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Hydro-Mechanical Perturbation of a Steep Hillslope – Failing to Fail a Hillslope

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Rapid shallow landslides are relatively common natural hazards in mountainous regions. The prediction of hydromechanical conditions inducing these events remains a challenge due to complex interactions of soil properties, vegetation and geologic conditions. Shallow landslides in alpine regions occur primarily in slopes steeper than 25 degrees and are triggered most often by heavy rainfall events. Nevertheless, extreme rainfall events on steep slopes >40 degrees in mountainous regions show remarkable stability. To analyze such hillslope response to extreme hydrologic input of long duration, we conducted a field experiment in the Loetschental valley (Wiler, Switzerland) where a small meadow (5 x 10 m) within a forest with soil depth between 0.3 and 1.5 m was instrumented with different sensors to monitor soil water pressure, soil and bedrock water content, electrical resistivity and occurrence of small movements. We applied water using two sprinklers and from a one meter deep trench upslope. Water was applied for two weeks at a rate of 36 L/hr/m2 (corresponding to annual rainfall amount of 860 mm applied in one day). Following this extended period of heavy rainfall, we supplied water to upslope trench (5 m wide and 1 m deep) at maximum rates of 200 L/min (potential seepage rates of 57 m per day!) resulting in surface runoff. Inflow rates less than 30L/min showed no surface runoff. Some tensiometers registered positive pore pressures in the range of 0.2 to 0.8 m of head, however, most of the applied water drained into bedrock and via preferential flow along macropores formed by decaying tree roots and rock fragment skeleton as indicated by geophysical methods and dye tracer experiments. The slope composition (roots, soil and rock fragments) and the interface between soil and bedrock show strong self-organization to maximize drainage capacity thereby reducing mechanical failure potential and landslide risk.