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Continuum modeling and limit equilibrium analysis of slope movement due to rainfall infiltration

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Hydrologically–driven landslides and debris flows are highly destructive events that threaten lives and critical infrastructure worldwide. Despite decades of extensive slope stability model development, the fundamental controls connecting the hydrologic and geotechnical processes that trigger slope failure are not well quantified. We use a fully coupled, physics-based finite element model to address this shortcoming. We develop and test a 3D continuum slope-deformation model that couples solid-deformation with fluid-flow processes in variably saturated soils, and assess the capability of the coupled model to predict stresses and deformation necessary to trigger slope failure. We then compare the continuum model with traditional limit equilibrium solutions based on the modified Bishop method of slices to assess the stability of the slope as a function of rainfall infiltration using a scalar stability indicator called factor of safety. For this assessment, we use extensive measurements from a densely instrumented mountain slope (The Coos Bay Experimental Catchment) where a large, rainfall-triggered slope failure occurred. The use of sophisticated, fully coupled numerical simulations combined with comprehensive field-measurements provides an unprecedented opportunity to advance the state of understanding of landslide failure processes and effective mitigation measures.