Geophysical Research Abstracts
Vol. 17, EGU2015-9992, 2015
EGU General Assembly 2015

Statistical Patterns of Triggered Landslide Events and their Application to Road Networks

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In the minutes to weeks after a landslide trigger such as an earthquake or heavy rainfall, as part of a triggered landslide event, one individual to tens of thousands of landslides may occur across a region. If in the region, one or more roads become blocked by landslides, this can cause extensive detours and delay rescue and recovery operations. In this paper, we show the development, application and confrontation with real data of a model to simulate triggered landslide events and their impacts upon road networks. This is done by creating a 'synthetic' triggered landslide event inventory by randomly sampling landslide areas and shapes from already established statistical distributions. These landslides are then semi-randomly dropped across a given study region, conditioned by that region's landslide susceptibility. The resulting synthetic triggered landslide event inventory is overlaid with the region's road network map and the number, size, location and network impact of road blockages and landslides near roads calculated. This process is repeated hundreds of times in a Monte Carlo type simulation. The statistical distributions and approaches used in the model are thought to be generally applicable for low-mobility triggered landslides in many medium to high-topography regions throughout the world. The only local data required to run the model are a road network map, a landslide susceptibility map, a map of the study area boundary and a digital elevation model. Coupled with an Open Source modelling approach (in GRASS-GIS), this model may be applied to many regions where triggered landslide events are an issue. We present model results and confrontation with observed data for two study regions where the model has been applied: Collazzone (Central Italy) where rapid snowmelt triggered 413 landslides in January 1997 and Oat Mountain (Northridge, USA), where the Northridge Earthquake triggered 1,356 landslides in January 1994. We find that when the landslide susceptibility map is adjusted along road corridors to take into account interactions between landslides and roads, the model reasonably well matches the two observed results. In Collazzone (length of road = 153 km, landslide density = 5.2 landslides km^{-2}), the median number of road blockages over 100 model runs was 5.0 ($\pm$2.5 s.d.), compared to the observed number of 5 road blocks. In Northridge (length of road = 780 km, landslide density = 8.7 landslides km^{-2}), the median number of road blockages over 100 model runs was 28.0.* ($\pm$14.4 s.d.) compared to the observed number of 48.0 road blocks. We are now working on applying the model to other locations and developing more sophisticated network impact analysis tools to improve the applicability of the model.