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Advances in assessing geomorphic plausibility in statistical susceptibility modelling

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The quality, reliability and applicability of landslide susceptibility maps is regularly deduced directly by interpreting quantitative model performance measures. These quantitative estimates are usually calculated for an independent test sample of a landslide inventory. Numerous studies demonstrate that totally unbiased landslide inventories are rarely available. We assume that such biases are also inherent in the test sample used to quantitatively validate the models. Therefore we suppose that the explanatory power of statistical performance measures is limited by the quality of the inventory used to calculate these statistics.
To investigate this assumption, we generated and validated 16 statistical susceptibility models by using two landslide inventories of differing qualities for the Rhenodanubian Flysch zone of Lower Austria (1,354 km^2). The ALS-based (Airborne Laser Scan) Inventory (n=6,218) was mapped purposely for susceptibility modelling from a high resolution hillshade and exhibits a high positional accuracy. The less accurate building ground register (BGR; n=681) provided by the Geological Survey of Lower Austria represents reported damaging events and shows a substantially lower completeness. Both inventories exhibit differing systematic biases regarding the land cover. For instance, due to human impact on the visibility of geomorphic structures (e.g. planation), few ALS landslides could be mapped on settlements and pastures (ALS-mapping bias). In contrast, damaging events were frequently reported for settlements and pastures (BGR-report bias).
Susceptibility maps were calculated by applying four multivariate classification methods, namely generalized linear model, generalized additive model, random forest and support vector machine separately for both inventories and two sets of explanatory variables (with and without land cover). Quantitative validation was performed by calculating the area under the receiver operating characteristics curve (AUROC). The error estimation was conducted by applying (non-spatial) holdout and spatial cross-validation.
Geomorphic plausibility was estimated by subjectively assessing the geomorphic situation shown in a high resolution hillshade and comparing this evaluation with the ranking of the final susceptibility maps. For instance, high geomorphic plausibility was assigned when our evaluation converged with the expression shown in the susceptibility map and vice versa.
The results demonstrate that a high geomorphic plausibility was assessed for maps generated using the ALS-based inventory whereas low qualitative maps were produced by using the BGR-inventory. In contrast, holdout validation results revealed that all models exhibit a high quantitative quality. High AUROC values could be observed for maps with apparent low practical usability. Spatial cross-validation was able to detect the spatially differing completeness of the BGR-Inventory (resulting in lower AUROC values). Generally higher (in some cases much higher) AUROC values were observed for models generated with land cover as an explanatory variable. The subsequent geomorphic plausibility check demonstrated that maps generated without land cover exhibit more realistic susceptibility values.
Finally, we conclude that the explanatory power of statistical performance measures highly depends on the quality of the inventory used to calculate this statistics. Thus, it is required to additionally assess the geomorphic plausibility of susceptibility maps and not to rely solely on statistical performance measures.