Diverging Hydrological and Hydrochemical Drought Responses in a Forested Pre-Alpine Headwater Catchment

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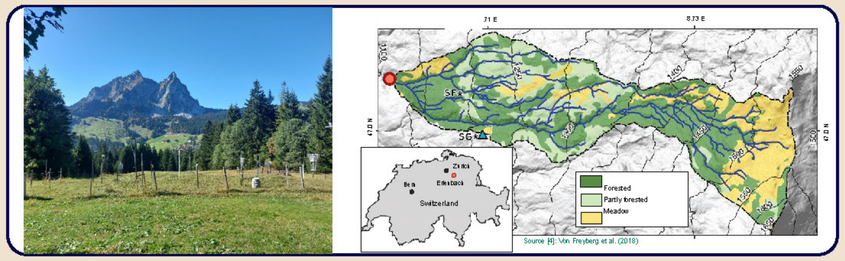
Motivation

Droughts can substantially affect stream water quality via various hydrological and biogeochemical processes, such as increasing evapoconcentation and travel times, decreasing hydrological connectivity and changing uptake and reaction rates[1,2,3]. To quantify the impact drought can have on our freshwater resources and to disentangle the underlying mechanisms, we analyzed solute export patterns across a wide range of solutes in a small pre-alpine catchment.



Study Area & Data

The Erlenbach Catchment

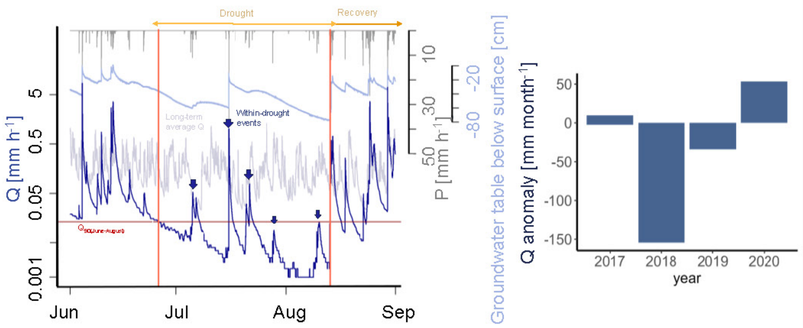
Area: 0.7 km²
Elevation: 1000 – 1655 m.a.s.l.
Geology: Flysch
Groundwater chemistry: Ca, Mg, HCO_3

Data

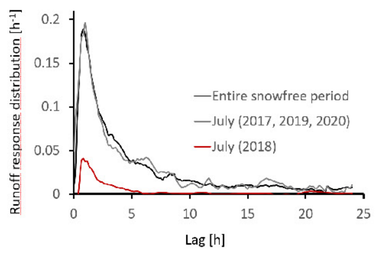
30 min to hourly hydro-meteorological data and concentrations of NO_3, Cl, K, Fe, Cr, Mn, SO_4, Ca, Mg and Sr, measured from 2017 to 2020 via IC or ICPMS[3,5]

Hydrological Drought Response

Summer drought in 2018 from June 26th to August 13th



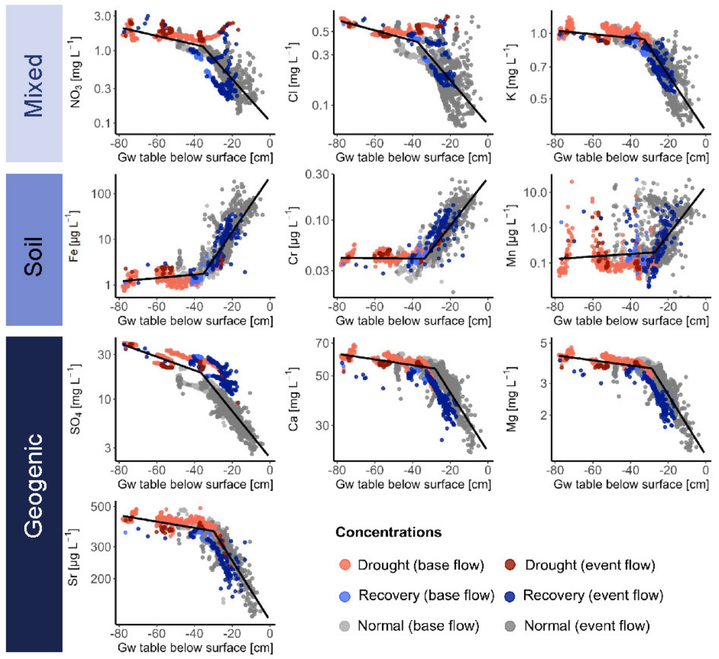
Ensemble Rainfall-Runoff Analysis (ERRA)



- The stream never went dry
- Five discharge events occurred during the drought events
- A considerably smaller fraction of rainfall converted into discharge

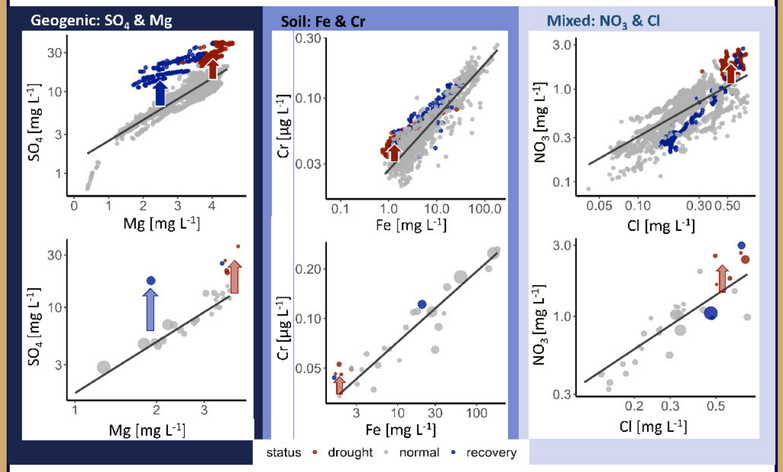
Hydrochemical Drought Response

Solute concentration – groundwater relationships



→ **Significant breakpoint between drought and normal conditions**

Concentration – Concentration Relationships



→ **Indication of biochemical processes that have changed the availability of specific solutes**

- Changing redox conditions in deeper geological layers can enhance the production of sulfate
- Changing redox conditions in the soils can change the mobility of metals in different directions
- Nutrient uptake decreases if soils are too dry

Take Home

The water quality response to drought cannot be explained by discharge dynamics alone; rather, a detailed assessment of both hydrological and biogeochemical processes is required to identify the underlying drivers.

During drought, old groundwater becomes the only remaining source of streamwater, reducing the variability in streamwater chemistry and causing comparably high concentrations of geogenic solutes and low concentrations of soils solutes.

Biochemical processes can alter the overall availability of solutes that are sensitive to those processes. For example via a change in redox conditions or a decrease in biological activity (nutrient uptake).

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