

Monitoring- and Modelling System for the assessment of stress on groundwater resources and drinking water supply

Kerstin Stahl¹, Jost Hellwig¹, Kathrin Szillat^{1*}, Robin Schwemmle¹, Julian Vahldiek¹, Jens Lange²,
Markus Weiler², Barbara Herbstritt², Daniel Glaser^{2*}, Sylvia Kruse³, Tanya Merger³, Jakob Kramer^{3*}
Elisabeth Angenendt⁴, Christian Sponagel⁴, Julian Börner^{4*},
Alexander Krämer⁵, Christof Hübner⁶

*PhD candidates

¹Chair of Environmental Hydrological Systems, University of Freiburg (UHYS)

²Chair of Hydrology, University of Freiburg Freiburg (HF)

³Chair of Forest and Environmental Policy, University of Freiburg (FUP)

⁴FG Farm Management, University of Hohenheim (UHOH)

⁵WWL

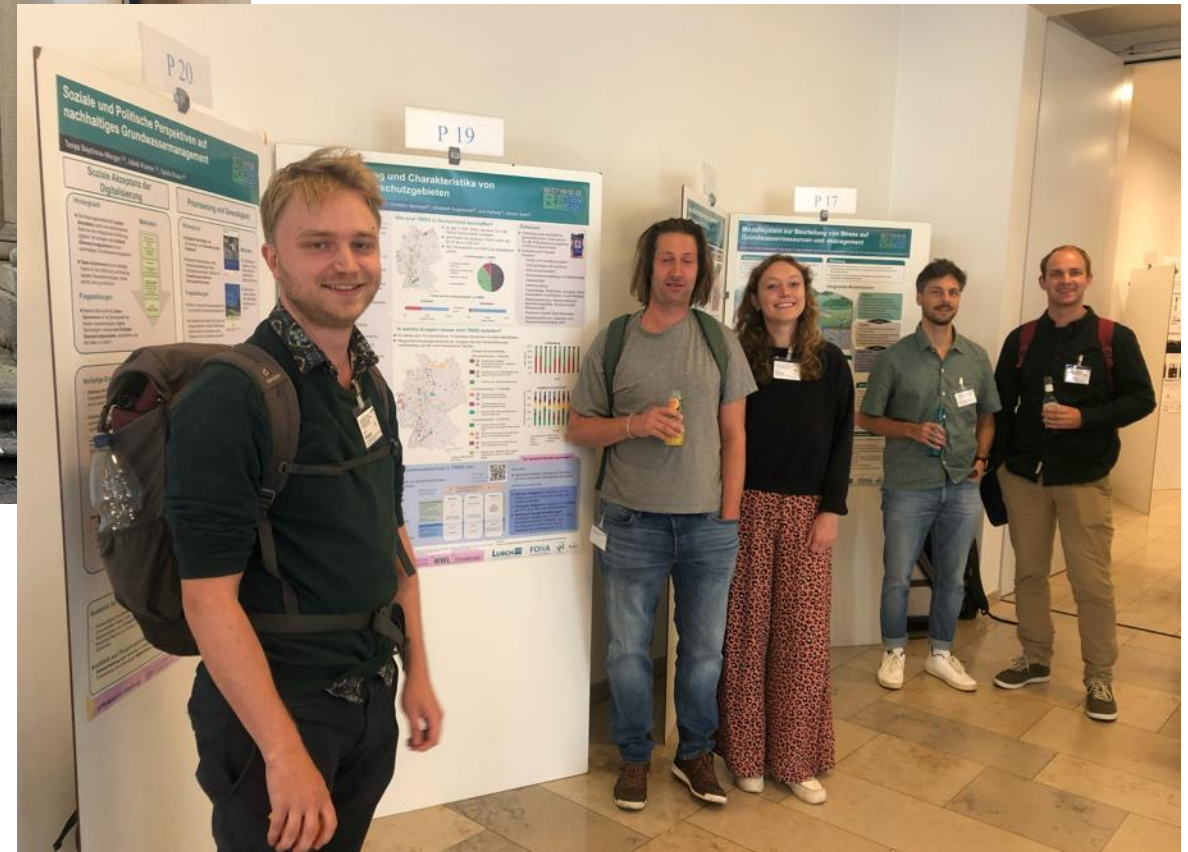
⁶TRUEBNER

The StressRes Project Team!



