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Discussions

Interactive comment on "Quantification of basal friction for glide-snow avalanche mitigation measures in forested and non-forested terrain" *by* T. Feistl et al.

Anonymous Referee #3

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This manuscript describes the quantification of basal friction for glide-snow avalanches in **non-forested** terrain (*'No avalanches were observed in forested terrain. (2952, 5)'*). A mechanical stauchwall model is used to estimate the basal friction of 67 observed glide snow avalanches. Additionally model results and field observations are compared to different European guidelines for mitigation measures (also in forested terrain). Topic and content of this paper fit well to the audience of NHESS.

The analysis includes an interesting data set of 101 avalanches of which 67 are suitable for model comparison. The collection of data is well described. For each

avalanche a categorization according to topography and vegetation is performed. With this, basal friction is linked to a roughness measure, taking into account the model calculation results.

The employed mechanical stauchwall model describes stress and strain rate in the stauchwall. The definition of a critical strain rate $\dot{\epsilon}$ allows to determine an avalanche release / stauchwall failure in dependence on basal friction μ, slope α and slab length l_m fixing other material constants (density ρ, elasticity E, viscosity η). However, the description of model calculations (i.e. section 3.2) and interpretation of results is somewhat confusing to me (see detailed comments below). I do not understand the evaluations concerning snow height h_s. The paper finishes with a helpful evaluation of European mitigation measure guidelines.

Overall the manuscript is well written with some exceptions concerning several (sloppy) technical formulations (e.g. 'lost ... forces' (2949, l. 9, 2954 l. 6) 'consuming the additional stress' (2949 l 17) 'transfer the lost tensile force into the ground' (2954 l 9) 'lost force is taken up by' (2954 l. 14), ...). However, the content is interesting and detailed comments can be found below.

Line-by-line comments:

- *2950, 26 'As the glide-snow avalanche model includes the important role of ground roughness – which is strongly influenced by the vegetation cover – we are able to quantify the friction of the ground cover of our test site'.* Formulation? I think you link the ground roughness of your test site to the coulomb friction which is employed in the model.

- *(2951, 20 '.... Release height was estimated with the snow height h_s measured at the meteorological station in Davos.* Generally, how is your snow height defined (slope normal or in direction of gravity?)? Why is the station data representative for all of your release areas? This is important, e.g. for *2952, 23 This allowed us to relate the observed heights to the calculated friction parameter*. How did you exactly determine l_g / distinguish between slab / stauchwall / (entrained) snow in the path (I think it is hard to define the end of a slab for a **ground avalanche** after release (even with time laps photography)?. What about days with bad visibility?.

- *2952, 0 'Segregation of avalanches'* Formulation.

- *2953, 6 '... Several events without stauchwall were neglected in further studies ...'.* Generally, do all events correspond to different locations or are there also multiple events (maybe with different slab length) at the same location? However, i do not see the relevance of the 101-67=34 avalanches for this paper.

- *2954, 4 '$m = \rho l_m$'* Should this not rather be mass per unit width and thus be $m = \rho\, h\, l_m$, compare also Bartelt et al. 2012. This is very important for your h_s evaluation.

- *2954, 14 'When the interface balances the lost tensile force, it is seen as an increase in the friction μ'.* Formulation?

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- *2955, 1 'The model predicts the total strain..'* This formulation is not clear to me. The relation of u and $\dot{\epsilon}$ is another (important) constraint!?

- *2955, 2 'When the strain-rates exceed a critical value, we consider the stauchwall to fail and an avalanche is released.'* This is a very important point/assumption and should be highlighted (earlier).

- *2956, 4 'In the model calculations we tested different snow types and snow heights to investigate the role these parameters had on glide-snow avalanche formation.'* Did you? I see that you varied density and height, which have an influence on the strain rate (and maybe then on the formation).

- *2956, 10 'Most releases in the Dorfberg study area where found on long grass (45 avalanches) and on low dwarf shrub vegetation (49 avalanches)..'* It would be more important how many of your 67 avalanches (which are actually important for the model comparison) are in which category.

- *2957, 18 'Snow height h_s (at the release) correlated only weakly'* How do you determine the correlation?

- *2958, 1 'stauchwall strength...'* You mean strain rate? What are your ranges for l_m, α and μ?

- *2958, 6 'We kept the material parameters...'* You should tell what values (and why!) you kept your material parameters constants. A short motivation why these values (and even the employed model) are chosen would be nice.

- *2958, 25 'The pressure on the stauchwall also depends on snow depth h_s'* Is pressure the correct term? If height of snowcover and stauchwall are the same, results should be invariant to changes of the snow height (Bartelt et al. 2012). In this context see my comment above.

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- *2959, 15 'Friction values between..'* Is this your model μ or a guideline μ ? Or are the μ employed in the same mechanical model? If not, you should include a description of the guideline model and watch your different μ_i.

- *2959, 16 'Observed terrain categories which are below stauchwall model calculation curves in Fig. 10 indicate lower ground friction than calculated.'* Below what? Please specify.

- *2959, 28 '...assume friction parameter ... '* See comment above, is this really the same model / μ? Provide more details on your employed guideline models (e.g. 2949, 21 − 2950, 8). You plot them anyways in your figures.

- *2961, 5'..predicts failure or resistance depending on the slab length, snow height, snow density and ground roughness...'* Formulation? Ground roughness is not a model parameter.

- *2961, 6 'We defined a critical strain rate which in turn defines the maximum slab length and slope angle allowable to prevent glide-snow avalanche release.'* This is very important and should be stated earlier in more detail.

- *2961, 8'...The model results...'* You should also state that you did not test for the other model parameters (elasticity E and viscosity η)

Figures:

- Fig. 1: For a better understanding of the paper it would be helpful to include your different l measures in this picture.

- Fig. 8: You should state what correlation measure R^2 is.

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- Fig. 9: Is this really the dependency of μ on l_m and α or rather combinations of the three that lead to a strain rate $\dot{\epsilon}$ greater than your critical value?, see also *2956 2 'Different friction parameters μ were applied in the model calculations. By comparison we could quantify the friction values we observed in the field.'*

- Fig. 10: The colors (yellow, light and dark green) are a bit hard to distinguish, maybe different colors and symbols would help?