

The Root System as a Hydraulic Architecture: Principles and Applications

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Many hydrological models including the process of root water uptake (RWU) do not consider the dimension of root system hydraulic architecture (HA) because explicitly solving water flow in such a complex system is too time consuming. However, they might lack process understanding when basing RWU and plant water stress predictions on functions of variables such as the root length density distribution.

On the basis of analytical solutions of water flow equations in a HA, we developed and validated a macroscopic model for both RWU distribution and plant water stress, which respects physical principles of water flow in root systems of any complexity. Rather than thousands of local parameters defined at the root segment scale, the new model has three macroscopic parameters defined at the plant scale: (i) the standard sink fraction distribution SSF, (ii) the root system equivalent conductance K_{rs} and (iii) the compensatory RWU conductance K_{comp} . It is simple, computationally light, clearly decouples the process of water stress from compensatory RWU, and its structure is appropriate for hydraulic lift simulation.

In a further study, the model was coupled to Richards' equation in the Windows-based computer software package HYDRUS-3D. A sensitivity analysis of soil water dynamics to RWU parameters was performed, and the feasibility of model inverse parameterization from synthetic soil water dynamics data, on different soil types, was questioned.