RC1: 'Review', Philippe Steer, 03 Nov 2021 reply

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.

Thank you for your time and effort toward our manuscript and for your words of encouragement.

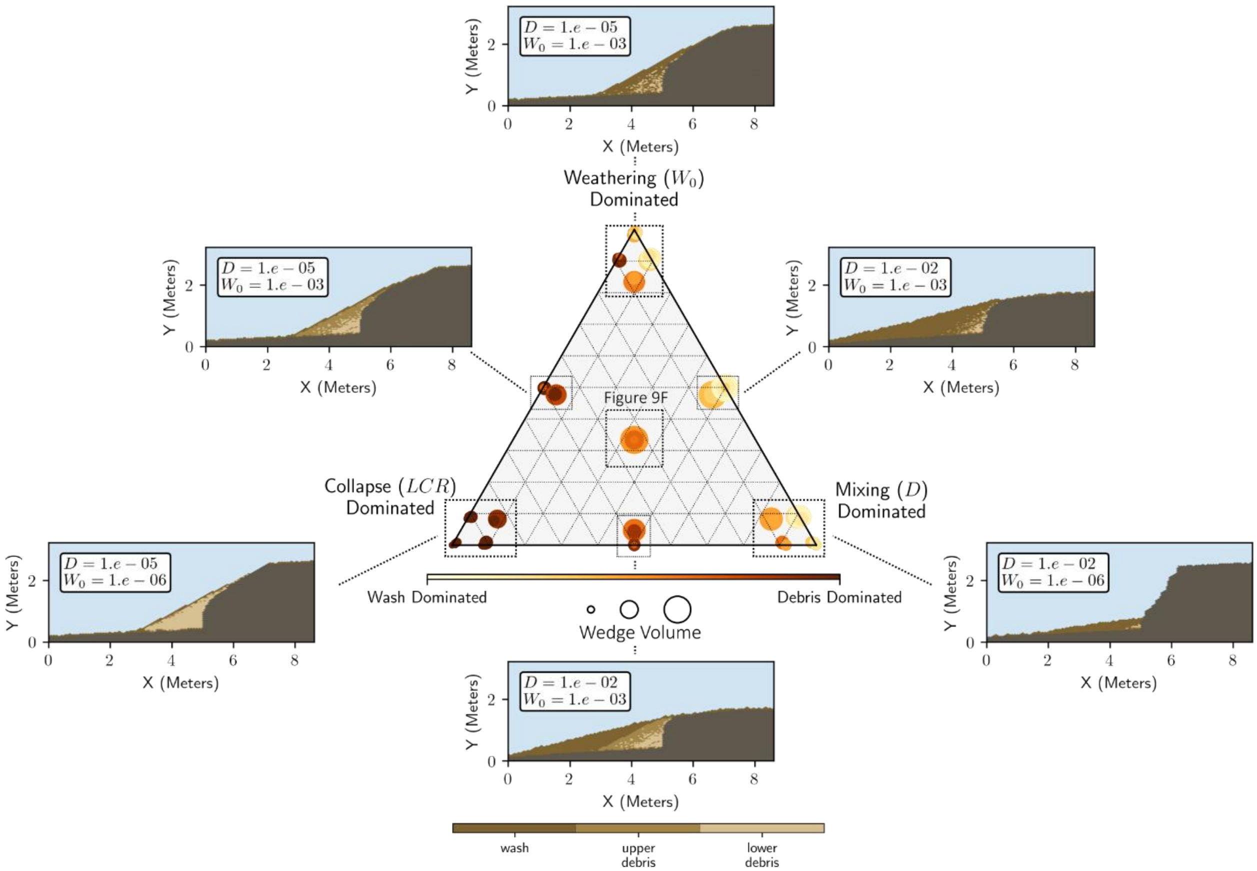
Main comment:

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.

This is a great point and we did initially consider casting model results in dimensionless values as you suggest. What may us decide against this approach is our desire to maintain accessibility to non-modelers, particularly more field-based researchers in paleoseismology, Quaternary geology, and sedimentology/pedology. Our hope was to cast the results in the form of 'variable X causes outcome Y' without the extra step of explaining how to interpret a non-dimensionalized value. The goal here is to connect a field-based researchers intuitive understanding of an environmental parameter, say mobile regolith (soil) formation with a theoretical colluvial wedge form and facies distribution. Yes, these results could be explained much more concisely if you assume the audience already has familiarity with model non-dimensionalization. However, I don't think this is necessarily a safe assumption for our target inter-disciplinary audience. However, we did do a basic non-dimensionalization for the ternary diagram shown in the figure below.

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.

A ternary diagram to display model results is a really clever idea. Here is what we ended up developing to replace figures 12 (similar figure made for Figure 11):



The axes, as described in the figure caption, are plotted as X/(LCR+W_0+D), where X is the axis variable (LCR,W_0,D). This allows us to plot the model results with the values for each of the three axes summing to 1 for each data point. With your suggested approach, we are able to show both the relationships of colluvial wedge size and relative amounts of wash/debris in a single plot. Thank you for this excellent suggestion.

Minor comments:

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

Agreed. Revised to “A robust method to predict colluvial wedge form and facies can develop knowledge toward understanding broader questions…”

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.

Agreed. Revised to “under what environmental conditions is a post-earthquake colluvial wedge preserved (or not);”

Line 40: remove the capital letter to “3) How”

Corrected. Thank you.

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.]

Good idea. However, my understanding is that we would need a value for the rupture length/area to estimate the magnitude correctly. Here we decided to point the reader to an example of a real-world fault system and case study with detailed application of the Leonard (2010) scaling relations. Inserted “In particular, this approximate size scarp often results from typical earthquakes (up to a moment magnitude of ~7) on large normal faults such as the Wasatch Fault in Utah USA (e.g. Bennett et al., 2018).”

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

Agreed. Revised as suggested. Thank you.

Lines 216-220: The choices of the velocity thresholds between the different facies seem rather arbitrary. Could you please justify these values?

Inserted: “The upper threshold for lower debris facies is the approximate average velocity of a hex cell state that travels almost entirely by gravitational free-fall, with a smaller component of movement due to impacts/rebound from other free-falling cells, and thus more likely to be debris.” The lower threshold is meant to exclude hex cell states largely traveling by raveling down the wedge slope. Both values are somewhat arbitrary, but allow us to broadly encompass and classified the groupings observed in the scatterplots. Future work should focus on a mechanistic explanation for the observed groupings.”

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).

The use of transport time is difficult because mobile regolith cells with short transport times includes both those that collapsed off the scarp, with those that were just a part of the pre-earthquake mobile regolith cover with limited periods of disturbance. The use of velocity captures both the distance and transport time which both affect the resulting sediment facies in real colluvial wedges. The use of dbscan to identify clusters is a good idea. However, I am not sure that an automated clustering method will give insight any further than our simple threshold value method because neither has a direct connection to the mechanics of the sediment transport that is occurring on the scarp.

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

Deleted the second “both”.

Figure 8: LCR is not defined in the caption.

Inserted “(LCR)” after “lateral collapse rates”.

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.

Agreed. Moved to supplemental material as suggested. Thank you.