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# Water as a critical zone currency: linking water storage and age to root uptake and biogeochemical transport

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## Background

Analyzing responses of water ages to changes in hydrological status (e.g., storage) gives insights into water-mediated CZ functions.

**Prospect.** Anticipating sensitivity of ecosystem health and biogeochemical balance to changing climatic and land-water use conditions.

## Questions

How do water flow paths control

1. the age of root uptake
2. the variability of water chemistry within and across the critical zone?

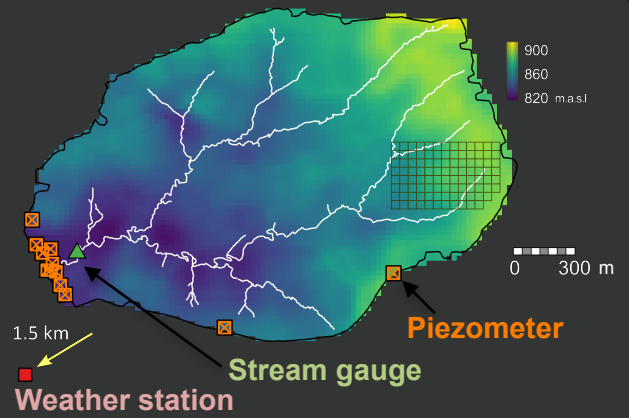
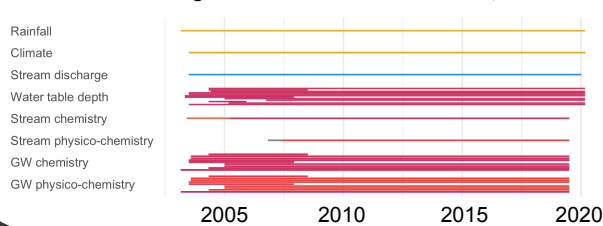
## Method

Coupling spatially-distributed **ecohydrological** and **geochemical** modeling approaches in **data-rich** critical zone observatories

## Study site

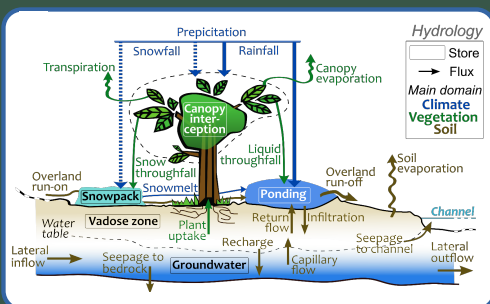
**Mule Hole**, a 4 km<sup>2</sup> sub-humid intermittent catchment in SW India, with a deep weathered profile on a granitogneissic basement, covered by a dry deciduous forest [1].

### Data availability



## Tracking water in the critical zone

**EcH<sub>2</sub>O-iso**, a process-based and spatially-distributed ecohydrological model, tracking water signature (age and conservative tracers) across grid cells and CZ compartments [2].

