Earth Surface Dynamics Discussions

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Review

Philippe Steer (Referee)

Referee comment on "A geomorphic-process-based cellular automata model of colluvial wedge morphology and stratigraphy" by Harrison J. Gray et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-70-RC1, 2021

I have taken a great pleasure to read the manuscript entitled “A geomorphic-process-based cellular automata model of colluvial wedge morphology and stratigraphy”. This manuscript investigates, using the GrainHill cellular automaton model (Tucket et al., 2018, 2020), the role of geomorphological processes in the development and geometrical structure of the sedimentary wedges that develops at the toe of normal fault scarps. The manuscript is overall well written, pleasant to read and, in my opinion, is original by efficiently linking geomorphological laws and processes to the facies and geometry of sediment wedges. It offers some outcomes that could have an impact in geomorphology (dynamics of the scarp-wedge system), but also in paleoseismology (interpretation of wedge structure and facies in terms of earthquake events) and sedimentology (by representing a neat study of the links between geomorphological processes and sedimentological facies). I congratulate the authors for that. In turn, the paper could be published as it is, as I have not noticed any methodological flaws or incorrect interpretation. However, I strongly believe the manuscript could be strengthened by better clarifying and structuring the results using physical dimensionless numbers (see my main comment below), which could also help to reduce the length of the paper (some parts are a bit long). I also give below some minor comments.

I also wish to mention that I am not a sedimentologist and that I was not able to properly assess the quality of the results in terms of sedimentological description.

Main comment:

The results of this manuscript, that are based on numerous models that were performed after a sensitivity analysis in the parameter space (e.g., disturbance rate, lateral collapse rate, weathering rate), could be described in a more structured (and clearer) manner by classifying some main types of models. This would really help to better understand the conditions required to produce different main types of wedges. In this case, the classification is not binary (e.g., transport- or detachment-limited) but considers three main driving processes which are defined by the weathering rate Wo, the disturbance rate D and the lateral collapse rate LCR. Three physical dimensionless numbers could be defined as Wo/D (i.e., the Peclet number already mentioned in the manuscript) to characterize the ability of the model to transport by disturbance (or diffusion) the produced regolith, Wo/LCR to characterize the ability of the model to transport by gravitational processes the produced regolith, and D/LCR to characterize the dominant mode of transport. Each model could then be classified using these three physical dimensionless numbers and discussed in the light of this classification. I strongly believe that this paper, in particular the Results and Discussion, would benefit from adopting this classified approach, which could really help to clarify the description of the models. In turn, wedges and scarps could be characterized by these numbers, in turn offering a clear physical description of the resulting wedge facies and structure.

I also believe that the main findings could be summer in a synthetic sketch using a kind of ternary-like diagram (with the axes Wo/D, Wo/LCR and D/LCR – even if the sum of these numbers is not necessary one) showing the main types of wedges and scarps.

Minor comments:

Line 38: "we desire this predictive power" – feels a bit strange in a scientific paper

Line 39: "do you preserve a post-earthquake colluvial wedge" – could be replaced by "is a post-earthquake colluvial wedge preserved" as the use of "you" seems unusual in a scientific paper.

Line 40: remove the capital letter to "3) How"

Line 167: It would be interesting here to mention the typical earthquake magnitude required to generate a 2m tall faut scarp using classical scaling laws between displacement and moment (or magnitude) [Leonard, M. (2010). Earthquake fault scaling: Self-consistent relating of rupture length, width, average displacement, and moment release. Bulletin of the Seismological Society of America, 100(5A), 1971-1988.]

Title section 2.2. I suggest rephrasing the title of this section for clarity "Facies definition and transport metrics based on cell tracking" or something else that suits the authors

Lines 216-220: The choices of the velocity thresholds between the different facies seem rather arbitrary. Could you please justify these values? I was also wondering why not using thresholds on the transport time, which intuitively appear as a more natural choice to divide the different facies and has the benefit of displaying some better resolved clusters (on Fig. 8) that would also likely be detected with classical clustering approaches (e.g., dbscan).

Lines 244: “both scarps both” – issue with the use of the word “both”

Figure 8: LCR is not defined in the caption.

Figure 11: This figure could go in supplementary as the fact that the volume of the wedge increase with Wo, D and LCR is relatively obvious, given the configuration of the model.