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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Modelling wet snow avalanche runout to assess road safety at a high-altitude mine in the central Andes" *by* C. Vera Valero et al.

Anonymous Referee #1

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Wet snow avalanches are getting more important as the global warming is in progress. Based on this background, the authors have already developed the wet snow avalanche model and confirmed its validity for the several cases. Then, in this manuscript, they applied the model to the situation at the mining in central Andes. I remember the authors submitted the manuscript entitled as "Point release wet snow avalanches", that included nearly the same contents to NHESS last May. At that time I sent the comment that it was not matured yet for the publication. Comparing to the previous manuscript, this version has been improved substantially; the model is described much more in detail and the discussion part was expanded largely. As a matter of fact, almost the same explanation of the model is also found in Valero et al. (2015),

this part can be shortened if the total volume became too large. Physical processes which may happen in the wet snow avalanches are carefully taken into account for the model construction. Probably showing the way we should take. However, the main purpose of this manuscript is not the model development, but the application to the snow avalanche safety for the he specific valley. This manuscript introduces the very well documented data sets of the wet snow avalanches. Data themselves are also very valuable. So, probably it might be a good idea to split all the contents into two. First one introduces the observed wet snow avalanches and analyze the releasing conditions more in detail with obtained meteorological data and the SNOWPACK analysis. Then, the second one discusses the aspect of avalanche movement, utilizing the model output. Not only the latter approach but also the former one is essential for the comprehensive snow avalanche safety. Wet snow avalanche model shown here strongly relies on the input parameters, in particular, the snowpack properties from the releasing point to the deposition zone. In fact, i the conclusion part (line 623), authors note that the avalanche model requires the fracture depth, snow temperature, snow density and water content in the release area and along the avalanche path. Thus, at any rate, authors need to show how the SNPOWPACK worked properly enough to express the snow condition. In line 85, they say that the SNOWPACK model results were validated with field measurements (snow pits) performed by the winter operation crew. It should be shown specifically in the manuscript. When the SNOWPACK performed well, the output is applicable to determine the snow stability for the wet snow avalanche release, that is much more direct and necessary information for them. As is mentioned above, when the SNOWPACK model is utilized for this approach, the warning from this aspect will be also possible. As is also commented for the previous manuscript, I am a bit anxious whether the depth-averaged shallow water equation model is able to describe the avalanche motion precisely on the steep clip as is shown in these examples. Furthermore, since this is the continuum model, usually the flow keeps going for the long period. Is there any stopping criteria in this model and definition in the model procedures for the issues called as "dry/wet problem"? How did you determine the initial snow depth on the avalanche track? It looks far from uniform according to the figures in the manuscript strongly depending on the topography. As you see, the re-distribution of snow by the wind will be the key issue. Needless to say, initial snow depth distribution gives the strong effect not only on the basal friction but on the erosion mass. I wonder the authors introduced ARPS as well as SNOWPACK models, and utilized to estimate the initial snow depth distribution. If it is not included in the initial condition, the following calculation sounds meaningless. As you see, snow properties, such as dry or wet, are far from satisfactory.

Following inquires need to be also addressed.

Figs. 6 to 10: SNOWPACK simulations shown here are for the releasing zone or somewhere else? Further, please describe the reason why you could conclude the SNOWPACK outcome is accurate enough for the input data of the avalanche simulation. Comparison with the pit observation should be displayed. Densities plot shown in Figs. 6 to 10 are total ones in which the water is involved in?

Fig. 10: If you could use the drone and take pictures, as you may see, the DEM for the target area and the volume of the released and deposited snow can be deduced with the software of "photoscan" . It will be very much useful when you verify the simulation output.

Table 3: This table is not necessary, because all the parameters except for ïĄąïĂăare the same for the five examples. I am wondering these nine parameters are completely enough to designate whole avalanche behavior and no other arbitrary parameters are involved in the model. No fitting parameters remained.

Line 447: " Calculated runout distances are in good agreements with the GPS measurements. . ...": It is probably a good idea to summarize in the table, Since the model output shown in Figs 6 to 10 are rather qualitative and detail are not clear.

Line 460: Perhaps it might be a trivial issue, but I am curious what caused such differ-

ences in the spreading? Do you have any idea how you can improve this issue?

In case of the point release avalanche, strictly speaking, it started from the specific point of the snowpack. How did you determine the initial volume? Assuming the triangle area, as is shown in the figures, maybe helpful but looks highly arbitrarily.

Fig.11: The outline of the deposits, observed by the winter operation crews, should also indicated in the figure and compared with the model output.

Fig. 12: Are there any specific reasons why the temperature shown in red becomes nearly steady sate at around -0.15 C (not 0C), even though the air temperature is substantially high and snow contains the melt water?

Fig. 13: LWC and random kinetic energy seem to correlate more or less each other. However, the relation between the friction and the LWC is not always the case. What makes such difference? Such arguments are essential in the discussion part because the models are developed in usual to recognize what is happening in the real snow avalanches; that is hard to get the information from the observations.

Fig. 17: According to my experiences, the dry snow avalanche runs longer distance with higher speed than the wet one in usual. I understand that the lubrication process plays an important role for the wet snow avalanches in particular, for the water saturated slush flows on the smooth rock surface. However, as is recognized on the figures the debris are not clean and apparently include the mud. That means the avalanche ran down over the ground, not the smooth snow surface. Do you have any idea what made such discrepancies with the conventional knowledge?

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