Meeting, March 2024 in Hohenheim

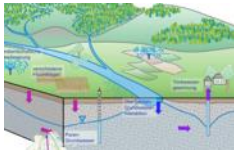
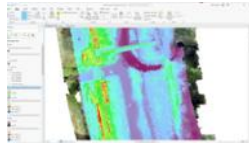
Last week in Frankfurt!



Background and Objectives

Stressors such as drought, competing water usages, pollution and climatic and economic changes require:

Interdisciplinary analyses, new monitoring tools and integrated models!



- **Situation:** Analysis of spatial, political und economic conditions and stressors
- **Monitoring direct und indirect groundwater recharge:**
 - Surface water – groundwater interaction
 - Observation with remote transmission of data (incl. water quality)
- **Model Stress Tests:** Stress Test analysis with a coupled model (agriculture-surface water-groundwater-water use)
- **Stress Test-Demonstrator:** Translation of results into generalized and widely applicable 'event scenarios'

Governance situation for groundwater-drinking water management

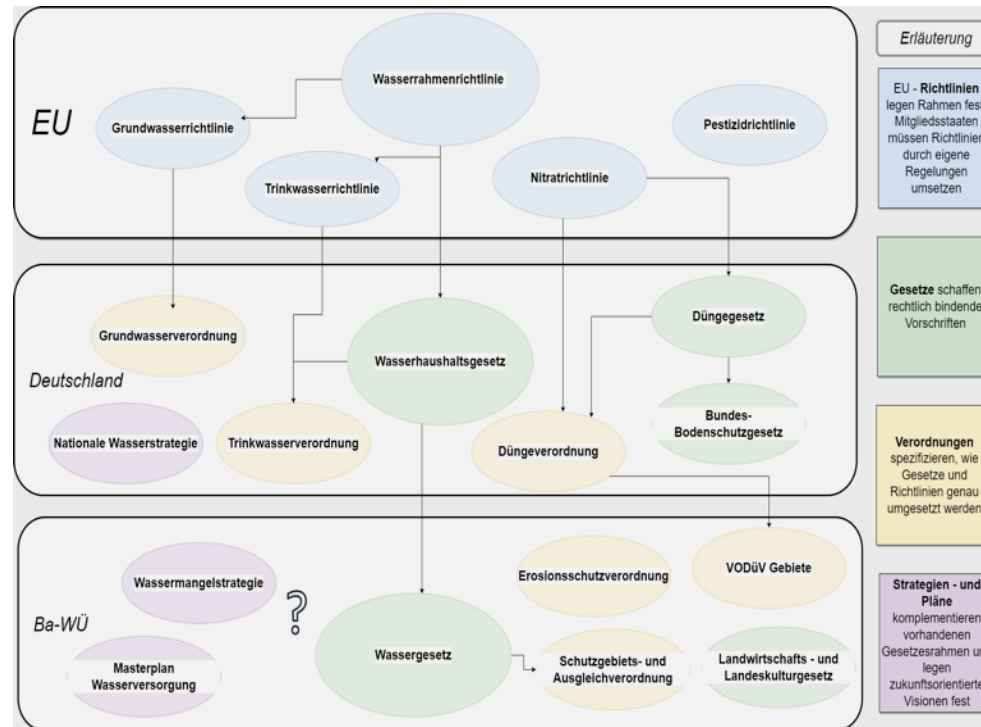


Policy Analysis Agriculture-Water



Two interview studies

1. Priorities in decision making
2. Social acceptance of digital solutions



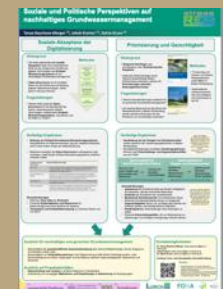
- Water rights / water allocation decisions differ strongly
- Objective rules/criteria vs room for individual decisions
- Real time monitoring as a decision criterion is used more by utilities than by agencies
- Slow uptake of digital solutions due to privacy issues, data security etc.

