

Reviewer 1

The authors would like to thank Prof. Alex Densmore for his time and the in-depth review of our manuscript. The review comments can be found in bold while our response to the comments are found below in normal font.

This is an innovative manuscript that attempts to develop a model of regolith generation and evacuation in a mountain belt, in order to understand the competing effects of earthquakes, aseismic deformation, and landsliding in causing topographic and bedrock surface uplift. Given the advances in our understanding of these different processes over the last few years, this is a timely and appropriate exercise, and the authors use their approach to demonstrate some interesting and provocative results. I think this manuscript will eventually make a strong contribution to the journal and an important step in this field; while we don't yet have all the components to really understand the relationships between these processes at the orogen scale, this kind of 0-d model is a very useful way forward.

We thank Prof Densmore for his kind words about our work.

I have made a number of comments and queries directly on the manuscript PDF, and I won't repeat them all here. I found parts of the manuscript confusing and hard to follow - in part because of some repetition of ideas between different sections, but also because of some inconsistencies in usage and units of the various parameters that the authors are tracking. I would urge them to consider a cartoon figure of the model and a list of symbols, with units, as well as a rigorous check that their usage is consistent across text, figures, and captions. The current Fig 1, while appealing, doesn't really convey very much information, and a cartoon depiction of their model, with appropriate labels and perhaps a couple of case-study examples of how it could evolve over time, would really help to clarify what they are trying to do.

We will check for clarity and consistency in the units and symbols used throughout the paper, we thank the reviewer for the thorough job he has done to highlight these areas on the .pdf version. We will replace our current figure 1 with figure of a model schematic demonstrating how the model works and relate the model space to the Longmen Shan and the Wenchuan Earthquake and will outline the major units and symbols.

Despite their statement fairly early on about the use of rigorous definitions, some elements of the work only become clear later in the manuscript - for example, their distinction between weathering and erosion in earthquakes, and the corresponding assumption about transport lengths in landslides. I don't disagree with what the authors have done, but it took me awhile to understand it.

In our manuscript we describe landsliding as a weathering process rather than an erosional process due to the short transport lengths of landslides. In our model there is no remobilisation or sediment transport, rather the regolith produced by landsliding remains on top of the bedrock until it is lowered by the constant flux of sediment out of the model. This model assumption is to replicate much of regolith produced by landsliding is deposited on the hillslope where it is acted upon by hillslope transport processes. We will ensure the explanation and definition of regolith is expanded on in the manuscript and is repeated during our interpretation of the model results to ensure greater clarity.

Related to this, I think it would be helpful for the authors to make a clear statement about what specific questions they are addressing or what specific experiments they are running. This

information is there but is scattered in a few different places, making it hard to move from the high-level ambitions of the manuscript to a clear understanding of what they're going to look at in section 3. Without this clear statement, it's a little hard to assess the overall contribution that the manuscript is making, because I'm left to guess a little bit at what the authors think is the main novelty of their work. It would be great to see this brought to the fore.

We recognise that the manuscript would benefit from a clear statement of aims and research questions and will include this in the introduction.

Finally, there are some minor typos and errors or inconsistencies in the text and figures, although these should be easy for the authors to sort out

We will go through the individual specific comments highlighted in the manuscript and correct the typos and errors highlighted and respond to any further comments.

Reviewer 2

We thank the reviewer for their in-depth and thorough review of our manuscript.

This study develops a novel and creative 0-dimensional model to investigate the absence of evidence of large earthquakes in the sedimentary archive. It makes use of empirical scaling laws for earthquake induced uplift, landsliding and other inputs and outputs of bedrock and regolith through the system to model the evolution of regolith on a hillslope and how this is perturbed by earthquakes. It also tracks cosmogenic nuclide concentrations within the bedrock and regolith through time enabling calculation of cosmogenic erosion rates and how these vary with earthquake activity. There are some really interesting and intriguing results e.g. regarding the timescales over which it is possible to detect the influence of large earthquakes on erosion rates.

Thank you for your kind appraisal of our manuscript.

However, I did find the manuscript quite difficult to follow and some of the assumptions and terminology used are confusing. I have commented extensively on the PDF version of the manuscript but some general comments/concerns are: I think you could do with a model schematic to help visualize what is going on and need to distinguish more between results from your modelling and results from other studies throughout.

We agree that a model schematic/cartoon would help to clear up how the model works. We will replace the current figure 1 with a new figure showing how the model works and its relationship to the Longmen Shan and the Wenchuan Earthquake. We will also restructure the results section of our manuscript to separate the results of the model from results taken from the literature to avoid confusion.

The research questions and experiments you conduct to address these need to be much clearer throughout and the use of terminology and symbols needs to be consistent.

We will write a paragraph explicitly stating our aims and research questions in our introduction. We also will include a table of symbols and units in our methodology to help clarify their use and ensure consistency.

I don't think it is correct to refer to the production of regolith by landslides as weathering. I can see that the production of regolith by earthquakes, i.e. a kind of earthquake preconditioning, is logical but as I understand it, landslides inherently remove regolith and bedrock, rather than

producing regolith. The mechanism by which landslides produce regolith needs more evidence and explanation.

We are happy to clarify our assertion that landslides produce regolith. In our study we define regolith as “the mobile transportable layer of sediment at the surface. Regolith can be created by two distinct weathering mechanisms; landslides cutting into bedrock to create transportable debris, and soil production by physiochemical processes”. In our model this is weathering rather than erosion as the landsliding does not transport the regolith, rather it adds a layer of regolith on top of the intact bedrock. The addition of landslide regolith to the top of the model space is similar to the majority of coseismic landslide deposits remaining on the hillslope after an earthquake. Regolith is removed from the model in a second step by a constant flux out of the model, this is to simulate the role of the fluvial system in mobilising regolith out of orogens and keep the model in a flux steady state. The addition of a model schematic/cartoon figure to replace our figure 1 will hopefully make our definition and use of regolith clearer. We will also include greater depth of discussion on the comparison between the findings of our model and field observations.

Another assumption is that the amount of regolith production by landslides is limited by the regolith already on the hillslope. Why? Does this somehow dampen the shaking caused by an earthquake? I think this paper is worthy of publication in this journal but with some restructuring and clarification throughout.

Landslide deposits are made up of a combination of fresh regolith, produced by landslides cutting into bedrock, and old regolith which is made by former landslide events and weathering processes. When an earthquake is generated in our model it produces a volume of landsliding, controlled by a scaling relationship between earthquake magnitude and total landsliding volume, we assume that if regolith exists on the hillslope it will be remobilised. This remobilisation of existing regolith rather than the generation of new material has the effect of dampening the erosional response of the earthquake. The effect we have modelled here is likely to occur in mountainous regions which are impacted by many earthquakes regularly, such as basins close to active fault lines, or areas with particularly high landslide densities. However, if a consistent regolith cover can be maintained across the mountain scale for multiple earthquake cycles then it is possible the effect of remobilising regolith could be significant across the entire orogen. The inclusion of a schematic model diagram and a clearer discussion of our model results in the discussion section of our manuscript will help to clear up any confusion around our modelling of regolith generation.