Interactive comment on **"Debris flow modeling at Meretschibach and Bondasca catchments, Switzerland: sensitivity testing of field data-based erosion model"** by F. Frank, B.W. McArdell, N. Oggier, P. Baer, M. Christen and A. Vieli

florian.frank@wsl.ch

Reviewer 2: Anonymous

General comments

The paper deals with bed entrainment for debris flows in Switzerland using numerical modelling. The topic is of interest for the Journal and the specific issues of this paper are relevant to scientists and practitioners. Some (mandatory) changes are required to improve the paper before acceptance. The list of specific comments and suggestions is given in the attached file.

Authors response: We are grateful for the helpful specific comments, especially literature citations which were not cited in the last version of the manuscript. These comments should substantially improve the manuscript. Please see our responses to the specific suggestions below.

Specific comments

Reviewer 2: Page 1, lines 23-24.

why this choice. Basal friction and bed entrainment are interplaying in natural processes. Why separate calibration?

Authors: We decided to first calibrate the runout of the model based on the total volume of the event and the runout distance, and then work with smaller initial volumes, then including the erosion algorithm, to refine the results. Our goal was to avoid a time-intensive iterative procedure, especially for the benefit of practitioners who generally do not have time to go through a long calibration process. However the model could also be calibrated by starting with small landslide volumes, so this is just a statement of how we performed the calibration.

Reviewer 2: Page 2, line 34.

you mean rheology?

Authors: This sentence would be better stated as follows: "Sediment erosion caused by debris flows causes flow bulking (in our case an increase in flow mass; Iverson 1997) which strongly influences the runout behavior of debris flows." We suggest to change it to clarify this.

Reviewer 2: Page 2, line 38.

quote also works of:

- Cascini et al. (2106) Eng Geol
- Cuomo et al. (2016) Eng Geol
- Cuomo et al., (2014) Canadian Geotechnical Journal

where bed entrainment is discussed as far as its spatial-temporal variation, and its interplay with rheology

Authors: Thank you for pointing out this additional literature, which we did not initially consider for this manuscript. However our focus in not on the rheology of the flow or changes in the rheology as a consequence of entrainment. As stated in the manuscript, we use the Voellmy friction relation and we do not adjust the Voellmy friction coefficients as a function of flow properties. However we propose including this as a discussion point, where we will be able to cite some of these publications.

Reviewer 2: Page 2, line 45.what is this? bed entrainment? you may also call erosion. But bulking process is hard to understand and not common in international literature.

Authors: The term "bulking" is commonly used in the literature to describe the increase in mass of a debris flow along the flow path ,e.g. see Iverson, R. M.: The Physics of Debris Flows, Reviews of Geophysics, 35, 245-296, 1997. doi: 10.1029/97RG00426, 1997, for a clear explanation in a paper which is very widely cited by debris-flow and landslide researchers throughout the world. A quick search on an academic search engine also indicates that "bulking" is commonly used in the debris-flow literature by authors from many countries outside of Switzerland, so we respectfully disagree with Reviewer 2 on this point. We realize that it may have other meanings in other academic disciplines, so we propose that we clarify the terms like this in the next version of the manuscript.

Reviewer 2: Page 2, line 55.

is there any difference?

Authors: Erosion removes sediment from the channel bed, bulking describes the increase in size (mass) of the flow, so the two terms are closely related but not interchangeable. As stated above, we will, in the next version, provide definitions of the terms.

Reviewer 2: Page 2, lines 57-61.

there are cases where neglecting erosion one may obtain unsafe future scenarios, as bed entrainment change the propagation pattern, and thus influence the global behaviour of the landslide. This is especially true for debris avalanches (not channelised). However, also for debris flows, including the entrainment helps obtaining better model estimates. See, for instance Cascini et al. 2014 Geomorphology

Authors: Thank you for pointing out this paper, which we will consider citing for the next version of the paper. We agree that including entrainment may help users to obtain more accurate predictions.

Reviewer 2: Page 2, lines 73-74.

add models by Pastor et al.. You may find applications in previous works of Cuomo et al.

Authors: Thank you for pointing out these additional papers, which we will cite, if appropriate, in for the next version of the manuscript.

Reviewer 2: Page 2, lines 76-79. Also line 165 (which does not have a comment, just a highlight).

are you using erosion, entrainment and bulking with the same content?

Authors: It is not clear to us if this comment is about the terminology or the differences in the bulk properties of the flow vs. the channel bed, so we will address both comments:

A. In our case, the bulking (increase in mass of the flow) produced by entrainment (the process described in the model which specifies how fast and where the additional sediment enters the debris flow) should be clear (also see our comments above regarding terminology). Net entrainment of sediment (erosion – deposition) results in net erosion of the channel bed (a decrease in the elevation of the channel bed), which can then be characterized in a spatial sense with a description of a pattern.

B. Although it is possible to specify a different mass density for the sediment that is entrained from the channel bed, to a first approximation the mass densities of the two are similar, at least in torrents which experience frequent debris flows. In more detail, the degrees of sorting and ranges of grain sizes in both the flow deposits and the channel bed are fairly similar. However the model accounts for differing densities, if such values are available.

Reviewer 2: Page 6, line 192.

turbolent factor. And, it is does not depend on v^2. rephrase the whole sentence.

Authors: Thank you for pointing out that this is not clear to you, we propose that we re-write the sentence in question.

Reviewer 2: Page 7, line 220.

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Authors: Thank you for pointing out the error in the reference number of the equation, we will fix that in the next version of the manuscript (it should be Eq. 6).

Reviewer 2: Page 7, line 221.

from where this value? / from where?

Authors: These values were described by Frank et al. (2015), however upon re-reading the paragraph above Equation 6, we realize that we should add more details in the next version of the manuscript. Additionally, we propose adding "Frank et al. (2015)" at the end of the sentence to make the origin more clear to the reader.

Reviewer 2: Page 7, lines 229-230.

check numbering of eqs

Authors: Thank you for pointing out the error in the reference to the equation, we will correct and verify all equation numbers when preparing the next version of the manuscript.

Reviewer 2: Page 9, line 281.

-2.5 ?

Authors: We agree with your suggestion we will also change the value to SI units, so -0.025 m/s, also for other occurrences of $\frac{dz}{dt}$ values in the manuscript.

Reviewer 2: Page 10, line 314.

how this was fixed?

Authors: The parameter ξ was determined by varying it within the range proposed by the developers of the RAMMS model (ξ = 100, 200, 400) and inspecting the results. The only realistic velocities (in the steep (≈60%) study reach of the Meretschibach channel) are obtained using ξ = 200 when combined with the variation of parameter μ (= 0.5, 0.6, 0.7). This is explained in the manuscript on page 10, lines 312-316. However to ensure that this is clear, we propose adding a sentence to clarify this procedure.

Reviewer 2: Page 13, line 432.

Alternative, but related definition is that of Hungr, i.e. landslide growth rate = Vfinal / Vinitial

Authors: Thank you for pointing out Hungr's definition. We will verify which metric are used in the other papers which we reference, and for the next version of the manuscript we will choose the most suitable metric (as well as cite Hungr's landslide growth factor).