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SLOWMOVE – A numerical model for the propagation of slow-moving landslides: a 1D approach and its application to the analysis of the Valoria landslide (Apennines, Italy)

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Understanding the behavior of landslides often starts with a numerical simulation that accurately accounts for observed physical processes. This research proposes a method for the implementation of the dynamic SLOWMOVE model to a high-mobility, moderate velocity earth flow located in the northern Apennines.

The Valoria landslide is 3.5 km long earth slide- earth flow that resumed activity in 2001. Landslide materials comprised of disaggregated Flysch, Marl and Claystones are mainly transported as earth slides in the upper slope, and as earth flows in the main track. Repeated acceleration events lasting several weeks occur seasonally since 2001 reactivation. During events it can reach velocities of about 10 m per hour with a cumulative displacement of hundreds of meters. Through this intermittent activity, more than ten million cubic meters have been transferred down-slope since 2001, changing significantly and several times the morphology of the slope.

The SLOWMOVE model postulates that landslide materials can be represented as a homogeneous material with rheological properties and constant density. The approach is based on the Navier-Stokes equations. Under the assumptions that the inertia of the moving mass can be neglected, the behavior of the landslide depends solely on the balance between driving forces and resisting forces which contain a Coulomb-viscous component. Excess pore pressure due to undrained loading and lateral force form the main parameters that control the acceleration. The effects of lateral force and excess pore pressure allow a numerical simulation of landslide reactivation by coupling of two landslide bodies. A numerical scheme based on a finite difference solution (2D Eulerian space with Cartesian coordinates) was implemented in Microsoft Excel and used to compute propagation of the mass in 1D. The model allows coupling between mass movements having different geotechnical characteristic. In practice, it allows simulating the reactivation of dormant landslide parts as an effect of undrained loading and changed pressure conditions caused by active movements approaching from upslope.

A representative landslide cross-section of the Valoria landslide, stretching from the main track zone down to the toe zone, was analyzed in SLOWMOVE. A large set of surface displacement data obtained since March 2008 through continuous total-station monitoring allowed for evaluation and calibration of the numerical implementations in terms of velocity. Multi-temporal Lidar surveys allowed for calibration of the model in terms of event-induced morphological changes along the selected cross section. Model parameters were defined, on such basis, via a trial and error approach starting from laboratory and literature data. The model was able to reproduce realistic velocities and morphological changes. The specific function of coupling between interacting portion of the mass movement, allowed for simulation of landslide toe reactivation, that was observed during major acceleration events as a result of the domino effect caused by active flows in the main flow track. Further development is needed in order to integrate in the model transient pore pressure conditions. Nevertheless, results are promising, as they point to a possible application of the model in quantitative hazard and risk assessment.