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Interactive comment on "Macro-roughness model of bedrock-alluvial river morphodynamics" *by* L. Zhang et al.

Anonymous Referee #1

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This paper presents some interesting developments in modelling the evolution of bedrock-alluvial systems, in a way that can incorporate transitions between alluvial and bedrock-alluvial conditions. The paper presents the application of the model to a number of different, relatively simple, scenarios, and provides a comparison with the Saltation-Abrasion model. The paper ends by identifying a number of exciting possible model extensions and future applications.

I'm not going to comment in depth on the technical aspects of the model formulation; rather I have some questions related to some of the model assumptions, and to the model outcomes. There are a few places where additional explanation of the model might make the paper more accessible to those who do not think in equations.

Cover formation: In MRSAA, the proportion of sediment cover is a function of the ratio

of sediment depth to bedrock roughness. This does make intuitive sense, although there are a few points that it might be useful to consider. Furthermore, given that prediction of sediment cover is a fairly significant part of the bedrock-alluvial literature, it would be worth further developing the explanation of this area of the model. The explanation of the relationship between cover and sediment depth is clear, but more could be said about associated assumptions, and how the value of sediment depth is derived in MSRAA.

Does the new cover formulation break down at any point? For example, it is possible to conceive of a situation with patches of sediment on a very smooth bedrock bed. The sediment depth (spatially averaged over both patches and bedrock) could be greater than the bedrock macro-roughness length, and yet pc would not be one (contrary to equation 16b). I think that the model is problematic when grain size is larger than the bedrock roughness length; given that some bedrock rivers can contain very coarse sediment and smooth surfaces, this is not an impossible combination.

The MRSAA model implies that sediment cover fills up the bedrock topography sequentially from the lowest elevations to the highest. The added complexities of the flow pattern induced by the bedrock topography may mean that this is not necessarily the case. In some cases, this may not matter, if the rate at which bedrock area is covered still increases in the same manner with sediment depth. On the other hand, flow (and indeed topographic) patterns could instead mean that as average sediment depth increases, some sediment patches will get steadily deeper rather than increase in aerial extent, in which case pc will not change with sediment depth.

I don't think that you necessarily need to perform runs with different relationships between sediment depth and pc, rather just give some indication of the situations under which the current formulation is valid, and to indicate that future runs could use a different formulation. What field/lab data would be needed to establish the form of the relationship between sediment depth and pc? There are also interesting questions about what is an appropriate macro-roughness length for a bedrock bed, and what properties and processes it is affected by.

Sediment transport: In the model, sediment flux from a bedrock-alluvial bed is calculated assuming a fully alluvial bed, which is then scaled by pc (page 310). Exposed bedrock will not only affect sediment flux through sediment availability; sediment grains are entrained at lower shear stresses from bedrock surfaces, and will travel easily over them once in transport. This might have the impact of increasing sediment fluxes over bedrock-alluvial beds; what implications might this have for the model results?

Model results: The different applications of the MMRSA model demonstrate its applicability to a range of scenarios. Would it be possible to compare any of these to measured field data, in order to provide some evidence that the model behaviour is reasonable? For example, are there any datasets that demonstrate that channel slope is insensitive to uplift at certain uplift rates? Or flume data of the translation of a sediment pulse over a bedrock surface – Chatanantavet's work maybe? How about any examples where there is a difference in behaviour between the CSA and MMRSA models? (On which, I'd expect a river to flow along a graben, not across it.)

Specific comments by page/line:

299/12: Assuming that all incision is through saltation-abrasion, which is not necessarily the case.

301/7: In the model, cover is not completely independent of sediment transport properties, because the balance between sediment supply and sediment transport affects the depth of the sediment layer, and hence the sediment cover.

304/9: Change to equation 5a?

304/10: Define τ*c

313/13: This paragraph is repeated on 314.

318/2: Any particular reason for using this equation instead?

323/17: How is the 1 m estimated; from the total range of bedrock elevations, or another measure?

324/8: Maybe clarify with 0.12 years of high flow.

324/13: Can you explain this change in wave speed in a more physical way? In a river this could be because grains are more mobile over a predominantly bedrock surface, but I don't think that this behaviour is encoded in the model.

324/18: What controls the steady state thickness, and what is the value of pc? I think that pc is about 0.8, which is the same as if predicted from the ratio of sediment supply to transport capacity; is this another example of the models converging under steady state conditions?

327/13: Wouldn't the models be more comparable if they were not set up with different initial and boundary conditions?

328/14: What about size selective transport, and how size-selectivity could vary as a function of pc?

329/6: Change to 'modified form of'

Figure 7: Useful to redefine χ in the caption.

Figure 8: Define S, Cz and Qbf in the caption and/or axes. Make sure all axes have labels.

Several other figure axes/captions also need definitions; it's useful to be able to understand a figure without having to search the body of the paper for definitions. (The nomenclature table is helpful though.)

Interactive comment on Earth Surf. Dynam. Discuss., 2, 297, 2014.