Dear Alejandro Casteller,

thank you for your comments and suggestions which will help us to improve our manuscript. Point-by-point replies are given below.

SPECIFIC COMMENTS:

Lines 18-19: Mountain forests are an effective biological protection measure against what?

>> We will add “against avalanches”.

Lines 59-60: which cases?

> > “Both cases” is related to the “small- to medium-scale avalanches” case and the “large-scale avalanches” case as described early in this paragraph. We think the argumentation is clear enough and would like to not explain it again in order to avoid repetitions. We hope that you agree.

Line 72: I believe citing a paper that is in preparation (Bovet et al., 2013) is not appropriate.

>> We think that this is okay since we have seen it in other NHESS publications, e.g. in the cited paper of Fischer (2013).

Line 92: define "manually"

>> “Manually”, in contrast to automatically, defines a manual and partly “optical” (image) interpretation, discussion and comparison of two-dimensional avalanche simulation results with observations. Since we refer to studies were two-dimensional simulation results were extensively discussed in that manner, we prefer to not define “manually” in the manuscript. We hope that it is clear that we applied with AIMEC an automatic analysis method. For details and a discussion of methods to analyze two dimensional model outputs see Fischer (2013).

Lines 103-105: this is an awkward sentence, as the reader might interpret this as a prerequisite of your methodological approach, when in reality it seems to be a description of the avalanche dataset.

>> It is the description of our dataset. We will rephrase the sentence: “The avalanche dataset employed to evaluate and operationalize the detrainment function proposed by Feistl et al. (2014) consisted of 40 avalanches which all started in forests. These small- to medium-scale forest avalanches either stopped in forested terrain within 50 to 400 m or ran through forests and stopped in unforested areas with a maximum runout distance of 700 m.”

Lines 149-151: and how do you arrive to this assumption?

>> For an answer to your question see also the reply to Margherita Maggionis comment to Line 149-151: Your concern is an important issue to discuss and needs further investigation. However, since the simulated avalanches all started in forested terrain, we assume that the mass removal behind trees starts immediately after the avalanche is released (see also Teich et al., 2012a) and that, therefore, detrainment is the predominant process. This assumption is also based on the numerical experiment performed by Feistl et al. (2014); however, we are not able to discuss this in more detail based on our dataset. Another reason why entrainment was not accounted for: The detrainment approach is only valid for small- to medium-scale

avalanches where the forest is not destroyed and the trees act as obstacles. When trees and other woody debris are entrained in the flow, they can become entangled in tree stands, leading to a complex flow state that is difficult, if not impossible, to model. The model results are sensitive to the selection of the starting mass, snow characteristics, the size and location of the release zone, entrainment processes and terrain features (which might be modified by avalanche deposits). However, this is a general problem in the simulation of small- and medium-scale avalanches. For a detailed discussion on the detrainment modeling approach see Feistl et al. (2014).

Line 183: what kind of orthophotograph analyses?

>> Vassella (2012) overlaid the DEM and the digitized starting points of the avalanches as well as the release width with old geo-referenced aerial photographs taken previously to the avalanche events and checked for larger forest gaps or less dense forest structures to delineate the release areas. The specified release areas were verified with photographs taken during field observations shortly after the avalanche events. However, we prefer to not include additional information in the text and refer to Vassella (2012) for further information.

Lines 202-204: so to determine the stage of development of the forest you need to make direct field observations of selected trees? I believe the age of the forest is not necessarily represented in its vertical structure, particularly for kummholz-type trees, which are typically found in the treeline.

>> We agree that a relation between the age of a forest and its vertical structure is not necessarily the case. However, for our dataset, the stage of development is defined by its estimated DBH distribution (see Table 1) and was correlated significantly with the vertical structure (see Table A2). Since this is not always the case, we wrote “somewhat”. However, we will rephrase these Lines and delete the link to the age of the forest: “The stage of development indicates the mean stem diameter distribution, which is, for our dataset, also represented by its vertical structure (Tables 1 and A2).” Krummholz-type trees are not considered, since they are not defined as “forest”. Here, Forests are characterized by a maximum distance between trees of 25 m, a minimum canopy density of 20%, and a dominant height above 3 m. We will add this definition to the manuscript, if needed.

