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Use of cosmic ray neutron sensors for soil moisture monitoring in forests

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Measuring soil moisture with cosmic ray neutrons is a promising technique for intermediate spatial scales. To convert neutron counts to average volumetric soil water content a simple calibration function can be used (the N0-calibration of Desilets et al., 2010). The calibration is based on soil water content derived directly from soil samples taken within the footprint of the sensor. We installed a cosmic-ray neutron sensor (CRS) in a mixed forest in the lowlands of north-eastern Germany and calibrated it 10 times throughout one calendar year. Each calibration with the N0-calibration function resulted in a different CRS soil moisture time series, with deviations of up to 0.12 m3 m-3 for individual values of soil water content. Also, many of the calibration efforts resulted in time series that could not be matched with independent in situ measurements of soil water content. We therefore suggest a modified calibration function with a different shape that can vary from one location to another. A two-point calibration proved to be adequate to correctly define the shape of the modified calibration function if the calibration points were taken during both dry and wet conditions spanning at least half of the total range of soil moisture. The best results were obtained when the soil samples used for calibration were linearly weighted as a function of depth in the soil profile and non-linearly weighted as a function of distance from the CRS, and when the depth-specific amount of soil organic matter and lattice water content was explicitly considered. The annual cycle of tree foliation was found to be a negligible factor for calibration because the variable hydrogen mass in the leaves was small compared to the hydrogen mass changes by soil moisture variations. We will also provide a best practice calibration guide for CRS in forested environments.