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Testing a new correction factor to account for the vertical sensitivity of cosmic-ray neutron sensing for soil moisture estimation

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In recent years cosmic-ray neutron sensing (CRNS) developed into a valuable method for indirect soil moisture measurements at the intermediate scale. The passive neutron detector is installed above ground and after calibration delivers an average soil moisture for a horizontal footprint of tens of hectares (radius around probe ∼240m) and an integration depth of tens of centimeter.

However, the sensor is most sensitive in the close range and for the upper soil layers and the support volume decreases with increasing soil moisture. In addition, the probe is not only sensitive to soil moisture but to all hydrogen within its footprint, thus taking into account lattice water and hydrogen in soil organic matter (SW) improves calibration results. Therefore, the values delivered by CRNS represent a weighted total water content (volumetric soil moisture plus SW). Compared to point sensors of, e.g., a soil net, CRNS performs well (RMSE $\sim$0.03 m^3/m^3) when the soil net data is corrected to include SW and weighted to account for the horizontal and vertical sensitivity of the signal. On the contrary, comparing CRNS soil moisture to the simple average of volumetric soil net data results in substantially higher RMSE. This complex interpretation is a drawback when CRNS is supposed to be used as a standalone method for soil moisture estimation.

Recently, Baroni et al. 2018 showed that one main factor leading to the discrepancy between the simple average and CRNS soil moisture is the shape of the soil moisture profile. They proposed a correction factor based on the profile shape to apply on CRNS soil moisture to reduce the RMSE and simplify the interpretation of CRNS results. In the present contribution, we further systematically test the performance of this correction factor based on data collected at several study sites. First results confirm the RMSE can be reduced by having a single vertical profile location giving the shape. In addition, with having 3-5 locations within a distance of 50 m from the probe the maximum performance is reached (RMSE $\sim$0.03 m^3/m^3). Point sensors should cover at least the penetration depth of the detected signal and deeper sensors did not increase the performance of the correction factor. Consequently, for the use of CRNS as a standalone approach for soil moisture estimation we recommend as best operating practice to install several point sensor profiles and the use of this new vertical correction factor.