TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

EGU 2022 DISPLAY MATERIAL

Coupled surface and groundwater modeling for the analysis of management options in groundwater affected catchment areas

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Session HS10.8

Institute of Hydrology and Meteorology

In cooperation with:

Büro für Angewandte Hydrologie

Content

- Motivation
- Catchment area
- Methodology and model
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Motivation

Implementing measures to protect peatlands meeting the goals of the climate protection plan (2050) of the German Ministry of Environment

Development of a water resource management plan for the southern Randowbruch (agricultural used peatland) to reduce CO_2 emissions

Analysis of the catchment area and its hydrologic processes

Implementing its specific properties in a computer model

Investigation of the water resources and possible water management options based on the simulations

Motivation

- **Implementing measures to protect the peatland area**
- **Providing an appropriate transition for the landowners (farmers) to guarantee their livelihood**

- **Development of a water resource management plan for the southern Randowbruch**

Motivation

Protection of the peatland:

- **Distribution** of the **available water resources** with the goal of a **maximum depth** to **groundwater of 0.4m** in summer for the near future as well as **0.1m long-term**

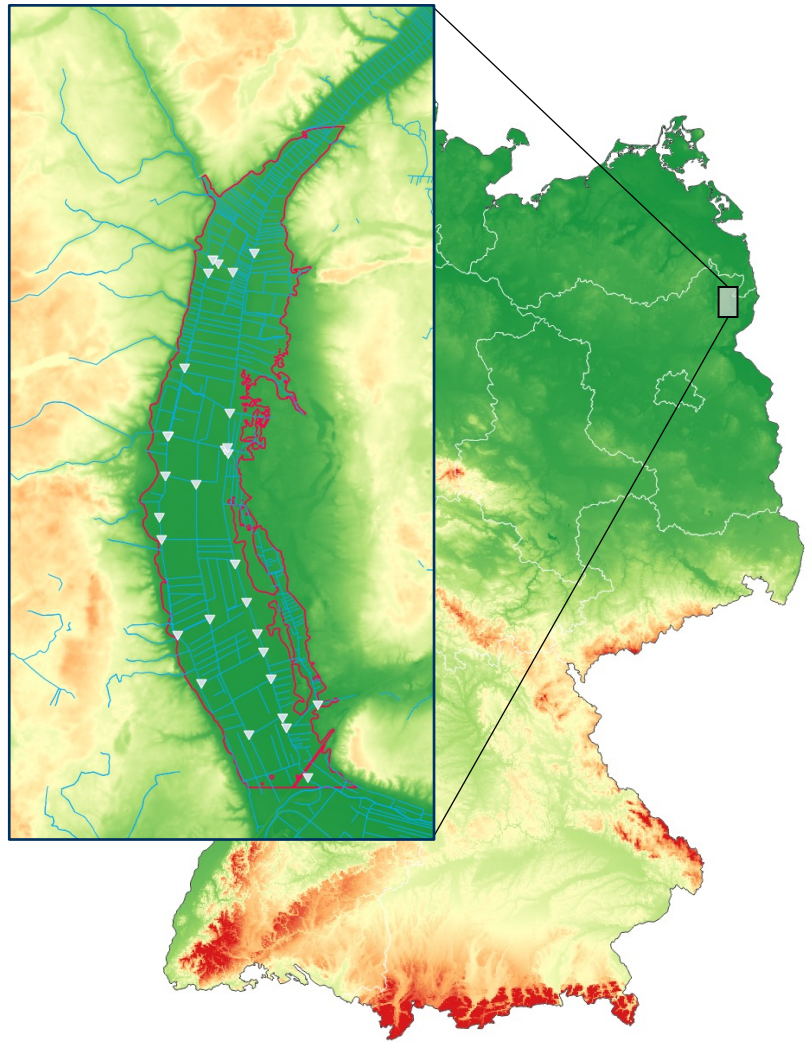
Agriculture:

- Transition of the **agricultural methods** regarding the goal of **wet peatlands by 2040**
- **Transformation** of the current state of the **water management system** for **dry periods**

Catchment area

The southern Randowbruch:

