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Dynamic analysis of long-term seismicity effects on the Piz Dora DSGSD (E Switzerland)

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Deep seated gravitational slope deformations (DSGSD) evolve over several thousands of years in changing environmental conditions, under the influence of multiple triggering processes. Although glacial and fluvial erosion, deglaciation processes and slope hydrology perturbations are recognized to be common drivers of these phenomena in alpine environment, there is evidence of possible effects of seismicity on their initiation and development. A major difficulty in quantifying such effects is related to the involved timescales. In fact, while earthquake-induced, instantaneous slope instabilities can be studied with reference to specific earthquake scenarios, a considerably large number of seismic events of different magnitude and recurrence may contribute to slope instability and displacements on the typical DSGSD timescale, possibly leading to catastrophic rock slope instabilities over the long-term. In this work, we used numerical modelling to investigate the effects of long-term seismicity on a DSGSD, affecting the Piz Dora (Val Müstair, E Switzerland) over an area of 12 Km2 and with a 1500 m local relief. The slope is made of a sequence of Austroalpine conglomerates, meta-conglomerates and phyllites, folded into a kilometre-scale anticline setting geometrical and geomechanical constraints on the large slope instability. The area has been experiencing tectonic uplift and fault activity since the Pliocene, and is characterized by frequent present-day shallow seismicity with maximum magnitude Mw>5 and dominant dip-slip mechanisms. After the Last Glacial Maximum (LGM), the slope experienced the removal of about 1000 m of ice. Morpho-structural characterization of DSGSD features and their relationships with glacial deposits and different generations of periglacial features (rock glaciers and protalus ramparts) allowed reconstructing a complex relative chronology of slope displacements and establishing local constraints on deglaciation. We used these constraints to validate a series of continuum 2D FEM dynamic simulations, set up starting from the signal characterization of a real earthquake occurred in 1999 few kilometers from the slope in a similar litho-structural seismo-tectonic setting. Available seismic hazard maps were used to scale in terms of PGA the dynamic input and describe events with specified return time. These were applied at the model base before, during and after slope deglaciation history, constrained by relative post-LGM paleoclimatic evidence. Comparison between static and dynamic simulations suggests a notable contribution of repeated seismic events to strain accumulation in different slope sectors, promoting the onset of DSGSD in marginally stable deglaciating alpine rock slopes.