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Application of a time probabilistic approach to seismic landslide hazard estimates in Iran

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Iran is a country located in a tectonic active belt and is prone to earthquake and related phenomena. In the recent years, several earthquakes caused many fatalities and damages to facilities, e.g. the Manjil (1990), Avaj (2002), Bam (2003) and Firuzabad-e-Kojur (2004) earthquakes. These earthquakes generated many landslides. For instance, catastrophic landslides triggered by the Manjil Earthquake (Ms = 7.7) in 1990 buried the village of Fatalak, killed more than 130 peoples and cut many important road and other lifelines, resulting in major economic disruption. In general, earthquakes in Iran have been concentrated in two major zones with different seismicity characteristics: one is the region of Alborz and Central Iran and the other is the Zagros Orogenic Belt. Understanding where seismically induced landslides are most likely to occur is crucial in reducing property damage and loss of life in future earthquakes. For this purpose a time probabilistic approach for earthquake-induced landslide hazard at regional scale, proposed by Del Gaudio et al. (2003), has been applied to the whole Iranian territory to provide the basis of hazard estimates. This method consists in evaluating the recurrence of seismically induced slope failure conditions inferred from the Newmark's model. First, by adopting Arias Intensity to quantify seismic shaking and using different Arias attenuation relations for Alborz - Central Iran and Zagros regions, well-established methods of seismic hazard assessment, based on the Cornell (1968) method, were employed to obtain the occurrence probabilities for different levels of seismic shaking in a time interval of interest (50 year). Then, following Jibson (1998), empirical formulae specifically developed for Alborz - Central Iran and Zagros, were used to represent, according to the Newmark's model, the relation linking Newmark's displacement Dn to Arias intensity Ia and to slope critical acceleration a_c. These formulae were employed to evaluate the slope critical acceleration $(A_c)_x$ for which a prefixed probability exists that seismic shaking would result in a Dn value equal to a threshold x whose exceedence would cause landslide triggering. The obtained a_c values represent the minimum slope resistance required to keep the probability of seismic-landslide triggering within the prefixed value. In particular we calculated the spatial distribution of $(A_c)_x$ for x thresholds of 10 and 2 cm in order to represent triggering conditions for coherent slides (e.g., slumps, block slides, slow earth flows) and disrupted slides (e.g., rock falls, rock slides, rock avalanches), respectively. Then we produced a probabilistic national map that shows the spatial distribution of $(A_c)_{10}$ and $(A_c)_2$, for a 10% probability of exceedence in 50 year, which is a significant level of hazard equal to that commonly used for building codes. The spatial distribution of the calculated $(A_c)_x$values can be compared with the in situ actual a_c values of specific slopes to estimate whether these slopes have a significant probability of failing under seismic action in the future. As example of possible application of this kind of time probabilistic map to hazard estimates, we compared the values obtained for the Manjil region with a GIS map providing spatial distribution of estimated a_c values in the same region. The spatial distribution of slopes characterized by $a_c < (A_c)_{10}$ was then compared with the spatial distribution of the major landslides of coherent type triggered by the Manjil earthquake. This comparison provides indications on potential, problems and limits of the experimented approach for the study area.

References

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