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.

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

Questions
1. How do water flow paths control root uptake and biogeochemical transport?

2. The temporal 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 gneissic basement, covered by a dry deciduous forest (1).

Data availability
- Temporal rainfall
- Stream discharge
- Water table depth
- Water chemistry

Preliminary configuration
- Daily simulations at 90m resolution, 2005-2017 (90-year spin-up)
- 30m-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 (1). Hysteretic relationship with CZ storage reflect cross-season carry-over. Large inter annual variability from hydroclimate.

Towards shallow roots (<1m).

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

Example with Ca²⁺: strong signature of varying water fluxes and storage.

Biogeochemical budget

WETCH: a modular chemical weathering model – simulating dissolution/precipitation rates of mineral phases (2).

Smectite dissolution?

Depth (m)

Example with Ca²⁺:

Biogeochemical transport

Water table depth

Rainfall

Stream discharge

Critical zone storage (mm)

Age of transpired water (yrs)

Spatial variability of calcium concentration

CATCH-scale age-storage simulations

Depth (m)

Catchment-scale age-storage simulations

Variability of calcium concentration

Biogeochemical budget

Stable isotopes (δ18O, δD)

Biogeochemical budget


Biogeochemical budget

Goddéris et al. (2006), Geochimica et Cosmochimica Acta, 70(5), 1219-1247 (1).

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