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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 Arnaud Temme (referred to as AT in the following) for thoughtful review comments. In particular, we are very pleased to find that AT recognizes the value of our study. We also appreciate 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 below will be reflected in the revised manuscript which is allowed to be submitted by HESS in the next step.

AT: l18 first mention of hydrometeors - perhaps explain this to the uninitiated (is it raindrops, or raindrops and/or snowflakes and/or hail, for instance).

Reply: According to the American Meteorological Society, the 'hydrometeor' is defined

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as "any product of condensation or deposition of atmospheric water vapor, whether formed in the free atmosphere or at the earth's surface; also, any water particle blown by the wind from the earth's surface." We have considered writing this definition in the text but decided not to do for two reasons: (1) this is a widely known terminology and (2) writing the definition requires a separate sentence, which can pause the smooth flow of the logic of the given paragraph.

AT: l40 rainfall depth as well is an unusual term (to me at least). Please add a few words to explain.

Reply: We will replace it with 'rainfall amount.'

AT: l69 "wonder" - do you perhaps mean "question" ?

Reply: Yes, we will correct it.

AT: l92 non-orographic large-scale vertically integrated condensation rate - so, does that mean through convectional uplift? I am not sure, but if it is, maybe that is worth mentioning to clarify the contrast with orographic uplift.

Reply: For clarification, we will revise the sentence as "Here, S_o is the background condensation rate, driven by large-scale (synoptic) vertical wind component. If the orographic effect is nil (either $\vec{v}$ or ∇z is zero), $S = S_o$."

AT: l136 "the entire landscape has been assumed..." - not quite. Models by Schoorl and by Lague, for instance, deal with both conditions, as far as I understand. I placed references below.

Reply: Thanks for the reference. We agree that the statement cannot be applicable for 'all' modeling studies. We will revise the sentence as "In most theoretical modeling studies, however, the entire landscape has been assumed as one of these conditions."

AT: l168 how do you deal with sediment eroding off the mountain range and entering the sea-cells? Is it assumed to disappear? The remainder of your text

does suggest that, but it would be good to mention that here.

Reply: We will add a following sentence: "Sediments eroded over the landscape, entering the surrounding ocean, are considered permanently lost, i.e., sea floor is assumed as of indefinite depth."

AT: l184 "is of a significant amount and so zdeta" . I suggest: "and so IS zdeta"

Reply: Will be fixed

AT: l207 Please specify the amount of noise (perhaps by providing the ranges of the uniform distribution), and I also suggest to confirm in the text that the noise is not spatially auto-correlated.

Reply: As suggested, it will be revised as "We adopted the former approach and the random noise, following a uniform distribution (not spatially auto-correlated), is given in the initial topography. 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."

AT: l208 Please specify the initial slope value. This is especially relevant since earlier work has shown extreme sensitivity to the initial slope (in non-uplifting settings at least). I think that work used the Child model and the original may be in a paper first-authored by G.E. Tucker, but I couldn't find it anymore for you.

Reply: See above reply.

AT: l211 At this point, you have explained the model in mathematical detail. As noted before, I feel that that is well done. However, I would really appreciate it if you could provide a figure about here that shows how the rainfall works out in model simulations. Perhaps showing the amount and net direction of descent of precip from the airmass moving over a hypothetical topography would work best, but any output that shows a bit of what is calculated before getting to the

excess rainfall that you show from here on out, would be welcome.

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 $t_d \times V$."

AT: l242 "landslide events" I don't believe you have yet told us that you simulate landsliding - or how it is done. Are you simply using a threshold slope gradient?

Reply: Yes, it is stated in L149-152 as "Shallow landslide is considered in the simple way, previously applied by Tucker and Slingerland (1994); any slopes greater than the angle of repose Θ shall fail, translating upslope mass at the rate q_f to downhill until the local slope reaches Θ. This contribution is combined with the fluvial sediment transport to form the total sediment flux $\xi(= q_s + q_f)$ at every cell."

AT: l243 "fluctuations" . That process is also discussed in Temme, 2006. I provide the reference below, feel free to disregard.

