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Spatial pattern characterization of landslides in Swiss Rhone Valley

M. Tonini, A. Pedrazzini, I. Penna, and M. Jaboyedoff

Institute of geomatics and risk analysis, Faculty of Geosciences and Environment - Lausanne University, Lausanne, Switzerland (marj.tonini@unil.ch)

The analysis of spatial distribution of natural hazards is very important for prevention and forecasting purposes. Moreover the assessment of statistical properties of the phenomena and simulation tests allow rejecting the hypothesis of independency among data (i.e. random distribution). In the case of landslide, determining their spatial relationship by applying mathematical models can help to evaluate their passive controls and/or trigger factors.
In the present study we investigate cluster behaviour of quaternary large slope instabilities (294 events) and shallow landslides (400 events) inventoried in the Swiss Rhone valley (Valais), a canton located in the southwest and covering an area of about 5’000 km2. The objective is to test if these events are clustered or randomly distributed and if the two classes of landslides are spatially attracted each other. Moreover, large slope instabilities were further classified into three classes based on their mechanisms and magnitude properties and each category was analysed separately. Spatial cluster properties of tectonics processes inventoried in the same area were also examined in other to explore possible relationships between the cluster behaviour of large slope instabilities and earthquakes.
We applied a global cluster indicator, namely the Ripley’s K-function, to measure and test for randomness. K-function considers the intensity of events, defined as the number of occurrences falling inside an area within a search radius at each analysis location. That way allows describing the spatial point process at many distance-values and defining a range at which events are random distributed, clustered or eventually dispersed. To account for the non-constant intensity of the phenomena, a modification of the K-function for inhomogeneous point process was adopted, accounting also for edge corrections. To discover if large slope instabilities (LSI) and shallow landslides (SL) are spatially independently distributed the cross K-function was computed. The results show that landslides are spatially clustered at well-defined distance range, provides with 0.1% confidence envelopes around the null hypothesis (i.e. 999 Monte Carlo simulations of spatial randomness). More in detail, the three classes of LSI are clustered at a distance ranging from about 500m up to about 10km. Globally LSI and SL show a similar pattern distribution with cluster ranging from about 75m up to about 9km. The cross K-function detected cluster behaviour in the range 0-4.5km, proving that at this distance the number of SL in the neighbourhood of LSI is bigger than expected. Indeed, globally 32% of shallow landslides are included in the area of large slope instabilities, showing that they are conditioned by the reduction of the rock mass strength. The K-function computational results indicate that LSI and earthquakes are both clustered from close to 0km up 10km. This spatial relationship could point out a link between earthquakes in one of the most seismically active region of Switzerland and the occurrence of large slope instabilities.

Keywords: Ripley’s K-function, landslides, cluster, spatial pattern distribution