Review of Topographic controls on divide migration, stream capture, and diversification on riverine life, by Lyons et al, submitted to Earth Surface Dynamics.

This paper is about the relationship between landscape evolution in response to base level fall or heterogeneous uplift and the evolution of species richness, based on a large number of numerical simulaitons. The authors use a free-access LEM to generate the landscape and develop a new component for the LEM to solve for species richness.
This work addresses very interesting questions on the links between perturbations, landscape and species richness. However, I found that the current form of the manuscript does not support this work as it should. The text is sometimes vague because of the use of generic words and absence of quantitative data, and some sentences are a bit complex and could be more straightforward. As a consequence, it is a bit difficult to follow the description and the arguments of the authors. I think the manuscript requires rewriting to clarify the context of this study, to ease the reading and to clearly support the purpose and the novelty of this work.

I hope my comments below can help,

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Introduction

First paragraph: I think the authors can present better what has been done before on drainage reorganization from field, lab and numerical studies. It seems that the real novelty of this work is the SpeciesEvolver they propose and the evolution of species within an evolving drainage network. This should be better presented and highlighted throughout the paper. In the current, this very interesting contribution is a bit lost among other things. Below is a small selection of papers that might be relevant for the general context and maybe elsewhere in the manuscript (sorry for the self-citation but it seems to be relevant for this paper. Note that I don't ask for reference to these papers, they are just some examples).

Second paragraph: add a reference at the end of line 25 to justify this statement or explain it a little bit here.

Third paragraph: the limits of the stream power model coupled to hillslope diffusion are discussed for quite some years (see for example Lague, 2014) and other models based on a different formalism have been proposed (see references below). As the choice of the model affects how the landscape responses to a perturbation (Armitage et al., 2018), this could be discussed in section 5.

Description of modelling tools

This section is too vague and it is difficult to get a correct idea of the numerical model used here. I suggest to be more specific, for example, name the fields, give the values, present the multiple components, etc. Also explain how the SolverEvolver is working: define what kind of species you are considering, how do you set the parameters, etc.

Experiment design

Here again, I suggest to be more specific and quantitative: what is the amplitude of the sea-level fall, of the uplift, how to you identify the variables and what are these variables (l.12). At the end of the first paragraph, you mention seven factors that are not listed below. Please name them and give range of values so that the following sections are easier to follow.

Sensibility analysis

Please clarify how you define the expected value of Y (l.4) and how the indices will be use in the following (end of the section).

Model trial progression

The values used in this study must be presented in the manuscript (at least in Supplementary Material)

Initial conditions phase

beginning of page 6: I don't understand how you generate the initial elevation grid. Please consider reformulate these sentences.

p.6 l.18 to 24 5mm/yr is also reported in New Zealand (eg, Jiao et al, 2017) while 10^{-5} corresponds to cratonic values. Maybe simply write that you consider uplift rates in the range of cratonic to orogenic values.

Additionnal references for erodibility and diffusion suggested below.

m and n: Kang and Parker (2018) suggest that the value of 0.5 should not be used as it leads to unrealistic behavior. Maybe the authors coudl run a few additional simulations to check whether they do observe the same behavior with m/n = 0.4 for example (this does not have to be part of the main manuscript).

p.7 l.12 describe or add a figure to illustrate.

Perturb phase

p.7 l.14 describe the steady state topography (for example the elevation and the number of catchments)
p.7 l.21 describe how the landscape responses to the perturbation. Is it only by knickpoint propagation ? What happens on the hillslopes ?
p.8 l.11 the way to define steady state could be recall here.

Model response variables

l. 13 what variables ?
p.9 l.1 the model descriptions must be within this manuscript.
p.9 l.4 specify what minimally implies
p.9 l.5 unclear, consider reformulate this sentence.
p.9 l.7 please give the size in meter
p.9 l.7 the sentence is odd with respect to the previous one saying that the streams are minimally affected. If so, why is the main divide migrating ?
p.9 l.9 a quantitative value or a figure to support this statement would be welcome.
p.9 l.12 «sufficiently» please quantify
p.9 l.16 please consider reformulate. This sentence suggests that they are two main divides (the main one and the main on the upthrow block), which is odd.

