Earth Surf. Dynam. Discuss.,
https://doi.org/10.5194/esurf-2020-80-RC1, 2020

ESurfD

Interactive comment

Interactive comment on "Top-down and bottom-up controls on mountain-hopping erosion: insights from detrital ^{10}Be and river profile analysis in Central Guatemala" *by* Gilles Y. Brocard et al.

Anonymous Referee #1

Received and published: 16 December 2020

General comments

The manuscript addresses landscape evolution in two parallel ranges in central Guatemala that were uplifted 7 Myr apart in the Miocene. The authors use Ar-Ar dating to date volcanic deposits that cap parts of the range and to calculate incision rates, 10Be-derived catchment-averaged erosion rates and hilltop exposure rates, stream profile analysis and knickpoint identification, and topographic analysis. This is an impressive ensemble of methods, all of which are standard tectonic geomorphology tools that appear to have been applied correctly, and a large amount of new data is presented. The authors conclude that uplift of the second range created a rain shadow

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Discussion paper

that slowed erosion rates on the northern flank of the first range and stalled knickpoints. Unfortunately, the manuscript has two major problems that need revising before publication. The first problem is that it does not adequately synthesize the large quantity of data that is presented. Many of the figures are confusing and contain too much information, and too much detail is included in the text. I recommend omitting (or moving to the supplement or another paper) all information that is not crucial to testing one or two hypotheses. The second problem is that the main conclusion that the observed spatial variation in erosion rates is controlled by climate is not supported by the evidence. The correlation between the erosion index (which take into account precipitation) and erosion rates appears to be weak (no measure of correlation is presented) and drainage basin dynamics (which appear to be important here) are not considered.

In a chi map for the region (see Giachetta and Willett, 2018, A global dataset of river network geometry), one can see that the slowly eroding northern flank of the older range are tributaries to a large basin that is predicted to be losing drainage area (see bottom left of attached screenshot in which one basin has higher chi – warmer colors – than the surrounding basins). Higher chi means higher predicted steady-state elevation. Thus, the basin will need to steepen for erosion rates to keep up with uplift rates. In response, erosion rates slow and the region is passively uplifted. The geometric disequilibrium could be a result of initial geometry or potentially a result of lengthening of the mainstem along the strike-slip faults. Deformation of channels along the faults is mentioned, but how that lengthening might impact erosion rates upstream is not addressed. Furthermore, the mechanism by which precipitation would impact erosion rates is not clearly explained. Theory says landscapes adjust their erosion rates to keep pace with uplift, so spatial variations in precipitation (with uniform uplift) should manifest as differences in normalized channel steepness (ksn), with steeper rivers in drier places, rather than differences in erosion rates. However, it's possible aridification resulted in a dramatic decrease in K (erosional efficiency of a river) which would lead to an increase in response times in rivers draining the drier zone, and so you wouldn't see steeper rivers in drier zones because the basin has not had time to respond (and yes you would also see stalled knickpoints as they do). Erosion rates would drop below uplift rates in the upper reaches that have lost precipitation but not steepened yet, and adjacent basins that have not lost precipitation would start to capture area off the basins that experienced aridification. If I were testing the hypothesis that aridification resulted in a slowing of erosion rates, I would also ask the questions: 1) Can the spatial variations in erosion rates be explained by drainage basin dynamics alone? 2) Is the whole region that experienced aridification now experiencing area loss?

Specific comments

The section on knickpoint analysis could be made more concise. I don't think you use any knickpoints that aren't migrating knickpoints, so you can just say you eliminated other knickpoints using image analysis. I think you can get rid of the section explaining all the different types of knickpoints. Are there knickpoints in multiple basins that you can trace to a single origin? If so you could use this as evidence for a change in K in basins that experienced aridification. Do the knickpoints you claim are stalled in SC cluster at the same chi value (and hence, have a single downstream origin)?

How were erosion rates for nested basins dealt with? Was a mixing model used to calculate the erosion rates from the additional area added with each larger area? If not, I think it would be a good idea to do this. Also, clarify why nested basins were chosen and what hypotheses they were used to test.

There is a lot of background and discussion mixed in with the results and it makes it hard to discern exactly what was done as part of this study. Keep results separate and move interpretation of results to the discussion.

3.3 – A "hillslope erosion index" is presented but then stream discharge and stream gradient are used, suggesting channel networks not hillslopes are actually being analyzed. Clarify what you are measuring and why.

Throughout: Ma should be used for "millions of years ago" and Myr should be used for millions of years. See Aubry et al (2009) Terminology of geological time: Establishment of a community standard

Line comments

169 fig 4 not fig 3 398 and with uniform uplift, otherwise K matters 654 I do not see a correlation, nor are correlation measurements presented for either b or c 711 theory is off here, see general comments 774-776 how does uplift lead to a slowing of incision rates upstream? 801 Not intuitive. Why doesn't it reflect the magnitude in change of forcing? Clarify. 807-808 I'm not familiar with Whittaker and Boulton, 2012, but stream power theory states celerity only depends on uplift rates if n is not unity (Whipple, 2001) 853 what? Knickpoints are areas where the rivers are anomalously steep so how can you say they are caused by river steepening? 873 what does it mean for a knickpoint to have an amplitude? 937-940 citation?

Figure comments

Fig 1 DEM resolution not great, also figure shows elevation not relief so title is confusing. Fig 2/3 recommend using the same colors for the paleosurface throughout Fig 5 make legend transparent also so colors match Fig 8 I find this figure very overwhelming. If you keep it, the legend needs reworking or it at least needs to be more clear that the numbers are knickpoints. Leaving off lithology would help. Fig 9 Do you say how many incision measurements you have? If so I missed it. Could make the boxes proper box plots rather than just showing range. Fig 10 This figure is confusing. Would be more helpful to see rates on a map. Fig 11 Clarify what this figure shows. Fig 13 How were the 10Be rates normalized? Recommend one map showing erosion rates and put the map of the erosion index in the supplement. Add main divides.

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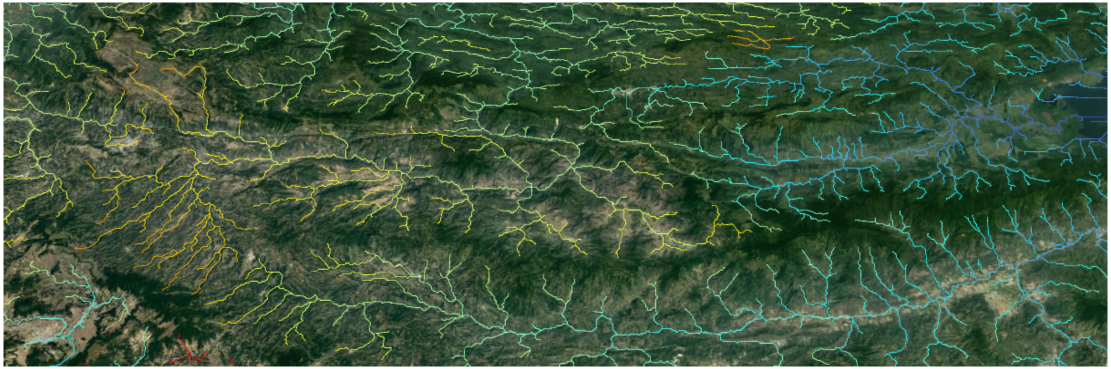

Fig. 1. Chi map of region from Global Chi dataset