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Shallow landslide susceptibility in the "Costa Viola" mountain ridge (southern Calabria)

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The “Costa Viola” mountain ridge (Calabria) is exposed to severe seismic and geo-hydrological risk conditions, in addition to tsunamis along the coast. In particular, in the Tyrrhenian coastal sector between Bagnara Calabra and Scilla – analyzed in the present study - the main morpho-evolutive factors are represented by tectonics (structural setting and seismicity), lithological and climatic characteristics, and human activities (e.g. cuts and disordered drainage network). The Palaeozoic metamorphic and crystalline bedrock is strongly tectonized, and deeply weathered. At the base of the mountain ridge, a NE-SW trending fault, belonging to the Calabrian-Sicilian Rift Zone, marks the transition between the basement and the overlying sedimentary terrains of the coastal plan. From a morphological point of view, the area is characterized by steep and uneven slopes, cut by deep canyons; a set of marine terraces can be recognized between 100 and ca. 600 m a.s.l. Along the coast, small high-gradient torrents drain the western slope of the Costa Viola mountain ridge. Cold winter air fronts commonly approach Calabria from NW, originating intense storms.

The study area is crossed by the railway, the highway “Salerno-Reggio di Calabria” (A3), and the southern Tyrrhenian trunk road (SS.18). The narrow and discontinuous strip of land between the coastline and the base of the ridge is densely urbanized. This sector has repeatedly been affected by slope instability events in the past, mainly related to debris slides, rock falls and debris flows. Among the most recent events, those occurred in 2001 and in 2005 severely hit the main infrastructures and sectors of the urbanized areas.

An attempt of shallow landslide susceptibility mapping has been performed for the coastal sector between Bagnara Calabra and Scilla. At this purpose, the location of the potential debris slides has first been investigated through a logistic regression (LR) approach, i.e. a multivariate type of analysis that allows estimating the presence/absence of a phenomenon in terms of probability (ranging between 0 and 1). In LR, the presence of a mass movement is a dichotomic dependent variable, whose probability of being true is determined on the basis of linear statistical relationships with a set of independent territorial variables. If these latter are causal factors concerning land characteristics, the spatial probability of mass movement occurrence can be considered as a measure of susceptibility. The adopted LR procedure consists of four steps: i) variable parameterisation, ii) sampling, iii) fitting, and iv) application.

Successively, the coastal sectors potentially exposed to debris flows have been evaluated by means of a semi-empirical model, inspired from the finite difference Diffusive Hydrodynamic Model. Flood routing in 2D is accomplished through a numerical integration of the equations of motion, and the conservation of fluid volume. The model is able to route rainfall-runoff and flood hydrographs over unconfined flow surfaces or in channels. A dynamic wave approximation to the momentum equation is adopted, allowing to simulating street flow, buildings and obstructions, sediment transport, spatially variable rainfall and infiltration, and floodways. The flow progression over the computational domain (discretized into uniform, square grid elements) is controlled by topography and resistance to flow. The model routes mudflows as a fluid continuum, by predicting viscous fluid motion as a function of sediment concentration.

The study considers the series of historical events of landslide occurred in the study area, and the related hydrological scenarios. The susceptibility analysis is therefore focused, on one hand, on the location of the potential debris sources in the watershed, and, on the other, on the evaluation of the coastal sectors mostly exposed to impact and deposition of the mobilized debris.