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Integral Quantification of Soil Water Content at the Intermediate Catchment Scale by Ground Albedo Neutron Sensing (GANS)

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Soil water content at the plot or hill-slope scale is an important link between local vadose zone hydrology and catchment hydrology. However, so far only few methods are on the way to close this gap between point measurements and remote sensing. One new measurement methodology for integral quantifications of mean areal soil water content at the intermediate catchment scale is the aboveground sensing of cosmic-ray neutrons, more precisely ground albedo neutron sensing (GANS). Ground albedo natural neutrons, are generated by collisions of secondary cosmic rays with land surface materials (soil, water, biomass, snow, etc). Neutrons measured at the air/ground interface correlate with soil moisture contained in a footprint of ca. 600 m diameter and a depth ranging down to a few decimeters. This correlation is based on the crucial role of hydrogen as neutron moderator compared to others landscape materials.
The present study performed ground albedo neutron sensing in different locations in Germany under different vegetative situations (cropped and bare field) and different seasonal conditions (summer, autumn and winter). Ground albedo neutrons were measured at (i) a farmland close to Potsdam (Brandenburg, Germany) cropped with corn in 2010 and sunflowers in 2011, and (ii) a mountainous farmland catchment (Schaefertal, Harz Mountains, Germany) in 2011. In order to test this method, classical soil moisture devices and meteorological data were used for comparison. Moreover, calibration approach, and transferability of calibration parameters to different times and locations are also evaluated.
Our observations suggest that GANS can overcome the lack of data for hydrological processes at the intermediate scale. Soil water content from GANS compared quantitatively with mean water content values derived from a network of classical devices (RMSE = 0.02 m3/m3 and r2 = 0.98) in three calibration periods with cropped-field conditions. Then, same calibration parameters corresponded well under different field conditions. Moreover, GANS approach responded well to precipitation events in both experimental sites through summer and autumn, and soil water content estimations were affected by water stored in snow.