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# SLOWMOVE - A numerical model for the propagation of slow-moving landslides: Issues and theoretical concepts

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Gravitational flows characterized by low velocities represent widely-spread and costly geological hazard and pose particular challenges for the development of a representative numerical model. In many cases their behavior depends on complex mechanical and fluid interactions.

The development of a physical-based numerical simulation that allows for an accurate model of observed landslide motion is particularly challenging and underlies a number of assumptions and simplifications. Many conventional techniques do not take hydromechanical effects into account or include the inertia of the moving mass which may result in an overestimation of velocities of the flowing materials.

A model concept of van Asch et al. (2006) and van Asch & Malet (2009) to investigate the potential transition of a block sliding process into a flow-like process was modified to overcome these drawbacks. With the proposed technique it is possible to account for a non linear intrinsic viscosity of the shear zone and the generation of excess pore water pressure due to undrained loading (hydromechnical effects). Under the assumption that the inertia of the mass can be ignored at low velocities, the balance of forces consists of the driving force and resisting forces that contain a Coulomb-viscous component.

In accordance to common gravitational flow models landslide materials are treated as one-phase homogeneous material with rheological properties. Assuming a vertical linear velocity profile, cumulated displacements with depth can be calculated thus giving an estimate on the shear zone thickness. The applied approach is based on the Saint Venant equations that are derived from depth-integrating the Navier-Stokes equations. The continuity and momentum equations can be numerically solved using finite differences with fixed-step discretization.

The balance of driving and frictional forces, together with viscosity and cohesion determine the rate at which the material moves. Velocity gradient is used to compute the strain and excess pore pressure. An increase of excess pore water pressure reduces shear resistance and may dramatically accelerate the movement.

Results from the sensitivity analysis show that pore pressure, slope geometry and viscosity are main input parameters controlling the displacement and velocity patterns of the simulations.