Integration of agricultural, hydrological and hydrogeological stressors into the modelling of groundwater used for drinking water extraction

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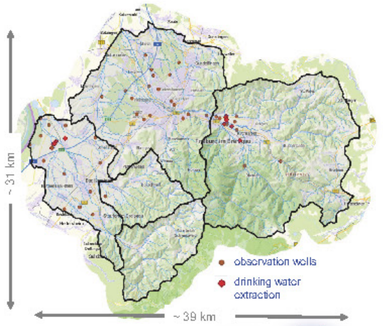
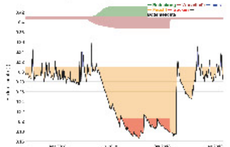
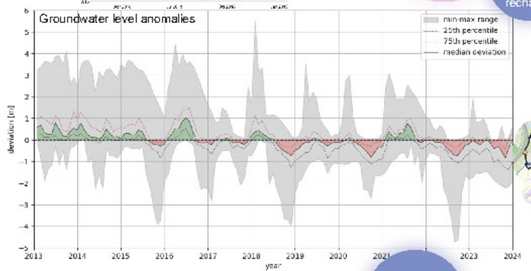
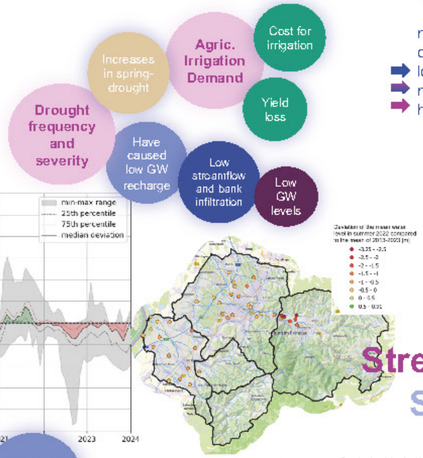
Background

- Groundwater is Germany's dominant source of drinking water; in particular near-surface groundwater resources
- Two different water works supply the city of Freiburg with groundwater from a valley aquifer and from an alluvial fan in the front range of the Black Forest mountains
- Pressures and emerging **stressors** are: unprecedented hydrological extremes, intense agriculture and related water quality issues



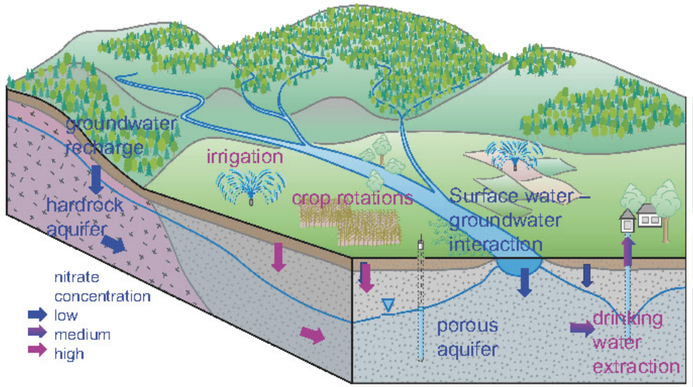






- These **stressors** challenge the assessment of the resources' sustainability, especially in times of increased use competition
- More integrated modelling and innovative model applications beyond climate impact model chain experiments are needed for risk assessment and planning

Integrated Model System



PALUD
- Geodata-based economic-ecological land use model
- Optimization of agricultural land use at the plot level based on linear programming
- Modelling of adaptation measures in agriculture

1-way Coupling

RoGeR
- Distributed, processes-based, hydrological model
- Simulation of groundwater recharge and irrigation demand
- StorAge Selection (SAS) functions for simulation of nitrate concentrations

2-way Coupling

MODFLOW
- Groundwater Model with 4 layers
- Simulation of water storage, flow and transport
- Allows extraction from wells for agricultural irrigation and drinking water supply

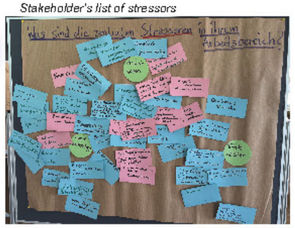
Objectives

- To develop a coupled modelling system for assessing integrated stress on groundwater
- To design and apply stress test scenarios that build on stakeholders' storylines

Stress test co-design

Storyline model scenario development

Stakeholder's list of stressors



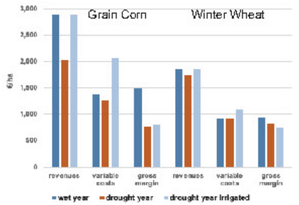
- Recent drought events can serve as stress test scenario for more frequent future droughts
- Stakeholders emphasize a need for quantification and prioritizations of resources
- Water quality management can benefit from collaboration of farmers with utility over e.g. fertilizer application

Conclusion

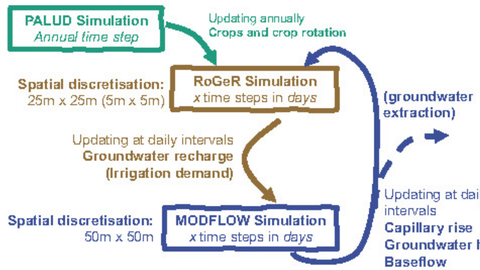
- Many stress test options beyond climate change
- Stakeholders have few resources to employ scenarios, but need is strong
- Model coupling increases storyline options
- Many modelling challenges yet to solve

Modelling Challenges

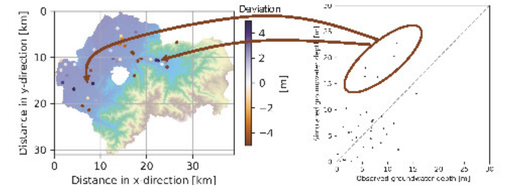
- Small scale, specialized agriculture und farming
- Uncertain future transformation pathways
- Economic assumptions to derive prices and costs



- Parameterization of crop water use und stress
- Lacking information on application of fertilizer and pesticides
- Different spatial and temporal discretizations



- GW-surface water interaction highly variable along rivers
- Solute transport to groundwater in the unsaturated zone
- Large area with strong elevation gradients
- Diverse hydrogeology, few observations in hardrock aquifer
- Challenges to reproduce groundwater levels in some location



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https://www.drought.uni-freiburg.de/stressres