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

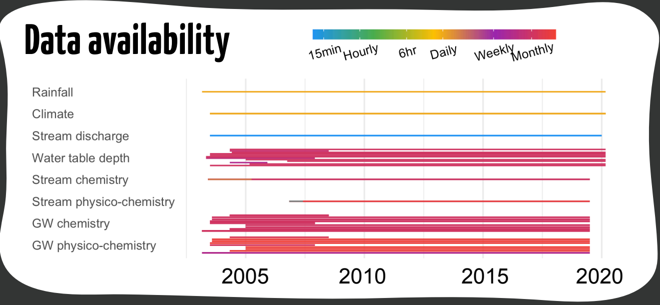
How do water flow paths control
1. the age of root uptake
2. the variability of water chemistry
within and across the critical zone?

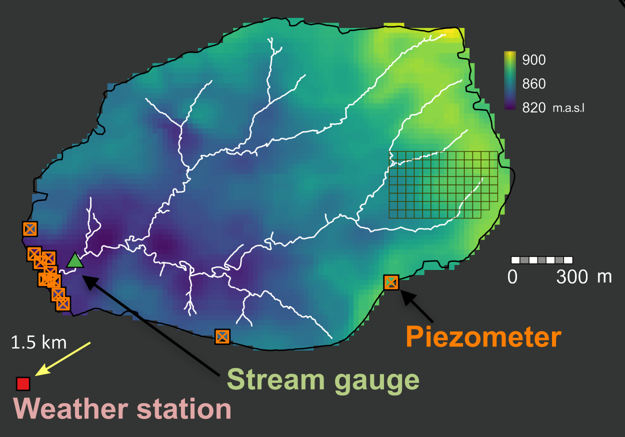
Method

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

Study site

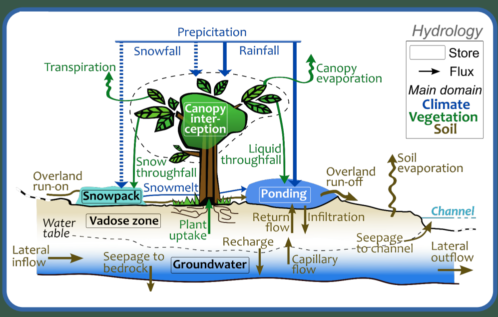
Mule Hole, a 4 km² sub-humid intermittent catchment in SW India, with a deep weathered profile on a granito-gneissic basement, covered by a dry deciduous forest [1].



