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Numerical runout-simulation of small debris avalanches in the Faroe Islands by use of DAN3D

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A key element in risk assessment of flow-type landslides is the analysis of landslide runout behavior. In the past two decades, several numerical models have been developed for simulating landslide runout behavior in one or more dimensions. The recently developed DAN3D-model (McDougall and Hungr, 2004; McDougall, 2006) facilitates runout-simulation of flow-type landslides across a three-dimensional terrain by use of several different rheological kernels.
In this study the DAN3D-model was applied with the aim to find the optimal rheology (Frictional or Voellmy) and model parameter set for predicting runout behavior of 10 debris avalanches (84m3 – 9216m3) in the Faroe Islands, North Atlantic Ocean. The islands, covering an area of 1397km2, are very susceptible to debris avalanches due to a steep landscape, shallow soils and high annual precipitation. Following several destructive debris avalanche events in recent years, a research project has been initiated to assess landslide risk in the Faroe Islands.
Model calibration was done by fitting predicted and actual runout behavior, in terms of material distribution and velocity in the runout path. Actual volumes, erosion characteristics and material distribution in the runout path were determined through fieldwork. Velocity information was obtained from eyewitness accounts, anecdotal sources and existing literature. Pre- and post-landslide ESRI ArcMap raster DEMs (cell size 0.75m x 0.75m) were constructed for the analysis. First, debris avalanches were individually back analyzed to find the optimal rheology and model parameters for each landslide. Subsequently, a general optimal rheology and model parameter set for all 10 debris avalanches were found by use of k-fold cross-validation statistics (Stone, 1974). The statistical method, which allows every debris avalanche to be used for both calibration and evaluation in the analysis, is a new implementation for quantitative model calibration in landslide runout research.
Initial results showed that runout behavior was best predicted using the Voellmy rheology. This contradicts results from other studies, where the Frictional rheology has shown superior in modeling small debris avalanches. Observed limited performance of the Frictional rheology in DAN3D is mainly caused by a low unit weight of the runout material (16.55kN/m3) compared to other studies ($\sim$ 20kN/m3). The lighter material causes substantially longer predicted runout lengths. Although work still remains to obtain the best fit Voellmy parameter set, this study reveals important limitations in the DAN3D model. Moreover, the k-fold cross-validation statistical method is introduced as an innovative approach for quantitative model calibration in landslide runout research.

References

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