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Topographic susceptibility for debris flow initiation along transport routes in NW-Norway

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The Norwegian transport infrastructure is frequently affected by rapid mass movements. Aside from snow avalanches and rock falls, debris flows account for high economical costs related to road and railway damages each year. However, studies investigating debris flow initiation conditions at a regional scale are rarely available for Norway. Thus, our objectives are to identify a set of terrain attributes as predictor variables for critical topographic conditions of debris flow initiation and to develop a statistical model to obtain a regional susceptibility map for NW-Norway.

A debris flow inventory and the terrain variables slope, curvature and flow accumulation derived from a DEM with a resolution of 20 m x 20 m serve as input to a Weights-of-Evidence (WofE) model that we use to estimate posterior probabilities of debris flow occurrence on a pixel basis. The inventory is a point dataset of initiation locations of 429 debris flow events documented between 1979 and 2008. We divide the dataset into a training dataset consisting of debris flow events prior to 2005 and a test dataset with the events in the ongoing years. We address three topics related to model quality: model adequacy, model robustness and model accuracy. The model adequacy is tested by applying two different classification schemes (fixed intervals, percentile intervals) to the three variables slope, curvature and flow accumulation independently, and in combination. The model robustness is addressed by running the model several times with small variations in the input data set, i.e. using a random selection of 2/3 of the training dataset. The model accuracy is determined by applying the best model to the test data set and by estimating its predictive performance. Beside the susceptibility map itself, WofE offers the possibility to conduct an uncertainty map related to the posterior probabilities. This map is used for spatial error quantification.

First results show that curvature is the strongest predictor of the three variables we tested as it results in very high positive weights. However, the variable slope has the highest reliability (highest true positive rates) and it turns out that slope is a good predictor by its own. Nevertheless the predictive performance is improved when combined with the two other variables. The final maps indicate that the data-driven classification via percentiles performs slightly better than the one using fixed intervals. Finally, the obtained susceptibility map is generalized to the scale of terrain segments, so-called mean curvature watersheds, for the sake of comprehensibility and practicability to the end-users.