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Climate services for adapting landslide hazard prevention measures in the Vrancea Seismic Region

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The Vrancea Seismic Region is covering an area of about 8 000 km2 in the Romanian Curvature Carpathians and Subcarpathians and it is considered one of Europe's most intensely multi-hazard-affected areas. Due to its geomorphic traits (heterogeneous morphostructural units of flysch mountains and molasse hills and depressions), the area is strongly impacted by extreme hydro-meteorological events which are potentially enhancing the numerous damages inflicted to a dense network of human settlements. An a priori knowledge of future climate change is a useful climate service for local authorities to develop regional adapting strategies and adequate prevention/preparedness frameworks. This paper aims at integrating the results of the high-resolution climate projections over the 21st century (within the FP7 ECLISE project) into the regional landslide hazard assessment. The requirements of users (Civil Protection, Land management, local authorities) for this area refer to reliable and high-resolution spatial data on landslide and flood hazard for short and medium-term risk management strategies. An insight into the future behavior of climate variability in the Vrancea Seismic Region, based on future climate projections of three regional models, under three RCPs (2.6, 4.5, 8.6), suggests a clear warming, both annually and seasonally and a rather limited annual precipitation decrease, but with a strong change of seasonality. A landslide inventory of 2485 cases (shallow and medium seated earth, debris and rock slides and earth and debris flows) was obtained based on large scale geomorphological mapping and aerial photos support (GeoEye, DigitalGlobe; provided by GoogleEarth and BingMaps). The landslides are uniformly distributed across the area, being considered representative for the entire morphostructural environment. Landslide susceptibility map was obtained using multivariate statistical analysis (logistic regression), while a relative landslide hazard index was computed based on semi-quantitative spatial multi-criteria evaluation (SMCE). The generation of the landslide hazard maps relies on the heuristic approach, since a historical record of landslide occurrences, necessary to produce magnitude-frequency relations, is lacking. Based on the assumption of Sanderson et al. (1996) that slopes' morphology has adjusted, since the last glaciation, to the region's "normal" climatic conditions in all aspects including failures, it becomes clear that an extreme character of precipitation would be highly likely to generate landslides. Therefore, in order to represent the landslides triggering factor, raster maps for both time horizons (present and future) as simulated within each climate scenario have been used to illustrate the probabilistic seasonal precipitation amounts expected within a 30-year and a 100-year return period respectively. These maps, considered reliable indicators for depicting the changes in landslide occurrence probability, were standardized according to their contribution to hazard before being included in the SMCE together with the susceptibility map. The resulted hazard index maps for the two time horizons were compared aiming at detecting the future potential climate-induced changes in the spatial patterns of landslide occurrence. The outcomes mostly meet the requirements for updating the regional landslide risk management strategies.