- Multi-level governance with nested but uncoordinated policies - difficult to respond to recent strategies

FUP
T. Baycheva
Jakob Kramer
Sylvia Kruse

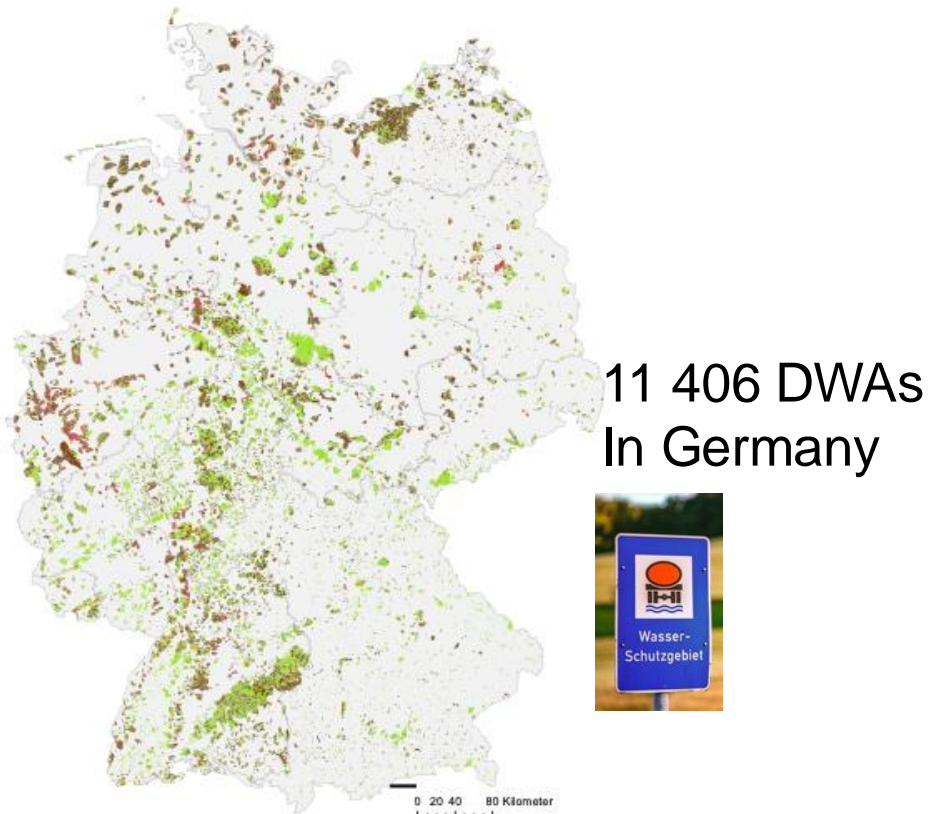
HOH
Julian Börner

> s. Poster



Spatial analysis of all drinking water protection areas in Germany

- How are landscapes of DWAs characterized?
- Can they be grouped into similar situations?



Geo-Data: interdisciplinary attributes

- Area, elevation, etc.
- Hydrogeology, groundwater drought response time
- Climate
- Land cover and agricultural use details (e.g. stock density, crop type, %pasture, %irrigated, no. of farms)
- Type of water supply source, demand, population, water cost
-
- Generalized maps of water quantity and quality 2022 (acc. to EU water framework directive reports)

- Different definitions per federal state
- Different overall areas (5% to 30%)

