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A model for hydraulic redistribution incorporating coupled soil-root moisture transport

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Abstract. One of the adaptive strategies of vegetation, particularly in water limited ecosystems, is the development of deep roots and the use of hydraulic redistribution which enables them to make optimal use of resources available throughout the soil column. Hydraulic redistribution refers to roots acting as a preferential pathway for the movement of water from wet to dry soil layers driven by the moisture gradient – be it from the shallow to deep layers or vice versa. This occurs during the nighttime while during the daytime moisture movement is driven to fulfill the transpiration demand at the canopy. In this study, we develop a model to investigate the effect of hydraulic redistribution by deep roots on the terrestrial climatology. Sierra Nevada eco-region is chosen as the study site which has wet winters and dry summers. Hydraulic redistribution enables the movement of moisture from the upper soil layers to deeper zones during the wet months and this moisture is then available to meet the transpiration demand during the late dry season. It results in significant alteration of the profiles of soil moisture and water uptake as well as increase in the canopy transpiration, carbon assimilation, and the associated water-use-efficiency during the dry summer season. This also makes the presence of roots in deeper soil layers much more important than their proportional abundance would otherwise dictate. Comparison with observations of latent heat from a flux tower demonstrates improved predictability and provides validation of the model results. Hydraulic redistribution serves as a mechanism for the interaction between the variability of deep layer soil-moisture and the land-surface climatology and could have significant implications for seasonal and sub-seasonal climate prediction.

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