



Upscaling of 3D root hydraulic architectures of trees to 1D root hydraulic models

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Root systems of trees are obviously much larger than those of herbaceous plants. Considering a root length of 30 km of roots below a surface area of 1 m² in a forest and considering that the root system of a single tree extends over a horizontal area of 10 m², this would mean that a root system of one tree is 300 km long. To simulate the water flow in the root system, the root system is typically discretized in 1 cm long root segments and a set of flow equations is setup and solved to derive the water potential and flux in each segment of the 3D root hydraulic architecture. For a system with n root segments and $n+1$ nodes at which segments are connected, this results in a set of n equations that need to be solved. Solving this set of equations corresponds with inverting an n by n matrix. For the root system of a tree, the size of this matrix would be $3 \cdot 10^7$ by $3 \cdot 10^7$. The linear equation matrix is sparse and could be solved using equation solvers that do not calculate the inverse matrix. But, also these solutions might still be too expensive so that an upscaled and reduced set of equations is needed. We developed an approach to upscale flow equations in root hydraulic architectures (Vanderborght et al., 2021), which were subsequently coupled to non-linear flow equations that account for resistance to flow in the soil around root segments (Vanderborght et al. 2023). But, these upscaling approaches require an inversion of the linear equation matrix. In order to address this problem, we developed an inversion method that uses the hierarchical structure of the root network to divide the inversion into a set of smaller inversion problems that can be solved in parallel. In this presentation, we outline the principle of the inversion method and demonstrate it for large root systems of trees.

References

Vanderborght, J., et al. (2021) From hydraulic root architecture models to macroscopic representations of root hydraulics in soil water flow and land surface models. *Hydrol. Earth Syst. Sci.*, 25(9), 4835-4860. <https://doi.org/10.5194/hess-25-4835-2021>

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