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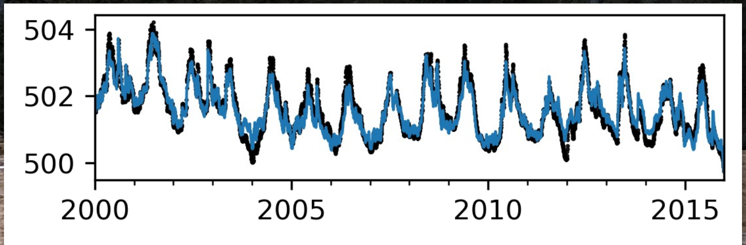
Analysis of nationwide groundwater monitoring networks using lumped-parameter models: a case study in Switzerland



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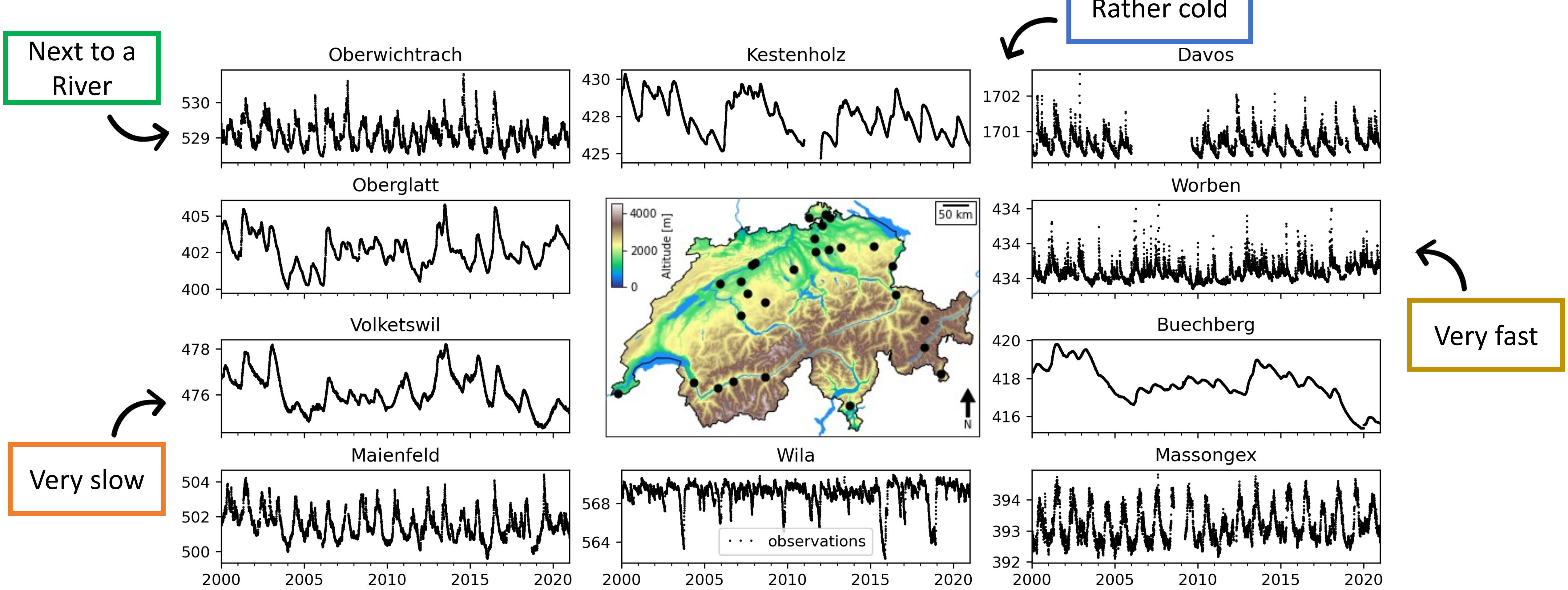
Sharing is encouraged

