Simulating preferential flow in a two water worlds context
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Introduction
Ecological separation has been observed across climates and
biomes, and at a fundamental level suggests that water in mobile
versus immobile domains may resist mixing over varying periods of time;
however little mechanistic evidence exists to explain this separation at a
process scale. Non-equilibrium flow in the vadose zone may partially
account for widespread perception of distinct hydrological domains yet no
studies have weighed its contribution.

Objectives
Determine the amount of preferential flow necessary to maintain a two
water worlds scenario (i.e., physical separation between mobile and
immobile water pools) using a simple isotope mixing technique.

Methods
We constructed 60 cm soil columns (20 cm-ID PVC) containing either
sieved soil material (low structure), subsoil structure (intact B
horizon), or soil material with tubing-reinforced macropores to limit
exchange with soil matrix water (no-exchange).

Columns were subjected to 3 rain storms of varying rainfall intensity
(−2.5 cm h⁻¹, −5 cm h⁻¹, and −11 cm h⁻¹) whose stable isotope signatures oscillated around known baseline values.

Leachate and soil matrix water (via direct vapor equilibration) were
measured periodically throughout the experiment and analyzed for their
isotopic signatures using off-axis integrated cavity output spectroscopy
(OA-ICOS).

Discussion
• We observed up to ~ 3 δ deviation of soil matrix water ²H signature from saturation values
suggesting that soils may strongly fractionate ²H relative to ³H (Figure 1).

• Soils with varying degrees of structure showed 100% mixing of rain water with soil matrix water
under low to moderate rainfall intensities (−2.5 ~ 5 cm h⁻¹) yet high intensity (−11 cm h⁻¹)
produced clear separation between columns with intact or artificial soil structure (no-exchange) and
those controlled for structure (low structure treatment; Figure 2 and Figure 3).

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References
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