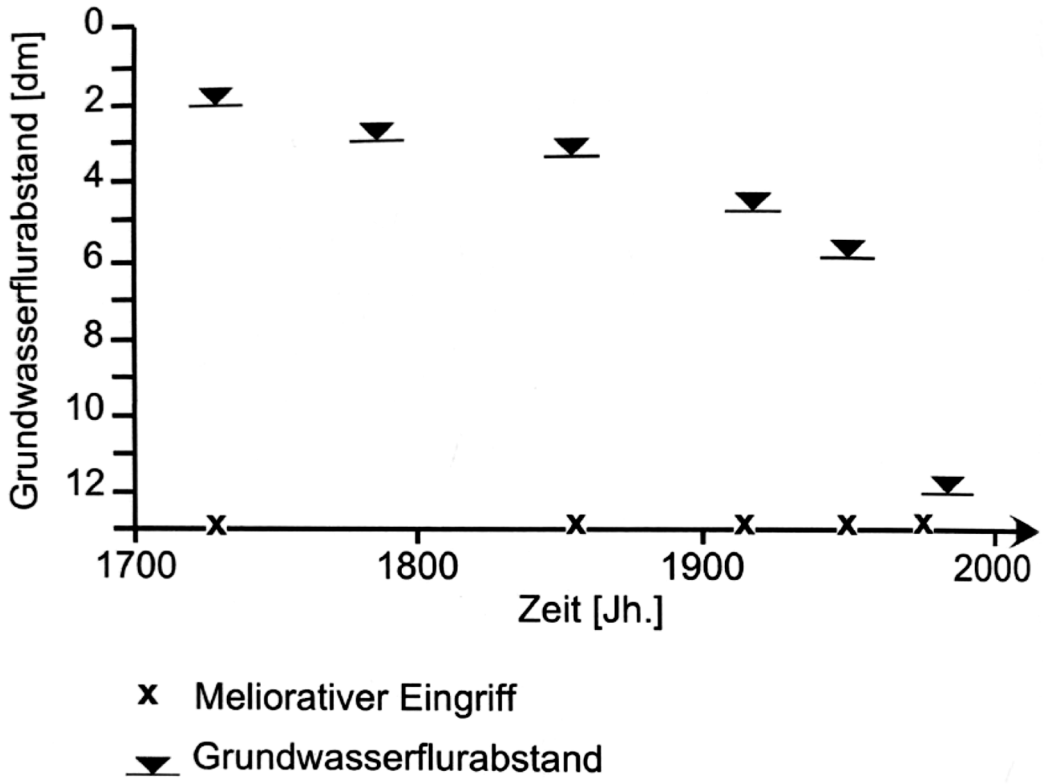
- Part of the **Randow-Welse-Bruchs** located in the **north east** of **Brandenburg, Germany**
- The **southern Randowbruch** formed during the Vistula Ice Age around **18,000 years ago** in a **washout channel** of a glacier
- As a result of **sedimentation** and **changing groundwater levels** a peatland formed



Catchment area

History:

- **Earliest measures** were taken in the **18. century**
- Installing **first ditches** to drain the area
- **Further measures** during the following centuries
- **Destruction** of the areas **water management system** in **1945**
- **Reconstruction** of the water management system and in the 70s **implementing further measures** with the **most significant effect of draining** the area

