Comparing methods of landslide data acquisition for landslide susceptibility and hazard assessments

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Storm events that trigger hundreds to thousands of shallow landslides in New Zealand’s hill country are associated with significant costs in terms of damage to land and infrastructure, agricultural losses and impacts on freshwater environments. To reduce the impacts of these landslide events, we require finer-resolution landslide susceptibility and hazard information to support improved targeting of mitigation measures that increase landscape resilience to storm impacts. The acquisition of landslide data for susceptibility and hazard assessments is a significant challenge given the typical size of affected areas and the number of landslides generated. This often prevents comprehensive mapping of storm-impacted areas, restricting the development of event-based landslide inventories due to the time and costs involved. Moreover, individual landslide source areas (scars) are typically small (approximately 50-100 m$^2$ in median scar size). As a result, we require high-resolution imagery to enable 1) accurate detection of individual landslide features and 2) separation of landslide scar and debris deposits for use in landslide susceptibility and hazard modelling.

Here, we compare manual and semi-automated methods for acquiring event-based landslide data and test sensitivity of three statistically-based landslide susceptibility models (logistic regression, neural network and random forest) to data acquisition method. Mapping focused on two high-magnitude storm events with maximum estimated recurrence intervals of 20 and 250 years using before and after high-resolution (<0.5 m) satellite or aerial imagery for the 175 and 178 km$^2$ study areas located on the North Island of New Zealand. Separate landslide inventories were prepared based on 1) manual mapping of all landslide initiation points and 2) semi-automated object-based image analysis (OBIA) mapping of landslide scar polygons within each study area.

We compare predictive performance between landslide inventories for the three models and their spatial predictions of landslide susceptibility. Our results highlight the challenges associated with semi-automated landslide detection over large areas where Producer’s and User’s accuracies ranged 57-76 and 50-61%, respectively, based on the number of OBIA-mapped landslide scars intersecting with a random sample of manually-mapped scars. Despite these levels of mapping accuracy, the mean area under receiver operating characteristic (ROC) curves was reduced on average by only 10% based on k-fold cross-validation using OBIA-mapped landslide scars compared to manual inventories. This suggests that landslide susceptibility analyses may be relatively insensitive to moderate classification error in semi-automated mapping when using...
large landslide inventories (here >7000 scars per study area) with high spatial densities. With growing demand for regional to national-scale quantitative information on landslide susceptibility and hazard that requires event-based data collection spanning a range in storm magnitudes, we see potential for semi-automated methods to complement manual methods of landslide data acquisition. This represents a balance between the amount of landslide data acquired, mapping accuracy, acquisition cost, and the resulting quality of landslide susceptibility and hazard assessments.