

## **Evaluating the impact of climate change on landslide occurrence, hazard, and risk: from global to regional scale.**

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According to the fifth report of the Intergovernmental Panel on Climate Change, “warming of the climate system is unequivocal”. The influence of climate changes on slope stability and landslides is also undisputable. Nevertheless, the quantitative evaluation of the impact of global warming, and the related changes in climate, on landslides remains a complex question to be solved. The evidence that climate and landslides act at only partially overlapping spatial and temporal scales complicates the evaluation. Different research fields, including e.g., climatology, physics, hydrology, geology, hydrogeology, geotechnics, soil science, environmental science, and social science, must be considered. Climatic, environmental, demographic, and economic changes are strictly correlated, with complex feedbacks, to landslide occurrence and variation. Thus, a holistic, multidisciplinary approach is necessary.

We reviewed the literature on landslide-climate studies, and found a bias in their geographical distribution, with several studies centered in Europe and North America, and large parts of the world not investigated. We examined advantages and drawbacks of the approaches adopted to evaluate the effects of climate variations on landslides, including prospective modelling and retrospective methods that use landslide and climate records, and paleo-environmental information. We found that the results of landslide-climate studies depend more on the emission scenarios, the global circulation models, the regional climate models, and the methods to downscale the climate variables, than on the description of the variables controlling slope processes. Using ensembles of projections based on a range of emissions scenarios would reduce (or at least quantify) the uncertainties in the obtained results.

We performed a preliminary global assessment of the future landslide impact, presenting a global distribution of the projected impact of climate change on landslide activity and abundance. Where global warming is expected to increase, the frequency and intensity of severe rainfall events, a primary trigger of shallow, rapid-moving landslides that cause many landslide fatalities, an increase in the number of people exposed to landslide risk is to be expected. Furthermore, we defined a group of objective and reproducible methods for the quantitative evaluation of the past and future (expected) variations in landslide occurrence and distribution, and in the impact and risk to the population, as a result of changes in climatic and environmental factors (particularly, land use changes), at regional scale. The methods were tested in a southern Italian region, but they can easily be applied in other physiographic and climatic regions, where adequate information is available.