion, we have added the following figure in the Discussion, to show why m/n = 0.45 is better than others.



Simon Mudd:

Finally one of the conclusions is that the new method does a better job than just assuming a critical drainage area. But we don't actually know if assuming a critical drainage area results in the same answers. There needs to be a discussion of this. It is pertinent because we know that the slope area method of extracting the channel head does not work very well, so this might be important if the method is sensitive to the location of the channel head.

There requests will involve some new figures and calculations, but they mostly clarify the existing analysis so I characterise my recommendations as constituting minor edits.

RESPONSE and CHANGES:

The main difference between our new methods and previous methods is that in our methods the critical drainage area (A_{cr}) are based on actual DEM data, and the two sides across the drainage divide can have different A_{cr} values. We have added more discussion on the improvement of the critical drainage area in our new methods. (Lines 480, 488-491)

Simon Mudd:

Line 14: Change to “the sedimentary”.

RESPONSE and CHANGES:

As suggested, we have added “the”. (Line 14)

Simon Mudd:

Line 16: Change to “determine drainage divides’ migration”.

RESPONSE and CHANGES:

Changed as suggested. (Line 16)

Simon Mudd:

Line 49: differences.

RESPONSE and CHANGES:

Changed as suggested. (Line 49)

Simon Mudd:

Line 51: Change to “River long profiles have been used to study earthquake events”.

RESPONSE and CHANGES:

Changed as suggested. (Line 51)

Simon Mudd:

Line 74: Add: Holly H. Young, George E. Hilley; Millennial-scale denudation rates of the Santa Lucia Mountains, California: Implications for landscape evolution in steep, high-relief, coastal mountain ranges. GSA Bulletin 2018;; 130 (11-12): 1809–1824. doi: https://doi.org/10.1130/B31907.1. One of the few papers that uses 10Be to try ans ascertain if divides are migrating. Not many people cite it because the title doesn't tell you what is in the paper.

RESPONSE and CHANGES:

Added as suggested. (Lines 74-75)

Simon Mudd:

Line 132: I would cite the 1972 Carson and Kirkby "Hillslope Form and Process" book here. typo. Should be Stock

RESPONSE and CHANGES:

Changed as suggested. (Line 133)

Simon Mudd:

Line 154: α or β: Formatting: these need to be italic throughout, since they are italic in the equation.

RESPONSE and CHANGES:

Changed as suggested. (Line 156)

Simon Mudd:

Line 157: This makes some assumptions about the geometry of the hillslope. It is basically assuming (I think) that the gradient upslope of the channel head remains constant if the channel head moves. I think this is probably not a bad assumption but it should be stated.

RESPONSE and CHANGES:

We have revised it make the representation of tanα and tanβ more clear. (Lines 158-160). We agree that the gradient remains constant in short time scale (kyr) when the channel head or the drainage divide move. Because the drainage divide migration rates calculated in this study are the instantaneous rate, we only need the current value of the topography gradient (tanα and tanβ) across the drainage divide. Therefore, we are not discussing whether they changed during the divide migration.

Simon Mudd:

Line 158: Assuming the erosion coefficient.

RESPONSE and CHANGES:

Changed as suggested. (Line 161)

Simon Mudd:

Line 196: Explain where the outlet is taken. I think this is important. The inset figures in figure 3c show why it is important: the most distorted part of the channel is near the top (which you have highlighted in the figure). Say that you concentrate on the top part of the channel here.

RESPONSE and CHANGES:

Changed as suggested. (Lines 201-204)

"z_b is the elevation of catchment outlet (at the top part of the channel to make the elevation-χ profiles quasi-linear between the channel head and the outlet)."

Simon Mudd:

Line 207-209: This is quite a nice method.

RESPONSE and CHANGES:

Thank you for your appreciation.

Simon Mudd:

Line 214-216: I will repeat a question from one of the reviewers: what is the uncertainty on these elevations. Do you know? The landscape is unvegetated so you should get a good point cloud. Were the elevations compared to GPS points? If this wasn't done it should be stated.

RESPONSE and CHANGES:

To be honest, we don't know the uncertainty of the elevations, and we didn't compared the elevations to the GPS points. We have added the statement in Lines 235-237. We believe that the data quality is sufficient for this study.

Simon Mudd:

Line 228: Note: If you look at the documentation for this DEM, it appears that it is a DEM that is derived from 30m SRTM data and then post-process to match the pixel spacing of the PALSAR radar data. It is not a "true" 12.5 DEM like TanDEM-X.

RESPONSE and CHANGES:

We have deleted "12.5 m resolution" in the full text.

Simon Mudd:

Line 245: I agree that these look captured and i am happy with this evidence. However, for me "barbed" means that the tributary joins the main stem at an oblique angle. That is, to be barbed the tributary needs to point upstream. Your examples don't do this. You could say tributaries have "abnormally high junction angles, which can suggest drainage capture".

