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Interactive comment on "Simulating the evolution of the topography-climate coupled system" *by* Kyungrock Paik and Won Kim

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We thank Omer Yetemen (referred to as OY in the following) for constructive review comments. In particular, we are very pleased to find that OY recognizes the value of our study. We also appreciate detailed line-by-line comments provided, which are very helpful to further improve the quality of this paper. Our reply to each point is listed below. Any change we mention in the below reply will be reflected in the revised manuscript which is allowed to be submitted by HESS in the next step.

[OY] L172-173. "Whole landscape evolution modeling usually runs over the geologic time scale. Accordingly, calculation time interval is usually greater than a year. On the other hand, a storm event lasts at best a few days." Landscape

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evolution models not necessarily work on annual time scale. Currently, there are modelling examples run on hourly precipitation and daily precipitation intervals (e.g., Yetemen et al. 2015)."

Reply: We agree with OY, and so we mentioned 'usually.' The purpose of these sentences is to explain our approach to the majority of readers who would be familiar with typical LEMs with a long time interval.

[OY] L196-197. "For the purpose of this study, an ideal simulation target can be a high and active mountain range (such as Andes and Himalaya) where orographic effect appears clearly." Orographically enhanced precipitation can be more obvious in these mountain range; however, it can be effective in intracontinental semiarid locations too (Wainwright, 2005). Wainwright, J. (2005). Climate and climatological variations in the Jornada experimental range and neighbouring areas of the US southwest. Advanced Environmental Monitoring and Modelling, 2, 39–110.

Reply: Thank you for good information and reference. This supports our modeling setup.

[OY] L208-210. "The initial topography is nearly flat with a very mild slope imposed to make sure surface water flows toward the ocean. The given random perturbation is tiny enough relative to the given initial valley gradient, and so no depression zone forms in the initial topography." A bit more clarification is needed!

Reply: As suggested, it is revised and clarified as "The initial topography is nearly flat with a very mild slope (10^{-5}) imposed to make sure surface water flows toward the ocean. The given random perturbation ($\pm 5 \times 10^{-4}$ m) is tiny enough relative to the given initial valley gradient, and so no depression zone forms in the initial topography."

[OY] What is the direction of flow, D8-steepest descent?

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Reply: Flow direction algorithm is stated in L129-134 as "GD8 (global eight-direction) method (Paik, 2008) was incorporated in LEGS for surface flow path extraction, which helps obtain reasonable results in terms of evolutionary speed and characteristics of simulated topography. For this study, we revised and upgraded the source code of LEGS, adopting many improved features. One of them is the replacement of GD8 with the improved GD8 method (Shin and Paik, 2017), which resolves known technical issues of the original GD8. The improved GD8 requires the assignment of start cells in a digital elevation model. This requires sorting cells according to their elevation values. Merge sort algorithm, invented by John Von Neumann (see e.g., Knuth, 1987), is adopted for this task."

[OY] So, the perturbation must ensure the some of the side slopes of the cells must be steeper than those of the profile slope. Otherwise, all flow drains straight downward, and you cannot generate meandering or dendritic channels!

Reply: The perturbation and profile slope (stated in the above reply) in our simulations are carefully determined to generate dendritic networks.

[OY] L213. "No-feedback simulation results are obtained by running the LEGS model with spatially uniform rainfall, invariant over time." Do the authors mean that a single precipitation pulse is repeating during the entire simulation?

Reply: Yes, please refer to our rainfall scenario description in the main text.

[OY] L277. For Figure 2b, can the authors provide/add 3D (oblique) view of the landscape? I am very curious to see this simulated topography. Following figure, 3b, 2D figure shows the densification in the counter lines but too black and height is not clear!

The mean elevation profile of Figure 2b is extremely asymmetric! Huge cliff on the leeward side, just about 5 km length. I am very surprised to see such asymmetric behavior when I compare with previous papers (Goren et al. 2014; Han

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et al., 2014; Han et al., 2015). Is it artifact of the model? Goren et al. 2014. Coupled numerical–analytical approach to landscape evolution modeling. Earth Surf. Process. Landforms 39, 522–545.

Reply: Upon the request, we generate a new figure as attached. This figure will be added in the revised manuscript. Figure caption would be "Schematic showing orographic rainfall over the 3-d bird view of topography. Results after 5 Ma from co-evolution simulations with V=16 m/s and t_d= 1200 s (shown in Figure 2b). Horizontal displacement of raindrop from generation to falling location is given as $t_d \times V$."

We believe that a new figure would satisfy OY's curiosity. Please note that asymmetry can greatly vary depending on topographic and climatic settings.

[OY] L296-7. "This leads to the downward peak migration and a steeper slope on the lee side (Figure 4c)". This definition can be valid for bare soil (as seen in lab experiments of Bonnet and Crave, 2003); however, in vegetated environment this may not be correct. Enhanced vegetation on the windward side as a result of more rainfall may impede erosion. The steepest side is defined by the competition between the erosion inhibition by vegetation and enhanced erosive power of increasing rainfall!

Reply: We concur. Please note that the role of vegetation is beyond the scope of this study. In fact, this will be the subject of our forthcoming research. In recognition of this important point, we will add another limitation of this study near the end of section 4 as "The scope of the present study is the bare soil landscape. In reality, vegetation has played a significant role in shaping the Earth's terrestrial surface. Incorporating vegetation dynamics could make co-evolution results much more complicated, as their feedback mechanisms have complex links with water, solar radiation, nutrient, carbon, sediment (soil), topography, etc. Modeling vegetation dynamics in the landscape framework has been actively studied in the last decade (e.g., McGrath et al., 2012; Yetemen et al., 2015). With ongoing efforts we will be eventually able to incorporate vegetation dynamics into the present co-evolution framework."

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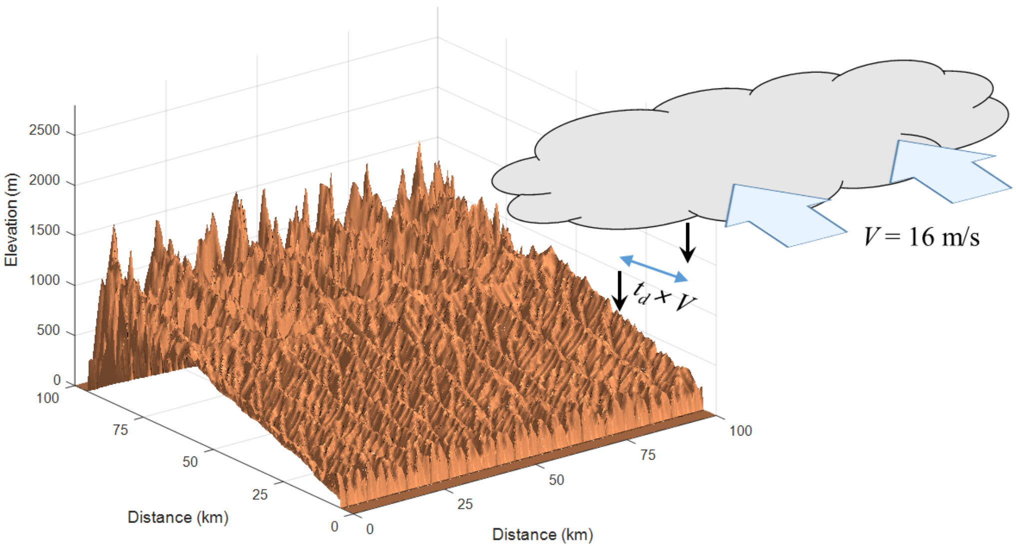

Fig. 1.

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