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The unique hydrological functions of rock outcrops in karst areas

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Rock outcrops (ROCs), a widespread surface component in karst landscape, play a unique hydrological role in the infiltration and redistribution of precipitation. We researched the outcrop runoff infiltration in three directions (i.e., lateral flow into the soil, vertical flow and lateral spread at soil-rock interface) differed greatly at the three sides of the ROCs, by applying dye tracer Brilliant Blue FCF, combined with soil loss survey and soil property measurements. Deep-but-narrow vertical flow was the most common infiltration pattern at the uphill sides; long-but-shallow lateral flow towards downslope dominated the ways of outcrop runoff movements at the lateral sides. However, at the downhill sides, the vertical flow at soil-rock interface was quantitatively equal to the lateral flow to soil. The difference of outcrop runoff infiltration at the three sides of ROCs may help to reveal the mechanisms of soil erosion as well as rocks' dissolution and biodiversity in a karst environment. Besides, ROCs exert important function in the dynamics of soil stored in between ROCs, especially for soil moisture spatial patterns (SMSP) and its temporal stability. that where ROCs emerged, soil moisture displayed higher spatial heterogeneity than reported from other terrestrial ecosystems, but this area also maintained high temporal stability in the SMSP, as indicated by the low standard deviation of relative difference $\sigma(\delta_i)$ and highly significant Spearman rank correlation (r_s) found. Linear-fitting analysis demonstrated the feasibility of using a single representative location to estimate large-scale soil water conditions in karst rocky ecosystems (R^2-values $\geq$ 0.88). More importantly, the spatiotemporal dynamics of SMSP were apparently driven by the joint effects of soil depth, vegetation, and precipitation. The SMSP was markedly homogeneous and stable in the deep soil layer, as well as during the rainy season; however, with the onset of the dry season, the vegetation tended to induce a temporary change in the root-zone SMSP. Our study suggests that the multifactor-influenced soil moisture and high temporal stability of SMSP offer both a challenge and an opportunity for better understanding the hydrological models and dynamics of rocky ecosystems.