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To: Dr. Michele Cooke
Referee, *Earth Surface Dynamics*

Reference: Response to referee comments to the manuscript *" Erosional response of granular material in landscape models"* [Paper esurf-2020-35] by R. Reitano, C. Faccenna, F. Funiciello, F. Corbi, S. D. Willett.

Dear Dr. Michele Cooke,

we would like to thank you for the corrections and the useful comments. We include hereafter, point by point, the reply (in *dark red italic* text) to all the Referee comments. We also upload the revised version of our manuscript. We hope the manuscript is now ready for the publication in *Earth Surface Dynamics*.

With my kindest regards,

Riccardo Reitano, on behalf of all authors.

Referee – Michele Cooke
The paper presents a nice parametric study for a range of potential analog materials that could be used in coupled deformation and erosion models. The careful study very nicely contributes to our knowledge of these materials and will be a very valuable resource for future studies. Delineating a material recipe that can effectively simulate both deformational and erosional processes within the same experiment will enable many future investigations into the fascinating coupled feedbacks between these processes. I have a few suggestions that may strengthen the paper. These suggestions primarily relate to the framing and presentation of the findings rather than the results themselves, which are nicely gathered.

Main Comments

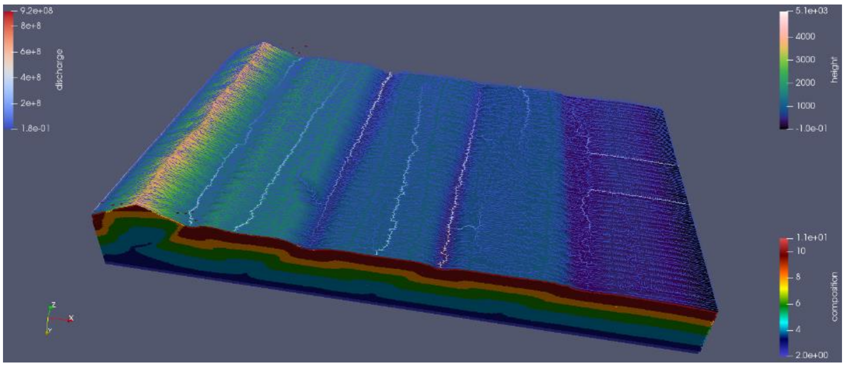
1) The need for analog models of erosion presented within the introduction can be strengthened. A reader unfamiliar with analog approaches might not be convinced that these approaches are needed from reading the somewhat vague statement in the manuscript that computation capacities are limited (line 40). Can you provide some examples of the limits of computational models? One approach may be to follow the reasoning presented in Reber et al (2020) for the benefit of analog models over numerical approaches. But the authors may have other even more compelling reasons to offer the reader.

In agreement with the Reviewer's suggestion, we have modified the text adding a part in which we clarify the reason why we are using analogue models, and which are the advantages as respect to numerical modelling (lines 40-44). We welcomed the suggestion by the Reviewer and implemented the text also citing the work from Reber et al. (2020).

2) The study can benefit from stronger support for the performance assessment. The manuscript frames its primary goal as "finding an analogue material that best mimics the erosional behavior of the natural prototype." The part that is missing is how specifically is good behavior assessed. How 'should' a slope of 15 degrees respond to the simulated precipitation rate? How do we know what experimental response is correct or wrong? The text states that a proper concave upward river profile is desirable (line 309) but are there some plausible conditions that would yield more or less concavity to the profile? My, albeit very

basic, understanding of fluvial mechanics is that the concavity of river profiles relates to the different strength of channel bed materials along the profile. If the material is uniform along the river profile, what degree of concavity is expected? This information is very important for helping us assess the performance of the material. Can you add to the figure 7 the range of expected profile shapes? Could you use numerical solutions for similar slope and precipitation but at crustal scale and with a range of soil/rock properties to validate the performance of the analog materials? The comparison of the laboratory observations to numerical models may be more straight-forward than comparison to natural systems because the numerical models can have uniform properties and starting slope.

