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Modelling the Probability of Landslides Impacting Road Networks

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During a landslide triggering event, the threat of landslides blocking roads poses a risk to logistics, rescue efforts and communities dependant on those road networks. Here we present preliminary results of a stochastic model we have developed to evaluate the probability of landslides intersecting a simple road network during a landslide triggering event and apply simple network indices to measure the state of the road network in the affected region. A 4000 x 4000 cell array with a 5 m x 5 m resolution was used, with a pre-defined simple road network laid onto it, and landslides 'randomly' dropped onto it. 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 This statistical distribution was chosen based on three substantially complete triggered landslide inventories recorded in existing literature. The number of landslide areas (N_L) selected for each triggered event iteration was chosen to have an average density of 1 landslide km^{-2}, i.e. N_L = 400 landslide areas chosen randomly for each iteration, and was based on several existing triggered landslide event inventories. A simple road network was chosen, in a 'T' shape configuration, with one road 1 x 4000 cells (5 m x 20 km) in a 'T' formation with another road 1 x 2000 cells (5 m x 10 km). The landslide areas were then randomly 'dropped' over the road array and indices such as the location, size (A_{BL}) and number of road blockages (N_{BL}) recorded. This process was performed 500 times (iterations) in a Monte-Carlo type simulation. Initial results show that for a landslide triggering event with 400 landslides over a 400 km^2 region, the number of road blocks per iteration, N_{BL},ranges from 0 to 7. The average blockage area for the 500 iterations ($\bar{A}_{BL}$) is about 3000 m^2, which closely matches the value of $\bar{A}_L$ for the triggered landslide inventories. We further find that over the 500 iterations, the probability of a given number of road blocks occurring on any given iteration, $p(N_{BL})$ as a function of N_{BL}, follows reasonably well a three-parameter inverse gamma probability density distribution with an exponential rollover (i.e., the most frequent value) at N_{BL} = 1.3. In this paper we have begun to calculate the probability of the number of landslides blocking roads during a triggering event, and have found that this follows an inverse-gamma distribution, which is similar to that found for the statistics of landslide areas resulting from triggers. As we progress to model more realistic road networks, this work will aid in both long-term and disaster management for road networks by allowing probabilistic assessment of road network potential damage during different magnitude landslide triggering event scenarios.