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Geoscientific Model Development Discussions
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Interactive comment on "HyLands 1.0: a Hybrid Landscape evolution model to simulate the impact of landslides and landslide-derived sediment on landscape evolution" *by* Benjamin Campforts et al.

Anonymous Referee #1

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Summary:
The authors present a new landscape evolution model, HyLands, that combines models of landsliding and bedrock evolution. The backbone of the model, SPACE by Shobe et al. 2017, can shift between both transport-limited and detachment-limited cases of landscape evolution and therefore simulate the continuum of bedrock to mixed bedrock-alluvial to alluvial rivers. Here, bedrock erosion is modulated by the cover effect, which greatly depends on the rate that sediment is delivered to the channel. HyLands combines SPACE with a landsliding model that allows for sediment delivery in a highly punctuated fashion instead of a steady rate. The authors first demonstrate the steady-state solutions for the SPACE model in the Topo Toolbox

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Landscape Evolution Model (TTLEM) framework. They then add landsliding to a natural landscape (Namche-Barwa region) and found that the modeled and observed characteristics of the landslide dynamics match quite well. Last, they devise a model run on a synthetic landscape where there is a 100-year period of intense landsliding to simulate widespread co-seismic landslides. They found that landslides create drainage rerouting from landslide blockage and generate channel knickpoints. They conclude by discussing calibration techniques and potential applications for HyLands.

Review:
This manuscript is well written and contains a detailed description of the numerical model, HyLands. The literature review covers the field of numerical landscape evolution modeling and makes a compelling argument for why a model like HyLands is needed. The objectives and motivation are well-thought out and are clear to the reader. The discussion is thorough, and I appreciate the effort the authors took to flesh out potential calibration techniques and applications to their model. They conclude by stating that their model is “well-suited to address a range of new questions related to how channel-hillslope coupling modulates landscape response," which I wholeheartedly believe. However, I think this manuscript should take a more in-depth look at the steady-state behavior of this model. I believe this manuscript should be accepted with some minor revisions.

Verification
The manuscript shows steady-state solutions for detachment-limited, transport-limited, and mixed bedrock-alluvial cases. These solutions and the associate figure are quite similar to the work in Shobe et al., 2017, and I am not sure it is totally necessary for them to be repeated in this manuscript. Figure 8 shows HyLands working remarkably well compared to the data of Larsen and Montgomery, 2012, but it seems that the model systematically overestimates landslide volumes for all scales of landslides. The author’s attribute the overestimation of small landslide volumes to the inability of the

model to deposit materials in the landslide scars. What is the reasoning for the model overestimating large landslide volumes?

Synthetic Landscapes

At what spatial scale is the drainage re-routing occurring? From Figure 9 (d, e, and f) and Figure 10, it does not seem that the channel profile's location has changed significantly. The figures make it seem like the channel moves on the order of one cell size due to valley blockage and the formation of epigenetic gorges. Could these slight reorganizations, over long periods, create major drainage reorganization or river piracy? Related, how computationally expensive is the landslide (non-linear deposition) routing compared to the rest of the model? I'm really excited for researchers to start using this model. I would be interested to know how fast the model runs, and how modifications that complicate or simplify the landsliding component of HyLands would affect the computational efficiency.

The first part of the model verification section details the steady-state behavior of detachment-limited, transport-limited, and mixed bedrock-alluvial landscapes. I would like authors to answer: **How does the steady state behavior of a mixed bedrock-alluvial landscape with landslides as the sediment delivery mechanism compare to a simulation without landslides?** My guess would be that the main controlling parameter would be t_{LS}, the return time for landsliding. For very small values of t_{LS}, small frequent landslides will dominate; however, there will be little time for the landscape to recover/build up storage of landslide material. In this case, I believe the model would act very similarly to the initial runs in SPACE. For large t_{LS} values, large but seldom landslides dominate. If the landslides are very rare, I think the landscapes will also act similarly to SPACE. In between these two extremes, I think there is potential for the landscape to behave quite differently. Please consider reading Zhang et al., 2018 (The AdvectiveâĂŘDiffusive Morphodynamics of Mixed BedrockâĂŘAlluvial Rivers Subjected to Spatiotemporally Varying Sediment Supply), which also considers the tool effect.

Line Comments:
Figure 2: Where is the function, $f(H/H_*)$, I do not think it is defined in the text. I am guessing it is $[1 - exp(-H/H_*)]$ and $exp(-H/H_*)$. Also, shouldn't the function be on the ordinate and the variable H/H_* be on the abscissa?

Line 171: "landslide" not "andslide"

Line 252: citation for the sink filling algorithm?

Figure 4: Not sure if this plot is made from actual data, but it would be interesting to show a similar figure before and after the landslide for visualization.

Table 1: (a) after Synthetic should be a superscript? Also, you may want to draw another line in the table to make it clear that the Pre, LS-Event, and Post columns refer to the Synthetic landscape and not the Namche-Barwa.

Table 2: Same as Table 1, it is not clear that Before intense LS period belongs to the Synthetic runs, instead of the Real DEM run.

Line 349: Why did you choose 20,000 years for the return time? Would this value affect your results? If it is too long, perhaps you would not collect enough data to generate Figure 8.

Figure 7: Should the unit be $m^{0.5}$, not m? Would log units be more useful? Also, perhaps switch the locations of E and D so D is on top, which corresponds to the color bar. Are the color bars for the 1st and 2nd column supposed to be different? Also, the figure caption shows the time steps for the 3rd column as 5, 500, 1500,

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and 2000 years, but the row titles show different values. Are they supposed to be different? Is so, why? Last, do landslides stop occurring in the simulation because of the absence of uplift?

Figure 8b: I think there are missing symbols in the legend.

Figure 9 (also, Figure 10 and movies): I think the color bar for topography in panels (a), (b), and (c) are incorrect. It should be from 0 to 300 meters, not 0 to 1 meter.

Figure 9 caption: I think there should be more explanation of how epigenetic gorges are formed in the text. I believe the river jumps out of its original channel after being filled by alluvium and is routed on bedrock. How sensitive is this behavior to the algorithm used to fill sinks?

Figure 10: Where is the rerouting? The channel pathway looks the same to me; is there a better way to illustrate the rerouting?

Line 417: Can you show knickpoint generation with a distance upstream vs. slope plot? The knickpoints are very apparent in the movies, but I do not think a series of topographic profiles would show the knickpoint adequately.

Line 419: “Figs.” not “Fig. s".

Line 453: Please consider citing Zhang et al., 2018. This paper looks at how varying sediment transport inputs (e.g. from landsliding) affects bedrock erosion with a tools and cover model.

Line 528: I would be very interested if your model can reproduce this.

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