

Dear Referee 3,

thank you for reviewing our article. Your remarks will help a lot to improve this article. You raised important questions, which we will try to answer in the point-by-point replies below.

Specific comments:

Pag. 2950, line 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.

>> We will change the sentence to '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 link the observed terrain roughness and ground vegetation to specific Coulomb friction values'.

*(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 / stauwall / (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?.*

>> We changed 'snow height' (perpendicular) to 'snow depth' (vertical) throughout the paper according to the European Avalanche Glossary, http://www.avalanches.org/en/includes/glossary/glossary_en_all.html#n106. See also comments to referee 1. Snow depth was measured in Davos (1560 m.a.s.l.) and on the Dorfberg on an elevation of 2150 m.a.s.l. We analysed both datasets to find a relationship between snow depth, slope angle and slab length. The correlation was only weak for slab length ($R^2=0,11$; see figure 8) and no correlation between snow depth and slope angle was found. The snow depth at the Dorfberg station was always between 20 and 60 cm higher than in Davos. But the result of our analysis was similar: no clear correlation. We chose the data from Davos because the snow depth in the release areas was smaller than on the flat field station on the Dorfberg. The release areas were all exposed to the sun, therefore we assume the measurements from Davos to be closer to reality. Of course there is an uncertainty, but we assume the measured snow depths to be representative, at least for our qualitative results.

You mention page 2952, line 23 in this context. In this paragraph we talk about terrain height h_t and vegetation height h_v , not about snow depth h_s . Maybe this is clearer now, that we changed 'snow height' to 'snow depth'.

The definition of the release length l_g was precise as the stauwall is fixed to the ground and a rest of snow stays fixed, even after release. The release areas without snow (brown underlying surface) were always clearly distinguishable. You are right, that an exact

definition of the stauwall area was hardly possible, therefore we followed observations, that the stauwall length l_s is approximately twice the snow depth h_s (page 2958, line 25). On days with bad visibility the first visible picture of the slope was used to document the release areas. All avalanches were documented within a few hours after release.

Page 2952, 0 'Segregation of avalanches' Formulation.

>> See comment to reviewer2: we will replace segregation with selection.

2953, 6 '... Several events without stauwall 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.

>> There were also some events at the same locations with different slab lengths and extent at different times.

We draw general conclusions from all avalanche events concerning the main vegetation and terrain types and their specific heights (section 3.1). More events lead thereby to stronger statements. For our comparison of avalanche events with model calculations we could only use cases with stauwall (section 3.3). Therefore we made this distinction.

2954, 4 'm = ρ l m' Should this not rather be mass per unit width and thus be m = ρ h l m, compare also Bartelt et al. 2012. This is very important for your hs evaluation.

>> You are right here; the formula should be: $m = \rho h s \cos \alpha l_m$. We will change that.

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

>> We will delete this sentence, because it is a repetition of line 7. We will include 'μ_m' in line 9 to clarify the denotation.

2955, 1 'The model predicts the total strain..' This formulation is not clear to me. The relation of u and ε̇ is another (important) constraint!?

>> We will change the sentence to: 'The model predicts the strain rate $\dot{\epsilon} = u/2l_s$ in the stauwall. The total strain ϵ and therefore total deformation is calculated by summing the strain-rates at every calculation step with length Δt :

$$\epsilon(t+\Delta t) = \epsilon(t) + \dot{\epsilon} * \Delta t'$$

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

>> We will include 'The avalanche releases if a critical strain-rate is reached.' in line 7 on page 2954.

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).

>> Good point. We will change the sentence to 'In the model calculations we tested different snow densities and snow depths to investigate the role these parameters had on strain-rates and therefore glide-snow avalanche 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.

>> This is a general observation and we think it is important to mention the total number. We will include a sentence in line 11 on page 2953: 'Of these 67 events 31 released on compacted long grass, 4 on upright short grass, 31 on low dwarf shrubs and one on strong lignified shrubs.'

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

>> In the caption of Fig. 8 the coefficient of correlation is written ($R^2=0.11$).

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

>> Yes, strain rate, we will change 'stauchwall strength' to 'strain rate'. The range of μ is written in line 10 on the same page ($0.33 < \mu < 0.81$). The tested slab lengths l_m (30m, 40m, 50m, 60m) and slope angles (30° , 35° , 40° , 45°) are clearly depicted in Fig. 8.

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.

>> You are right! We will include the sentence 'The material parameters and the critical strain rate were defined according to the work of Von Moos et al. (2003), Scapozza (2003) and Bartelt et al. (2012).'

 and include the values of the material parameters in line 6 ($E_m = 1.5 \cdot 10^8$, $E_k = 1.5 \cdot 10^7$, $\eta_m = 1.4 \cdot 10^9$, $\eta_k = 2.5 \cdot 10^6$). These values are typical for snow densities of around $\rho = 250 \text{ kg/m}^3$.

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.

>> Results are not invariant to changes in snow depth. The mass of snow m depends on the snow depth. What we want to stress here is, that variations in snow depth have only a small influence on model results which is an important result. Glide-snow avalanches release almost independently of the snow height. The temperature of the snow-soil interface (melt-water accumulation) and ground friction are much more important parameters. Snow depth influences the compaction of shrubs and other large growing vegetation and therefore maybe has an influence on the ground friction but we did not find a clear correlation.

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 .

>> We will follow your suggestion here and include a short description of the model used for the guidelines in Switzerland in line 7 on page 2950. The μ is defined as 'angle of friction' in

the guidelines. We will denote this μ with μ_d to account for the different usage and the model ' μ ' to ' μ_m ' throughout the paper.

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

>> We will change the sentence to 'A lower ground friction of the observed events is indicated if the length $l_m + l_s$ of the three terrain and vegetation categories is lower than the model calculation curves in Fig. 10'. We hope this is clearer now.

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

>> see comment above.

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.

>> We will replace the expression 'ground roughness' with 'basal friction'.

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.

>> See comment above.

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

>> We will include a sentence stating that: 'The material parameters elasticity E_m , E_k and viscosity η_m , η_k were kept constant.'

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

>> We will follow your suggestion and include l_g and l_s here.

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

>> We will include 'coefficient of correlation' to clarify that.

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.*'

>> We will include '...for a critical strain rate $\dot{\epsilon} = 0.01$ ' in the first sentence.

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

>> see reply to reviewer 1. We will change the colors and symbols.