Topographic relief and landform change

The first paragraph is a bit complexe to follow, it could be written in a more straightforward way to ease the reading.
l.25 11 000 m seems high for a terrestrial landscape.
l. 29 the evolution of the topography is controlled by the stream power model (your equation 5). The main controlling factors are U and K so I don't think the total order Sobol indices analysis is required here. This would simplify this section.
p. 10 l.3 please quantify «low relative»
p. 10 l.8 please quantify «high»
p. 10 l.10 could you add a figure to support this statement ?
p. 10 l.14 please quantify «low»
p. 10 l.17 please quantify «sufficiently high»
p. 10 l.23 please define what is a divide change

Stream capture occurrence

This section is more about the controls of the occurence than the occurence itself so the title could be adjusted to better reflect the content of this section.
p. 11 l.33 please quantify «moderately high»

Species richness

Here again, the section is more on the controls on the species richness than on the richness itself. The title should be adjusted to reflect the content of this section.
l.9 unclear, please consider reformulate
l. 16-22 this paragraph should come first in the section
p. 12 l.21 please specify «less than» what ?

Discussion

p.13 l.8 a short description to the chi metric could be proposed here and a proper chi analysis could be performed to support the discussion.
p. 13 l.15 please quantify «greater increase»
p.13 l.17 define «a certain relief»
p.14 l.4 did you work with higher Pm values ? Does it influence this behavior ?
p.14 l.4 quantify «relatively high»
p.14 l.4 define what is an «elongated divide migration»
p.14 l.14 specify «more than » what
p14 l16 captures should be captured

Conclusions

As suggested for the introduction, it seems that the novelty of this work is the relationship between species richness and drainage reorganization rather than reorganization itself. This should be better highlighted here.
Can the authors comment on the value of 439% ? Is there a way to compare with natural landscape ?
This kind of quantification is missing in the rest of the paper to support the work of the authors.

Table 2 considering the range of uncertainties, the statistics could be close to 0. Could the authors comment on that ?

Figure 6c-d missing labels

Some references about drainage reorganization and chi

- Bishop (2007) Long-term landscape evolution: linking tectonics and surface processes
- Bonnet (2009) Shrinking and splitting of drainage basins in orogenic landscapes from the migration of the main drainage divide
- Perron and Royden (2012) An integral approach to bedrock river profile analysis
- Guerit et al (2018) Landscape 'stress' and reorganization from chi-maps: Insights from experimental drainage networks in oblique collision setting

Reference to landscape and species evolution (with references inside that might be very relevant to this work)

- Salles et al (2019) Mapping landscape connectivity as a driver of species richness under tectonic and climatic forcings

Reference to the stream power model (and references therein)

- Lague (2014) The stream power river incision model: evidences, theory and beyond

References to other models

- Armitage et al. (2018) Numerical modelling of landscape and sediment flux response to precipitation rate change
- Carretier et al. (2016) Modelling sediment clasts transport during landscape evolution: Earth Surface Dynamics, v. 4, p. 237–251
- Shobe et al. (2017) The SPACE 1.0 model: A Landlab component for 2-D calculation of sediment transport, bedrock erosion, and landscape evolution: Geoscientific Model Development, v. 10, p. 4577–4604,
- Langston and Tucker (2018) Developing and exploring a theory for the lateral erosion of bedrock channels for use in landscape evolution models: Earth Surface Dynamics, v. 6, p. 1–27
- Yuan et al. (2019) A new efficient method to solve the stream power law model taking into account sediment deposition: Journal of Geophysical Research: Earth Surface
- Jiao, R., Herman, F., and Seward, D.: Late Cenozoic exhumation mo- del of New Zealand: Impacts from tectonics and climate, Earth- science reviews, 166, 286–298, 2017.
- Kwang and Parker (2018) Landscape evolution models using the stream power incision model show unrealistic behavior when m/n equals 0.5

References to m/n, K, Kd

- Whipple and Tucker (1999) Dynamics of the stream-power river incision model: Implications for heigh limits of mountain ranges, landscapes response timescales, and research needs
- Snyder et al. (2000) Landscape response to tectonic forcing: Digital elevation model analysis of stream profiles in the Mendocino junction region, northern California
- Wobus et al. (2006) Tectonics from topography: Procedures, promise, pitfalls
- Perron et al. (2009) Formation to evenly spaced ridges and valleys.