Very different groundwater dynamics

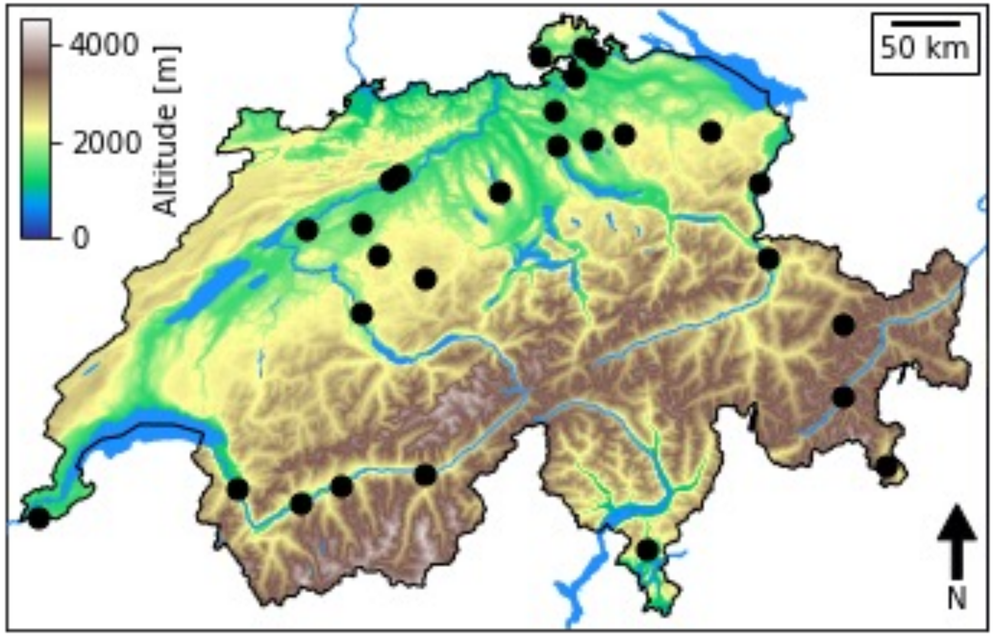


Objectives

1. Assess applicability of Pastas lumped-parameter models in Switzerland.

2. Identify stresses and processes influencing groundwater dynamics.

3. Test the use of a degree-day snow model to alter recharge pattern.



28 monitoring wells with daily head data (2000-2020) from the Swiss Groundwater monitoring Netwerk (NAQUA) operated by the FOEN (Swiss Federal Office for the Environment).

Methods

Described in detail in : Collenteur et al. (2021) HESS.

The basic model structure to simulate the observed groundwater table ($h(t)$) is written as:

$$h(t) = \sum_{m=1}^{M} h_m(t) + d + r(t)$$

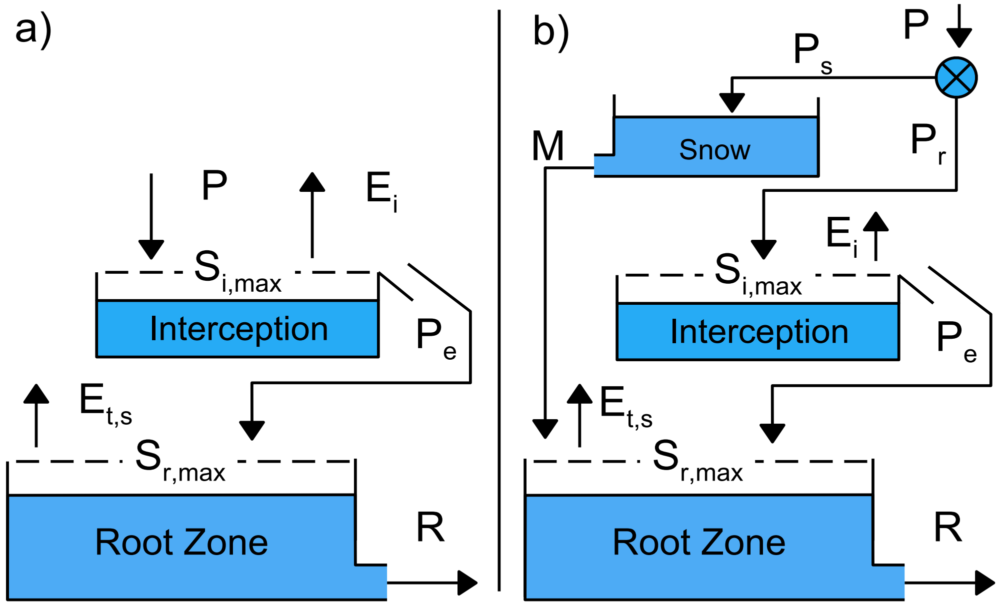
where:

- $h_m(t)$: contribution from stress *m (e.g., recharge)*.
- d: Base elevation of the model.
- $r(t)$: Residual

Model setup:

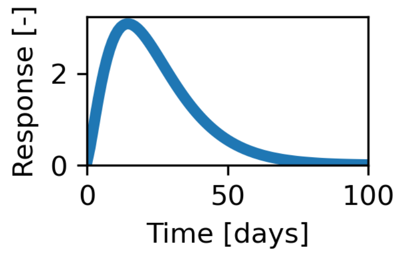
- Testing different model structures for each well:
    - Without snow (a) or with snow (b)
    - With river stage stress and without
- Calibration 2000-2015, Validation 2015-2020
- Use of noise model to account for autocorrelation

Contribution from precipitation and evaporation:



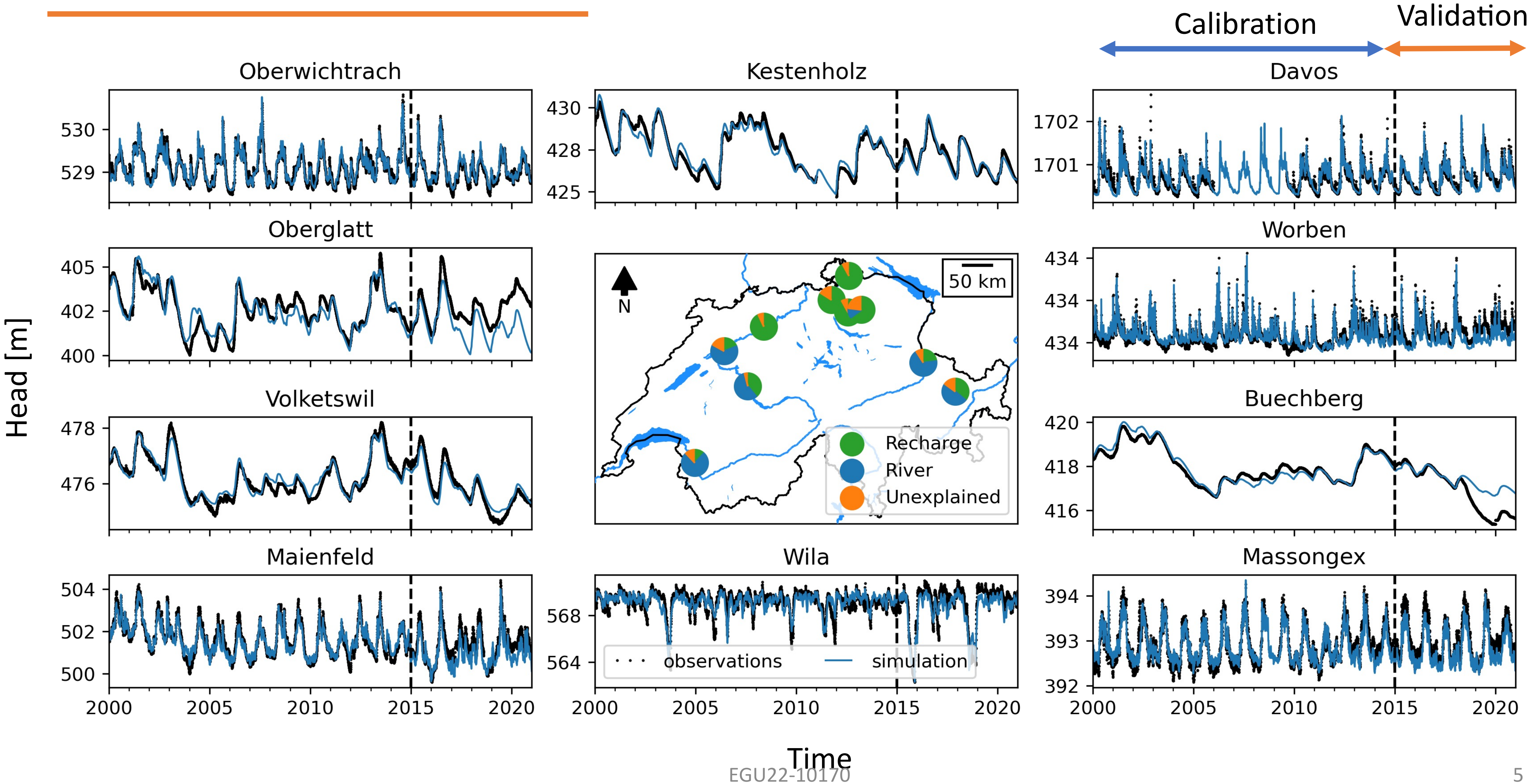
Convolution of recharge flux with response function:

$$h_r(t) = \int_{-\infty}^{t} R(\tau)\theta(t-\tau)d\tau.$$

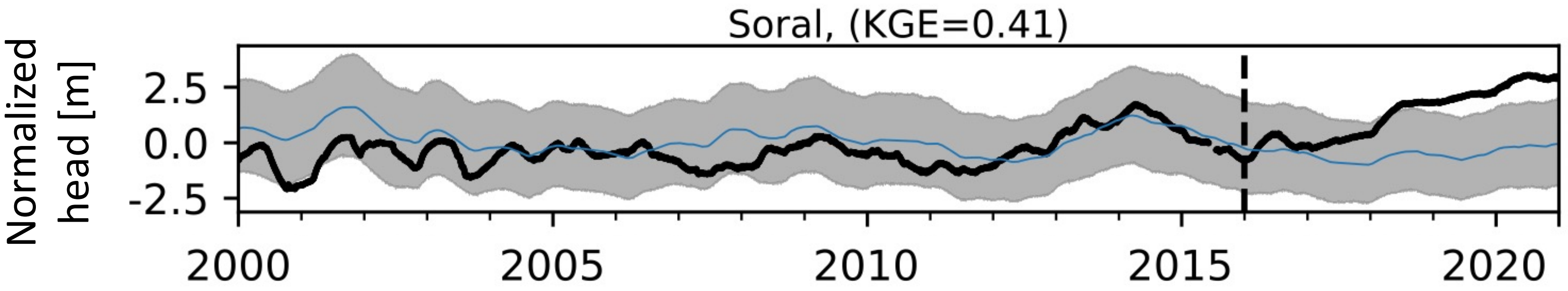


R(t) is computed using a bucket-type model.

Generally, good results were obtained ...

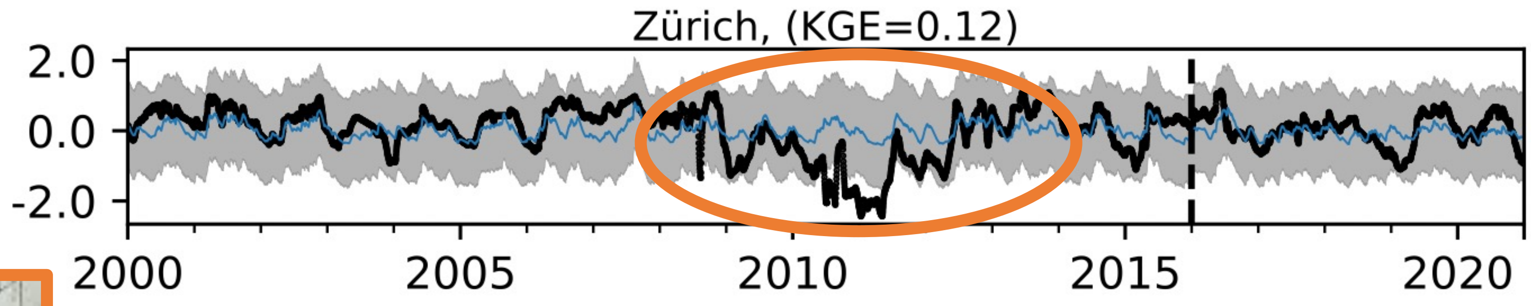


... But not always (which is just as interesting!)



Model structure not suitable to simulate effect of a very thick unsaturated zone (±80 meters)?

Deviation could be linked to the building of a tunnel in the area (durchmesserlinien, Kobel, 2009).