UHyS/HF
Kathrin Szillat
Jost Hellwig
Max Schmit
Kerstin Stahl

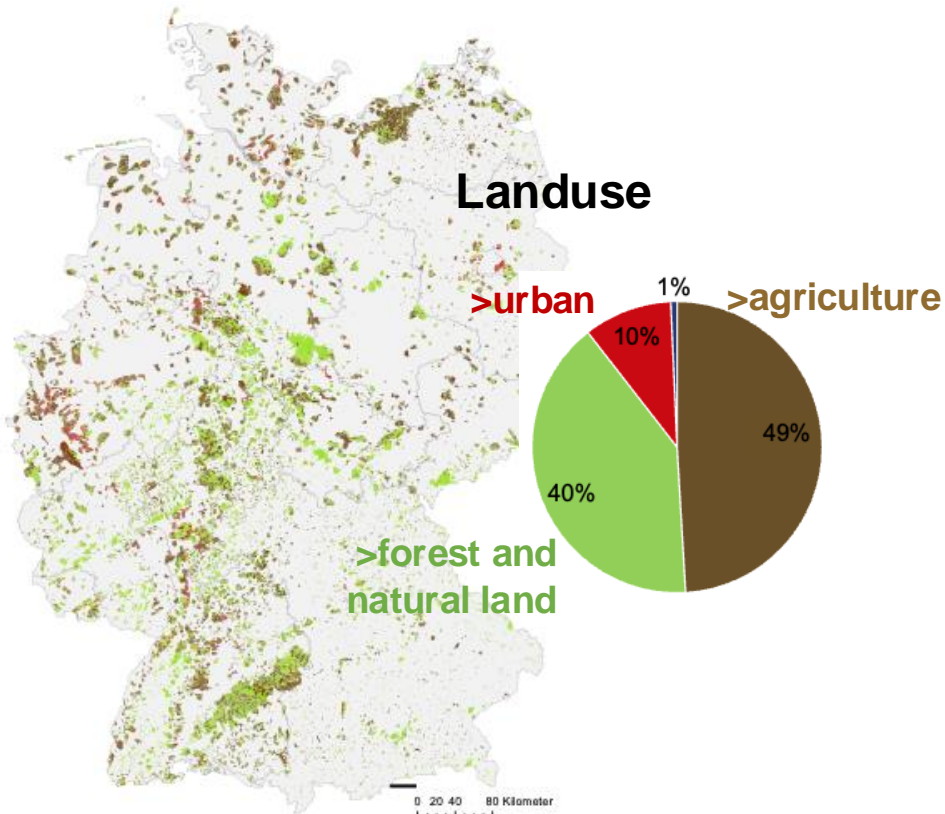
HOH
Julian Börner
Ch. Sponagel
E. Angenendt

FUP
Sylvia Kruse
> s. Poster



Spatial analysis of all drinking water protection areas in Germany

- How are landscapes of DWAs characterized?
- Can they be grouped into similar situations?



Analysis of the acceptance of groundwater protection by farmers Survey as Discrete Choice Experiment

Dürrewahrscheinlichkeit: 20 %
In 1 der kommenden 5 Jahre kommt es zu landwirtschaftlicher Dürre

	Option 1	Option 2	Option 3
Maßnahmen zum Grundwasserschutz			
Reduktion der jährlichen gesamtbetrieblichen N-Düngung		Keine Reduktion	
Anbau einer winterharten Zwischenfrucht oder Untersaat auf der gesamten Ackerfläche	Ja	Ja	Keine zusätzlichen Maßnahmen gefordert
Verzicht auf synthetische Herbizide	Verzicht auf 20 % der Betriebsfläche	Verzicht auf 10 % der Betriebsfläche	
Ausgleichsleistungen / Maßnahmen			
Wasserpreis für Bewässerungsmaßnahmen	0,20 €/m ³	0,60 €/m ³	1,00 €/m ³
Verfügbare Wassermenge zum angegebenen Preis	unbegrenzt	unbegrenzt	500 m ³ /ha (bzw. 50 l/m ²) pro ha Betriebsfläche und Jahr

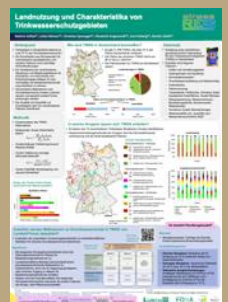
>still ongoing!