Reply: Yes, the variation of SDR in Temme (2006) is similar to what we see in this study. The reference will be cited.

AT: l262-264 I felt that this information is perhaps better placed in the model description section, and is distracting here.

Reply: We concur and will relocate this sentence to section 2.

AT: Figure 3: The legend font is too small here. I noticed that the font size varies substantially among figures. Can you choose one font size and apply it to all figures?

Reply: We will reproduce all figures with a consistent font size.

AT: Figure 3 caption: Numbers in the legend indicate (no "s")

Reply: Will be fixed.

AT: l305-310 Can you here compare with overall topographic features in some of the world's mountain ranges that are closest to your condition that U=0? I believe the Andes have U=0, approximately. Do the Andes (or other mountains) match your simulated topography with feedbacks better than they do the topography without feedbacks, or even better than the topography with feedbacks from the Roe at al model? If this is not possible, you might consider here pointing at the difficulty of making comparisons with existing orogens.

Reply: We appreciate this insightful comment. The Andes could be a great target to be examined. We, however, determine that such comparison with a real topography at this stage would be premature in a publishable work, although this could be a great topic for future study without a doubt. There are still technical improvements needed from the numerical model side as we stated in the limitation section. We also added the role of vegetation in that section 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."

AT: l327 I suggest " was found to be nonlinear"

Reply: Will be fixed.

AT: l344 Opposite: I sugggest "In contrast"

Reply: Will be fixed.

AT: l345/6 Visualizing this rainfall displacement through wind and delayed forma-

tion is exactly what would work really well in a "Figure 0" as mentioned above.

Reply: See above reply. A new figure (attached) would satisfy this comment.

AT: l357 " indebted" : i suggest "due"

Reply: Will be fixed.

AT: l398 I agree with your sentiment that cooperative efforts are needed to document coevolution. If possible, can you share any thoughts what that could look like? I can imagine that thermochronology, for instance, can help constrain the topographic side of the co-evolution. Is the problem mostly with reconstructing spatiotemporal patterns of rainfall?

Reply: Thanks for thoughtful comment. Encouraged by AT, we will add a sentence "On this issue, we indeed witness new lights such as thermochronology in topography reconstruction and paleo-climate simulations using General Circulation Models."

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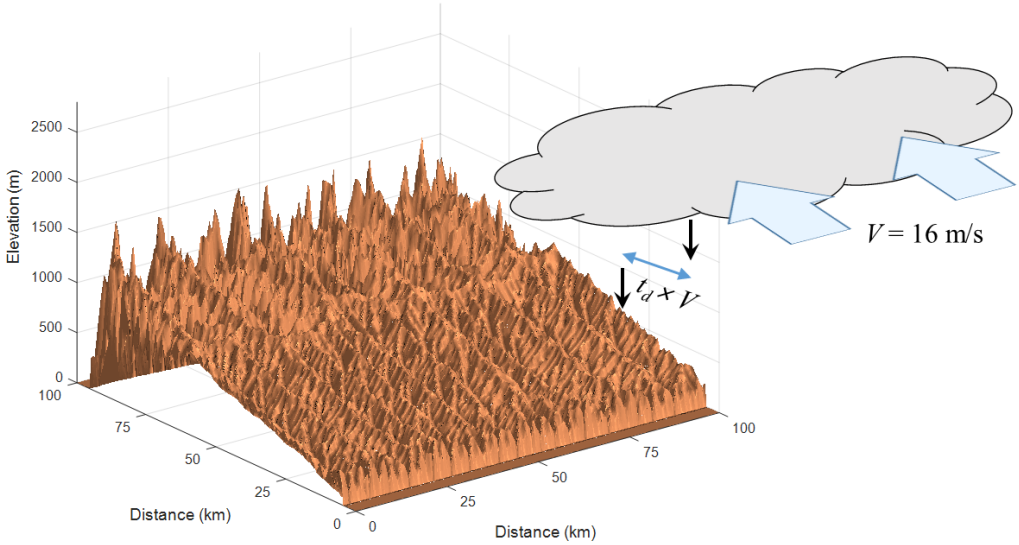

Fig. 1.

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