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A whole-plant hydraulic capacitance approach to modeling distributed root water uptake and actual transpiration

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In the present study, we propose a simple transpiration stream model, based on the concept of whole-plant hydraulic capacitance. The suggested algorithm is implemented in a one-dimensional soil water flow model involving vertically distributed macroscopic root water uptake. The proposed transient plant water storage approach is compared with the more conventionally used quasi-steady-state approach. Both approaches are used to simulate soil water flow and diurnal variations of transpiration at a forest site covered with Norway spruce. The key parameter of the transient storage approach – plant hydraulic capacitance – is estimated by comparing the variations of potential transpiration rate, derived from micrometeorological measurements, with observed sap flow intensities. The application of the proposed model leads to improved predictions of root water uptake and actual transpiration rates. The algorithm can be easily implemented into existing soil water flow models and used to simulate transpiration stream responses to varying atmospheric and soil moisture conditions including isohydric and anisohydric plant responses to drought stress.