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Improved understanding of hillslope-scale hydrological processes using high-resolution soil moisture measurements

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Soil moisture is a key variable that controls e.g. matter and energy fluxes, slope stability, occurence of flood events and soil-vegetation-atmosphere exchange processes. Deriving detailed process understanding at the hillslope scale is not trivial, because of the non-linearity of hillslope response to rainfall due to local soil moisture dynamics. Characterizing this variability is one of the major challenges in hillslope hydrology. Long-term monitoring of surface and subsurfce soil moisture at various depths can provide a comprehensive picture of the spatial and temporal pattern of soil moisture dynamics, and facilitate understanding the controlling factors of underlying hydrological processes.

In the Schäfertal catchment (located in the Harz Mountains, in Central Germany) a 2.5 ha hillslope area was permanently instrumented with a wireless soil moisture and soil temperature monitoring network. Ground-based electromagnetic induction (EMI) measurements and topographic data were included into a geostatistical sampling strategy in order to optimize the placement of the network nodes. In total, 240 sensors were distributed to create 40 pairs of instrumented soil profiles, providing hourly measurements of soil water content and soil temperature at 5, 25 and 50 cm depth. The soil spatial variability was mapped and the soil texture was determined for each node location and each soil horizon.

For the selected monitoring period of 14 months, the soil moisture pattern and its variability through time were analyzed. Seasonal and event-based analysis shows the varying relevance of topography and soil properties in determining several near-surface processes such as preferential flow, subsurface lateral flow and dynamics of the groundwater table.