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Spatial and temporal variability in rates of landsliding in seismically active mountain ranges

R. Parker (1,2), D. Petley (1,2), N. Rosser (1), A. Densmore (1), R. Gunasekera (2), and M. Brain (1)

(1) University of Durham, Institute of Hazard, Risk and Resilience, United Kingdom (r.n.parker@dur.ac.uk), (2) Willis Research Network, 51 Lime St, London, EC3M 7DQ, U.K.

Where earthquake and precipitation driven disasters occur in steep, mountainous regions, landslides often account for a large proportion of the associated damage and losses. This research addresses spatial and temporal variability in rates of landslide occurrence in seismically active mountain ranges as a step towards developing better regional scale prediction of losses in such events.

In the first part of this paper we attempt to explain reductively the variability in spatial rates of landslide occurrence, using data from five major earthquakes. This is achieved by fitting a regression-based conditional probability model to spatial probabilities of landslide occurrence, using as predictor variables proxies for spatial patterns of seismic ground motion and modelled hillslope stability. A combined model for all earthquakes performs well in hindcasting spatial probabilities of landslide occurrence as a function of readily-attainable spatial variables. We present validation of the model and demonstrate the extent to which it may be applied globally to derive landslide probabilities for future earthquakes.

In part two we examine the temporal behaviour of rates of landslide occurrence. This is achieved through numerical modelling to simulate the behaviour of a hypothetical landscape. The model landscape is composed of hillslopes that continually weaken, fail and reset in response to temporally-discrete forcing events that represent earthquakes. Hillslopes with different geometries require different amounts of weakening to fail, such that they fail and reset at different temporal rates. Our results suggest that probabilities of landslide occurrence are not temporally constant, but rather vary with time, irrespective of changes in forcing event magnitudes or environmental conditions. Various parameters influencing the magnitude and temporal patterns of this variability are identified, highlighting areas where future research is needed. This model has important implications for landslide hazard and risk analysis in mountain areas as existing techniques usually assume that susceptibility to failure does not change with time.