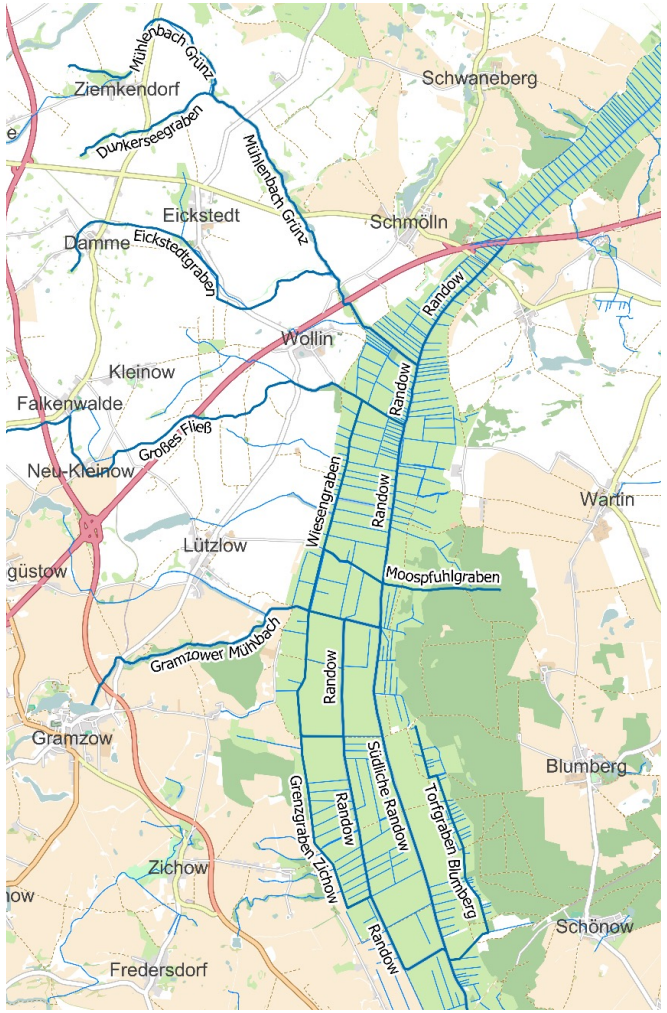


Depth of groundwater level over the period of the last 300 years in the southern Randowbruch (y-axis - depth of groundwater [dm], x-axis - time [years]) (Source 1)

Catchment area

Hydrology:

- The **Randow** is the **main receiving river**
- Average **discharge** of **500 l/s**
- **Three smaller streams** in the north west **providing ca. 20%** of the overall average discharge
- **Other discharge is provided by lateral inflow** through an **aquifer** beneath the peatland
- **Transporting** the **groundwater recharge** from the **surroundings to the southern Randowbruch**



The southern Randowbruch - OpenStreetMap (Source 2)

