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Moisture and humidity dependence of the above-ground cosmic-ray neutron intensity

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The novel method of Cosmic-ray neutron sensing (CRNS) allows non-invasive soil moisture measurements at a hectometer scaled footprint. Using this technique one can relate the flux density of albedo neutrons, generated in cosmic-ray induced air showers, to the amount of water within a radius of several hundred meters. In the recent years the understanding of neutron transport by Monte Carlo simulations led to major advancements in precision, which have successfully targeted a manifold of use cases. For example the improvements in the signal interpretation have meanwhile also been applied to the determination of snow water in Alpine regions. Up to now, the conversion of soil moisture to a detectable neutron count rate relies mainly on the equation presented by Desilets and Zreda. While in general a hyperbolic expression can be derived from theoretical considerations, their empiric parameterisation needs to be revised as many groups have found site-specific calibrations, which are simply based on different empirical data sets.

Investigating the above-ground neutron intensity by a broadly based Monte Carlo simulation campaign revealed a more detailed understanding of different contributions to this signal, especially targeting air humidity corrections. The packages MCNP and URANOS were used to derive a function able to describe the respective dependencies including the effect of different hydrogen pools and the sensor response function. The resulting formula significantly improves the soil-moisture-to-intensity conversion and allows for a more comprehensive instrument data quality, which especially closes the gap between observations of very dry and wet conditions.