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Functional-structural modelling of root water uptake based on measured MRI images of root systems

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In the course of climate change, the occurrence of extreme weather events is expected to increase. Drought tolerance of crops and careful irrigation management are becoming key factors for global food security and the sustainable resource use of water in agriculture. Root water uptake plays a vital role in drought tolerance. It is influenced by root architecture, plant and soil water status and their respective hydraulic properties. Models of said factors aid in organizing the current state of knowledge and enable a deeper understanding of their respective influence on crop performance. Water uptake by roots leads to a decrease in soil moisture and may cause the formation of soil water potential gradients between the bulk soil and the soil-root interface. Although the Richards equation in theory takes these gradients into account, a very fine discretization of the soil domain is necessary to capture these gradients in simulations. However, especially during drought stress, the drop in hydraulic conductivity in the rhizosphere could have a major impact on the overall water uptake of the root system. In order to investigate computationally feasible alternative approaches for simulations with source terms that take these hydraulic conductivity drops into account, we conducted experiments with lupine plants. The root architecture of the growing plants was measured several times using an MRI. Subsequently, these MRI images were used in a holobench for manual tracing of the roots. We were able to mimic the root growth between the measurement dates using linear interpolation. In addition to root architecture, soil water contents and transpiration rates were monitored. We then used this data to systematically compare the computational effort of different approaches to consider the hydraulic conductivity drop near roots in terms of accuracy and computational cost. Eventually we aim at using these results to improve existing root water uptake models for the presence of hydraulic conductivity drops in the rhizosphere in an efficient and accurate way.