- N-Reduction more accepted than herbicide-Red.
- Requested waiver for irrigation water cost acc'ly

UHyS/HF
Kathrin Szillat
Jost Hellwig
Max Schmit
Kerstin Stahl

HOH
Julian Börner
Ch. Sponagel
E. Angenendt

FUP
Sylvia Kruse
> s. Poster



Monitoring developments: gw recharge and nitrate leaching

HS

Daniel Glaser
B. Herbstritt
Jonas Schwarz
Jens Lange
Markus Weiler

WWL

Alex Krämer

TRUEBNER

Ch. Hübner
Heinke Paulsen

Badenova

Simon Brenner



> s. Poster



Direct recharge in DWAs with high % agriculture

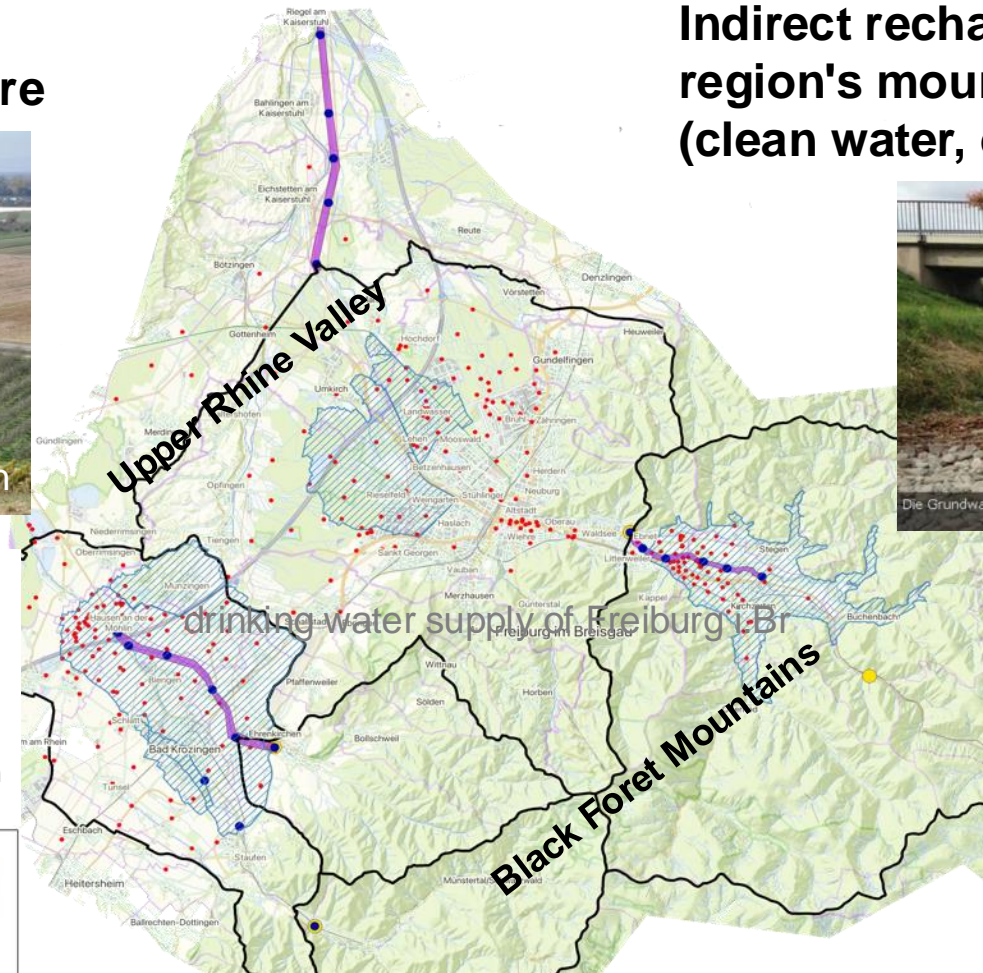


Quelle: LGRB Wissen

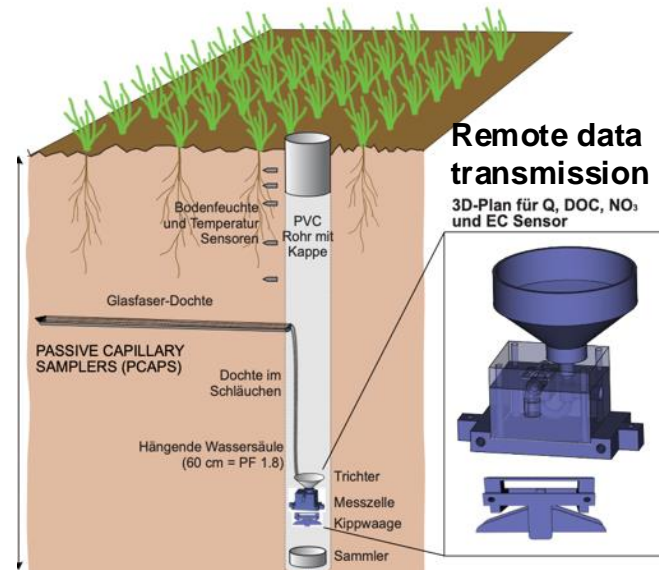
Indirect recharge typical in region's mountain-lowland setting (clean water, e.g. low nitrate)



