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Improving macroscopic modeling of the effect of water and osmotic stresses on root water uptake.

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Accurate modeling of water and salt stresses on root water uptake is critical for predicting impacts of global change and climate variability on crop production and soil water balances. Soil-hydrological models use reduction functions to represent the effect of osmotic stress in transpiration. However, these functions, which were developed empirically, present limitations in relation to the time and spatial scale at which they need to be used, fail to include compensation processes and do not agree on how water and salt stresses interact.

This research intends to develop a macroscopic reduction function for water and osmotic stresses based on biophysical knowledge. Simulation experiments are conducted for a range of atmospheric conditions, soil and plant properties, irrigation water quality and scheduling using a 3-D physically-based model that resolves flow and transport to individual root segments and that couples flow in the soil and root system (Schröder et al., 2013). The effect of salt concentrations on water flow in the soil-root system is accounted for by including osmotic water potential gradients between the solution at the soil root interface and the root xylem sap in the hydraulic gradient between the soil and root. In a first step, simulation experiments are carried out in a soil volume around a single root segment. We discuss how the simulation setup can be defined so as to represent: (i) certain characteristics of the root system such as rooting depth and root length density, (ii) plant transpiration rate, (iii) leaching fraction of the irrigation, and (iii) salinity of the irrigation water. The output of these simulation experiments gives a first insight in the effect of salinity on transpiration and on the relation between the bulk salinity in the soil voxel, which is used in macroscopic salt stress functions of models that do not resolve processes at the root segment scale, and the salinity at the soil-root interface, which determines the actual root water uptake. In a next step, simulations considering the whole root architecture will be conducted to evaluate how the outcome of the single root simulation experiments can be upscaled to the whole root system scale.

Schröder, N., N. Lazarovitch, J. Vanderborght, H. Vereecken, M. Javaux (2013): Linking transpiration reduction to rhizosphere salinity using a 3D coupled soil-plant model. Plant and Soil: 1-17. doi: 10.1007/s11104-013-1990-8