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Mobile single-sided NMR technology as a calibrating tool for areal soil moisture mapping

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Passive and active electromagnetic methods such as L-Band radiometry and radar reflectometry have great potential to provide, from ground or as remote applications, soil moisture maps on local or regional scales. To calculate values of absolute water content from the measured dielectric constant, calibration data is necessary. This is usually acquired in the lab by weighing soil samples. The required drying lasts several days to weeks depending on the soil type. A large number of samples distributed over the entire investigation area is desirable in order to increase the accuracy of the derived moisture maps. This, however, requires increased effort and thus higher costs.

We suggest the use of nuclear magnetic resonance (NMR) to gather this kind of calibration data. NMR measures the water content in porous media directly by stimulating the proton spins of the water molecules. The amplitude of the received response signal is linearly correlated with the number of protons in the sensitive volume of the device, i.e., with the amount of water in it: zero is measured when water is absent, while 100% water corresponds to maximum signal amplitude. In contrast to conventional laboratory NMR, the single-sided NMR technology enables mobile tools that are easy to handle in the field. Absolute soil moisture data is collected just by placing the sensor at the size of a shoebox or suitcase on the ground and the result for a single spot is available after a few minutes instead of days when taking and drying samples.

We successfully tested the single-sided NMR technology at one of our L-Band radiometry test sites predominated by clayey loam. In addition to the quad-bike based passive areal L-Band data acquisition, pointwise single-sided NMR measurements were performed on a profile with the length of 600 m at 10 m spacing. The sensitive NMR volume was adjusted to a depth of 1 cm. A total of 10 samples were taken for verification and analysed in the lab. The absolute water contents provided by NMR excellently agree with those of the samples. Moreover, the NMR profile results are also in good agreement with the L-Band measurements on the same profile. Future investigations will focus on the feasibility of the single-sided NMR method for other soil types and on the interpretation of the NMR relaxation behavior, which allows estimating the water-filled pore size distribution. In addition to the water content, this additional information is useful to estimate water mobility and storage capacity in the topsoil.