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Debris flow hazard mapping at regional scale in Emilia Romagna (Northern Italy): a pragmatic approach to define and integrate spatial and temporal probability

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Several debris flows occurred (including both mature and immature debris flows) in the northern Apennines of Emilia Romagna Region, during the alluvial events of Parma province in October 2014 and Piacenza province in September 2015. Such events highlighted the need to develop hazard maps at regional scale to support emergency planning in the mountain areas. It is well known that hazard mapping at regional scale is a rather delicate task and it necessarily requires a number of simplifications in order to estimate, over large areas, both the spatial and the temporal probability of occurrence of phenomena. The aim of this work was to develop a pragmatic approach in order to map debris flows hazard at regional scale by exploiting the key information collected during the above mentioned alluvial events of 2014 and 2015.

The temporal probability, ranked in 0-1 range as the annual probability of exceeding triggering thresholds related to 1h- and 3h-rainfall peaks, was mapped by regionalizing results obtained by rainfall thresholds analysis presented in the abstract by Ciccarese & Corsini in EGU2018 session NH1.11. The spatial probability, also ranked in a 0-1 range, was defined by first performing susceptibility mapping and then by reclassifying susceptibility classes. Susceptibility was assessed using Logistic Regression (LR, in Arc-SDM Spatial Data Modeller) based on datasets at 1:5000 scale of debris flows occurrences during Parma 2014 and Piacenza 2015 (supporting dependent variable) and predisposing factors maps covering the whole region (independent variables, such as lithotechnics, slope, curvature, aspect and flow accumulation). The supporting evidences dataset included 136 triggering points: 106 were used to train the model and 30 to validate it. In must be pinpointed that, in the areas covered by points of the training dataset, all thematic classes of all causal factors were represented, thus allowing to use supporting evidences located only in a specific portion of the study area for a regional scale analysis. The LR model, run over the whole regional area, returned a validation ROC curve with an AUC (area under the curve) higher than 0.8, indicating significant predictive capability. Based on the ROC curve distribution, the LR Posterior Probability values were grouped into classes that where then heuristically associated to spatial probability of occurrence (ranked in a 0-1 range). Visual inspection over the areas of Parma and Piacenza events, highlighted that high probability terrains are represented by limited portions of the higher sub-basins and streams in which, actually, the vast majority of the inventoried debris flows were located.

Finally, the by-pair combination of the one map of spatial probability and of the two maps of annual temporal probability, resulted in two Debris Flows Hazard Maps related to the 1h-rainfall and 3h-rainfalls exceedance. In both maps, the hazard values (also ranging 0-1) were grouped into classes, in order to make the maps more intelligible and, potentially, directly usable as additional knowledge base in the development of emergency preparedness plans for the municipalities located over the whole mountain sector of Emilia Romagna Region.