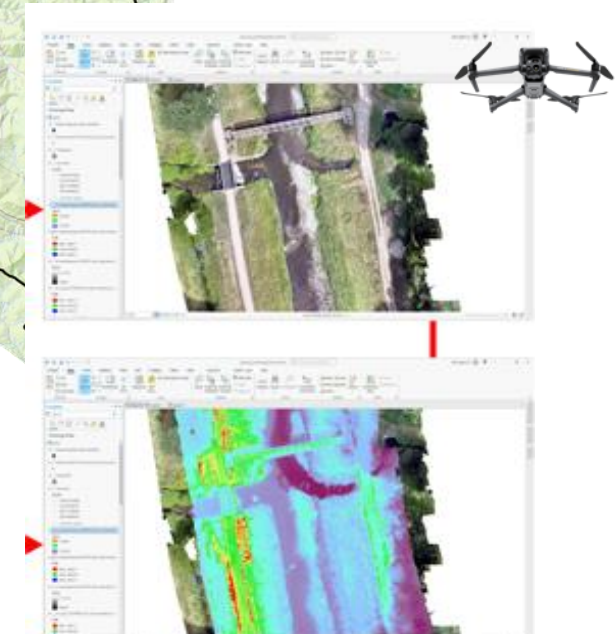
Die Grundwasserdürre 2018/19 in Deutschland ist eine der schwersten der letzten 50 Jahre



- UV-Vis Spectrophotometer
- Discharge gage
- Drone flights
- Groundwater wells
- Drinking water protection area



Mini-"UV-Vis-Spectrophotometer" (LED+photodiode)



Drone-mounted thermography to detect gw-sw

Model integration – work in progress

UHOH

Ch. Sponagel
Julian Börner
E. Angenendt

UHyS/HF

R. Schwemmler
Jost Hellwig
Max Schmit
Kerstin Stahl
Markus Weiler

PALUD (UHOH)

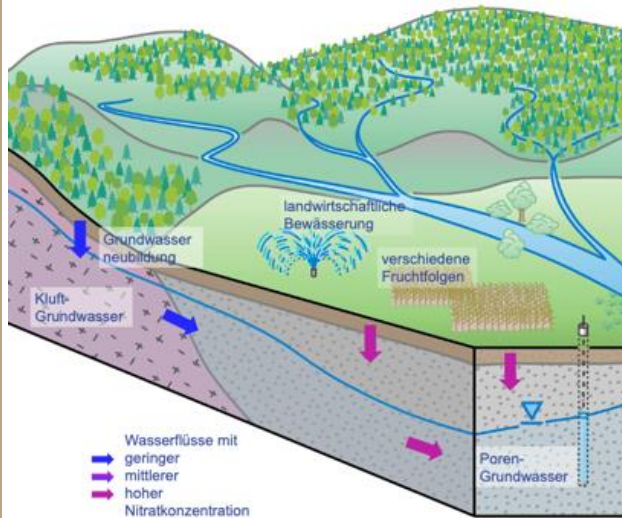
- ◆ Economic-ecologic landuse model
- ◆ Incl. adaptation measueres