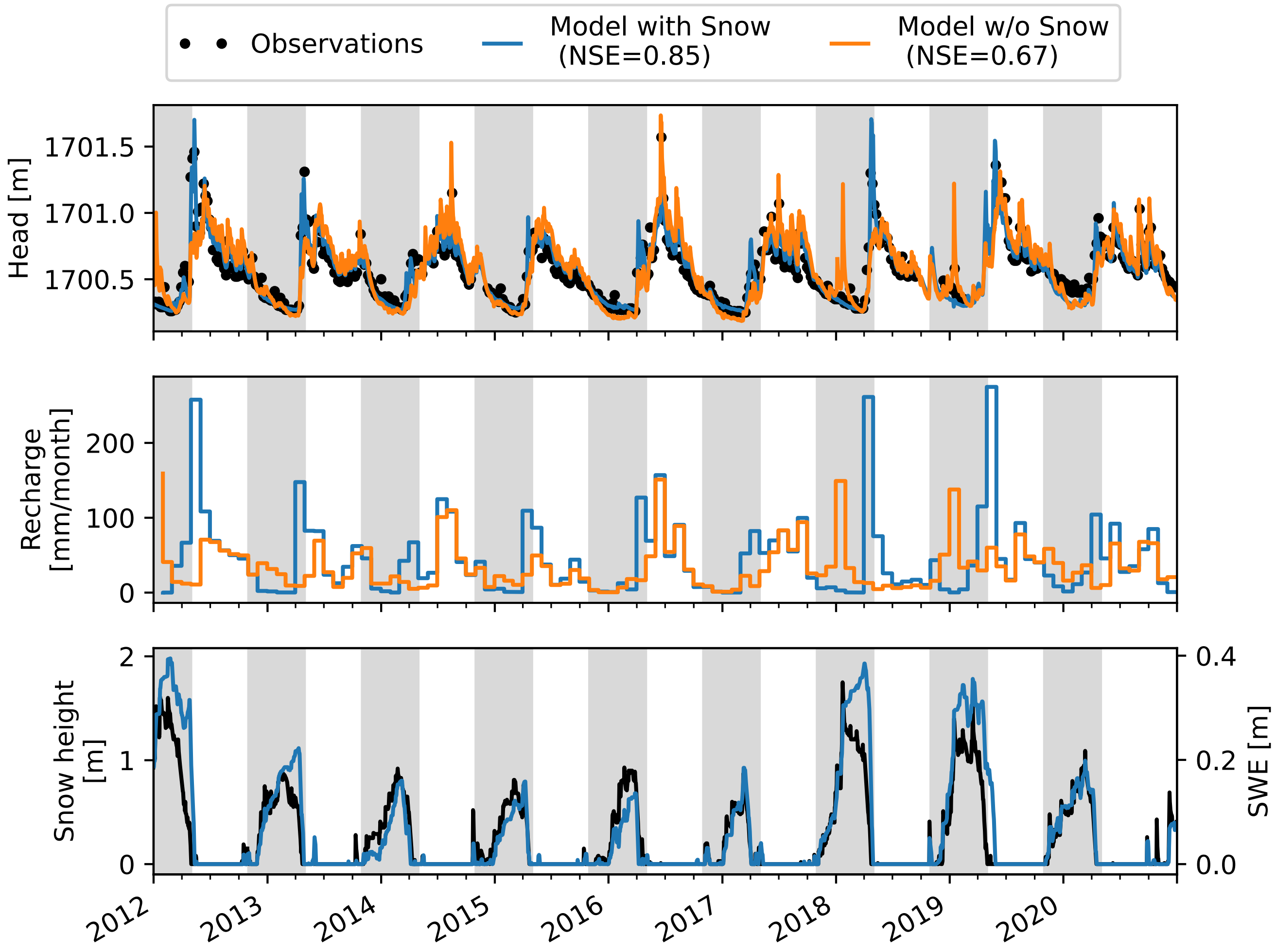


Are these aquifers influenced by human activities?

Can we use such data to investigate long-term GW developments?

Snow processes impact the hydraulic heads in Davos (+1702 MASL)

- Adding a degree-day snow(melt) model substantially improved the head simulation.
- Internally, the model computes a very different groundwater recharge pattern.
- Modeled snow water equivalent (SWE) also compares well to observed snow height pattern.



Take home messages

- Lumped-parameter models were able to accurately simulate heads in diverse hydrogeological settings in Switzerland
- Precipitation, evaporation, and river stages can explain most of the observed groundwater dynamics.
- We should test multiple model structures to make sure we take the right processes (e.g., snow, rivers) into account.

Outlook

- Apply the models to asses the sensitivity of Swiss aquifers to drought events.
- Assess robustness of model parameters.

Get in touch! ☺

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