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Comparison of a 2D dynamical model with an empirical GIS-based model for debris flow runout and varying DEM grid sizes

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Modelling is an important tool for assessing hazard potential from debris flows, yet there are few studies that compare the corresponding performance. The objective of this study is therefore to evaluate and compare two models for two specific case studies. We systematically tested the influence of varyingly spaced digital elevation models (DEM) on model results and further how protection structures (e.g. retention basins and deflection dams) influence flow characteristics.

We used two different 2D-flow models. RAMMS is based on a modified Voellmy-Salm friction relation incorporated into a hydraulic model based on the shallow-water equations which have been extended for granular flows. The MSF model is a strongly topography-based GIS model that describes the probability of a flow following different flow paths. Both predict the area of inundation, whereas RAMMS in addition is able to calculate flow height or velocity of the moving mass.

In this study we investigated two well-known debris flow events in the Swiss Alps. The first one occurred in October of 2000 in Fully (Valais) and mobilized 250’000 m^3 debris, which devastated among other things several acres of vineyards. The second event occurred in October of 2005 in Guttannen (Berne), where half a million cubic meters material was eroded and subsequently deposited on an important mountain highway and a river. Consequently a village was flooded.

Three different DEMs with grid spacing of 25, 10 and 2 m were used in conjunction with both flow models. Generally, we can state that both flow models are capable of replicating the debris flow events to within a given degree of accuracy. For both flow

models the 25 m DEM is not accurate enough to delineate areas affected by debris flows in order to be useful for hazard mapping. In contrast, calculations with 10 and 2 m DEMs predict the inundated areas relatively accurately. The simulated debris flows follow the existing channels and are in accordance with observed dispersion and deposition patterns. The improvement of the results by using a 2 m instead of a 10 m DEM was not essential. The main flow was even with one 10 m grid cell correct modelled.

In Fully we tested the influence of a retention basin and a deflection dam built after the event on flow behaviour in contrast to the original topography. With RAMMS the effectiveness of the protective measurements were mainly confirmed, because not only the deflection but also the retention volume is calculable.

Generally, MSF is useful for first rapid assessments because of its simple structure and short calculation time. RAMMS instead is more detailed and thus more delicate to apply. However with a known input parameter span the model provides reasonable estimates of flow behaviour.

The modelling of multiple flow surges is a challenge for both models. Particularly, erosion on debris fans, such as the case in Guttannen, that strongly determine deposition areas and debris flow behaviour, is not yet feasible to simulate with these models.

The study shows that for a reliable assessment of debris flow hazards, it is important to systematically evaluate models. DEM grid size plays an important role for model outputs. Nevertheless, both models could simulate debris flow events and the influences of protection measurements accurately for the test sites and provide essential information for hazard mapping.