Geophysical Research Abstracts
Vol. 13, EGU2011-12630, 2011
EGU General Assembly 2011

Modeling root water uptake with R-SWMS using magnetic resonance imaging experiments

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Growing crops in continuously changing climate conditions is one of the biggest challenges of the modern world. Root hydraulic properties influence water and solute uptake processes in soil. However, the availability of water resources for plants, known to influence the rates of transpiration and leaf expansion, is influenced also by the soil hydraulic properties. Therefore, a strong knowledge of both, root and soil hydraulic properties, is required in creating plant genotypes with drought resistance and capacity to uptake water from high resistance soils. Yet, direct in situ monitoring of root water uptake distribution along the root system is still impossible. Therefore novel methodologies are needed to characterize the sink term and be able to assess the impact of plant genotypes on its root properties and water extraction capacity.

In this work, we propose to combine high resolved root extraction experiments with forward root water uptake modeling to assess the distribution of the sink term. A lupine plant in a pot was submitted to a stress experiment. Cumulative transpiration was followed by gravimetrically, while high resolution Magnetic Resonance Imaging (MRI) was performed to monitor 3D water depletion on a daily-basis. The root architecture was also imaged by MRI two times during the experiment and the final actual architecture was scanned at the end of the experiment. This experiment was used to calibrate a 3D water flow model, which predicts the root water uptake based on the hydraulic gradient between soil and roots (R-SWMS). The experimental transpiration data were used as initial boundary condition, the hydraulic properties of the soil were measured independently, and roots hydraulic properties were obtained from the literature.

A prospective sensitivity analysis was also performed to show the sensitivity of the plant and soil hydraulic parameters and investigate the possibility of using this methodology to obtain plant parameters with inverse modeling.