RESPONSE and CHANGES:

We have changed the “barbed tributaries” to “captured channels” in Fig. 3 and the sentence in Line 290.

Simon Mudd:

Line 251-252: Can you specifically say if you determined the ksn from the chi profiles or from S-A analysis. I am fairly sure it is the former but it isn't stated.

RESPONSE and CHANGES:

In fact, both methods in this paper use ksn to calculate the erosion rate and the drainage-divide migration rate. The Channel-head-point method corresponds using S-A analysis to get ksn, while the Channel-head-segment corresponds using chi profiles to get ksn. When we get the ksn map in the whole Wutai Shan (Fig. 2B), we use the S-A analysis. We have added more description on how k_{sn} is calculated. “The ksn is calculated based on S and A (k_sn=SA^(m/n)) extracted from ALOS DEM (downloaded from https://search.asf.alaska.edu/) using TopoToolbox (Schwanghart and Scherler, 2014),” (Lines 224-227, and Lines 365-367)

Simon Mudd:

Line 257-259: This sentence would sound better if it said "Middleton et al (2017) showed that the Quaternary...".

RESPONSE and CHANGES:

Changed as suggested. (Lines 302-304)

Simon Mudd:

Line 259: If you take my advice on the previous sentence, this becomes: "They showed, using low-temperature thermochronology, that...".

RESPONSE and CHANGES:

This sentence is changed to “Clinkscales et al. (2020) showed, using low-temperature thermochronology, that the time-averaged long-term throw rates in the late Cenozoic is about 0.25 mm/yr”. (Lines 304-307)

Simon Mudd:

Line 270: refer to equations earlier in the paper.

RESPONSE and CHANGES:

Added. (Line 316)

Simon Mudd:

Line 281: Unclear. What do you mean by this?

RESPONSE and CHANGES:

We have changed this sentence. Lines 327-328.

How the S_{ch} is calculated is now described in the Section 2.3. “The slope of the channel head (S_{ch}) is calculated, according to the 100 m long channel on the river's long profiles around the channel head (50 m upstream and downstream).” Lines 255-256.

Simon Mudd:

Line 281-282: Earlier in the paper you said that you were measuring the gradient in the segment downstream of the channel head. This seems like a different measurement. You need to state clearly what part of the first order channel you are measuring. We find out later that you do two analyses, using equations 4 and 8. Say that here. Basically I think the explanation of which of the equations you sue and then how you calculate either the slope or the k_sn (measured via the chi profile) in one place. And at that place explain why you use the two different methods.

RESPONSE and CHANGES:

We have added how the S_{ch} is calculated in the Method (Lines 255-256). “The slope of the channel head (S_{ch}) is calculated, according to the 100 m long channel on the river's long profiles around the channel head (50 m upstream and downstream).”

Simon Mudd:

Line 284: Refer to figure 4 D,G, J here.

RESPONSE and CHANGES:

Added as suggested. (Line 332)

Simon Mudd:

Line 285-286: Explain why this is assumed.

RESPONSE and CHANGES:

We have added the explanation for this assumption. (Lines 333-334)

Simon Mudd:

Line 291-292: 1. It should say here how sensitive the results are to m.

RESPONSE and CHANGES:

We have added the how the result (migration rates) changes following to the different *m/n* values. (Lines 342-344)

Simon Mudd:

2. There should be a chi plot with tributaries so we can see which of the m values is more consistent with the profiles. So this would be of a larger basin than that shown in figure 4 with several tributaries and the profiles run with m = 0.35, 0.45, 0.55.

RESPONSE and CHANGES:

We have added a figure (Figure 6) in the Discussion, to show why m/n = 0.45 is better than others.

Simon Mudd:

Line 313: Say with what method.

RESPONSE and CHANGES:

Added in Lines 365-366.

Simon Mudd:

Fig. 5D: Can you explain somewhere why the channel head point is upstream of the lower point of the dotted line used to calculate alpha and beta?

RESPONSE and CHANGES:

We have changed the Figures 4 DGJ & 5 DJG to reveal the topographic gradient (tanα or tanβ) is calculated above the channel heads.

Simon Mudd:

Line 423-428: 1. Are the answers different if you use A_cr 10^5 m^2? Do we really need a very high quality DEM to use this method? 2. I ask this because you have used the S-A plot to get the channel head, which we know does not work very well (see the Clubb et al 2014 paper that is already cited in this manuscript). So does the extraction method make a big difference to the result?

RESPONSE and CHANGES:

This response is same with a previous response: The main difference between our new methods and previous methods is that in our methods the critical drainage area (A_{cr}) are based on actual DEM data, and the two sides across the drainage divide can have different A_{cr} values. We have added more discussion on the improvement of the critical drainage area in our new methods. (Lines 480, 488-491)

Simon Mudd:

Line 476: typo. Should be Stock.

RESPONSE and CHANGES:

Changed. (Line 534)