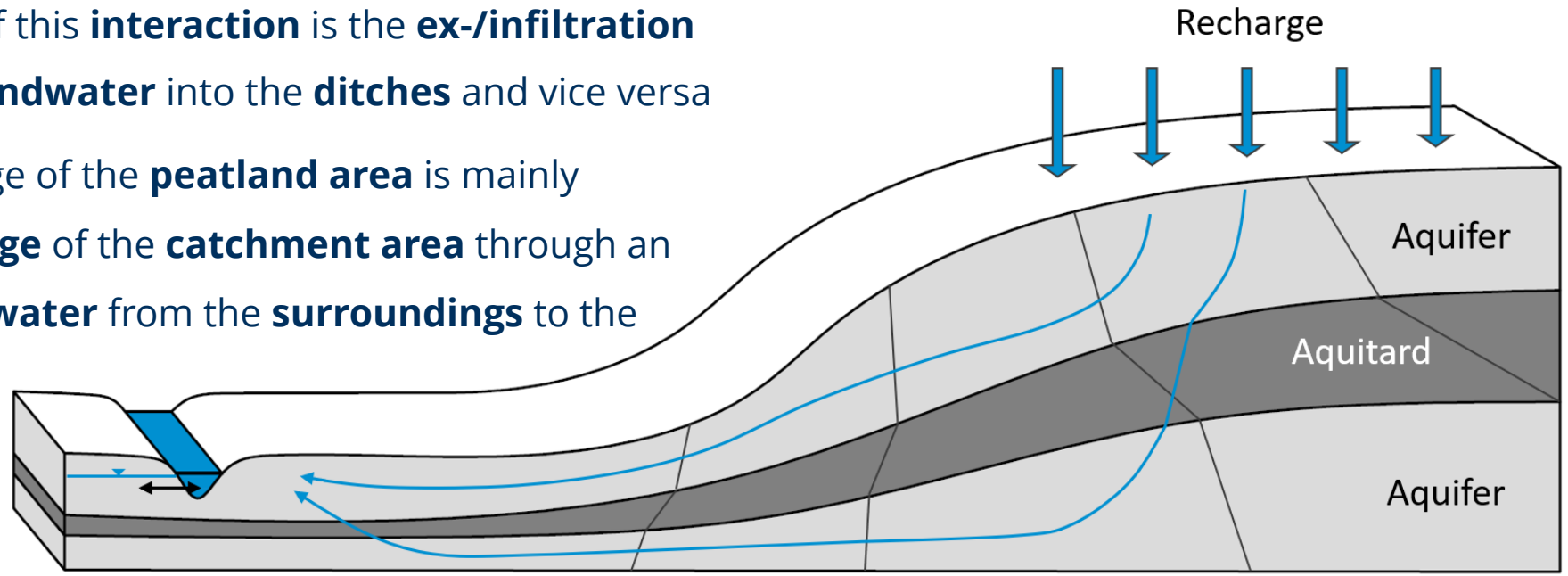
Catchment area

Hydrologic processes:

The area is largely affected by the interaction between groundwater and surface water

The **interaction** is divided into **two dominant processes:**

1. The **primary process** of this **interaction** is the **ex-/infiltration** of **water** from the **groundwater** into the **ditches** and vice versa
2. In addition, the discharge of the **peatland area** is mainly **provided** by the **recharge** of the **catchment area** through an **aquifer, transporting water** from the **surroundings** to the **peatland**



