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A physically based slope stability simulator for HPC applications

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HIRESSS (HIgh REsolution Slope Stability Simulator) is a physically based distributed slope stability simulator for analyzing shallow landslide triggering conditions in real time and on large areas using parallel computational techniques. The physical model proposed is composed of two parts: hydrological and geotechnical. The hydrological model receives the rainfall data as dynamical input and provides the pressure head as perturbation to the geotechnical stability model, that computes the factor of safety (FS) in probabilistic terms. The hydrological model is based on an analytical solution of an approximated form of the Richards equation under the wet condition hypothesis and it is introduced as a modeled form of hydraulic diffusivity to improve the hydrological response. The geothecnical stability model is based on an infinite slope model that takes into account the unsaturated soil condition. During the slope stability analysis the proposed model takes into account the increase in strength and cohesion due to matric suction in unsaturated soil, where the pressure head is negative. Moreover, the soil mass variation on partially saturated soil caused by water infiltration is modeled.
The model is then inserted into a Monte Carlo simulation, to manage the typical uncertainty in the values of the input geotechnical and hydrological parameters, which is a common weak point of deterministic models. The Monte Carlo simulation manages a probability distribution of input parameters providing results in terms of slope failure probability. The developed software uses the computational power offered by multicore and multi processor hardware, from modern workstations to supercomputing facilities (HPC), to achieve the simulation in reasonable runtimes, compatible with civil protection real time monitoring.
A first test of HIRESSS in three different areas is presented to evaluate the realibility of the
results and the runtime performance on large areas.