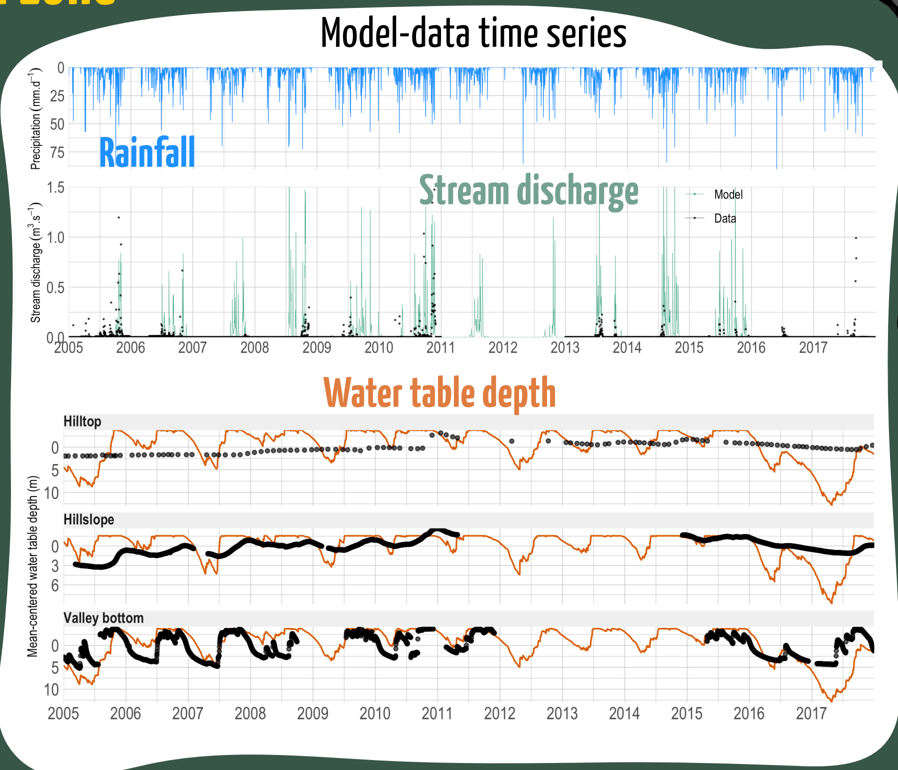


Tracking water in the critical zone

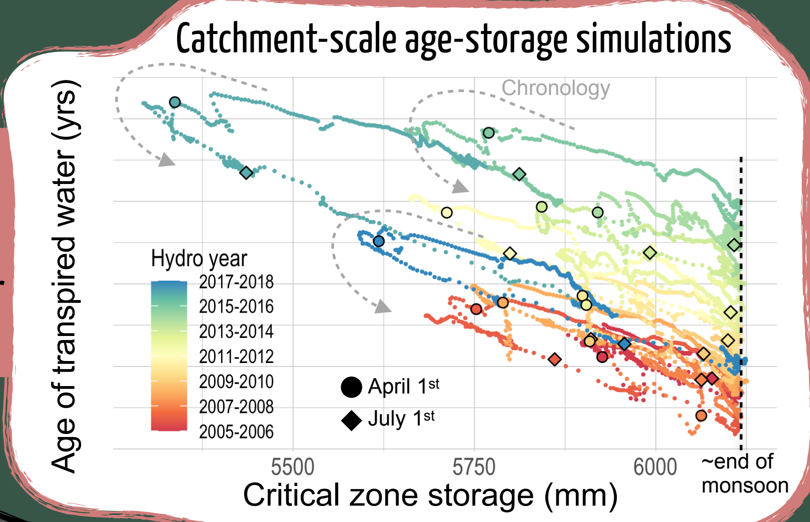
EcH$_2$O-iso, a process-based and spatially-distributed ecohydrological model, tracking water signature (age and conservative tracers) across grid cells and CZ compartments [2].



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.

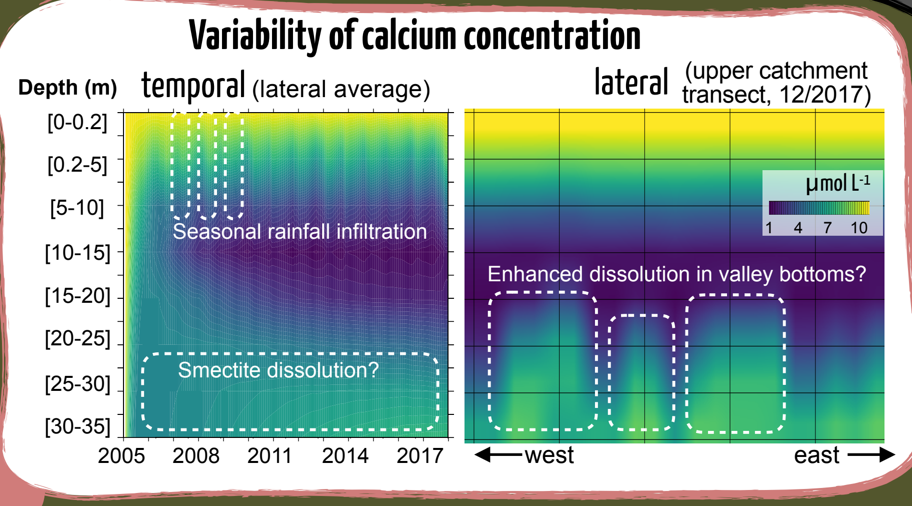


Biogeochemical budget

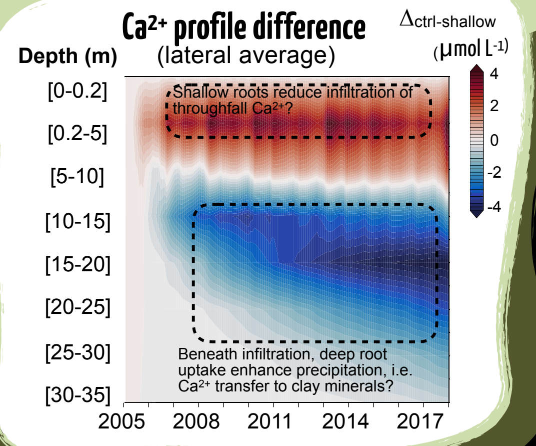
WITCH, a modular chemical weathering model – simulating dissolution/precipitation rates of mineral phases based on kinetics laws [4] (spatialized version).

Preliminary simulations
Monthly simulations forced with EcH$_2$O-iso water fluxes and contents.
No spinup. Laterally-uniform mineralogy, 9 vertical layers.

Example with Ca^{2+}: **strong signature of varying water fluxes and storage**



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



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 (2018), *Journal of Ecology*, *106*(4), 1495-1507 [link]
[4] Goddéris et al. (2006), *Geochimica et Cosmochimica Acta*, *70*(5), 1128-1147 [link].