

## Authors' Response to Reviewer 1

**Reviewer 1:** *This paper describes a new approach to incorporating lateral channel erosion into landscape evolution models. This is clearly a worthwhile goal and I was excited to read this. That said, there are aspects of the model setup and motivation, as described below, that I think can be improved upon and which I think will lead to a paper with more impact.*

**Authors:** Thank you, we appreciate your suggestions to help our manuscript have more impact and interest to a broad audience.

**Reviewer 1:** *1. Specifically, this paper uses a curvature based wall erosion law. While the authors don't expressly say they are modeling meandering, this is the implication of the choice of model. This makes sense as meanders are ubiquitous in bedrock channels and the process is clearly important in many settings.*

**Authors:** We view the class of “streams with fully developed meandering” as a relatively small subset of “streams able to widen valleys through lateral erosion.” In our field experience, there are plenty of examples of streams that most geomorphologists would classify as single-thread, and yet which clearly show evidence of erosion and lateral migration at locations where an outer bend in the channel impinges on a valley wall or terrace. Conceptually, therefore, our approach is not meant to represent exclusively channels with fully developed meandering. To clarify this point for readers, we have added text to the manuscript in the section describing the lateral erosion component of the model.

**Reviewer 1:** *The first numerical model of river meandering that I am aware of is Howard and Knutson (1984). Their first iteration of the model is one in which erosion scales inversely with the radius of curvature, which is basically the same as the model posed in equation 10. Howard and Knutson point out that such a model results in a channel that breaks down into 3 point bends with alternating positive and negative curvature. When applied to an existing meander bend, the bend can't be maintained. The ultimate conclusion of Howard and Knutson (1984) is that lateral channel motion can't be driven only by local curvature because such a model fails to produce realistic meander kinematics (down stream translation, cutoffs) as well as realistic meander forms. This is what leads to their downstream convolution approach, which in a simply way simulates the advection of the effects of upstream curvature downstream. Given that the setup of the model in the submitted MS is based on a centrifugal acceleration argument, and given that the morphologies of the channels produced in the model are reminiscent of the 3 point bends described by Howard and Knutson, it's not clear to me how this model represents a significant advance in understanding and modeling lateral erosion. Moreover, it's not clear how the river even changes from moving in one lateral direction to the other.*

**Authors:** These comments arise reflect an understandable confusion about the key differences between a meander model and a landscape evolution model. We have now added a substantial amount of text to the new “Approach and Scope” section to articulate these differences. In brief, the former represents the trace of a single channel whereas the latter represents the topography in which channels are embedded. This is a very important distinction, which we hope is now clear in the revised manuscript.

Example excerpt from text added to new “Approach and Scope” section: “Considerable advances have been made in developing theory and models for the planform dynamics of single-thread meandering channels. As a result, the scientific community has a good understanding of how meander patterns form and evolve, and how meander wavelength and migration rate scale with properties such as water discharge, valley gradient, and sediment grain size (Hooke, 1975; Nanson

and Hickin, 1986; Schumm, 1967; Langbein and Leopold, 1966; Lancaster and Bras, 2002, e.g.). This body of work addresses the planform pattern of river channels, but does not deal with the broader drainage-basin topography in which those channels are embedded. [...] There is also a well-developed literature on process models of landscape evolution, and in particular the evolution of ridge-valley topography sculpted around drainage networks. We refer to these models as Landscape Evolution Models, or LEMs. LEMs differ from meander models in treating a self-forming, two-dimensional flow network rather than a single channel reach, and in explicitly modeling the evolution of topography.”

**Reviewer 1:** *What is novel, from my perspective, are the two different formulations of the wall erosion law. Why not, then, simply use the Howard and Knutson meandering model and then explore how the two different wall erosion formulations influence the emergent valley form? Given that field evidence that can discriminate between the two proposed lateral erosion processes should be straightforward to collect, I could see such an exercise leading to numerous field testable hypotheses.*

**Authors:** Identifying field sites and collecting data to evaluate the model’s performance is part of the future plan, but is beyond the scope of this manuscript, which is meant to introduce the model to the community. See also response below.

**Reviewer 1:** *2. While I like the exploratory aspect of this paper, I think it could benefit from either a sharply formulated research hypothesis or a field example or two that are targeted. As is, it’s not clear how we can evaluate the performance of the model other than by simply noting that the river causes the valley walls to move. But I think we could do better.*

**Authors:** We have added a figure with examples of bedrock valleys and strath terraces that are much wider than their channels in several different environments, including wide valleys created by both meandering and non-sinuuous rivers. This figure demonstrates qualitatively the differences between a typical narrow bedrock valley and a valley that has experienced a phase of significant lateral erosion. We have also added a significant amount of text at the end of the discussion section where we discuss different measurements and metrics needed from field or lab experiments in order to test this and future models. We also present a potential test of the model presented in the manuscript in a specific field site.

## References

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- Nanson, G. C. and Hickin, E. J. (1986). A statistical analysis of bank erosion and channel migration in western Canada. *Geological Society of America Bulletin*, 97(4):497–504.
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