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Root System Architecture Stencil: a process-based model improves vegetation water uptake predictions at a flux tower site.

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Root system architecture (RSA) can significantly affect plant access to water, total transpiration, as well as its partitioning into water uptake by soil depth, with implications for surface heat, water, and carbon budgets. Despite recent advances in terrestrial model (TM) descriptions of plant hydraulics, RSA has not been included because of its three-dimensional complexity, which makes RSA modelling generally too computationally costly. This work introduces the recently developed "RSA stencil," a process-based 1D layered model that captures the dynamic shifts in water potential gradients of 3D RSA in response to heterogeneous soil moisture profiles (discretised by depth). In validations using root systems calibrated to the rooting profiles of four plant functional types (PFT) of the Community Land Model (CLM), the RSA stencil predicts plant water potentials within 2% of the outputs of the 3D plant models, despite its trivial computational cost. In transient simulations, the RSA stencil yields improved predictions of water uptake and soil moisture profiles compared to a 1D model based on root fraction alone. Present work focuses on calibrating the RSA stencil to time-series observations of soil moisture and transpiration to move towards a water uptake PFT definition for use in CLM 5. This model-data integration exercise aims to improve TM predictions of soil moisture dynamics and, under water-limiting conditions, surface fluxes. These improvements can be expected to significantly impact predictions of downstream phenomena, including climate-vegetation feedbacks and soil nutrient cycling.