Hydrologic processes in the catchment area of the southern Randowbruch (ex-/infiltration ditches & recharge – discharge mechanism)

Methodology

Problem:

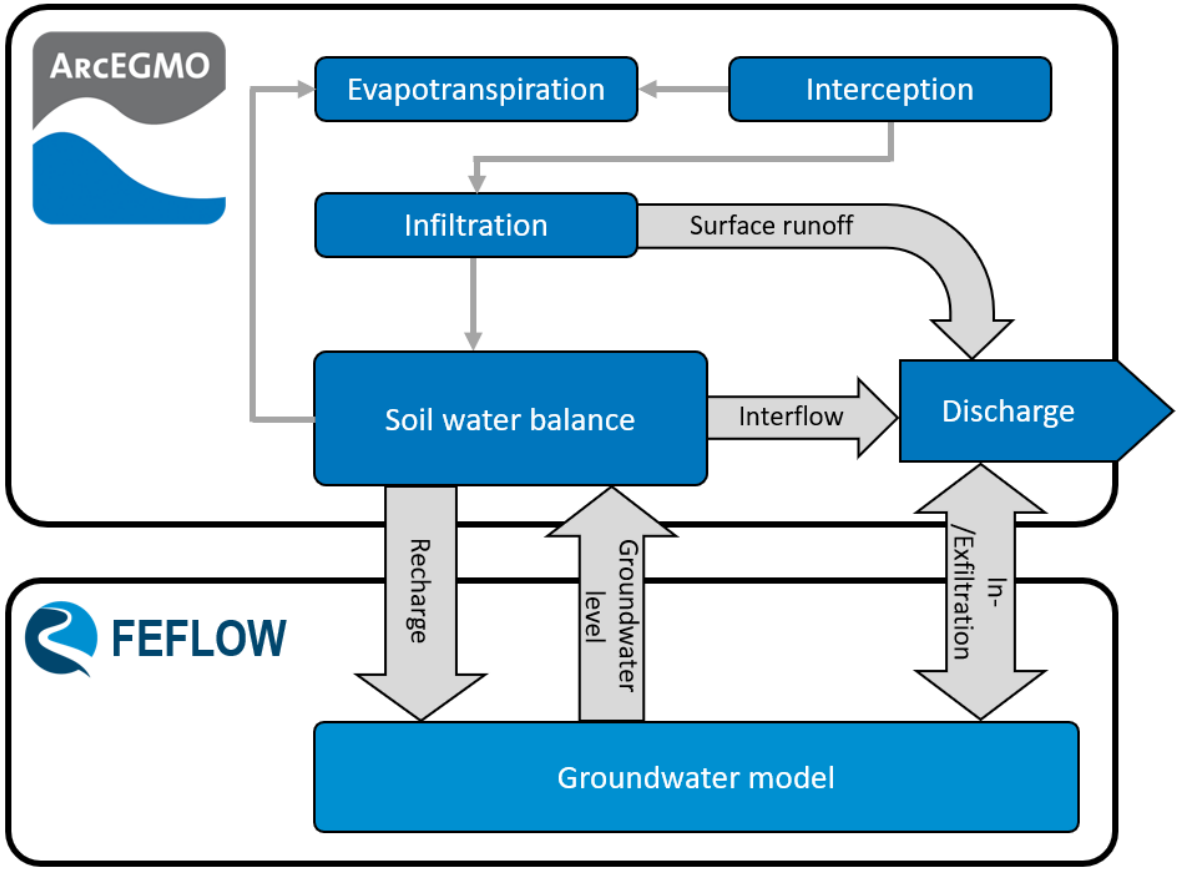
- **Large scale** of the catchment area (> 350 km^2)
- **Complex soil water balance**
- **Complex groundwater flow**
- **Interaction** between groundwater and surface water
  - **Discharge** is provided by **recharge**
  - **Weirs** affect the **groundwater levels**
  - **Groundwater levels** affect the **evaporation**

