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Assimilation of Cosmic-Ray Neutron Data to Improve Soil Moisture in the Distributed Hydrological Model mHM

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Mesoscale hydrological models like mHM (Samaniego et al., 2010, WRR) are usually evaluated with observed discharge, which is a spatially integrated signal of the watershed. However, an accurate prediction of spatially distributed soil water content is of much higher value for hydrologic prediction. For hydrologic models operating at intermediate to regional scales, Cosmic-Ray Neutron Sensors provide unrivaled soil moisture data which are much more representative and of higher spatial-temporal resolution than most point-scale or remote-sensing products.

We are aiming to improve soil moisture calibration and evaluation in mHM with the support of the intermediate-scale data from cosmic-ray neutrons. The relationship between soil moisture profiles in the footprint and the corresponding cosmic-ray neutron counts is non-linear and not unique. Therefore we assimilate cosmic-ray neutron data directly by employing the nested forward model COSMIC (Shuttleworth et al. 2013, HESS), which calculates neutron counts from the modeled soil moisture.

In optimization mode, mHM is able to calibrate parameters of both, the hydrological system and/or the neutron prediction model itself. Sub-daily model performance is evaluated with independent measurements of soil moisture patterns from several catchment-wide TDR campaigns, time series of a Wireless Sensor Network and discharge in the small catchment “Schäfertal” (1.6 km2) in central Germany.

This work is an important step towards the assimilation of continuous spatial data from mobile Cosmic Ray Sensing (Schrön et al. 2014, TERENO Conference Abstracts). The so-called TERENO:Rover delivers highly-resolved spatial patterns of water content in a whole catchment, which has a great potential to improve spatial performance of hydrological models.