Dear Editor and Reviewer,

We would like to thank you again for your time and for providing further constructive feedback on our manuscript. We sincerely appreciate your continued engagement, which has been instrumental in helping us refine our work.

We have carefully considered the remaining points raised by the third reviewer in the previous round of reviews. In response, we have made targeted revisions to the manuscript to address these specific comments.

Below, we provide a detailed, point-by-point response (in green) to each comment, outlining the specific changes (in blue) made in the revised manuscript. We have also attached a version of the manuscript with tracked changes for your convenience.

We believe these revisions have addressed all outstanding concerns and have further improved the clarity and impact of the paper. We hope the manuscript is now suitable for publication and look forward to your decision.

Sincerely,

Yinbing Zhu (on behalf of all co-authors)

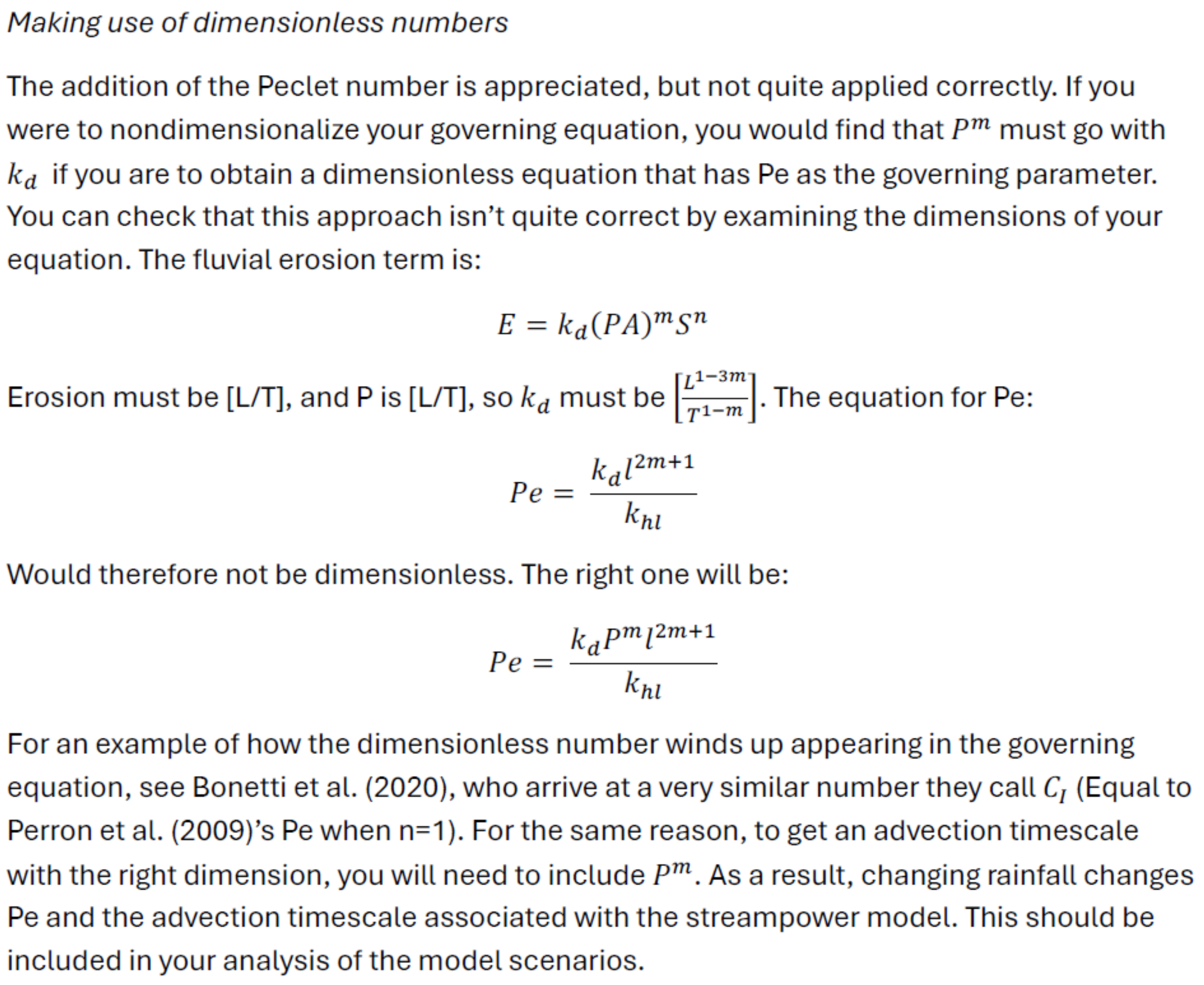
Response to comments from Anonymous Referee #3

Thank you for your detailed response to my comments. I have a few follow-up points below.

Caveats about climate's role in fluvial and hillslope processes

I appreciate the authors adding additional introduction and discussion regarding the likely climate dependency of the diffusion coefficient, and the limits of interpreting climate in terms of only a change in mean rainfall. At the present there's still a little bit of a mix of calling what you are testing rainfall or climate. I don't think you need to remove every reference to climate, but it might be worth clarifying what you test throughout.

