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A GRASS GIS Semi-Stochastic Model for Evaluating the Probability of Landslides Impacting Road Networks in Collazzone, Central Italy

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During a landslide triggering event, the tens to thousands of landslides resulting from the trigger (e.g., earthquake, heavy rainfall) may block a number of sections of the road network, posing a risk to rescue efforts, logistics and accessibility to a region. Here, we present initial results from a semi-stochastic model we are developing to evaluate the probability of landslides intersecting a road network and the network-accessibility implications of this across a region. This was performed in the open source GRASS GIS software, where we took 'model' landslides and dropped them on a 79 km^2 test area region in Collazzone, Umbria, Central Italy, with a given road network (major and minor roads, 404 km in length) and already determined landslide susceptibilities. Landslide areas (A_L) were randomly selected from a three-parameter inverse gamma probability density function, consisting of a power-law decay of about –2.4 for medium and large values of A_L and an exponential rollover for small values of A_L; the rollover (maximum probability) occurs at about A_L = 400 m^2. The number of landslide areas selected for each triggered event iteration was chosen to have an average density of 1 landslide km^{-2}, i.e. 79 landslide areas chosen randomly for each iteration. Landslides were then 'dropped' over the region semi-stochastically: (i) random points were generated across the study region; (ii) based on the landslide susceptibility map, points were accepted/rejected based on the probability of a landslide occurring at that location. After a point was accepted, it was assigned a landslide area (A_L) and length to width ratio. Landslide intersections with roads were then assessed and indices such as the location, number and size of road blockage recorded. The GRASS-GIS model was performed 1000 times in a Monte-Carlo type simulation. Initial results show that for a landslide triggering event of 1 landslide km^{-2} over a 79 km^2 region with 404 km of road, the number of road blockages ranges from 6 to 17, resulting in one road blockage every 24–67 km of roads. The average length of road blocked was 33 m. As we progress with model development and more sophisticated network analysis, we believe this semi-stochastic modelling approach will aid civil protection agencies to get a rough idea for the probability of road network potential damage (road block number and extent) as the result of different magnitude landslide triggering event scenarios.