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Earth Surface Dynamics
Discussions
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Interactive comment on "River patterns reveal landscape evolution at the edge of subduction, Marlborough Fault System, New Zealand" *by* Alison R. Duvall et al.

Anonymous Referee #1

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This paper by Duvall et al is interesting, well written, well illustrated and well worth publication in eSurf.

1 Response to eSurf's review guidelines.

Does the paper address relevant scientific questions within the scope of ESurf?
YES
Does the paper present novel concepts, ideas, tools, or data?
Data

Are substantial conclusions reached?
Partly regional (NZ northern tip), but with possible extension to other orogens.
Are the scientific methods and assumptions valid and clearly outlined?
Yes, but little criticism of the method (drainage anomalies) is presented.
Are the results sufficient to support the interpretations and conclusions?
Yes for the conclusion regarding the data and interpretations presented. But the general conclusion is also the starting point of the study.
Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?
Yes
Do the authors give proper credit to related work and clearly indicate their own new/original contribution?
They do give credit mostly to their own work, but omit a body of literature.
Does the title clearly reflect the contents of the paper?
Yes
Does the abstract provide a concise and complete summary?
Yes
Is the overall presentation well structured and clear?
Yes
Is the language fluent and precise?
Yes
Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?
Yes
Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?
Not really needed for the paper to reach its conclusions. But perhaps they could extend their review of previous work, their assessment of the limits of their method to 1) pick drainage anomalies and 2) interpret drainage anomalies, and

review if needed some of the more recent analysis related to chi-maps and its ability to reveal potential drainage rearrangement. Up to the authors.
Are the number and quality of references appropriate?
No. See 7.
Is the amount and quality of supplementary material appropriate?

2 General remarks/Questions

I outline here below a few remarks that you may want to consider.

I am puzzled by the conclusion that "faulting, uplift, river capture and drainage network entrenchment all dictate drainage patterns and that each factor should be considered when assessing tectonic strain from landscapes, particularly at long-lived and complex tectonic boundaries". Indeed, this is the starting point on the research performed is based, as in the second part of the second sentence of the introduction: "Rivers, in particular, are influenced strongly by tectonic forces, as they are affected both by the ensuing mountain uplift (e.g.Whipple 35 and Tucker, 1999; Bishop, 2007) and by material weakening along faults (e.g.Koons, 1995; Molnar et al., 2007; Koons et al., 2012; Roy et al., 2015; 2016a;2016b;2016c)", and in the second chapter "Drainage network morphometry may additionally yield evidence of catchment reorganization of catchments by ridge migration (Pelletier, 2004; Willet et al., 2014) or by whole sale river capture (Craw et al., 2003; Clark et al., 2004; Craw et al., 2013) and flow reversal (Benowitz et al., 2019), often in response to tectonics. Recent studies focusing on fractures in bedrock channels have also revealed the importance of material strength in setting the orientation of rivers (Koons et al., 2012; Roy et al., 2015; 2016a; 2016b; 2016c; Scott and Wohl, 2019). Detailed field and numerical modeling studies of

rivers in faulted landscapes demonstrate the sensitivity of fluvial incision to gradients in erodibility between weak fault zones and the surrounding stronger bedrock (Roy et al., 2016c). These studies further show that structurally aligned drainages, with anomalously straight reaches, originate in response to the localization of fluvial erosion along the zones weakened by tectonic strain (Roy et al., 2015; 2016a;2016b)".

So, is there a circular argument here? Can you really conclude this if you start from it? Or should you rather say perhaps that you confirm your hypothesis? I do not know the answer, I just find it surprising to conclude on something which is stated as demonstrated in the introduction.

By the way, I think the paper by Molnar et al 2007 cited here is more on the influence of rock weakening on erosion in general, rather than on any influence on river patterns along faults.

I find that the way in which previous work has been reviewed, with regard to the questions posed, is a little too NZ-centered and ignores quite a significant body of literature. The papers you (self-)cite by Craw, Roy, Koons are all relevant (and acknowledged pioneer), but other people outside NZ have also worked on these questions. More than a sensitivity issue about the credit to these works (some of which is still measured by citations counts despite the DORA agreement), perhaps you may be interested in reading this literature. And there is much more than what I cite below.

