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Interactive comment on "DebrisInterMixing-2.3: a Finite Volume solver for three dimensional debris flow simulations based on a single calibration parameter – Part 1: Model description" *by* A. von Boetticher et al.

Anonymous Referee #2

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General comments:

The manuscript of von Boetticher et al. report of a new three dimensional debris flow simulation tool based on a Volume of Fluid Approach solved with the software Open Foam. As I am not a specialist for numerical solution schemes, my comments here focus on the model description and I assume correctness of descriptions in section 3. The authors report of a three-phase model that shall describe the flow behavior of sediment-water mixtures over complex terrain. I think it is an interesting study and the new model might have useful applications in engineering practice for 3-d problems.

In my opinion the main weakness of the paper is that the authors promise a two (or three?) phase debris flow model (abstract, introduction), but as far as I understand later it turns out that effectively it is a one-phase flow model without substantial new insights of the real physics of deforming sediment fluid mixtures, but with a probably nice and elegant way of solving governing equations. There are separate formulations for flow resistance of the solid and the fluid phases, which are then averaged and phases cannot interact, so an "equivalent fluid" approach might better describe the model. The simplifications for reducing it to a model with only one calibration parameter are not well founded (or should be better explained) and may only be justified in the view of engineering applications. The lack of new physical insight seems to be also the main critic of reviewer 1. I suggest that the authors revise the manuscript in a way that they clearly state advantages and disadvantages of the model and better explain the innovative aspect of their approach. In my mind the paper is well written and English style and grammar are appropriate. There are deficiencies in structure and some unclear formulations, which I list below.

Specific comments:

Title: Why DebrisInterMixing-2.3 ? Are there earlier versions?

P 6350:

Section 1 – Introduction: Apart of some references on the hazard potential of debris flows and the effect of climate change, there is not one reference in the introduction to related earlier work, but only unproven statements of the authors. I strongly recommend to re-write the introduction including recent work on modeling the constitutive flow behavior of grain-fluid mixtures.

P 6351:

L 3: scaling might be uncertain in the view of the authors, however, at least there are attempts to tackle that problem, and it might be worth mentioning (e.g. see Iverson,

2015)

L 5: Please define the interaction between a granular flow and a viscous force! What do you mean?

L 13: I recommend being more cautious with using the term “viscous”. It seem that the authors use it instead of “fluid” or “water”. What is a "viscous concentration"? Note that the authors later assume a Herschel-Bulkley model for the fluid, which is actually a visco-plastic flow law (as there is a yield stress)

P 6352:

L6: For the reader’s convenience, I would add here the information which rheologic models are used.

L12: I don’t understand the connection between this statement and Figure1. Figure 1 is not easy to understand, so additional explanations are needed.

L 18ff: it seems to me that the authors assume that there is only one possible interaction between the solid and the fluid phase (=drag) and that this interaction is neglected in their analysis as it would complicate things. Hence their averaging of the flow resistance of the solid and the fluid phase yields a “quasi” one flow resistance model for the whole mixture, which would be similar to an “equivalent fluid approach” (Hungr, 1995). What about the effect of buoyancy and excess fluid pressure, especially when fine sediment is present? (e.g. McArdell et al., 2007; Iverson et al., 2010; Kaitna et al., 2014).

P 6354:

L 20ff: Kaitna et al. (2007) might be the wrong reference. Kaitna et al. refer to work which found the relation (k = 0.3 * yield stress), but also refer to work that does not support that finding. In any case, the relation between yield stress and K might depend on material composition, similar as the formulation of Yu et al. for the yield stress. It might be interesting how sensitive the model results are on the assumption k = 0.3 *

yield stress.

P 6356:

L 13-14: The first sentence of this section seems unnecessary.

L 15: change “viscit phase” to “fluid phase”

L 15-18: I don’t understand these sentences. These statements are given without justification or explanation (e.g. why do you know that the shear thinning fluid behavior of the fluid is important for flow resistance? Is that as important as the flow resistance of the grains?).

L22ff: the granular flow law is not only pressure depending, but also shear rate depending. I recommend to make this clear also in earlier sections of the paper (e.g. abstract, or section 2.1). Is now the final averaged flow resistance of the mixture shear thinning, shear thickening, does this matter at all, or is the pressure dependence more important? Another issue in my opinion is that the authors always talk about two phases, but the normal stress term is only vaguely defined. Is p the effective normal stress experienced only by the grains, or the bulk total normal stress? This raises the question of the effect of effective fluid density (which impacts buoyancy and therefore the effective normal stress).

P 6358

L 4: please clarify to which laboratory tests you are referring!

P6363: Section 3.3 could be part of a discussion section

P 6365-6367:

Section 4 - Discussion: The first part of the discussion section (until p 6367, L 3) reads like a nice literature review, which was missing earlier in the introduction section. I suggest replacing parts of it into Section 1. The test of model performance with clear water appears rather short. Since the model is tested against a rather simple water

flow, it might be interesting to add the theoretical analytical solution of the logarithmic velocity profile for steady uniform flow.

Hungr, O. (1995): A model for the runout analysis of rapid flow slides, debris flows, and avalanches. Canadian Geotechnical Journal 32, 610-623

Iverson, R. M. (2015): Scaling and design of landslide and debris-flow experiments. Geomorphology 244, 9-20 (doi: 10.1016/j.geomorph.2015.02.033)

Iverson, R. M.; Logan, M.; LaHusen, R. G. & Berti, M. (2010): The perfect debris flow? Aggregated results from 28 large-scale experiments. Journal of Geophysical Research: Earth Surface 115 (doi: 10.1029/2009JF001514)

Kaitna, R.; Dietrich, W. & Hsu, L. (2014): Surface slopes, velocity profiles and fluid pressure in coarse-grained debris flows saturated with water and mud. Journal of Fluid Mechanics 741, 377-403 (doi: 10.1017/jfm.2013.675)

McArdell, B. W.; Bartelt, P. & Kowalski, J. (2007): Field observations of basal forces and fluid pore pressure in a debris flow. Geophysical Research Letters 34, 4 (doi: 10.1029/2006GL029183)

Interactive comment on Geosci. Model Dev. Discuss., 8, 6349, 2015.