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Preface

"Progress in landslide hazard and risk evaluation"

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The special issue of Natural Hazards and Earth System Sciences entitled "Progress in landslide hazard and risk evaluation" contains 9 out of more than 30 oral and poster contributions originally presented in the "*NH3.11 Landslide hazard and risk assessment, and landslide management*" session held at the General Assembly of the European Geosciences Union, in Vienna (Austria), on 22–27 April 2012.

The session was aimed at comparing qualitative or quantitative landslide hazard and risk estimates in different physiographic and geographical settings for different kinds of processes affecting the environment at different spatial scales. Presentations focusing on the adoption and integration of different modeling approaches for quantitative assessments were welcomed, and papers providing information on the quality, reliability and limitations of process-oriented or statistical models were encouraged.

The meeting proved to be a valuable opportunity to discuss and compare methods, techniques and tools for the recognition, evaluation and mitigation of landslide hazards and the related risks. In particular, the quality, the reliability and the limitation of models, input variables and output maps have been discussed for presented case studies at different geographical scales and in different physiographic environments. This is important information for filling the gap between academic research and application of the results in environmental planning and management. The special issue contains the following selected papers presented and discussed at the session.

Voumard et al. (2013) have calculated **risk along roads** using a dynamic traffic approach that simulates the duration of the presence of vehicles inside hazardous areas during a given time interval. The risk is analyzed along three road sections threatened by different natural hazards (active landslide, debris flows and dolines) along a mountain road: Aigle – Col du Pillon (western Switzerland). Two different scenarios were simulated: (1) a road without obstacles and (2) a road regulated by traffic lights. Results of the dynamic risk assessment were compared with the static methodology that considers an average number of vehicles per time unit and a constant vehicle speed. The main advantage of the dynamic approach is a better representation of the real traffic regarding the interaction between different vehicles of different types (cars, trucks, coaches). The dynamic approach with a microscopic traffic simulator was well designed to analyze the risk on relatively short road sections (up to a few kilometers) in detail. At the regional scale, the risk estimations would be averaged over the entire network (with large parts at no risk), and differences between static and dynamic risks may not be so pronounced. Thus, the interest of this method is to analyze hotspots, i.e., strongly hazardous short road sections, and to see for example how the location of traffic lights can increase or reduce the risk.

Catani et al. (2013) have performed different tests to understand how **model tuning and model parameters** can affect landslide susceptibility mapping. In the paper, the authors have adopted the random forest (RF) technique to produce an ensemble of landslide susceptibility maps for a set of different models, input data types and observation scales. The RF model was initially applied using the complete set of input variables, then an iterative process was implemented, and progressively smaller subsets of the parameter space were considered to estimate the relative importance of single input parameters and to select the optimal configuration of the classification model. The main results are that (i) the optimal number of parameters varies with scale and resolution, (ii) the importance of each conditioning variable is influenced by the model settings and the available data, and

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(iii) the choice of the training set (both for dimension and location) is an important issue in obtaining accurate results.

Nicolet et al. (2013) propose a model to assess the **risk due to shallow landslides** for a large region, using information on a rainfall event in Switzerland. In the paper, the authors describe the event of August 2005 both from a meteorological and a lithological viewpoint. They introduce a methodology to assess the landslide probability as a function of rainfall accumulation and lithological context, and present the risk analysis results in terms of the expected number of landslides, the number of affected buildings and the associated cost based on the precipitation amounts and lithological units. Using stochastic geometry, the authors prepare a model to evaluate the probability of a landslide reaching a building and the damage cost from the estimated mean damage cost using an exponential distribution to account for the variability. Although the model reproduces well the number of landslides, the number of affected buildings is underestimated. This is interpreted as resulting from human influence on landslide occurrence.

In the paper presented by Marques et al. (2013), the **landslide susceptibility along a sea cliff** is evaluated by exploiting bivariate information value and multivariate logistic regression statistical methods, using a set of predisposing factors, mainly related to geology (lithology, bedding dip, faults) and geomorphology (maximum and mean slope, height, aspect, plan curvature, toe protection). For this study, the cliff failure inventory was compiled using multi-temporal aerial digital photogrammetric methods, using aerial photographs of 1952, 2002 and 2007. The susceptibility models, validated against an inventory data using standard success rate and reciever Operating Characteristic (ROC) curves, provided encouraging results, indicating that the proposed approaches are effective for susceptibility assessment of sea cliff failures for planning purposes, which is a step towards objective sea cliff hazard assessment.