Methodology

Solution:

- **Combined** model of **ArcEGMO and FEFLOW**:
- **ArcEGMO** -> hydrologic water balance and water bodies
- **FEFLOW** -> groundwater flow
- **Main functions** of the **combined model**:
  - Transfer of the **recharge** from ArcEGMO to FEFLOW
  - Transfer of the **groundwater levels** from FEFLOW to ArcEGMO
  - **Ex-/infiltration** along the ditches calculated considering the difference of water levels in the ditches and the groundwater

Methodology



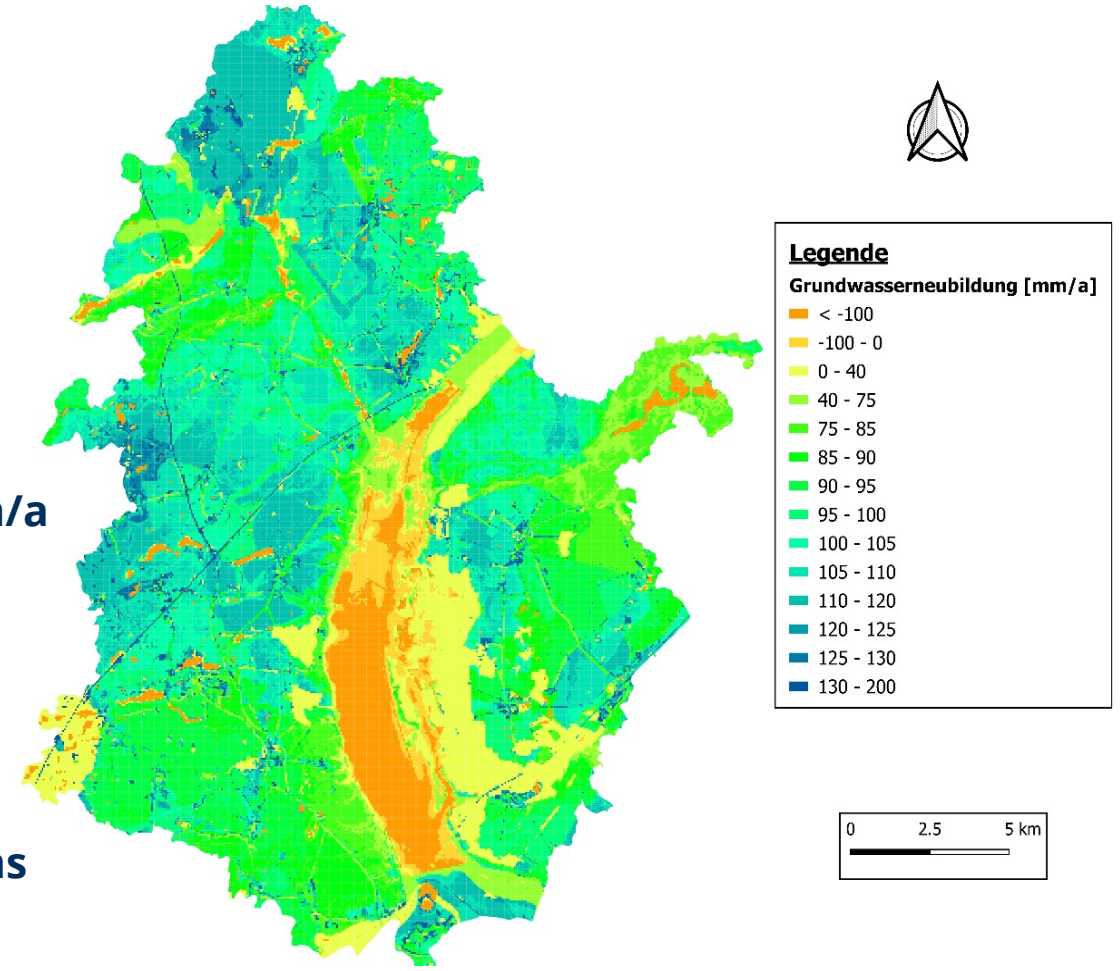
Verification

Calibration and Validation:

1. **Initial Calibration** of the models **separately**
2. **Combined calibration** and **validation**

Verification:

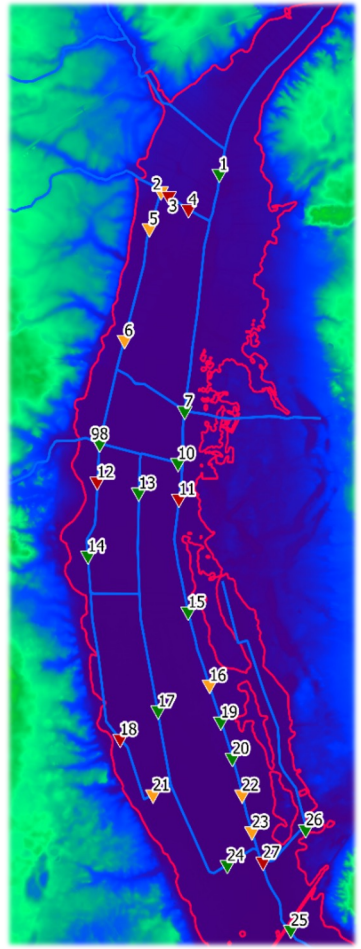
- Checking both **recharge** and **discharge**
  - → **Average recharge** of the modelled area **60 mm/a**
  - → **Equals** the models **average discharge** of **0.45 m^3/s**
- Proving that the **discharge** is **provided** by the **recharge** of the **catchment area**
  - → **Model reproduces** the **hydrologic mechanisms** of the catchment area in the desired way



Analysis and results

Analysis of the current state:

