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Flow pathways, transit time, and tree water sources: linking ecohydrological processes with stable isotopes in a small forested catchment

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A holistic understanding of ecohydrological processes that regulate the variability of tree water use, water flow pathways through the soil and to groundwater and the stream, and the transit time of water at the catchment scale is still challenging. In this work, we rely on an integrated dataset of isotope tracers and hydrometric data to show new evidence on the main ecohydrological processes and their controls that link runoff origin, sources of tree water uptake, and water transit time in a small mountain, forested catchment in central Italy.

The Re della Pietra experimental catchment is located in the Tuscan Apennines. The catchment is 2 km^2 in size and ranges in elevations between 650 and 1280 m a.s.l.. Forests cover more than 95% of the area, and the main tree species are beech and oak trees, with a much smaller proportion of conifers. Mean annual precipitation is around 950 mm. We collected water samples from April 2019 to January 2023 from precipitation, throughfall, soil, groundwater, springs, stream at different sections, and xylem of beech trees, and determined their isotopic composition. Weather data, streamflow, soil moisture, groundwater level, and throughfall were monitored in a 0.3 km^2 headwater sub-catchment. Stream stage and electrical conductivity as additional tracer were measured in three stream sections from the headwater sub-catchment down to the Re della Pietra outlet. Streamflow, groundwater, spring flow, and soil moisture are characterized by a marked seasonality, reflecting the strong seasonal variability in the meteorological forcing, typical of the Mediterranean climate.

Based on field observations and preliminary data analysis, we aim to test the following hypotheses:

- i) Trees growing along a steep hillslope in the headwater sub-catchment use different water sources (soil water vs. shallow groundwater) as a function of their topographic position.
- ii) Hillslope soil water is an important contributor to streamflow only during wet conditions (i.e., in winter, late fall, and early spring).
- iii) Spring water flows through shallow pathways and is a negligible contributor to streamflow, especially during dry conditions.
- iv) Water transit time increases as a function of increasing catchment size (i.e., increasing drainage area).

The results will contribute to the conceptualization of the interrelated ecohydrological processes driving water fluxes in Mediterranean forested catchments.