Margarint et al. (2013) prepared **landslide susceptibility maps** using binary logistic regression in study areas in Romania situated along the hilly areas of the Transylvanian Plateau and Moldavian Plateau and in the lower mountain region (Sub-Carpathians). The study focused on identifying and analyzing the spatial variability and range of variation for the regression coefficients of landslide predictors under four different geographical conditions. Landslide susceptibility is mainly controlled by slope angle, land use, slope height, and lithology, while other predictors (profile curvature, plan curvature, elevation, and distance from the drainage network) play a secondary role. The least relevant predictors are the mean curvature and aspect. For all the study areas, high values of predictor coefficients were obtained for slope angle and land use. In one mountainous sector, the model confirms that, under high geological diversity conditions, lithological variables have a significant relevance for the landslide susceptibility. The results of the study may help to improve the accuracy of landslide susceptibility and hazard mapping in Romania, by taking into account new landslide predisposal factors and the differentiation of their weights within major geographical units.

Petschko et al. (2014) present an **evaluation of the quality of landslide susceptibility** maps by addressing uncertainty issues associated with statistical modeling regarding input data (parametric uncertainty), model performance (model form uncertainty) and the final susceptibility map. In the study area, located in Lower Austria, they focus on the model form uncertainty to assess the quality of a flexible statistical modeling technique, the generalized additive model (GAM). The study area was divided into 16 modeling domains based on lithology classes, and a model representing the entire study area was constructed by combining these models. The performances of the models were assessed using repeated k-fold cross-validation with spatial and random subsampling. This reflects the variability of performance estimates arising from sampling variation. Measures of spatial transferability and thematic consistency are applied to assess model quality empirically. The authors also analyze and visualize the implications of spatially varying prediction uncertainties regarding the susceptibility map classes by taking into account the confidence intervals of model predictions. The map resulting from their study was planned for implementation by municipal authorities. For this reason, the authors pointed out the need to assess, minimize and communicate uncertainties involved in susceptibility modeling, to be communicated in an understandable manner to the stakeholder to allow for informed decisions instead of giving an impression of certainty.

Heckmann et al. (2014) investigated the **effect of sample size on a logistic regression model** with a parameter selection procedure that is based on an information criterion. The case study aims at predicting the spatial distribution of debris flow release zones in two small catchments located in the Austrian Central Alps. The study had two main objectives: first explore the sensitivity of stepwise model selection to sample size by investigating if an "optimal" sampling size can be found as a compromise between samples too small and too large. Second, the uncertainty inherent in a stepwise modeling approach is quantified with respect to (i) the selection of geofactors, (ii) model parameters, and (iii) the spatial pattern of uncertainty in the resulting susceptibility map. Using stepwise model selection with 1000 random samples, the authors investigated the inclusion and exclusion of geofactors and the diversity of the resulting models as a function of sample size. The diversity of models as a function of sample size was determined using diversity indices (Shannon entropy and Simpson diversity index), and the predictive power of the models was measured using ROC curves (AUC, area under the curve). Sample size apparently did not influence the average predictive power of the model ensemble, but smaller samples increased the range of AUC and hence also the proportion of comparatively poor models.

Fressard et al. (2014) present a study aiming at assessing the **impact of the data set quality** for landslide susceptibility mapping using multivariate statistical modeling methods. The research was conducted on the Pays d'Auge plateau (Normandy, France) at a 1 : 10 000 scale, in order to fit the French guidelines on risk assessment. Five sets of data of increasing quality (considering accuracy, scale fitting, and geomorphological significance) and cost of acquisition are used to map landslide susceptibility using logistic regression. The best maps obtained with each set of data are compared on the basis of different statistical accuracy indicators (ROC curves and relative error calculation), linear cross-correlation and expert opinion. The results highlight the fact that only high-quality sets of data supplied with detailed geomorphological variables (i.e., field inventory and surficial formation maps) can predict a satisfying proportion of landslides.

Yuan et al. (2014) analyzed the **huge earthquake-induced Donghekou landslide** triggered by the Wenchuan earthquake in 2008. They used a two-dimensional granular discrete element method to characterize the kinematic behavior and the mechanics of this "ejection landslide". The simulated results show that the large local seismic acceleration and a free face under the sliding body caused by the dip difference between the upper sliding face and the natural slope were responsible for the "ejection" phenomenon (e.g., the "jumping" of the landslide body over some slope distance) of the landslide. This study indicates that numerical modeling has the potential to impose tight constraints on landslide behavior, using information based on available observations and measurements, such as geological and geomorphological conditions, and rock mechanics. Two-dimensional modeling based on field observations can explain the kinematic processes of slope failure well, but to understand the geometry of the motion and the lateral spreading of landslide materials better, three-dimensional modeling should be exploited.

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