Hydrology and electron acceptor availability in heavily managed lowland peat meadows

Hydrological model setup and preliminary results on soil redox measurements

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This research is part of the national NOBV programme on greenhouse gas emissions from lowland peat meadows in the Netherlands. More information on this programme is available in the session BG3.21 Peatland Management, D739 | EGU2020-11169

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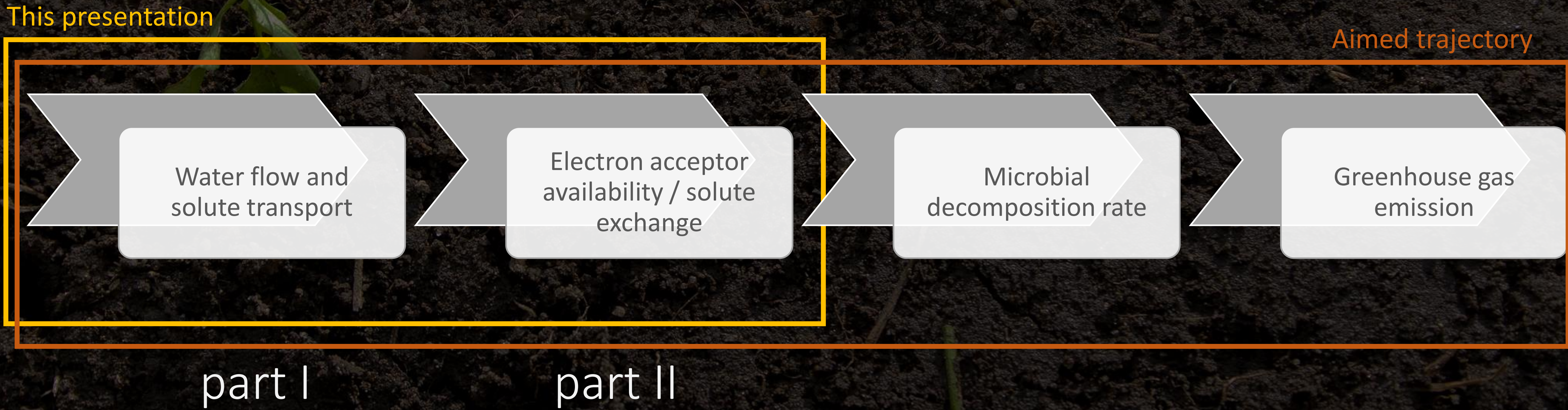
Long term research framework

This research has recently started. Therefore, the presentation is mainly about the research approach. Nevertheless, I would be very interested hearing your thoughts and comments about the research, so please do not hesitate to leave comments/questions or contact me.



(Boonman et al., EGU2020)

(Boonman et al., EGU2020)

Hypotheses

1. High flow velocity -> high oxidator supply + discharge of reaction products
   -> high peat decomposition rate
2. Electron acceptor availability is related to peat decomposition

Aim

Short term:

- Understanding water movement and transport in various conceptual managed peatsoils

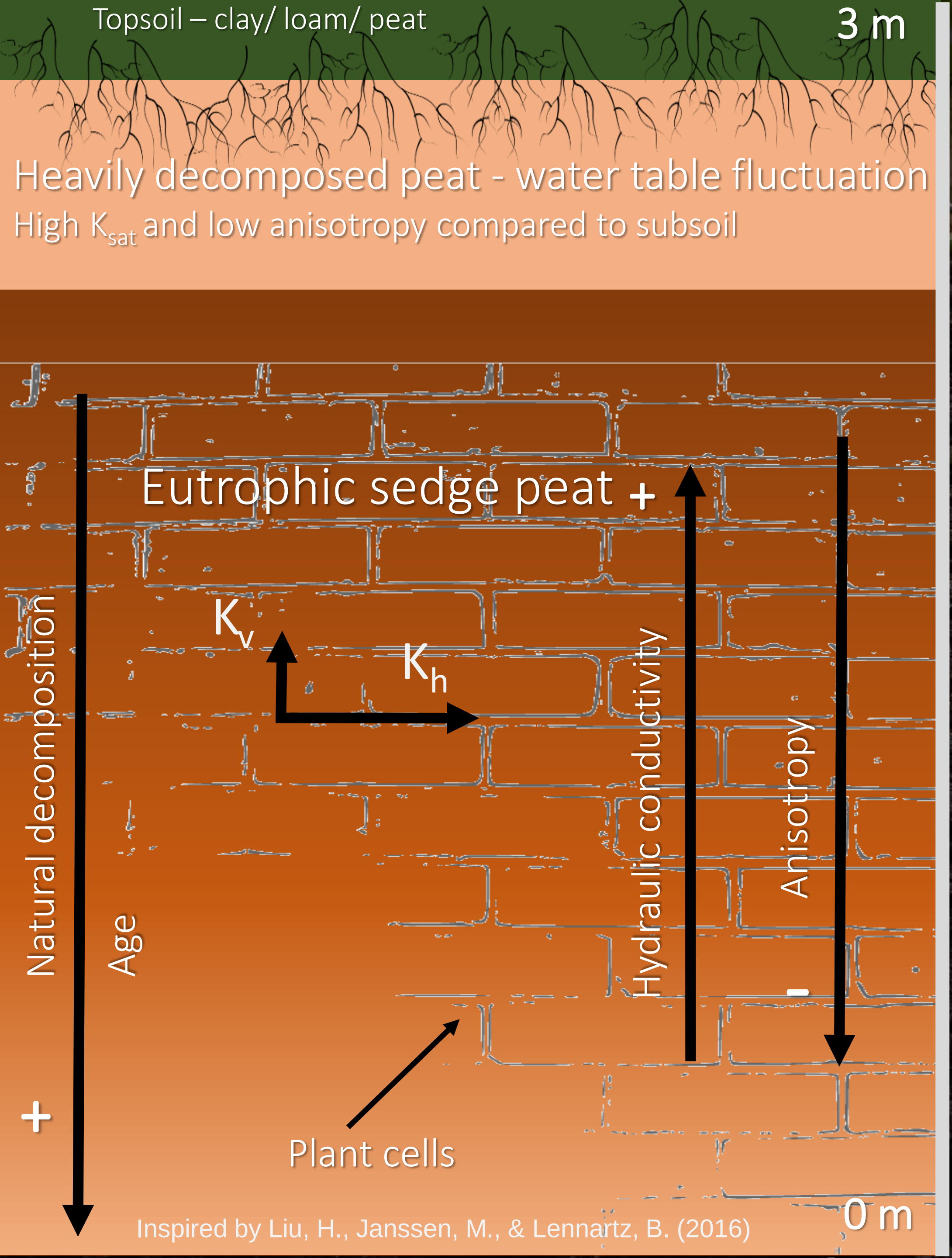
Long term:

