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A slim-line NMR logging tool to measure moisture in soils

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The transport of water in soils is a physical phenomenon of importance in soil science and climatology. This work reports progress in the development of slim-line NMR logging tool ("the sensor") to characterize soil moisture, developed within the DFG-funded interdisciplinary collaborative project TR32. To demonstrate the capability of the NMR technique to follow the drying process of water in soils, several moisture measurements were performed with the sensor on two different types of model soils (sand FH31 and a mix of sand FH31/ silt W3) during an one-step outflow experiment. The soils were packed in columns approximately one meter high. The sensor could be raised and lowered inside a plastic tube (2 mm thick) in the soil column similar to a wire-line logging tool. Working at a frequency of 12 MHz, the sensitive volume lies 6 mm away from the outer sensor surface, measuring the NMR signal of proton spins lying 4 mm inside the soil. Using the direct proportionality between the amplitude of the NMR signal and the water content, partial saturation profiles before, during and after outflow can be obtained. By comparing the data to numerical solutions by means of HYDRUS 1D, we the hydraulic parameters K_s, α, n and l of the Mualem - Van Genuchten model can be assessed for the model soils under study. Furthermore, technical advances to make this tool sturdier for outdoor field measurements and to increase the signal sensitivity are discussed. They include a reduction of the echo time by damping the magneto-acoustic oscillations and the use of the gradiometer coils to make the sensor less sensitive to far-field noise. The performance of the sensor with different coils and under different shielding principles is evaluated to find the optimum design and operating conditions. First field measurements of the sensor from the Selhausen test site are presented.