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Geoscientific Model Development

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EDDA: integrated simulation of debris flow erosion, deposition and property changes

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We would like to thank Referee #1 for making thoughtful comments and constructive suggestions. We have carefully considered all the review comments and revised the paper to the best of our ability. Listed below please find our responses to the review comments. Both the review comments and our corresponding responses have been tabulated for ease of reference. The major changes are also highlighted in the revised text.

<u>Response to Comments from Referee #1:</u>

Reviewer's Comments	Response by the Authors
1. The authors stress that a change in the rheology in relation to changing concentration, can be significant which may be true. However whether that plays a major role in the run-out velocity or run out distance was not clearly demonstrated in the different tests. Comparisons between measured and calculated velocities are missing. Probably sensitivity analyses with the proposed model can at least as a first step demonstrate in a theoretical way the importance of the transient rheology.	Thanks so much for the suggestions. The flume tests in Tests 3 and 4 were reported in Takahashi et al. (1992). In their work, measured flow velocity is not available. Therefore, no comparison of flow velocity is made. However, the flow discharge at the outlet of the flume and the time-varying debris fan are compared in Test 4, which reflects the comparison of flow velocities to some extent.
	According to your suggestion, sensitivity analyses for erosion and deposition processes have been conducted in Tests 3 and 4 (P15 L26 and P17 L20).
	In test 3, with the increase of coefficient of erodibility, K_e, the erosion process becomes more intensive. For example, C_v reaches 0.46 when the flow marches by only 1 m if K_e is 3.5×10^{-4} m^3/(Ns); while C_v is only 0.16 when the flow marches by 4 m if K_e is 1×10^{-5} m^3/(Ns).
	In test 4, with the increase of δ_d, the runout distance decreases while the maximum thickness of the debris fan increases significantly, and most solid materials deposit near the outlet. When the debris flow

	runs out of the outlet, it decelerates gradually and deposition occurs. Larger δ_d values lead to faster deposition near the outlet. With the deposition process, the amount of the moving debris flow mixture decreases, leading to decreases in the kinematic energy and potential energy, and hence the runout distance of the moving debris flow.
	Therefore, erosion and deposition processes do significantly influence the property changes and runout characteristics of debris flow.
2. The discussion can be extended a bit. For example: how far this erosion module cover all the debris flow and entrainment processes of these debris flows: break through of landslide dams, cascading effects of dams, side wall failure by undercutting, bed failure. Also it should be mentioned that this model describes a special category of debris flows which are run-off driven. Debris flows originated from landslide failure is another category requiring a different modelling approach.	This capability of the model has been presented in Section 5 (P21 L7): "The model is suitable for describing the initiation and movement of debris flows originated from runoff-driven channel bed failure or breaching of landslide dams by overtopping erosion, which has been tested in this study. The model is also able to consider surficial material entrainment from collapses of bank material or detached landslide material as shown in the governing differential equations. But the latter capability has not been tested and further work is needed."
3. 7268/25 Explain these processes.	The process has been explained as follows (P2 L4): "Basal erosion, side erosion, and any other surficial material entrainment during the marching process entrain additional material into the flow."
4. 7269/14 Add also Medina et al 2008 and Quan-Luna et al 2009 who considers bed erosion as a Mohr-Coulomb failure process.	The suggestion has been well taken. The two references have been added in the introduction part (P3 L18) and the erosion and deposition part (P9 L24). "The Mohr-Coulomb failure process is adopted to simulate bed erosion (e.g. Medina et al., 2008; Quan Luna et al., 2012)." "Medina et al. (2008) and Quan Luna et al. (2012) consider bed erosion as a Mohr-Coulomb failure process." Medina, V., Hürlimann, M., and Bateman, A.: Application of FLATModel, a 2D finite volume code, to debris flows in the

	northeastern part of the Iberian Peninsula, Landslides, 5(1), 127-142, 2008.
	Quan Luna, B., Rema île, A., van Asch, T. W., Malet, J. P., and Van Westen, C. J.: Analysis of debris flow behavior with a one dimensional run-out model incorporating entrainment, Engineering geology, 128, 63-75, 2012.
5. 7284/13 Does the partition not disturb the entrainment process?	In experiment test, the partition may disturb the entrainment process. In the simulation, the influence of the partition on debris flow is neglected, and has been specified. "The partition and sampler are assumed to have no influence on the flow." (P15 L3) "the partition is assumed to have no influence on the flow" (P16 L7)
6. 7285 /13-29 Fig 13 How did you monitor the different phases in time of the deposition process?	The method is described in the text (P17 L4): "The flow depth, deposit thickness, debris thickness, volumetric sediment concentration, and flow velocity can be monitored for all cells. If deposition occurs somewhere, deposit thickness there will be larger than zero. The thickness of debris fan is the sum of the flow depth and the deposit thickness."
7. 7288/17 This is a bit strange that the Cv value at 1-1 is zero assuming no entrainment at all in the source catchment	Since Section 1-1 is upstream the main source material (Figs. 14 and 15), no erosion occurs there and Cv is hence 0.
8. 7308 Fig. 10 It is not clear how the debris flow is simulated. The figure suggests that the water "bumps" again the back side of the sediment I presume that this back side is protected by an impermeable shield and the water flows over the surface of the sediment. So a bit more detail here	Thanks for the suggestion. Fig. 10 in the last version is confusing and has been revised in the revised version as follows. The sediment stretches a little bit upstream, forming a small flat area. Water is supplied upstream to trigger the debris flow.

	(a) (b)
7309 Fig 11 Same question as for Fig 10.	Fig. 11 has also been revised as follows (a) (b)