Imaging of 3D patterns of slow flow in porous media

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Understanding root water uptake is indispensable for the optimization of plant growth and crop yield against the background of growing world population. One strategy to understand how root water uptake functions is the knowledge of water movement from bulk soil to the root, passing the root-soil interface: the bottleneck for water uptake. Whereas direct imaging of fluxes in the above-ground plant stem has been performed by the group of Van As [1], little is known about the 3D flow pattern, dispersion and velocities in the soil-root compartment. This is due to the heterogeneous and hierarchical structure of the root system [2], resulting in small fluid displacements of some tens of micrometer per second based on the transpiration rate of the plant. It has been shown by Spindler et al. [2] that mean flow rates of a homogeneous flow as low as 0.06 mm/s can be measured even under the influence of internal magnetic field gradients (caused by the heterogeneity of the soil as a porous material) using 13-interval stimulated echo multi-slice imaging (STEMSI).

This contribution will report on further challenges if STEMSI is used for the acquisition of water transport in a heterogeneous root phantom and around the roots of a life plant system. While a 3D MRI image of the root system with sufficient spatial resolution is necessary it is also important to obtain the full 3D information of the velocity vector for the water movement in the vicinity of the plant roots. These requirements need to be balanced against the necessary acquisition time for this 6D data set since the plant is growing and therefore changing its root system over time. To meet this requirement the concepts for Stimulated Echo Acquisition Mode (STEAM) [4] have been fully incorporated into the STEMSI method, thus enabling rapid multi-slice acquisition while retaining sufficient signal to noise ratios.

References

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