RoGeR (HF)

- ◆ Hydrological process modell →
- ◆ New: irrigation demand, nitrate leaching

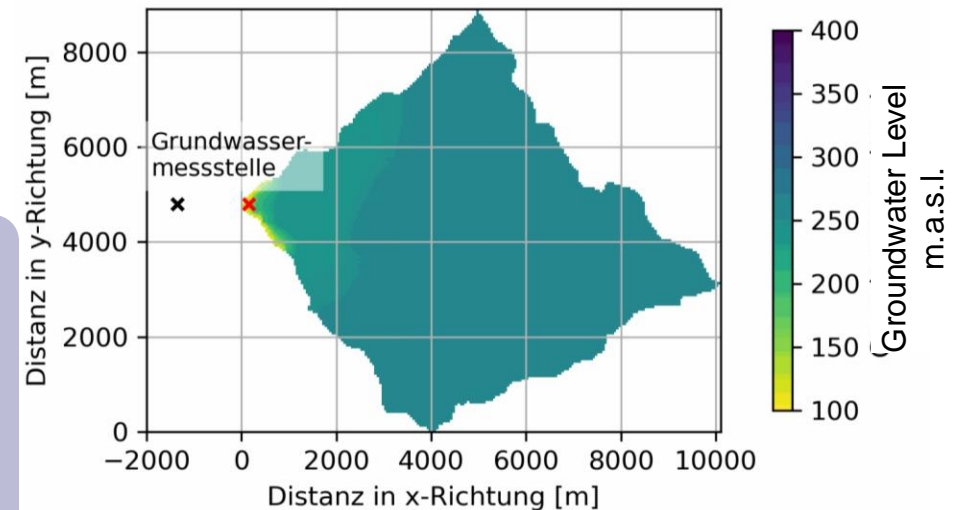
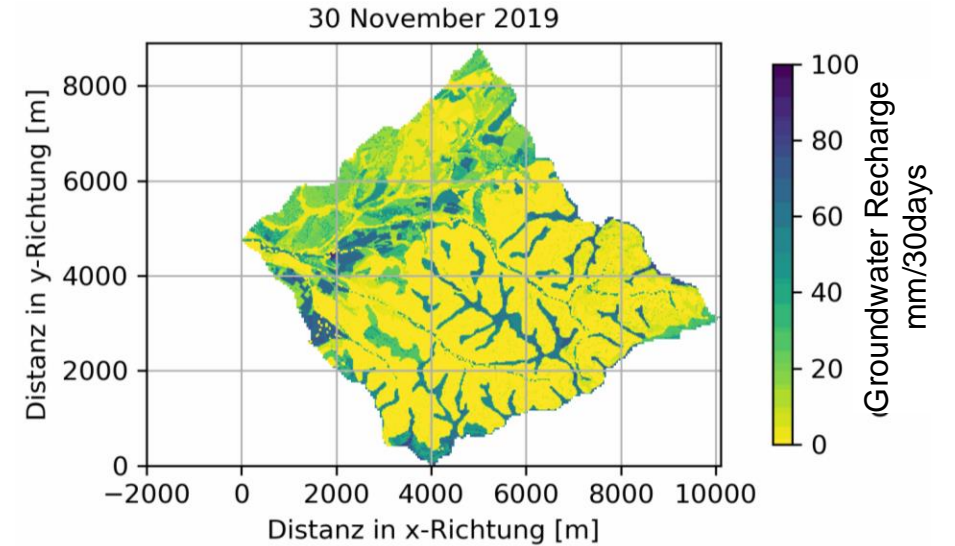
MODFLOW (UHyS)