The questions posed in the introduction "how do drainage networks evolve as an orogen deforms and over what timescales do the rivers respond to the changing tectonic boundary conditions? Are patterns in the drainage network overprinted as older faults change and new faults form? How important is the development of topography along faults and the process of river capture in the establishment of structurally aligned drainages?" Have been addressed by many others, but I would advise reading some of the many papers by the group of Babault, e.g.:

Babault, J., Van Den Driessche, J., Teixell, A. (2012). Longitudinal to transverse drainage network evolution in the High Atlas (Morocco): The role of tectonics. Tectonics, 31(4), n/a–n/a. http://doi.org/10.1029/2011TC003015

Struth, L., Babault, J., Teixell, A. (2015). Drainage reorganization during mountain building in the river system of the Eastern Cordillera of the Colombian Andes. Geomorphology, 250(C), 370–383. http://doi.org/10.1016/j.geomorph.2015.09.012

Viaplana Muzas, M., Babault, J., Dominguez, S., Van Den Driessche, J., Legrand, X. (2015). Drainage network evolution and patterns of sedimentation in an experimental wedge. Tectonophysics, 664(C), 109–124. http://doi.org/10.1016/j.tecto.2015.09.007

Viaplana Muzas, M., Babault, J., Dominguez, S., Van Den Driessche, J., Legrand, X. (2018). Modelling of drainage dynamics influence on sediment routing system in a fold-and-thrust belt. Basin Research, 31(2), 290–310. http://doi.org/10.1111/bre.12321

And others as:

Giletycz, S., Loget, N., Chang, C. P., Mouthereau, F. (2015). Transient fluvial landscape and preservation of low-relief terrains in an emerging orogen: Example from Hengchun Peninsula, Taiwan. Geomorphology, 231(C), 169–181. http://doi.org/10.1016/j.geomorph.2014.11.026

Ramsey, L. A., Walker, R. T., Jackson, J. (2007). Geomorphic constraints on the active tectonics of southern Taiwan. Geophysical Journal International, 170(3), 1357–1372. http://doi.org/10.1111/j.1365-246X.2007.03444.x

Ramsey, L. A., Walker, R. T., Jackson, J. (2008). Fold evolution and drainage development in the Zagros mountains of Fars province, SE Iran. Basin Research, 20(1), 23–48. http://doi.org/10.1111/j.1365-2117.2007.00342.x

In the introduction you mention, "The planform rotation of river basins has been used as a marker of crustal strain (Hallet and Molnar, 2001) and to assess the style and rates of off-fault deformation (Goren et al., 2015; Gray et al., 2017)". Another interesting paper, also NZ-centered, but not cited, has demonstrated "assessing tectonic strain from landscapes, particularly at long-lived and complex tectonic boundaries" (from your abstract's conclusion) is by

Castelltort et al., in 2012, River drainage patterns in the New Zealand Alps primarily controlled by plate tectonic strain. Nature Geoscience, 5(10), 1–5. http://doi.org/10.1038/ngeo1582).

This group has also recently produced experimental tests of drainage networks as markers of stress or potential rearrangements (chi maps):

Guerit, L., Dominguez, S., Malavieille, J., Castelltort, S. (2016). Tectonophysics. Tectonophysics, 1–13. http://doi.org/10.1016/j.tecto.2016.04.016

Guerit, L., Goren, L., Dominguez, S., Malavieille, J., Castelltort, S. (2018). Landscape "stress" and reorganization from χ-maps: Insights from experimental drainage networks in oblique collision setting. Earth Surface Processes and Landforms, 43(15), 3152–3163. http://doi.org/10.1002/esp.4477

Chapter 3.1

"Drainage anomalies, or unusual patterns in river planform, can indicate recent river captures and reorganization of drainage networks, often in response to active tectonics (e.g.Bishop, 1995; Brookfield, 1998; Hallet and Molnar, 2001; Burrato et al., 2003; Clark et al., 2004; Delcaillau et al., 2006; Willett et al., 2014)". Since you cite Bishop 1995 here, who actually provides an in-depth examination of this issue, I would emphasise that the "can" is very important: indeed in the next sentence you explain "We mapped drainage anomalies across the study site and found abundant evidence of fluvial disruption within both domains. Following McCalpin (1996) and

Craw and Waters (2007), we demarcated river elbows, locations where major rivers take an 90° bend and barbed tributaries, which are channels that join their main river in an upstream rather than downstream direction (Fig. 2b)" . In the rest of the chapter describing these observations, the interpretation provided is that these anomalies "likely, possibly, could" indicate e.g. captures, rearrangements etc. => So, how robust is the interpretation of such "anomalies"?

"In the earliest phase of the KaikÅ■ura orogeny": hard for outsiders to know when that is, perhaps it would be good to put xMa in brackets after this and elsewhere in the text (rifting of Gondwanaland and/or early KaikÅ■ura orogeny shear).