Thank you for your helpful suggestion. We have adjusted the text to be more precise, primarily using "rainfall" when referring to the specific model parameter being changed, while reserving "climate" for broader discussions. This resolves the ambiguity.



Making use of dimensionless numbers

The addition of the Peclet number is appreciated, but not quite applied correctly. If you were to nondimensionalize your governing equation, you would find that P^m must go with k_d if you are to obtain a dimensionless equation that has Pe as the governing parameter. You can check that this approach isn't quite correct by examining the dimensions of your equation. The fluvial erosion term is:

$$E = k_d (PA)^m S^n$$

Erosion must be [L/T], and P is [L/T], so k_d must be $\left[\frac{L^{1-3m}}{T^{1-m}}\right]$. The equation for Pe:

$$Pe = \frac{k_d l^{2m+1}}{k_{hl}}$$

Would therefore not be dimensionless. The right one will be:

$$Pe = \frac{k_d P^m l^{2m+1}}{k_{hl}}$$

For an example of how the dimensionless number winds up appearing in the governing equation, see Bonetti et al. (2020), who arrive at a very similar number they call C_I (Equal to Perron et al. (2009)'s Pe when n=1). For the same reason, to get an advection timescale with the right dimension, you will need to include P^m. As a result, changing rainfall changes Pe and the advection timescale associated with the streampower model. This should be included in your analysis of the model scenarios.

Thank you for this detailed and constructive feedback. We have updated the formula for Pe and Pe values in Table 1.

$$\mathrm{Pe} = \frac{k_d P^m l^{2m+1}}{k_{hl}}$$

Table 1. Diffusion coefficient, erodibility, and initial Pe of four models

Model	Diffusion coefficient k_{hl} (m^2/yr)	Erodibility k_d (1/yr)	Initial Pe (Rainfall = 2 m/yr)
M1	0	2.3×10^{-6}	∞ (no diffusion)
M2	1	2.3×10^{-6}	5204
M3	2	2.3×10^{-6}	2602
M4	2	4.6×10^{-6}	5204

To clarify how the Pe changes with rainfall, we have added a new table (Table 2) and revised the text. This new table explicitly lists the Pe values for the Stage 2 rainfall-change scenarios.

The revised text and the new table are as follows:

This design yields 16 individual experiments (Fig. 2), allowing us to assess landscape responses to changes in rainfall and uplift rates separately. A key consequence of our experimental design is that a change in rainfall rate directly changes the advection timescale associated with river incision. Thus, this changes Pe and alters the fundamental balance between advective and diffusive processes, as shown in Stage 2 (Table 2).

Table 2. Pe for Stage 2 rainfall-change scenarios

Model	Pe (Rainfall = 0.67 m/yr)	Pe (Rainfall = 6 m/yr)
M2	3004	9014
M3	1502	4507
M4	3004	9014

In addition, we have revised part of **Section 4.1 in Discussion** to more explicitly frame our analysis in terms of the advection (fluvial) and diffusion timescales. We now clarify that a change in rainfall directly alters the advection timescale, which in turn changes Pe and drives the transient disequilibrium we observe.

The revised text is as follows:

The transient slope change reversal is driven by a disequilibrium between the hillslope diffusion timescale and the channel advection (incision) timescale. Pe quantifies the ratio of these two timescales. Following a change in rainfall rate, the advection timescale, which is inversely related to incision efficiency, adjusts almost instantaneously. In contrast, the diffusion timescale, governed by topography, does not (Clubb et al., 2019). This abrupt shift in their ratio (i.e., the change in Pe) creates a lag and drives the transient behavior at the headwaters. For instance, following a decrease in rainfall rate, the advection timescale lengthens (river incision becomes less efficient) due to lower discharge (Mitchell, 2020; Montgomery et al., 2000). However, sediment continues to diffuse from divides to channels at a rate set by the pre-existing topography (i.e., the diffusion timescale is initially unchanged).

One final point

Line 172: “doubling only the diffusion coefficient reduces the surface roughness by ~15% and, surprisingly, increases the mean elevation by ~20%” This is the effect observed by many, but described in depth by Litwin et al. (2025). That paper might be helpful for understanding some more of your results because it focuses on the influence of diffusion on channel profiles, albeit at steady state.

Thank you for this great suggestion. We have removed the word "surprisingly" when describing the increase in mean elevation with higher diffusion. In addition, we have revised the explanation of the increased mean elevation due to the increase in the diffusion coefficient in **Section 3.1**.

The revised text is as follows:

Stronger diffusion smooths local slopes, but it also causes the net deposition of sediment into valleys. To maintain equilibrium with a constant uplift rate, the river needs to erode not only the uplifted bedrock but also the additional materials from the hillslope. This process forces the channels to become steeper to gain the necessary power to cut through the combined load of bedrock and sediment (Litwin et al., 2025). As stronger diffusion widens valley spacing and forces channels to steepen, the total relief and mean elevation of landscapes increase.

References

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