TRAILS: Towards A Multi-Scale Understanding Of Groundwater Quality Interlinkages

Climate change and extremes require advancing our understanding of water quality to explicitly consider groundwater-surface water connections

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Earth System Modeling

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

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OUR MOTIVATION

The quality of water is as important as the quantity, but there is still a lack of understanding of how the interfaces between groundwater and streams, wetlands, lakes, and costal waters shape water quality issues, especially at regional-to-continental or even global scales. We want to identify the dominant processes affecting groundwater quality across multiple temporal and spatial scales to apply existing knowledge in new contexts and develop new approaches, such as large-scale modeling tools.

OUR HYPOTHESES

- Water quality is a multi-scale problem across different temporal and spatial scales.
- We require new data assessment and modeling tools that can consider quality issues across hydrological interfaces.
- Groundwater quality is highly sensitive to ongoing and future intensification of extreme flooding, droughts, and compounding events.
- Perceptual models help us built, collect, and communicate system understanding and identify knowledge gaps.

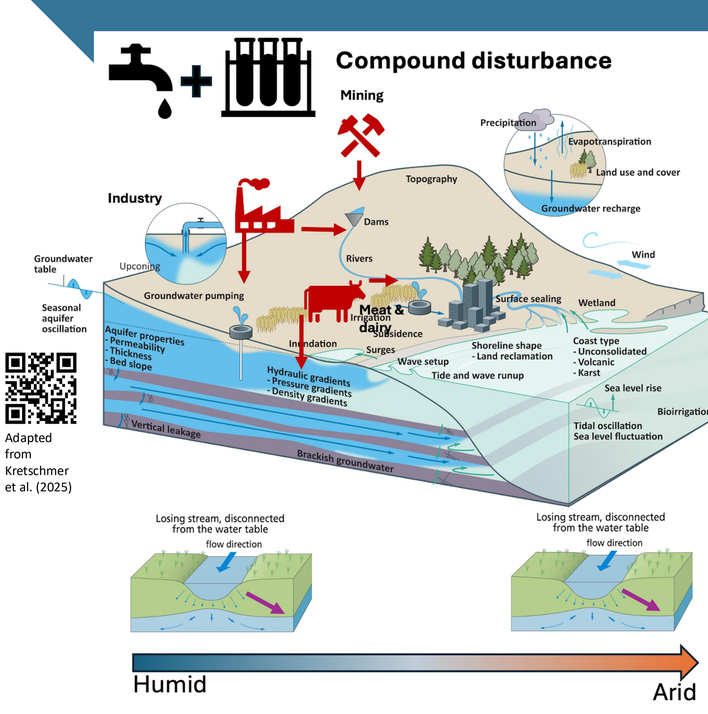
NEXT STEPS

- A review paper with our perceptual models as one section is in progress.
- Determine where and when data on surface water-groundwater-ocean interactions are available simultaneously, at the same location, for water quality and quantity.

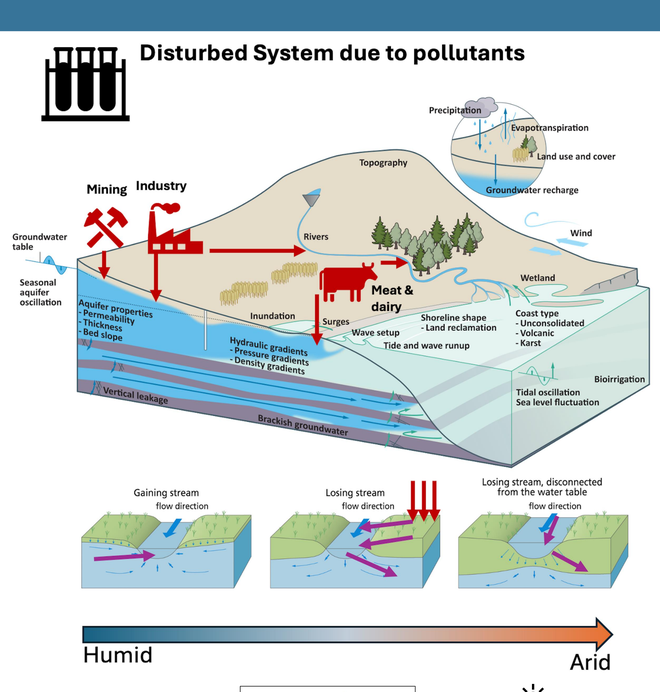
DRAW your own perceptual model!

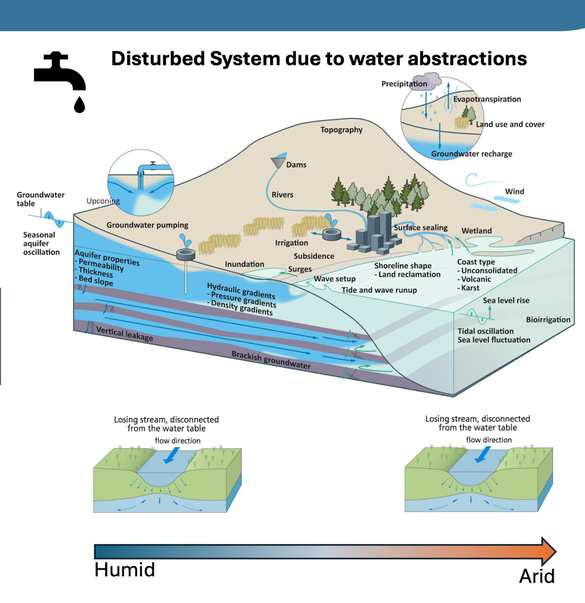
PERCEPTUAL MODELS

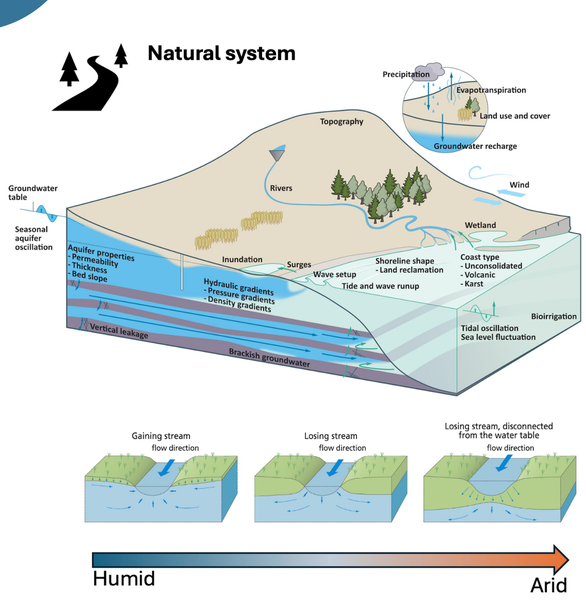
...are qualitative expressions of how *you* perceive (and understand) the components of a system.



Adapted from Kretschmer et al. (2025)







Additional important things that are not (yet?) shown

- Temporal aspects, such as legacy effects
- More detailed information on the different water quality constituents
- Settings with differing climate, topography, geology, soil, and human influence

Pollutant point source

Pollutant

Pollutant flux

EXTREMES impact groundwater quality

Droughts & heatwaves

- Disconnect of groundwater-surface water
- Change of redox state, temperature, and direction of flux

Floods & heavy rainfall

- Remobilization of previously solid-bound pollutants
- Wastewater overflows

- Development of diseases (health risks)
- Additional deposition and leaching of pollutants
- Changes in biochemical processes