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Does cohesion improve the accuracy of runout of hillslope debris flows? A systematic comparison using well-documented events in Switzerland.

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Mass movements such as hillslope debris flows are a significant hazard for people and infrastructure in mountainous areas, necessitating hazard mapping and other protective measures. Therefore, knowledge of runout distances and areas affected by hillslope debris flows is a key issue. Simulation models like RAMMS-Debris Flow are helpful tools to estimate possible travel lengths and the affected areas. The Voellmy friction relation, used in RAMMS and in other mass movement runout models is typically easy to calibrate using historical data. The RAMMS debris-flow runout model is based on a depth-averaged 2D solution to the equations of motion for debris flow runout over 3D topography (Christen et al., 2010). A new friction approach being tested by the WSL, within the RAMMS model, includes an additional cohesion term (equivalent to a yield-stress term) to the Voellmy friction relation. This approach apparently improves the accuracy of runout prediction for snow avalanches (Bartelt et al., 2015) and debris-flows (Berger et al., 2016). However, it has not yet been tested for application to hillslope debris flows. Hillslope debris flows may be different from channelized debris flows because they are unchannelized, have small volumes and comparably small flow depths, they may contain large particles of vegetation-bound soil, and they are often considered to be not fully saturated. Herein we describe a systematic evaluation of the Voellmy+Cohesion friction relation in RAMMS using 19 well documented hillslope debris flow events that occurred in 2005 and 2012 in the Entlebuch and Eriz regions in Switzerland. All 19 events were modelled with the RAMMS-Debris Flow-Model (version 1.6.65) by using cohesion data which was derived from soil samples. These simulation results are compared with the observed runout area and additionally with simulations without cohesion. The results show that the cohesion used in RAMMS was more dependent on the values of the friction coefficients than on the triggering event, the volumes or the soil classification. Consequently, the cohesion in the model behaves like a constant value depending on the magnitude of the other friction coefficients. Compared with modelling using the standard Voellmy friction relation (without cohesion), the simulation results showed no general improvement in modelling the inundated area. However, in some cases a more realistic simulation of the runout area was observed using a small cohesion value. Furthermore, a slight correlation between the measured silt and clay content in the soil samples and the calibrated cohesion values was found for simulations neglecting the friction parameters.

References:

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