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Modelling long term rockslide displacements with non-linear time-dependent relationships

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Rockslides undergoing rapid changes in behaviour pose major risks in alpine areas, and require careful characterization and monitoring both for civil protection and mitigation activities. In particular, these instabilities can undergo very slow movement with occasional and intermittent acceleration/deceleration stages of motion potentially leading to collapse. Therefore, the analysis of such instabilities remains a challenging issue.
Rockslide displacements are strongly conditioned by hydrologic factors as suggested by correlations with groundwater fluctuations, snowmelt, with a frequently observed delay between perturbation and system reaction.
The aim of this work is the simulation of the complex time-dependent behaviour of two case studies for which also a 2D transient hydrogeological simulation has been performed: Vajont rockslide (1960 to 1963) and the recent Mt. de La Saxe rockslide (2009 to 2012).
Non-linear time-dependent constitutive relationships have been used to describe long-term creep deformation. Analyses have been performed using a “rheological-mechanical” approach that fits idealized models (e.g. viscoelastic, viscoplastic, elasto-viscoplastic, Burgers, nonlinear visco-plastic) to the experimental behaviour of specific materials by means of numerical constants. Bidimensional simulations were carried out using the finite difference code FLAC. Displacements time-series, available for the two landslides, show two superimposed deformation mechanisms: a creep process, leading to movements under "steady state" conditions (e.g. constant groundwater level), and a "dynamic" process, leading to an increase in displacement rate due to changes of external loads (e.g. groundwater level).
For both cases sliding mass is considered as an elasto-plastic body subject to its self-weight, inertial and seepage forces varying with time according to water table fluctuation (due to snowmelt or changing in reservoir level) and derived from the previous hydrogeological analysis (see EGU2015-14374). All non-linearities are lumped into a thin layer representing the main rockslide basal shear zone. Due to the great number of parameters characterizing viscous rheological models we separated the modelling into different stages. Firstly, starting from available geotechnical data, we carried out shear strength reduction analysis for solving elasto-plastic critical parameters of the basal shear band. Then, according to the chosen approach, we applied different viscous rheological models in order to simulate steady and dynamic creep.
We identified the Burgers-creep viscoplastic model (Mohr-Coulomb failure criterion coupled with general Burgers-creep time-dependent nucleus) as the most appropriate one for simulating the behavior of the two case studies and more generally of large rockslides that exhibit similar movements. Due to the adopted continuum numerical approach, the models reproduce only portions of displacements curves associated with first and secondary creep phenomena.
The models have been calibrated and subsequently validated on long temporal series of monitoring data, and reliably simulate the in situ data.