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Regional-scale evaluation of past and future impacts of climate and environmental changes in rainfall-induced landslide occurrence

Stefano Luigi Gariano (1), Guido Rianna (2), Olga Petrucci (3), Monia Santini (4), and Fausto Guzzetti (5)

(1) CNR - IRPI, Perugia, Italy (gariano@irpi.cnr.it), (2) CMCC Foundation, Capua (CE), Italy (guido.rianna@cmcc.it), (3) CNR - IRPI, Rende (CS), Italy (olga.petrucci@irpi.cnr.it), (4) CMCC Foundation, Viterbo, Italy (monia.santini@cmcc.it), (5) CNR - IRPI, Perugia, Italy (fausto.guzzetti@irpi.cnr.it)

Scientific community recognizes warming of the Earth climate system unequivocal. The warming could induce substantial climate changes (CC) with relevant variations due to the region, weather patterns and time horizon of interest. In this perspective, the impact of CC on weather-induced disasters represents a crucial topic also due to the associated high socio-economic costs. However, the quantitative evaluation of the impact of CC on landslide occurrence, activity, and frequency remains a complex scientific question. Moreover, also land use and land cover (LULC), and their variations, affect landslide occurrence and the related risk.
According to the fifth report of the Intergovernmental Panel on Climate Change, an increase in the frequency and the intensity of extreme rainfall is expected in the Mediterranean area. This might result in a variation in the temporal and spatial distribution of rainfall-induced landslides, and in an increase in the size of the population exposed to landslide risk.
Exploiting detailed landslide information, climatic, and LULC data, and future projections in a Mediterranean region (Calabria, Southern Italy), we propose three linked methods – quantitative and reproducible – for the regional-scale evaluation of past and future variations in the occurrence of rainfall-induced landslides, in response to changes in climate (rainfall regimes) and LULC.
First, using historical landslide information and daily rainfall in Calabria between 1921 and 2010, we study the temporal and the geographical variation in the occurrence of 1466 Rainfall Events with Landslides (REL; the occurrence of at least 1 landslide during or immediately after a rainfall event) and in their impact on the population. We find changes in the geographical and temporal distributions of REL, and in their rainfall characteristics. In addition, we evaluate the impact of the events on the population, revealing a complex picture of changes.
Second, we use a subset of the previous dataset, related to the reference period 1981–2010, and high-resolution climate projections based on RCP4.5 and RCP8.5 scenarios for the future period 2036–2065. Calculating correlations between REL occurrence and weather variables estimated in the reference period, we assess future variations in REL occurrence, expecting a substantial regional increase in REL occurrence for the period 2036–2065, under both scenarios. We also investigate future variations in the impact of REL on the population, finding higher increases.
Third, using the whole landslide dataset and two maps of LULC of the region (released in 1956 and 2000) we define empirical relationships linking the observed LULC variations to landslide occurrence, finding changes in the spatial distribution of landslides. Then, we calculate the projected variations (to year 2050) in landslide occurrence related to 32 scenarios of LULC changes, revealing a modest increase in landslide occurrence in all of them.
We uphold that the observed and the projected variations in the occurrence of rainfall-induced landslides in the study area are related to interlaced changes in triggering, environmental, and societal components.