Geophysical Research Abstracts
Vol. 12, EGU2010-7217, 2010
EGU General Assembly 2010

Root Water Uptake and Tracer Transport in a Lupin Root System: Integration of Magnetic Resonance Images and the Numerical Model RSWMS

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Combination of experimental studies with detailed deterministic models help understand root water uptake processes. Recently, Javaux et al. developed the RSWMS model by integration of Doussan´s root model into the well established SWMS code[1], which simulates water and solute transport in unsaturated soil [2, 3]. In order to confront RSWMS modeling results to experimental data, we used Magnetic Resonance Imaging (MRI) technique to monitor root water uptake in situ. Non-invasive 3-D imaging of root system architecture, water content distributions and tracer transport by MR were performed and compared with numerical model calculations. Two MRI experiments were performed and modeled: i) water uptake during drought stress and ii) transport of a locally injected tracer (Gd-DTPA) to the soil-root system driven by root water uptake.
Firstly, the high resolution MRI image (0.23x0.23x0.5mm) of the root system was transferred into a continuous root system skeleton by a combination of thresholding, region-growing filtering and final manual 3D redrawing of the root strands. Secondly, the two experimental scenarios were simulated by RSWMS with a resolution of about 3mm. For scenario i) the numerical simulations could reproduce the general trend that is the strong water depletion from the top layer of the soil. However, the creation of depletion zones in the vicinity of the roots could not be simulated, due to a poor initial evaluation of the soil hydraulic properties, which equilibrates instantaneously larger differences in water content. The determination of unsaturated conductivities at low water content was needed to improve the model calculations. For scenario ii) simulations confirmed the solute transport towards the roots by advection.
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