

Response to Reviewers/Editors:

We appreciate the thoughtful, thorough, and constructive reviews of the manuscript from reviewers and the associate editor. Both referees brought up several valid concerns and provide many excellent suggested edits and comments to address the problems. We have made major revisions to the manuscript in accordance with these suggestions and feel the paper has improved significantly.

Major changes to the manuscript include:

- A new title that better reflects the content and conclusions of the paper.
- Reformulation of the paper to a traditional format that includes a more comprehensive introduction, background, methods, results, and discussion section.
- Referee #1 noted that we focused our background and discussion too narrowly on New Zealand and as a result omitted a large body of literature on the subject of drainage network evolution in faulted landscapes and with respect to material strength heterogeneities in bedrock. We appreciate their literature suggestions and have incorporated these and other relevant works into the revised manuscript. We believe this provides a more holistic treatment of the subjects in question and helps to make the paper more universally relevant.
- Reanalysis of the faults and rivers orientations based on three geomorphic domains designated from study area topography rather than 8 arbitrary squares. We also include circular statistics in the figures and a new data table.
- The paper now includes 6 rather than the original 4 figures. We broke up figure 1 into a second figure with topographic swath profiles (Figure 2) and broke out the fault orientation data and the river orientation data into their own separate figures (Figures 3 and 4). We now include a chi map in figure 5.
- We reordered the discussion section such that the description of MFS landscape evolution comes last.
- We added a supplementary information file with a figure that includes a geologic map of the study area and the locations of low-temperature thermochronology samples from Collett et al (2019) as well as chi-elevation and distance-elevation plots of the Awatere and Clarence rivers.

The following table shows additional comments that we addressed. We present point by point referee comment and author response for the line edits, questions, and comments provided by the reviewers. We thank them for taking the time to provide these detailed suggestions and think that the revised manuscript is much improved as a result.

Comment (Reviewer 1)	Response
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.	Reference to this paper was removed from the manuscript.

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	We agree and have added a sentence that makes it clear that drainage anomalies, or unusual patterns in river planform, do not necessarily indicate recent river captures (lines 45 – 50).
“In the earliest phase of the Kaikoura 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.	Throughout the paper, we have added ages in brackets to show the specific timing of events mentioned in the text.
“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.	We agree with the reviewer and regret that in the original draft we wrote the word transverse here but we meant longitudinal. There were a few other instances of this unfortunate mistake in the original draft. We have corrected each of these instances in the revised manuscript.
Comment (Reviewer 2)	Response
Line 50: based on your later results, I suggest writing “the position and orientation of rivers” rather than only orientation.	We added these words to the sentence – line 55.
Lines 66-67: in this sentence you are listing all your analysis, so I do not think that saying “including” is appropriate here, as it gives the impression that there are more analysis than those on the list. I would rephrase to simply say “In this study, we present analysis on the topography, fluvial morphologies in planform and profile forms, and orientations of rivers compared to active and inactive faults”	We have rephrased according to the reviewer’s suggestion – line 80 - 82.
At present, the last 3 paragraphs of the Geologic Setting read a bit convoluted because they go from making a general statement on the overall evolution, to talking about the present-day configuration and slip rates, to the early deformation phase, and the evolution from Late Miocene to today. I would suggest following a chronological order, so switching lines 88-94 to the end of the section.	We have revised section 2 of the paper (the Geologic Background) to include three separate sections: Geologic Setting, Plate Tectonic History and Study Area Topography. Hopefully these subheadings make the information presented less convoluted and more clear. Lines 85 – 155.
Line 90: how have these slip rate estimates been derived? GPS? Offset dated surfaces? A large number of studies are referred, but readers should not need to be familiar with those in order to have a general idea – a general statement saying “derived from...” would be helpful.	These slip rates were derived from offset dated features and this has now been added to the paper. Line 135.
Line 97: please be more specific with the geologic time you are referring to when saying “Early in the plate boundary history” (is it Late Oligocene,	We are now more specific with the geologic time period that we are referring to.

<p>Early Miocene, Early to Mid Miocene...?). You could add a parenthesis specifying this before the coma.</p>	
<p>Line 98: what type of structures? Just saying “a few important structures” is vague. Figure 4 suggests that these were primarily thrusts and folds associated with them, but this information should be clearly presented in the geological setting, particularly given that it is going to be heavily included in the discussion.</p>	<p>We now more explicitly describe the structures in detail in the updated Section 2 (Geologic Background).</p>
<p>Line 104: again, I think the readers would benefit from greater clarity on the time you are referring to (25 Ma?). Also, to follow a clear chronological order, I would suggest that this sentence goes when the geological history is starting to be discussed, at the beginning of the 2nd paragraph.</p>	<p>We have added more details on the timing of events in the Geologic Background Section.</p>
<p>Line 108: here or when discussing current slip rates – could you provide with some estimates on the partitioning of vertical vs. lateral motion? “Lesser” is quite vague.</p>	<p>We have added details about the ratio of horizontal to vertical slip on the faults. Lines 126 – 128.</p>
<p>Line 110: readers would benefit from a brief statement describing how have the “estimates of timing, cumulative decrease in total offset, and increase in slip rates” have been derived, or at least what type of data set they come from. Also, could you please explain what is meant by “cumulative decrease in total offset”? I understand how an increase in offsets could inform about the time since fault activity started, but I am not sure how could a decrease in offsets inform of that, or how it could even be identified or resolved.</p>	<p>These details have been added and the sentences revised for clarity. Lines 135 – 143.</p>
<p>Given that the dividing line is arbitrary, and that many of the landscape features are transitional – is dividing the area in “domains” actually necessary? I suggest that the authors simply refer to the ENE and WSW parts of the study area, or include some other features (peaks, towns) as a point of reference, rather than making an arbitrary division that I also think complicates their interpretations in the following figures, given that this divide position does not actually correspond with any clear geomorphic boundaries.</p>	<p>We now more simply refer to the three geomorphic domains as eastern Marlborough north of the Hope fault, western Marlborough north of the Hope fault and south of the Hope fault.</p>
<p>The first two paragraphs of this section read a lot like information that should be on the Geological Setting section, given that, except the swath profiles, there is no “result” of analysis presented. I suggest moving these paragraphs that simply describe the landscape features from the DEM and the positions of the faults based on published</p>	<p>These paragraphs have been moved into their proper sections. Information about the DEM and fault database has been added to the text.</p>