We revised the manuscript following the Reviewer's comment. What we are searching for in this study is a material that creates the same morphologies of those observed in natural orogens when is subjected to a) a tilt of 15° (the choice of the angle comes also from previous works as indicated in the text at lines 209, 384); b) a rainfall rate between 25 and 30 mm/h; c) by the only gravitational force without any other external forcing. In particular, the main argument when defining a "good" or "proper" analogue material is the channelization. A proper material should display channelization, with branching river network. As highlighted in section 2.2.1, we have channelization when the ratio between precipitation rate and infiltration capacity induces the surface runoff that, together with the mechanical properties of the material (cohesion, internal friction angle), allows for the formation of channels. Moreover, as explained in sections 2.2.1, 4.4 and 4.5, the model must be consistent with Hack's Law and slope-area scaling. We applied changes to the revised version of the manuscript trying to clarify this goal (lines 80-81, 185-187, 403-407). Following the Reviewer's suggestion, we also changed Figure 7, adding the shapes where concavity (θ) is 0, 0.5 and 1. Due to the very big range of natural values for θ (and also k_{sn}), we think it would be clearer for the reader to see the shapes of the theoretical profiles. As far as the potential strength of the comparison between analogue and numerical simulations is concerned, we really appreciated the Reviewer's comment, as this topic will be studied in a future work not only because time consuming but also because of its high importance. Here we attach a picture of the coupled models we are currently running.



3) Presumably, each of the tested combinations of analog materials may be suitable for different conditions of geologic substrate or precipitation rate. Perhaps one recipe is best suited for 'typical' settings but others could be used if you want to look at some atypical geomorphic settings. Providing some guidelines for the conditions under which each recipe could be suitable (or not) would be helpful.

We agree with the Reviewer's comment. It is true that a combination of those materials may lead to some typical geomorphological settings (narrow or wide channels, more or less incise etc.). The difficulties lay in the link between the applied rainfall and the developed morphologies. The CM1 experiment is a good example of this concept. The rainfall imposed for the experiments (including CM1) remarks wet regions on Earth. But the structures that we observe in our model CM1, can be developed in nature in arid regions. Anyway, other materials (or combinations of materials) would not be suitable for landscape evolution models, because they do not satisfy the criteria for "good" or "proper" analogue material highlighted before, even in different climatic conditions or geological settings. Unfortunately, such study would be very time consuming and specific for a given process, while we are focusing on mountain building and erosion.

4) The comparison in section 4.5 of geomorphic parameters to measurements from crustal geomorphic systems and the limits for various processes is very interesting. Can you please add the values of K and theta for detachment limited and transport limited systems to figure 12? This will aid in the comparison.

The last sentence of this paragraph asserts the match of the parameters with nature. Please add the ranges for geomorphic estimates of K and theta to figure 12.

In agreement with the Reviewer's comment, figure 12 displays now also natural values for k_{sn} and θ. These values have been selected from field data coming from different areas and data compilations.

5) Just a small note on porosity. If I understand correctly, the porosity is measured my comparing the volume prior to and after shaking. Doesn't this presume that they packing has no voids after shaking? If so, this doesn't seem realistic within granular materials which cannot pack with zero porosity. Maybe I'm missing something about this particular method of porosity measurement.

The approach used to measure the material porosity has been implemented to reproduce measuring conditions close to the experimental ones. We are not assuming that the packing has no voids after shaking, but we are measuring the porosity before and after the shaking. The selected porosity value is the one recorded once the porosity values reach a plateau. We confirmed these values measuring the weight of material water-saturated and after the oven drying.

Last but not least, in the revised version of the manuscript we have edited every grammatical error/mistyping the reviewer has highlighted. We have also added the references proposed by the Reviewer.

References

- Reber, J. E., Cooke, M. L. and Dooley, T. P.: What model material to use? A Review on rock analogs for structural geology and tectonics, Earth-Science Reviews, 103107, 2020.