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Incorporating the time dimension into statistical landslide hazard models

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Statistical techniques have been extensively applied in the last years to the analysis of the spatial distribution of landslides. The reasons are the easy learning and application of many multivariate statistical techniques, the flexibility to accept many kinds of information, including indirect variables, and the generalization of geographic information systems and the availability of many statistical packages. Techniques applied include bivariate analysis, regression (simple and generalized linear models, general additive models), classification techniques (discriminant analysis) and neural networks. Statistical techniques are data driven, i.e. they do not rely on the underlying physical processes controlling landsliding but on similarities between units which experienced slope failure. The models are fed with an inventory of landslides and landslide-free units, along with their characterisation in a vector of variables which are considered as favouring factors (i.e. the slope). The main output usually comes in the form of a continuous landslide susceptibility value, which ultimately allows to classify the units (pixels, unit slopes, homogeneous units) as safe or unsafe according to specified criteria.

Typical applications of statistical techniques to landslide hazard zonation are time-independent. Data sets usually consist on a landslide inventory made in the field or by aerial photo interpretation. They are very exhaustive in the spatial domain but most often they completely lack of information about the timing of the landslides. For the purposes of hazard assessment, however, a susceptibility value (preferably in the form of a probability) has to be referred to a given return period. This is the only way to determine the expected costs within a given time period, which is the information required for risk management planning.

Information about the rate of landsliding can be obtained easily by comparing consecutive landslide inventories from two different moments. This is possible for many study areas, for which historical aerial photos exist. In the case of shallow landslides, which often have a high recurrence rate, a time span of one or two decades between the aerial photos can be enough to determine occurrence rates with reasonable certainty. Probabilities of landsliding can then be attributed to a given recurrence period. For the needs of model validation a third inventory is needed, since comparisons have to be made with a different time period. Comparison of occurrence rates and spatial distribution of events between the two periods, however, can also show that differences have occurred in the process of landsliding. This can be the case, for example, if important changes have occurred in land use during that period. This poses additional questions about the validity of statistical approaches to landslide hazard zonation.