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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Role of friction terms in two-dimensional modelling of dense snow avalanches" *by* Marcos Sanz-Ramos et al.

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Comment 1 Congratulations on this research and development of this very useful tool. It is of great interest for practitioners to spread the tools for granular flows analysis in a well-balanced way: realistic physically based and easy understand and use. (Line 541): I completely agree that 2D models are useful for avalanche hazard analysis and assessment.

Comment 2 It is very promising the implementation of these 3 friction terms in IBER, not only both original of Voellmy-Salm model. (Line 45): If I understood correctly, it could be said that the stopping criterion based on momentum (user-defined fraction of achieved maximum momentum as lower threshold) corresponds to a macroscopic point

of view, which stops whole calculation. In contrast, the additional friction term related to snow cohesion is a real physical snow property, which has an effect of retention and can stop the avalanche locally, where is needed due concavity or other issues along the avalanche path. Daring suggestion: the friction–cohesion model could be called Voellmy–Salm-Bartelt friction model. Even more, if we want to summarize the evolution in such avalanche models, it could be used also the name Voellmy-Salm-Gruber-Bartelt snow avalanche model.

Comment 3 It seems that cohesion term plays a main role where the slope changes rapidly. Is that right? In the paper, only a real avalanche case is tested. It will be very interesting to see further examples, and I suggest testing run-up problems, for instance with a protection dam. Keeping in mind the hydrological origin of IBER it will be of great interest the analysis of avalanche dynamics across a concrete dam placed on a channel in a gully part of the path still in steep terrain. These are typical solutions of the first half of XXth century in the Pyrenees. Under these conditions, the effect of the dam is the lamination of the flow pulse, not only the deposit of part of the mass. How is that reproduced by IBER? Does the cohesive-friction term play an additional effect of velocity reduction, that could be critical in this kind of configurations?

Comment 4 Another avalanche case that could be interesting and useful for testing the application of avalanche formulation in IBER is the catastrophic avalanche sequence in Sewell (Chile). The avalanches occurred in 1914, 1926, 1941 and 1944 offer different scenario: wet and dry snow conditions, run-up or deflection, etc. (Line 106): IBER uses a first-order Godunov-type upwind scheme for convective fluxes and the geometric slope source term, in particular the Roe scheme, and a centred scheme for the turbulent diffusion friction source term. Therefore, the scheme achieves balancing of the bottom slope source term with the flow tensor, thereby avoiding spurious oscillations of the free surface and retaining quiescent water even when working with complex irregular geometries. According to that, it will be interesting to explore if run-up problems need some variation in these schemes, or they are already properly solved.

Comment 5 (Line 106): “IBER solves the described 2D-SWE through a conservative finite volumes scheme and on unstructured meshes of triangles and quadrilaterals.” This could be a stong point for IBER in avalanche analysis, allowing a better description of topography roughness, channels... in comparison to the raster based models.

Comment 6 (Line 101): “IBER was initially developed for hydrodynamic and sediment transport simulations. . . Iber has been recently enhanced to simulate snow avalanches and a specific numerical treatment of the friction–cohesion model was implemented to adapt it to the particularities of the numerical scheme used by Iber.” As far as Iber is used for flooding risk analysis, it will be a natural way to make easier the implementation of debrisflood and debrisflow scenarios in such studies. Are you planning to apply Iber to debrisflow?

Comment 7 (Line 180): When you mention the Avalanche Database of Catalonia (BDAC) could be referred to the reference: https://www.researchgate.net/publication/318724068_THE_AVALANCHE_DATA_IN_THE_C https://www.researchgate.net/publication/318723626_AVALANCHE_MAPPING_IN_THE_CA

Comment 8 Is Iber able to consider friction parameters varying along space/time? It could be a next step? For instance, in a wet avalanche, friction parameters increase at deposition zone... In case 3, could this fact improve the result reducing the lateral spreading in the east part of deposit?

Line 418: to reproduce slab avalanche it is also possible to introduce higher value for cohesion at initial steps?

Comment 9 Line 406: “1. The pivoting point of the free surface is the same for all simulations, maintaining the length and depth positions in approximately 5 m and 0.9 m, respectively.” What is the sense of this pivoting point in Fig. 12? Is it related to the instability degree in the starting zone (balance of topographic slope and friction slope)? If Kp factor is influencing the inertia term at the begining, it could have a big influence on tiny avalanche simulation?

Comment 10 I've found 2 minor errors: Figure 13: the caption says kp=0,5 instead of 0,1 Line 430: xi=2000 is also considered and shown in the figure 13

Comment 11 Line 500: Gaume et al 2019 are implementing the Material Point Method, which is specially able to describe both the initial instability and movement generation, and also the large scale deformation along the path, considering 3D variability of variables. With 2D-SWE it is clearly not possible to deal with the initial part (describing the activation of movement) ... But it is not necessary for common hazard analysis, where instability is defined by the scenario and the interest is focussed at the bottom of the slope where facilities are placed.

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