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Analysis of spatiotemporal soil moisture patterns at the catchment scale using a wireless sensor network

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Soil water content plays a key role in partitioning water and energy fluxes and controlling the pattern of groundwater recharge. Despite the importance of soil water content, it is not yet measured in an operational way at larger scales. The aim of this paper is to present the potential of real-time monitoring for the analysis of soil moisture patterns at the catchment scale using the recently developed wireless sensor network SoilNet [1], [2]. SoilNet is designed to measure soil moisture, salinity and temperature in several depths (e.g. 5, 20 and 50 cm). Recently, a small forest catchment Wüstebach (∼27 ha) has been instrumented with 150 sensor nodes and more than 1200 soil sensors in the framework of the Transregio32 and the Helmholtz initiative TERENO (Terrestrial Environmental Observatories). From August to November 2009, more than 6 million soil moisture measurements have been performed.
We will present first results from a statistical and geostatistical analysis of the data. The observed spatial variability of soil moisture corresponds well with the 800-m scale variability described in [3]. The very low scattering of the standard deviation versus mean soil moisture plots indicates that sensor network data shows less artificial soil moisture variations than soil moisture data originated from measurement campaigns. The variograms showed more or less the same nugget effect, which indicates that the sum of the sub-scale variability and the measurement error is rather time-invariant. Wet situations showed smaller spatial variability, which is attributed to saturated soil water content, which poses an upper limit and is typically not strongly variable in headwater catchments with relatively homogeneous soil. The spatiotemporal variability in soil moisture at 50 cm depth was significantly lower than at 5 and 20 cm. This finding indicates that the considerable variability of the top soil is buffered deeper in the soil due to lateral and vertical water fluxes. Topographic features showed the strongest correlation with soil moisture during dry periods, indicating that the control of topography on the soil moisture pattern depends on the soil water status. Interpolation using the external drift kriging method demonstrated that the high sampling density allows capturing the key patterns of soil moisture variation in the Wüstebach catchment.

References:
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