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True colors - changing perceptions of hydrological processes at a hillslope prone to slide

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This study determined the dominant runoff formation processes of a pre-alpine hillslope prone to slide. The experimental grassland/pasture plot (10 m x 10 m) is located in the northern front range of the Swiss Alps on a WNW facing hillslope (30-35°, 1100 m asl, 2000 mm annual precipitation). More than 20 landslides were registered in the vicinity of the experimental plot during a heavy rainfall event in August 2005. A shallow gley (Ah-Go-Gr) overlies a weathered marlstone and conglomerate (sub-alpine Molasse). We monitored groundwater with a network of 10 groundwater wells, two drainages in 0.25 and 1.0 m depth, and volumetric water content using TDR-probes at four profiles at various depths. Our monitoring data indicates that even during relatively dry periods soil moisture is saturated for all TDR's with exception of the 0.25 m level. The groundwater wells and the drainages respond quickly to storm events above a threshold of 10-15 mm precipitation. In summer/fall 2011 we conducted two sprinkling experiments with variable rainfall intensities using natural lake water (experiment I) and artificially deuterium-enriched water (experiment II). During both sprinkling experiments we conducted fluorescein line-tracer injections to evaluate surface and subsurface flow velocities and tracer recovery for the different horizons. We performed NaCl pulse injections into the sprinkling water when changing rainfall intensities to monitor sub-surface flow velocities with 2-D electrical resistance tomography, and tracer break through/ recovery for the different horizons. Saturation overland flow occurred only at high rainfall intensities above 20-25 mm/h. The sprinkling experiment data exhibit a quick tracer break through after 30-60 min, illustrating the efficient drainage of the high infiltration capacity of vertical macropores linked to lateral soil pipes in the deeper soil horizons. Thus we considered subsurface stormflow as the dominant runoff formation process. To gain advanced understanding of runoff formation with emphasis on the link of vertical macropores to lateral soil pipes, a dye tracer experiment (experiment III) was conducted after a dry weather period in November 2011. A plot (4 m x 1.5 m) was sprinkled for 2 h with 240 L of brilliant blue (concentration 6.25 g/L, max. rainfall intensity 20 mm/h to avoid surface losses). The dye tracer experiment completely changed our perceptual model of the hillslope. The distribution of the dye showed vertical macropores up to 50 cm depth – mostly earthworm burrows – with little to no macropore-matrix exchange. The 3-D excavation of the dye tracer (experiment III) highlighted the dominance of lateral subsurface storm flow and return flow in the topmost soil layer (Ah-horizon, 0-25 cm). Lateral drainage decreased strongly with depth. We could not find a deep lateral drainage network in the Go or Gr horizons or at the soil-bedrock interface as suggested by the sprinkling experiments I and II.