MAPPING EARTHQUAKE INDUCED LANDSLIDE HAZARD IN ITALY

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Earthquake generated ground shaking triggers widespread environmental coseismic phenomena, defined as secondary Earthquake Environmental Effects in the Environmental Seismic Intensity scale (ESI). Among them, Earthquake Induced Landslides (EILs) are the most diffused, especially affecting young, high relief terrains associated to the ongoing plate tectonic dynamics. EILs can be reactivation of pre-existing landslides or activation of new ones where favourable geologic conditions exist. In this work, we try to answer the following questions: which of the pre-existing landslides more probably will be reactivated, and where is more probable to trigger new EILs during future earthquakes?

We used complementary datasets available for the Italian territory: 1) the Italian and European seismic hazard models showing, over spatially uniform grids, the probability of exceedance of the seismic action within a fixed time span; 2) the Database of Individual Seismogenic Sources (DISS; https://diss.ingv.it/), that includes faults responsible for the seismic activity; 3) the Italian Landslide Inventory database (IFFI); and 4) the European Landslide Susceptibility Map (ELSUS v2). We also used new empirical relationships relating the variation of EILs density with distance from the earthquake epicentre (A), and the variation of EILs density with seismic shaking (B), that were calculated using the Italian database of historical seismic induced landslides (Zei et al., 2023) and a shakemap dataset of historical earthquakes as input data.

To answer the first question, we used the distance corresponding to the 95th percentile of landslide occurrence (95DIST), derived from the empirical relationship (A). This allowed to sum for each landslide the number of possible epicentres located along the DISS composite seismogenic sources and falling within that distance. The location of the epicentres was determined using a floating fault approach, where a typical fault associated to a maximum credible earthquake (MCE), was shifted of a fixed distance along-strike of the seismogenic faults. We also calculated the probability of occurrence of each MCE and derived the probability for each landslide that an earthquake of a certain magnitude could occur within 95DIST.

The second question was addressed merging over a uniform grid the seismic hazard and the landslide susceptibility data, by multiplying their values, and highlighting in this way areas where the probability of triggering new landslides is maximum due to seismic and geologic predisposing factors.

Finally, to obtain the EILs hazard, we calculated the conditional probability of reactivation of each landslide of our dataset. This was obtained combining 1) the cumulated probability of occurrence of the earthquakes of different magnitude classes falling within the 95DIST with 2) the probability of reactivation of the landslide in function of the epicentral distance, as derived from the empirical relationship (A). We also calculated the conditional probability of inducing new landslides using the landslide density function of empirical relationship (B) applied to the seismic hazard and landslide susceptibility combined map.

References

1. Zei, C., G. Tarabusi, C. Ciuccarelli, D. Mariotti, S. Baranello, G. Sgattoni, V. Piatteli, J. Cinosi,T. Piacentini, E. Miccadei, P. Burrato (2023). Earthquake induced-landslides: from historical data to new empirical relationships. 6th World Landslide Forum, 2023, Florence, Italy.