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Vegetation controls on soil water dynamics and runoff production in a headwater catchment in the Ore Mountains

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Spatial variability of soil hydraulic parameters and soil structures dominate surface runoff production as well as soil water dynamics at the hillslope and headwater scale. These seem to be common grounds in soil physics and was our credo when we instrumented a small headwater (10 km2) of the Weiáeritz with six rain gauges, a meteorological station, shallow piezometers and two STDR clusters to investigate soil moisture control on runoff and surface runoff production. Both TDR clusters consist of 35 individual TDR sensors of 60 cm depth covering an extend of 15m by 15m. Cluster 1 one is located at a grassland site, cluster 2 is located in a nearby forested area. The soil at the grassland site is a clayey loam with a high content of organic matter, a very large porosity of 0.63 in the top 20 cm and a soil hydraulic conductivity of on average around 4 * 10-5 m/s. Soil at the forested site is similar with an even higher infiltrability and higher organic content of the top soil. Both soils exhibit a high gravel content and rather high spatial variability of soil properties.

Despite of this large heterogeneity of soil parameters, we found that vegetation exerts crucial control on average soil moisture dynamics, its spatial variability and most interesting on the development of the spatial covariance structure of the soil moisture patterns. Correlation length at the grassland site was rather short but increased with increasing average wetness. So did the nugget to sill ratio of the variogram. At the forested site correlation length did not vary with average wetness and was constantly 50% of the maximum probe distance. We therefore conclude that the correlation structure at the forested site is dominated by the pattern of through-fall and interception and therefore vegetation.

During a modelling exercise we found that despite of the large heterogeneity of the soils a homogeneous soil setup allowed a good reproduction of observed soil moisture dynamics at the hourly scale for a period of more than 3 months. At both sites simulations were most sensitive to small changes of key plant parameters. Especially root depth, leaf area index and plant coverage and their evolution during the vegetation phase were of prime importance for a good model performance. Surprisingly, evapo-transpiration and thus vegetation determines near surface soil moisture dynamics and therefore surface runoff production at this headwater catchment. Consequently, survey of key plant parameters such as leaf area index, plant coverage and their evolution during the vegetation phase is of prime importance for model predictions of soil moisture dynamics and surface runoff production in this headwater.

Many process-orientated model studies put their major efforts into assessment of soil parameters and treat vegetation as something static that can be characterized by a few constant parameters. Model studies ? including some of our own ? often just devote a single statement such as ?vegetation was short grass and parameters were taken from the literature? to characterize vegetation in their model structure. This story shows that sometimes even grown up process hydrologists don?t see the wood for the trees.