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Modelling landslide susceptibility in large and heterogeneous regions with generalised additive models: case study Lower Austria

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While numerous landslide susceptibility studies apply standard methods such as logistic regression to relatively small areas, the particular challenges and possible solutions in the analysis of heterogeneous study areas with a size of 10,000 km^2 or more need special attention. Since landslide susceptibility maps can be a powerful tool for spatial planning measures aiming at hazard mitigation, it is of great practical importance to generate consistent landslide susceptibility maps for an entire province or state in order to allow for comparisons between different municipalities.

The objective of this study is to model consistent landslide susceptibility maps and therefore to develop an appropriate study design that meets the challenges that arise due to the heterogeneity of large study areas. To develop a suitable study design that can be applied to an entire state with reasonable time and computing efforts, a representative test study area was selected in the state of Lower Austria. Since the heterogeneity of this state is mainly influenced and produced by the specific characteristics of slope geometry, land cover and landslide susceptibility in the different geological units the main selection criteria was the coverage of all present units. Therefore the districts Amstetten, Waidhofen/Ybbs and Baden were selected, that are of convenient size for evaluating the suitability of the study design. The main geological units of Lower Austria are the Bohemian Masif, the Molasse Zone, the Flysch- and the Klippen Zone, the Northern Calcareous Alps and different types of eastalpine crystalline.

The method applied for modelling the landslide susceptibility maps is a generalised additive model. The main difference to a generalised linear model, such as linear or logistic regression, is that the additive model is able to represent nonlinear relationships by means of nonparametric transformations of the predictor variables. One approach to dealing with the geological heterogeneity is to split the study area according to the geological units, train separate models for the different units, and combine the resulting maps in a subsequent step. The predictive performance is assessed by calculating the area under the ROC curve (AUROC) on the training and on an independent test data set.

Predictor variables available for this study are derived from a geological map (1:200,000), a Lidar-derived DTM with a spatial resolution of 1 m x 1 m, a land cover map with a spatial resolution of 10 m x 10 m, and a landslide inventory that was mapped on the basis of the high resolution DTM. Terrain attributes such as slope angle, slope aspect, landform classification, topographic wetness index (TWI) and curvature were calculated from the DTM.

The resulting landslide susceptibility models achieve satisfactory AUROC values around 0.78 on the test data sets. Splitting the study area according to geological units into smaller model domains was a major step towards better characterisation of the specific properties of these units. This step allows us to avoid the excessive use of interaction terms that would be necessary in a single model in order to represent, for example, geology-dependent relationships between slope angle or TWI and slope stability, which may result from different material properties. In the next step, it is intended to implement the proposed study design in the entire state of Lower Austria.