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Physically-based assessment of the effects of climate change on landslide hazards in Central Italy

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Potential effects on the stability of slopes due to climate change remains an open issue. For rainfall induced landslides, the point consists in determining the effects of the projected changes in the duration and amounts of rainfall that can initiate slope failures. We investigated the relationship between fine-scale climate projections obtained by downscaling and the expected modifications in landslide occurrence in Central Italy, using a deterministic landslide model within rainfall events extracted from measured and downscaled precipitation data.

We used rainfall measurements taken by 56 rain gauges in the 9-year period 2003–2011, and the RainFARM technique to generate downscaled synthetic rainfall fields from regional climate model projections for the 14- year calibration period 2002–2015, and for the 40-year projection period 2010–2049. Downscaled precipitation data for the future scenario was obtained in RainFARM from WRF RPC4.5 model data. Using a specific algorithm, we extracted a number of rainfall events, i.e. rainfall periods separated by dry periods of no or negligible amount of rain, from the measured and the synthetic rainfall series. Out of the many thousands of extracted rainfall events, we selected a subset of 50 representative events from the measured series, and a subset of 50 events from the synthetic series for each decadal time period, amounting to a total of 250 events from the downscaled precipitation data. Then, we used each of the selected rainfall events to force the Transient Rainfall Infiltration and Grid-Based Regional Slope-Stability Model TRIGRS v. 2.1. We analyzed the results in terms of variations in the rainfall thresholds for the possible initiation of landslides, in the probability distribution of landslide size (area), and in landslide hazard. Analyzing results in terms of rainfall thresholds and size distributions is a novel approach to investigate the effects of climate change on landslide hazard, which allows to mitigate the uncertainties introduced by the specific modeling chain adopted in this study.

Results showed that the downscaled rainfall fields obtained by RainFARM can be used to single out rainfall events, and to force the slope stability model. Results further showed that while the rainfall thresholds for landslide occurrence are expected to change in future scenarios, the probability distribution of landslide areas is not. We infer that landslide hazard in the study area is expected to change in response to the projected variations in the rainfall conditions, within the scenario considered in this study. We expect our results to contribute to regional investigations of the expected impact of projected climate variations on slope stability conditions and on landslide hazards.