- ◆ Groundwater and transport
- ◆ Abstractions: drinking water, irrigation



coupling

coupling



> s. Poster



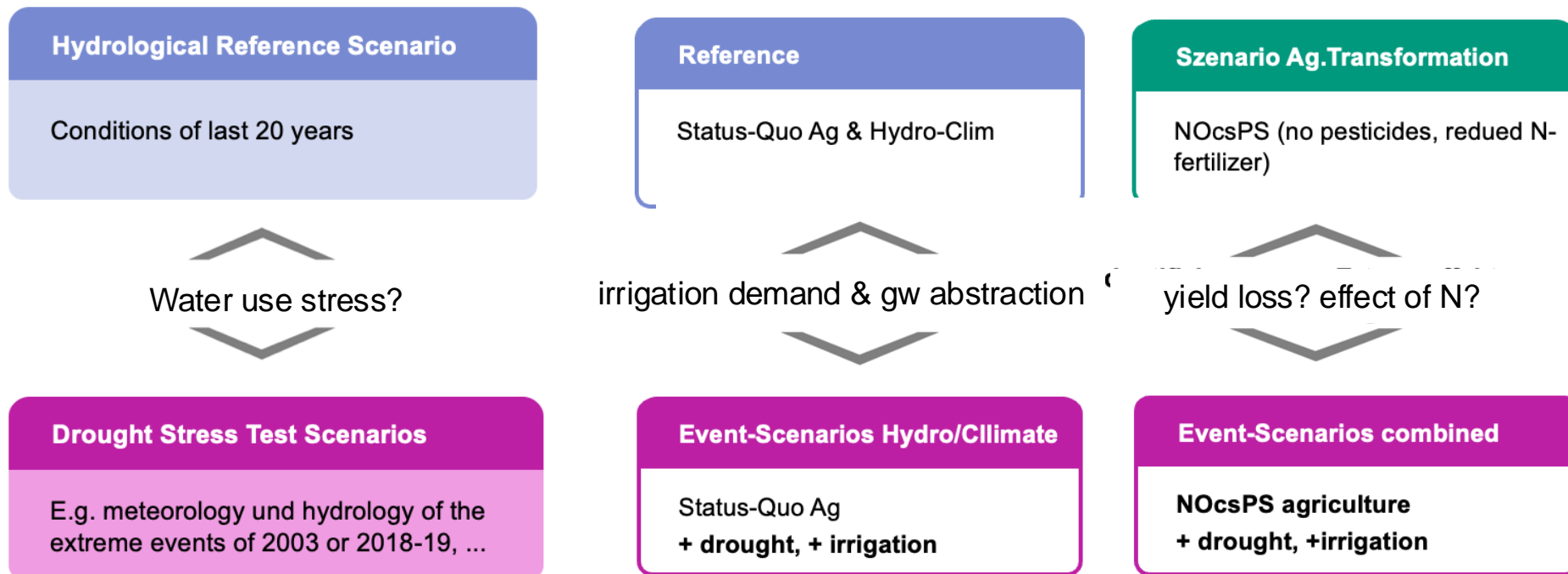
Targeted Stress Test Scenarios – planned work

- Targeted "stresstest" scenarios instead of climate projections
- Initial Scenarios: combinations of known drought events with different crop scenarios and with/without irrigation
- Co-designed stakeholder scenarios: 'future' storylines combining multiple usages and transformations

UHOH
Ch. Sponagel
Julian Börner
E. Angenendt

UHyS/HF
R. Schwemmler
Jost Hellwig
Max Schmit
Kerstin Stahl
Markus Weiler

WWL



> s. Poster



First results and further planning

- Many recent triggers for transformation
 - Pressure at all governance levels
 - Hesitation in decisions, lacking digital solution implementation
- Typical 'situations' can be identified, but
 - Harmonized data availability or access (e.g. of real. drinking water catchment areas) lacking
- Monitoring/Messung
 - New sensors, new opportunities locally – scalable?
- Integrative modelling of agriculture-hydrology-hydrogeology necessary
 - But, complex, time and data consuming – applicability?
- Event Stresstest-Scenarios als Tool
 - Test if more targeted and more applicable than climate projection ensemble model chains