<p>data, to a sub-section of the Geological Setting. Also, I see that the DEM used and the source of the faults map are listed in the caption of the figure, but this is important information that should be included on the main text, in a Methods section.</p>	
<p>Lines 154: can you use these slip rate estimates to infer minimum time since the Clarence started flowing to the SE in its lower reaches? Or using the offset to estimate the beginning of slip in the Keckerengu fault? This would better highlight the potential of drainage patterns on informing about tectonic evolution.</p>	<p>Yes, we now add this estimation to the text. Lines 292 – 296.</p>
<p>Line 166: the previous line mentions both the Awatere and the Clarence river, so it is not clear what river and what segment is referred to when saying “this segment”, please be more specific.</p>	<p>We are now more specific about which river we refer to.</p>
<p>Lines 167-168: this short sentence says twice “in the headwaters of the Awatere river”</p>	<p>Reworded the sentences.</p>
<p>Figure 2a and 2b: these are two important figures for the paper’s results, but it is often hard to follow the results because the figures are too small and cluttered, and two important features for the analysis, the relief and the faults, are displayed in other figures, making it harder to relate them to the drainage network. I suggest moving the faults and river orientation analysis (panels c and d) to another figure, and make this figure a bigger panel figure with 4 or 2 panels,</p>	<p>We have broken out the fault and river analyses into two separate figures (Figure 3 and Figure 4).</p>
<p>Lines 175-177: These sentences belong in the Geological Setting, they are not the results of this paper.</p>	<p>Moved to Geologic Background section.</p>
<p>Lines 180-183: This information is important, but belongs in a methods section. Also, please explicitly state whether you follow the same criteria as GNS to consider if a fault is active or inactive, and what do you mean by “mature” faults (ie. An inactive fault could be mature? For example if it was active for long enough to significantly weaken the bedrock).</p>	<p>Yes, we have now added a proper Methods Section. We explicitly state that we are following GNS criterion for fault activity. By “mature” we mean that the fault has had enough displacement/time to promote material strength weakening along the fault. We are more clear with this description and language in the revised draft.</p>
<p>Clearly A5 and A8 span both domains, so it is problematic to overlap the previous Inland Malborough vs. Kaikoura domains to this grid pattern. I understand the practicalities of dividing the area in grids, but as they are right now, these grids are not truly representative of the different areas, and if anything, they could be masking some trends.</p>	<p>We have removed the arbitrary 8 squares and now perform the analysis in the 3 domains.</p>

Line 186: why have these channel orders been selected? This needs a brief justification in the methods.	The new methods section has a better description and justification for the channel orders chosen and more properly describes the analysis methods.
Line 187: some description of what these “network segment and plotting routines” are and do is needed in the methods.	These have been added to the new methods section.
Line 186: again, this belongs in the methods, it is not a result. How have you done this normalization?	Yes, agreed. The description of our segment weighting process is now included in the new methods section.
I strongly suggest using a more quantitative, statistics-based way to assess the overlap of the inactive and active faults and river orientations	We have added circular statistics to this revised manuscript.
Lines 208-218: none of this are results from this study, this paragraph belongs in the introduction.	Moved to introduction.
Line 220: I suggest adding a lithological map of the study area, it would be very helpful for readers not familiar with this area of NZ but interested in your drainage evolution results.	We have added a geologic map showing different lithologies across the study site to a supplemental data file. This map also includes low-temperature thermochronology sample locations from Collett et al. (2019).
Lines 225-234: all this belongs in a Methods section. What “default values”? From what paper/software?	Yes, this information has been added to the new methods section. We include all useful information and no longer point to “default values”.
Line 233: the chi-plots used to identify breaks in slope should be included in the supplementary information.	These are now included in the supplementary information.
Line 236: ksn should have units of m ^{0.9} if a reference concavity of 0.45 (~0.5) is used.	Ksn has units of m as we used 0.5 as the reference concavity.
Lines 245-251 and 254-256: contextualizing this paper’s findings with previous published studies belongs in the discussion, not in the results.	Moved to the discussion.
Line 292: and as they responded to the increase in uplift...	Added
Line 332-333: this should have been mentioned in the results.	It is now included in the results.
Line 364: I suggest adding “enough displacement to...or to produce significant relief”	We added this phrase.
Line 400: please do state explicitly what factors were investigated – many people read the conclusions of a paper before deciding whether to read it entirely or not, so this would be relevant information.	We have now updated the conclusions to state what was investigated.
Line 38: space missing between “e.g.” and “Wobus”	Corrected
Line 17: for clarity, please insert “drainage” here, so that it reads “history of drainage capture and rearrangement”	We inserted the word drainage to this sentence.
Line 64: space missing between “e.g.” and “King”	Corrected

Line 69: I suggest changing “complicated” for “complex”, otherwise the word “complicated” is repeated 3 times in 6 lines.	Changed to complicated to avoid repeating the same word too many times.
Line 75: typo, “Puysegur” not “Puyseguer”	Corrected
Line 139: space missing between “e.g.” and “Bishop”	Corrected
Line 409: it is “Philippe Steer” not “Phillipe Steere”	Corrected