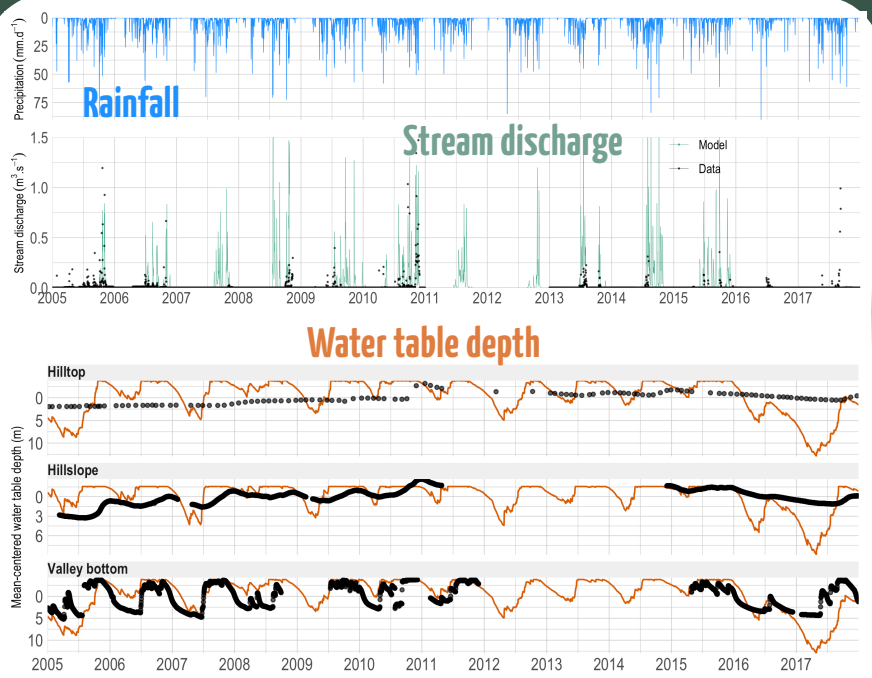


### Preliminary configuration

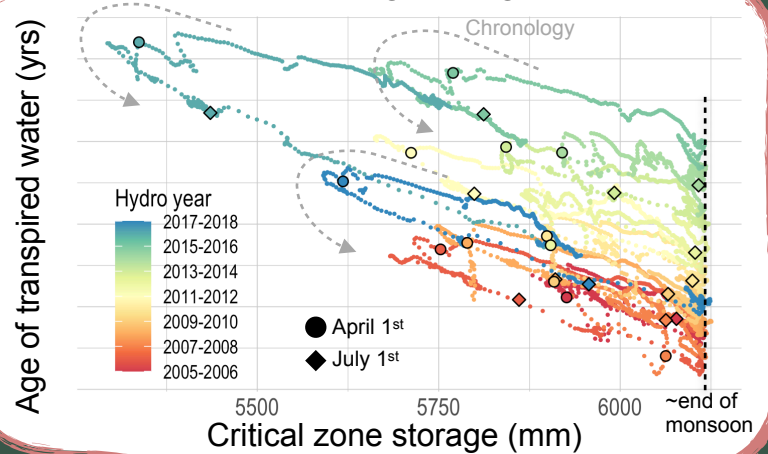
Daily simulations at 90m resolution. 2005-2017 (+90-year spinup) 35m-deep hydrological domain. Uniform vegetation cover (deeply-rooted trees 90%). Manual parameters calibration to discharge and piezometric levels.

**Root uptake accesses deep, old waters, consistent with previous studies [3]. Hysteretic relationship with CZ storage reflect cross-season carry-over. Large inter annual variability from hydroclimate.**

### Model-data time series



### Catchment-scale age-storage simulations



## Biogeochemical budget

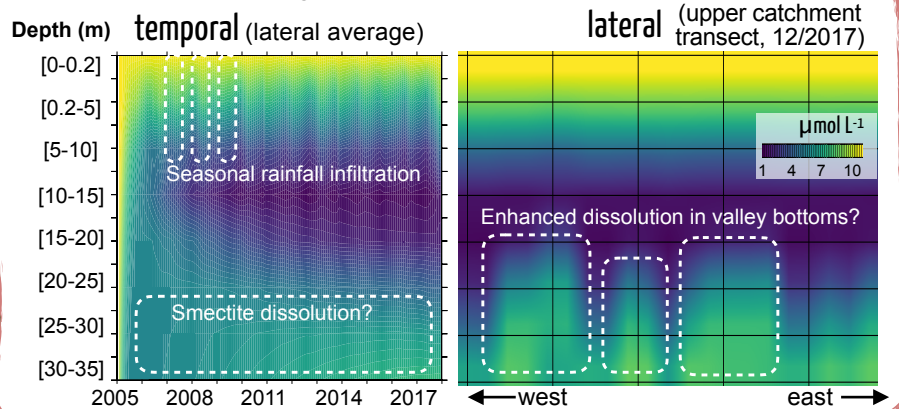
**WITCH**, a modular chemical weathering model – simulating dissolution/precipitation rates of mineral phases based on kinetics laws [4] (spatialized version).

### Preliminary simulations

Monthly simulations forced with EcH<sub>2</sub>O-iso water fluxes and contents. No spinup. Laterally-uniform mineralogy, 9 vertical layers.

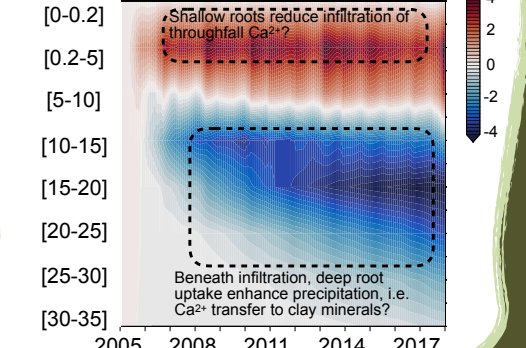
**Example with Ca<sup>2+</sup>: strong signature of varying water fluxes and storage**

### Variability of calcium concentration



**Effect to root uptake depth:** alteration of control configuration (roots >25m) towards shallow roots (<1m).

### Ca<sup>2+</sup> profile difference



## Summary

**Proof-of-concept:** even when simplifying the Critical Zone structure, space- and time-changing water flow paths create complex patterns of rock - root - water interactions *within* and *across* the landscape

Multi-scale datasets are required for model evaluation

## References

[1] Riotte et al. (2014), *Geochimica et Cosmochimica Acta*, 145, 116-138 [link]. [2] Kuppel et al. (2018), *Geosci. Model Dev.* 11(7), 3045-3069 [link]. [3] Chitra-Tarak et al. (2018), *Journal of Ecology*, 106(4), 1495-1507 [link]. [4] Godd ris et al. (2006), *Geochimica et Cosmochimica Acta*, 70(5), 1128-1147 [link].