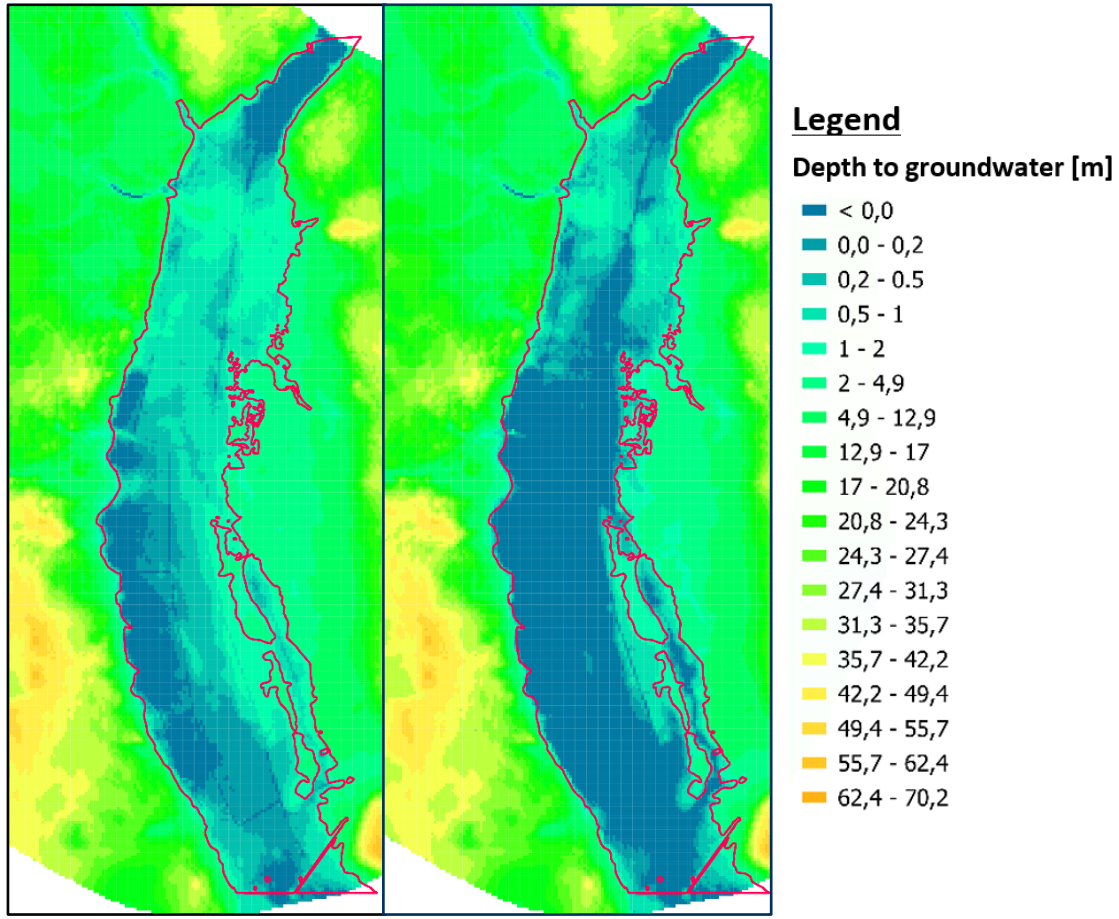
- Analysing the **effects of the weirs on the groundwater level** in the **current state** of the water management system.
- Weirs with a **green mark** are working and were **active** during the **simulation.**
- **Two scenarios:**
    1. Scenario – weirs get lowered from May till June (1m)
    2. Scenario – weirs stay on the highest possible level throughout the entire year



Analysis and results

Analysis of the current state:

- Significant increase of the groundwater level
- Southern part and some northern areas benefit massively
- Northern tip remains a high groundwater level
- Areas with less or no effect in the north show little to no effect due to a relatively high slope and a lack of weirs in those areas.



Average depth of the groundwater level [m] (left scenario 1, right scenario 2)