Line 219: which is the RAMMS version you are referring to?

>> We employed RAMMS::AVALANCHE Version: 1.5.01 (c) WSL/SLF; we will specify this in the manuscript in form of a footnote at least.

Lines 230-231: these three parameters are not the same as the ones mentioned before and is thus confusing for the reader.

>> See reply to Margherita Maggionis comments: we will delete “such as forest density, age or undergrowth”.

Lines 240-242: measured or estimated release heights?

>> Mainly measured release heights. See also reply to Margherita Maggionis comment to Lines 189-192: Release heights were measured in the field for 38 out of 40 observations. Only for two avalanches (#39 and #40) release heights were estimated but not measured based on field visits in combination with measured snow and weather data. We will add this information to the revised version of the manuscript. We will delete “measured” at Line 241.

Lines 445-448: I would not say that the detrainment coefficient K "controls" the amount of snow caught behind trees (...) but rather that is associated with it. Rephrase.

>> We will rephrase this: "The aim was to evaluate and improve the forest detrainment function (Eq. 6) and, therefore, to quantify the detrainment coefficient *K* which is associated to the amount of snow caught behind trees in the avalanche path."

Lines 451-455: wouldn't it then be by "decreasing" friction in this case or large avalanches that incorporate trees on their way?

>> To answer your question, we refer to Feistl et al. (2014) who discuss the differences between the friction approach and the detrainment approach in detail and also performed a numerical experiment simulating forest avalanches of different sizes with both approaches. They state: "…in the current version of RAMMS, coefficient ξ [for forested areas] is assumed to be 400 m s^{-2} (significantly smaller than the open-terrain value of 2000 m s^{-2}); coefficient μ is only slightly increased (Gruber and Bartelt, 2007). These values are based on energy arguments in which different failure modes (tree overturning, trunk fracture, entrainment of woody debris) extract flow energy from the avalanche (Bartelt and Stöckli, 2001). The fundamental assumption in this approach is that the avalanche is both large enough and fast enough to induce tree failure." For references see manuscript.

Line 520: I think that only 2 avalanches are a very small dataset to evaluate your derived k-values.

>> We agree; however, the case studies are more a first test of our *K*-values rather than verification. Therefore, we never specify this testing as verification, but think the examples are a good illustration of the significance of our study. At this point, no more observations were available, but RAMMS including the detrainment function is currently tested by practitioners based on the results of this study.

TECHNICAL CORRECTIONS:

Line 49: Bebi et al. 2009 is not listed in the References.

>> See also reply to Margherita Maggionis comments to Line 49. We will add the reference: Bebi, P., Kulakowski, D., Rixen, C., 2009. Snow avalanche disturbances in forest ecosystems - State of research and implications for management. Forest Ecology and Management 257(9), 1883-1892. to the Reference list.

Lines 110-169: I believe point 2 should be included in the Material and methods section. I am not a physicist, so I am not able to determine if the formulas presented here are correct.

>> See also reply to Margherita Maggionis comments on the structure of the manuscript: We will move Section 2 into the "Material and methods" sections as suggested. Moreover, we will rename the heading "Theory" in "Avalanche modeling in forested terrain" as well as merge the two Subsections "Avalanche flow model" and "Improved avalanche modeling in forested terrain" into one section. With the revised structure, we try to direct the focus on the simulations and their analysis and, therefore, on the subject of the presented study.

Line 429: check year of reference (is it 2010a?)

>> See also reply to Margherita Maggionis comments to Line 429: We refer to the reference Christen et al. (2010a) and will clarify this in the revised manuscript.

Line 484: the complete last name of this author is Vera Valero, as stated in line 711.

>> We will add the complete last name “Vera Valero” in the revised version of the manuscript.

Lines 589-591: not cited.

>> See also reply to Margherita Maggionis comments to Line 589: The reference Bartelt and Stöckli (2001) is cited at Lines 55, 65-66, 452-453 and 455. However, we will carefully check the reference list and the citations in the text.

Lines 622-625: I would place reference 2010a above 2010b.

>> Thank you for this correction. The references were already switched in the online version of the discussion paper.

Figure 5: please enlarge this figure.

>> We will ensure that all figures are large enough in the final version of the paper.