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Magnetic Resonance Imaging Methods for Monitoring Root Water Uptake and Architecture

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Magnetic Resonance Imaging (MRI) is a powerful tool for the non-invasive investigation of below-ground processes. This technique, which is well known from medical applications, probes the physico-chemical environment (T_1-, T_2-relaxation, diffusion etc.) of ^{1}H nuclei in an external magnetic field, and 3D images are obtained by additional switching of magnetic field gradients. In porous media the obtained signals depend mainly on the spatial distributions of i) water content, ii) pore size, and iii) paramagnetic ions.

However, the relation between recorded signal and the water content is not linear, since the relaxation times vary also with changing water content. Therefore, one should monitor the temporal development of nuclear magnetic relaxation which yields 4D data-sets:

$S(n_E t_E, x,y,z) = S_0(x,y,z) \exp(-n_E t_E/T_2) + background$, (1)

where n_E is the number of echoes, t_E is the echo-time, x, y, z are the Cartesian coordinates, and T_2 is the transverse relaxation time. The desired water content is calculated from S_0, which is obtained by fitting Eq. 1, in combination with a convenient calibration phantom.

In this presentation we apply this multi-slice-multi-echo approach (MSME) to moni-

tor the root water uptake by ricinus and maize plants in a model soil under progressive water depletion over a period of about two weeks. The procedure is further compared to an earlier approach that uses another MRI-method, so-called SPRITE. By co-registration with the root architecture, which is visualised by a 3D fast spin echo sequence, we conclude that the largest water content changes occurred in the neighbourhood of the roots and in the upper layers of the soil.