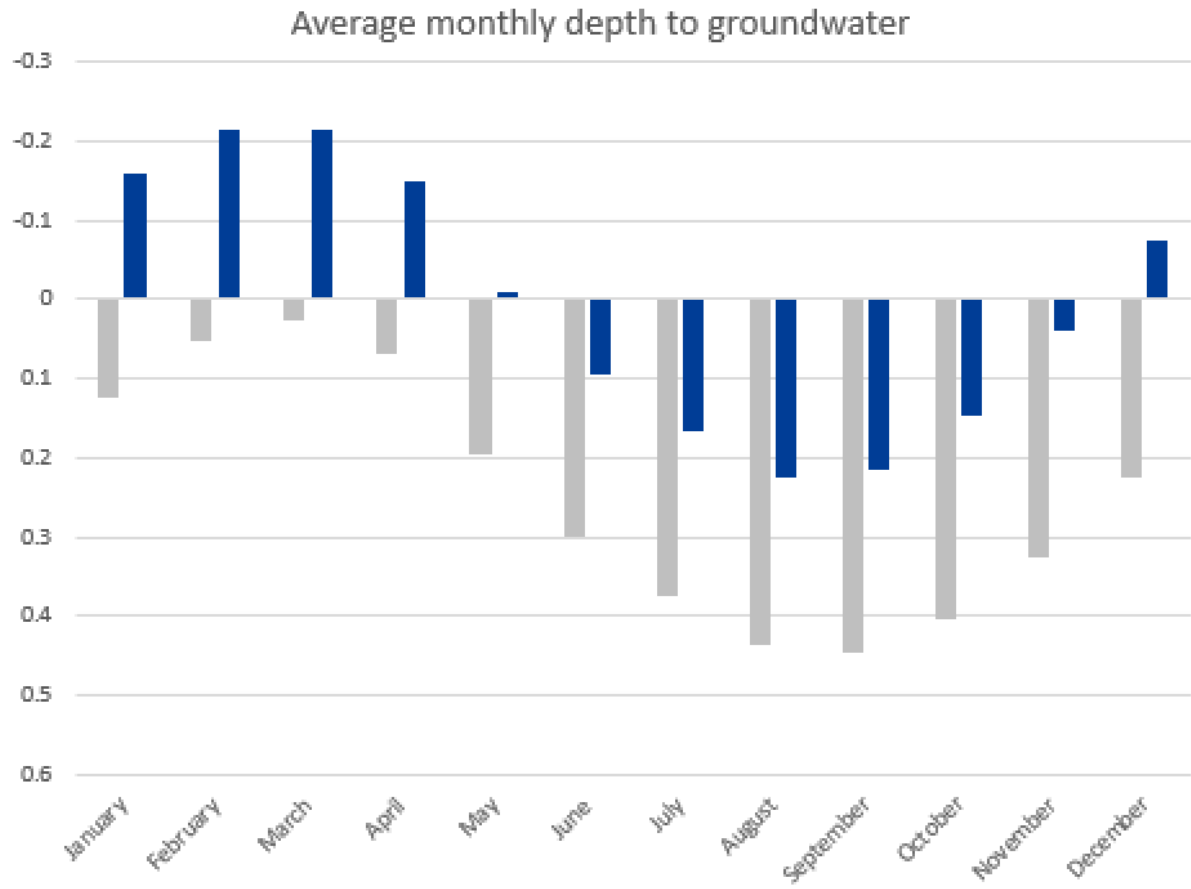
Analysis and results

Analysis of the current state:

- The average monthly groundwater level shows a significant increase as well.
- More than 0.2m in winter and summer.
- The goal of a maximum depth to groundwater of less than 0.4m is possible.

! Info: The area within the red borders was evaluated !

(As seen on the last slide)



Average monthly depth of the groundwater level [m] (grey scenario 1, blue scenario 2)

Conclusion

Model:

The **combined model** (ArcEGMO & FEFLOW) **reproduces** the **hydrologic processes** of the catchment area:

- **Ex-/infiltration** between **groundwater** and **surface water** along the ditches
- **Discharge** is provided by the catchment area's **groundwater recharge**
- **Effects** of the **regulation of the weirs** on the **groundwater level**

The model provides the quality to develop a reliable water management plan for the southern Randowbruch.

Conclusion

Project:

- The **systematic retention** of water with the weirs in the ditches and the groundwater is **possible**.
- The goals of a **depth to groundwater of 0.4m** in summer is manageable as well.
- Possibility to **target certain areas** with certain weirs.
- Necessity of **building more weirs/rebuilding the ones out of order** to target areas with high slope and lack of weirs.

Conclusion

During the project further scenarios were considered, such as:

- a **structured weir management** dividing the peatland into four stages/sectors (from north to south by elevation).
- different variations of **refilling ditches** to reduce draining effects.
- different variations of **channelling the water** to keep it in ditches with higher elevation (e.g., ditches on the eastern and western slope or in the north).

The different scenarios were simulated and evaluated with the regional and local authorities as well as with the stakeholders (farmers).

Conclusion

Finding the ideal solution to protect the peatland and achieve the highest groundwater levels as well as guarantee periods of accessibility of the agricultural used land for the farmers during the year was the real deal in this project.

The measures for an ideal retention of groundwater with high groundwater levels conflict with the interests of the farmers, requiring low groundwater levels to access the peatland with machinery.

Therefore the regional authorities need to provide the financial basis to develop new agricultural methods in cooperation with the farmers as well as value chains to guarantee their livelihood.

This presentation participates in OSPP

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Outstanding Student & PhD candidate Presentation contest

THANK YOU!

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References

1. Lehrkamp, H. (1987): Die Auswirkungen der Meliorationen auf die Bodenentwicklung im Randow-Welse-Bruch, Diplomarbeit – Humboldt-Universität zu Berlin, Berlin.

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