

Nat. Hazards Earth Syst. Sci. Discuss., referee comment RC3
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Comment on nhess-2021-289

Anonymous Referee #3

Referee comment on "Detrainment and braking of snow avalanches interacting with forests" by Louis Védérine et al., Nat. Hazards Earth Syst. Sci. Discuss.,
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The manuscript "Detrainment and braking of snow avalanches interacting with forests" by Védérine et. Al. is a computational study on how detailed numerical modelling approaches can contribute to investigate how gravitaitonal mass flows interact with obstacles. The forest (obstacles) can offer a protective effect which reduces the size or frequency of avalanches by stopping the formation of avalanches or reducing the magnitude of an event. This work focuses on quantifying the mass and energy reduction capabilities of forest (detrainment and braking) in the transit zone of a small or medium sized avalanches by detrainment, which reduces the kinetic energy of the avalanche by removing mass.

The work highlights the possibility of using purely numerical methods (MPM) to quantify the potential effect of forests and parameterize the forest snow interaction within simple relationships of terrain (slope), flow (velocity) and forest parameters (density). The simulation experiments were carried out on a generic slope with a constant slope angle, examining the influence of mainly avalanche type/velocity and different forest formations/density with respect to mass/energy reduction. The parameters of the MPM avalanche model are defined by prior experiments to resemble the behavior of colder to warmer flow regimes and calibrated with regards to snow forest interactions based on a single documented field observation. The single event validation could be considered as weakness of the study. However it is known that corresponding data is sparse – but it would be interesting to comment on other the possibility of other parameter combinations that might lead to similar results, or how they would change for another observation example. Another clarification would be desirable for the definition (and numerical implementation) of detrained mass (see specific comments below) in the MPM model and how changing boundary conditions (slope angle) would influence the results.

Generally, the manuscript is well written and well organized, providing suitable figures and supplementary material. Some possible enhancements include the figures in the energy analysis and the consistency between equations and figures (e.g. fig 5, "velocity" = " v_f " in eq. 7, more examples in the specific comments (e. g. Fig 10)).

Specific comments:

- l 11: "wet compared to dry snow": Since this is a numerical study i would suggest to rephrase (or is there evidence in field observations?): "for the parametrizations of cold to warm snow"
- l 36: What about the study of "BroÅ¾ová, N., Fischer, J. T., Bühler, Y., Bartelt, P., & Bebi, P. (2020). Determining forest parameters for avalanche simulation using remote sensing data. *Cold Regions Science and Technology*, 172, 102976 (11 pp.). <https://doi.org/10.1016/j.coldregions.2019.102976>". Does it relate or include relevant data to evaluate the results of this study?
- Table 2 "Case 1..3": I think it could be beneficial to name the cases "cold/intermediate/warm" here and throughout the paper to make it easier for the reader (and please check consistency of warm/wet and cold/dry throughout the paper).
- l 143, "some arches appear in case 3": Can you comment on how "arches" (surges?) are defined in this context?
- l 165 "detainment mass": Does this mean snow is considered detrained if its velocity < 0.5m/s and adds to "M_stopped" – how does it relate to (frictional) stopping – are these numerical of flow model quantities? A clarification on the definition of "M_stopped" seems to be crucial for the paper and could be included at this point, particularly the difference between "stopped" (Fig 5), "maximum" and "final" (Figs 5,6) or "stored" (Fig 7). Please also check the corresponding units [kg] or [kg/m²] used for "M_stopped".
- l 192: Does maximum detrained mass refer to the maximum over time (detrained snow = $v > 0.5\text{m/s}$?, see comment above)?
- l 214: Should this not be p_3 and p_4?
- l 243: This sentence is confusing, please clarify: decreases linearly, as function of ..?
- l 281: Is the statement that the random distribution has a higher protective effect valid after checking one specific distribution?
- l 301: Please double check the argument with low/high velocities.

Equations:

- Why Is "." Sometimes used as mathematical symbol for multiplication in the manuscript (e.g. eq. 7-11)?

Figures:

- Fig 2: "d" and "e" are used twice once for tree diameter and spacing and once for the forest arrangements. "snow profile" should rather be "vertical velocity profile"?
- Fig 6: legend wrong? 3.5 and 3.4 are the ones in Feistl et al. And eq. 3.4 is the same as eq.8?
- Fig 7: is this for case 2?
- Fig 10: is "M_d" from MPM the same as "M_stopped" in the previous figures (same,

"M_d" from eq. 11 = "m_d"). What kind of r^2 is used? Is it possible to comment on how the different cases (1-2) are distributed in this figure?

- Fig 11: Do both avalanches reach the bottom after 9s (effect of forest on front velocity)?