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

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The novel method of Cosmic-ray neutron sensing (CRNS) allows non-invasive soil moisture measurements at a hectometer scaled footprint. Up to now, the conversion of soil moisture to a detectable neutron count rate relies mainly on the equation presented by Desilets et al. (2010). While in general a hyperbolic expression can be derived from theoretical considerations, their empiric parameterisation needs to be revised for two reasons. Firstly, a rigorous mathematical treatment reveals that the values of the four parameters are ambiguous because their values are not independent. We find a 3-parameter equation with unambiguous values of the parameters which is equivalent in any other respect to the 4-parameter equation. Secondly, high-resolution Monte-Carlo simulations revealed a systematic deviation of the count rate to soil moisture relation especially for extremely dry conditions as well as very humid conditions. That is a hint, that a smaller contribution to the intensity was forgotten or not adequately treated by the conventional approach. Investigating the above-ground neutron flux 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 detector-specific response function. The new relationship has been tested at three exemplary measurement sites and its remarkable performance allows for a promising prospect of more comprehensive data quality in the future.