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Two water worlds: Isotope evidence shows that trees and streams return different pools of water to the hydrosphere

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Climate-soil and vegetation interactions are dynamic and few integrated tools exist for quantifying these spatial and temporal dynamics and interactions among the major components of the terrestrial hydrologic cycle. This talk explores how isotope-based field studies in forest ecohydrology can provide new insights into water cycling. We analyzed stable isotopes of oxygen (O-18) and hydrogen (2-H) in water to quantify spatial and temporal changes in precipitation, evaporation, soil water, tree water and stream discharge isotopic signatures at Watershed 10 at the HJ Andrews Experimental Forest in the Cascade Mountains of Oregon, USA. The region has a Mediterranean climate with very dry summers and wet winters. At the end of the wet season (June), measured soil-water storage was at its maximum, and isotopic data suggested that plant water uptake occurred primarily from the surface soils. As the dry season progressed, plants relied on deeper soil water as surface soils dried out. Evaporation from the soil surface resulted in a distinct isotopic signature on tightly bound soil water. Our isotope data indicate that most water taken up by plants during the summer was affected by evaporation at some point, including soil water deeper than 30 cm. In contrast, mobile water reaching the stream and forming stream water did not show any evidence of an evaporation signature even though discharge rates showed distinct diurnal cycles driven by transpiration. During the fall wet up, soil lysimeter water and stream water were consistent with meteoric water signatures but with variation damped temporal dynamics with a several week lag period. Bulk soil water also began to look isotopically similar to lysimeter and stream water as soils wetted-up. Nevertheless, tree water did not change with the onset of winter precipitation indicating that tree water residence time was very long during the winter dormacy period. Tree water also retained its evaporated signal. We conceptualize these ecohydrological findings as two distinct and separate pools of water held within the soil: one a mobile pool held at relatively low matric tension, making it more subject to gravitational transport to streams when more water is added to the system. The other pool is water held under higher matric tensions and has a longer residence time within the soil, and a higher propensity to be taken up by plants.