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Simultaneous measurement of depth profiles of root water uptake and redistributive soil water flow

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Water use by plants depends on several shoot and root traits and their response to local water availability, especially under drought conditions. Water management strategies and plant phenotype optimization therefore require systematic investigation of root and soil water fluxes under various drought scenarios. However, root water fluxes and redistributive soil water flows are concurrent processes that are very hard to distinguish with present techniques, causing a near complete lack of measured data on the subject of local root water uptake. Most available data relies heavily on modeling and comes with considerable uncertainty due to its dependency on soil water conductivity data.

Here we present a highly precise soil water sensor (precision of 6e-5 cm3/cm3). Furthermore, we demonstrate that such a high sensitivity can be used to quantify root water uptake (RWU) depth profiles when plant transpiration fluctuates. Since macroscopic redistributive soil water flow (rSWF) is a much slower process, it can be separated from RWU based on time scale. This approach was simulated and shows that the fluctuations in the soil water depletion rate caused by the roots are quite local under a wide range of conditions. We demonstrate also how to follow the RWU pattern changes with progressing soil dehydration without any knowledge of the root distribution, water retention characteristics of soils, nor rely on modeling.

The sensor (SWaP, Soil Water Profiler) we present is low-cost and user-friendly. Data analysis of soil water depletion rate fluctuations requires only a few calibration steps after which root water uptake depth profiles can be obtained in a straightforward manner.