"There, the active faults are primarily strike-slip and have not generated the fault-parallel, high-relief ranges (Fig.1) that would aide in the development of transverse drainage" - It can be readily observed in many mountain ranges, but also in field and roadcuts, or in the lab, or in numerical experiments, that transverse drainage develops easily, without needing the aide of faults. See Hovius 1996 for instance for a first review of this.

Hovius, N. (1996). Regular spacing of drainage outlets from linear mountain belts. Basin Research, 8, 29–44.

The rest of the chapters describes and quantifies to some extent drainage in the study area and examine the relation between drainage and the tectonic pattern. I regret a lack of use of recently utilised chi-maps (see papers by Willett's group for instance:
Willett, S. D., McCoy, S. W., Perron, J. T., Goren, L., Chen, C. Y. (2014). Dynamic Reorganization of River Basins. Science, 343(6175), 1248765–1248765. http://doi.org/10.1126/science.1248765

Fox, M., Goren, L., May, D. A., Willett, S. D. (2014). Inversion of fluvial channels for paleorock uplift rates in Taiwan. Journal of Geophysical Research: Earth Surface, 119(9), 1853–1875. http://doi.org/10.1002/(ISSN)2169-9011)

I would say that "correlation does not imply causation", and some statistical tests of the means / medians could add the comparison, but still, here the correlation is very convincing and I think the conclusions of the authors that "our dataset indicates the importance of fault characteristics such as age, displacement and sense of slip, as well as river characteristics, such as incision and entrenchment, headward erosion and capture, in setting patterns in drainage networks" is well supported by the data and interpretations.

Last remark: what do you mean by "mature"?

3 Bibliography

Babault, J., Van Den Driessche, J., Teixell, A. (2012). Longitudinal to transverse drainage network evolution in the High Atlas (Morocco): The role of tectonics. Tectonics, 31(4), n/a–n/a. http://doi.org/10.1029/2011TC003015 Fox, M., Goren, L., May, D. A., Willett, S. D. (2014). Inversion of fluvial channels for paleorock uplift rates in Taiwan. Journal of Geophysical Research: Earth Surface, 119(9), 1853–1875. http://doi.org/10.1002/(ISSN)2169-9011) Giletycz, S., Loget, N., Chang, C. P., Mouthereau, F. (2015). Transient fluvial landscape and preservation of low-relief terrains in an emerging orogen: Example from Hengchun Peninsula, Taiwan. Geomorphology, 231(C), 169–181. http://doi.org/10.1016/j.geomorph.2014.11.026 Guerit, L., Dominguez, S., Malavieille, J., Castelltort, S. (2016). Tectonophysics. Tectonophysics, 1–13. http://doi.org/10.1016/j.tecto.2016.04.016 and Guerit, L., Goren, L., Dominguez, S., Malavieille, J., Castelltort, S. (2018). Landscape “stress” and reorganization from χ-maps: Insights from experimental drainage networks in oblique collision setting. Earth Surface Processes and Landforms, 43(15), 3152–3163. http://doi.org/10.1002/esp.4477 Hovius, N. (1996). Regular spacing of drainage outlets from linear mountain belts. Basin Research, 8, 29–44. Ramsey, L. A., Walker, R. T., Jackson, J. (2007). Geomorphic constraints on the active tectonics of southern Taiwan. Geophysical Journal International, 170(3), 1357–1372. http://doi.org/10.1111/j.1365-246X.2007.03444.x Ramsey, L. A., Walker, R. T., Jackson, J. (2008). Fold evolution and drainage development in the Zagros mountains of Fars province, SE Iran. Basin Research, 20(1), 23–48. http://doi.org/10.1111/j.1365-2117.2007.00342.x Struth, L., Babault, J., Teixell, A. (2015). Drainage reorganization during mountain building in the river system of the Eastern Cordillera of the Colombian Andes. Geomorphology, 250(C), 370–383. http://doi.org/10.1016/j.geomorph.2015.09.012 Viaplana Muzas, M., Babault, J., Dominguez, S., Van Den Driessche, J., Legrand, X. (2015). Drainage network evolution and patterns of sedimentation in an experimental wedge. Tectonophysics, 664(C), 109–124. http://doi.org/10.1016/j.tecto.2015.09.007 Viaplana Muzas, M., Babault, J., Dominguez, S., Van Den Driessche, J., Legrand, X. (2018). Modelling of drainage dynamics influence on sediment routing system in a fold-and-thrust belt. Basin Research, 31(2), 290–310. http://doi.org/10.1111/bre.12321 Willett, S. D., McCoy, S. W., Perron, J. T., Goren, L., Chen, C. Y. (2014). Dynamic Reorganization of River Basins. Science, 343(6175), 1248765–1248765. http://doi.org/10.1126/science.1248765

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