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How the hydraulic parametrisation of roots affects overall plant-soil interactions

M. Bechmann (1), Ch. Schneider (2), A. Carminati (3), D. Vetterlein (2), and A. Hildebrandt (4)

(1) Friedrich-Schiller-University Jena, Germany (Marcel.Bechmann@gmx.com), (2) Helmholtz Centre for Environmental Research (UFZ), Germany, (3) Georg-August-University Göttingen, Germany , (4) Friedrich-Schiller-University Jena, Germany

Research during the last decades suggests strongly that root length density (RLD) is unsuitable for predicting root water uptake on small scales. Nevertheless, RLD is still the most used parameter for modeling root water uptake in state-of-the-art soil-plant-atmosphere schemes. One reason might be the deficient understanding of the processes at the soil-root interface and the lack of appropriate other approaches. Considering the heterogeneous nature of root hydraulic properties (from coarse to fine roots) as well as the effects of local processes at the soil-plant-interface (the so called rhizosphere), we investigate the role of hydraulic parameterization and topology on overall plant water uptake, using two modeling studies.

First, we use a conceptual model of simple branching structures to understand the influence of branching location and transitions in root hydraulic properties on root water uptake patterns.

Second, we apply a physical model called “aRoot” to test our conclusions on complex root system architectures. aRoot calculates the distribution of xylem potential within arbitrary root geometries to satisfy a given water demand depending on the available water in the soil. Redistribution of water within the bulk soil is calculated using the Richards equation.

Simulations showed that vertical root water uptake profiles are governed both by root properties as well as by the overall root system’s topology, because they result from two combined re-distribution patterns over time: One within a rooting branch and a second one between the different rooting branches. This leads to complex vertical uptake profiles, which cannot be predicted from a combination of root abundance and soil moisture.