- Connecting soil redox measurements to water quality measurements and hydrological flow model results
- Approximating peat decomposition zones

Questions

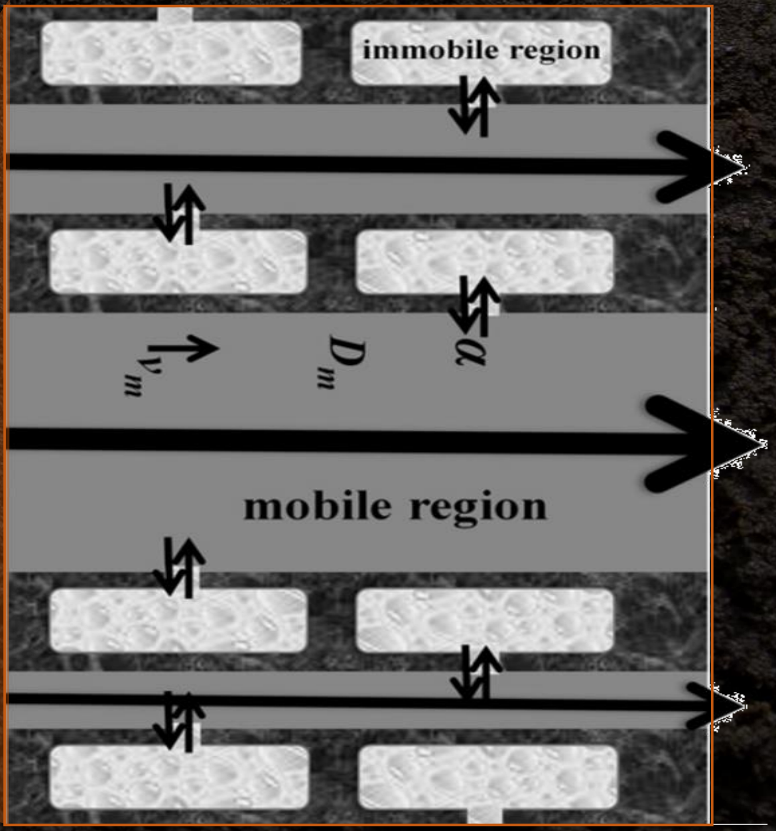
- How is modelled water and solute transport affected by a mobile–immobile pore system?
- What is the soil water origin during different seasons?
- Which soil zones mainly facilitate water flow?
- What is the effect of submerged drain subsurface irrigation on active flow zones?
- How can we relate groundwater hydrology to electron acceptor availability?

Background: hydrology and solute transport

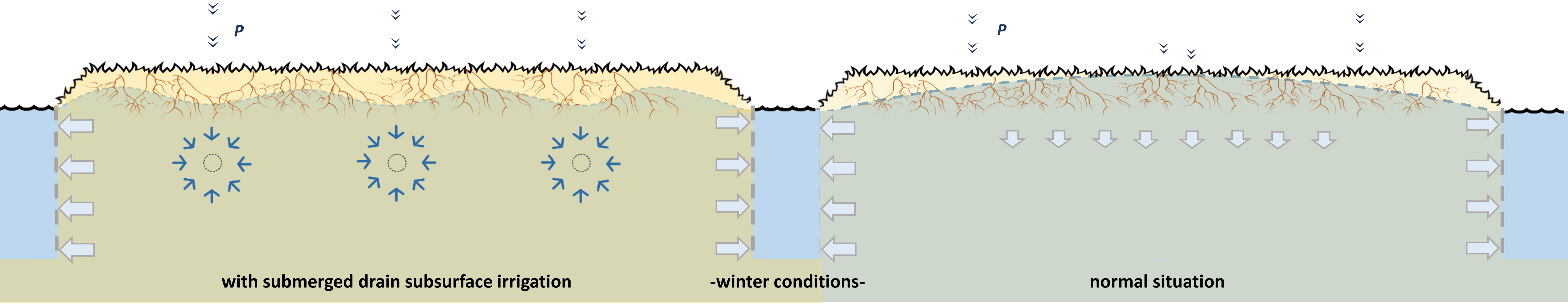


Rezanezhad et al. (2016):
"Dual-porosity concept of peat soil including a *mobile region* with advective flow and an immobile region that exchanges solutes with the mobile region via diffusion. Symbols: D_m: dispersion coefficient in the mobile region; v_m: advective pore water velocity in the mobile region; α: first-order mass transfer coefficient governing the rate of solute exchange between the mobile and immobile pore water regions. Note that the figure assumes an upward hydraulic gradient."

Mobile – Immobile pore structure

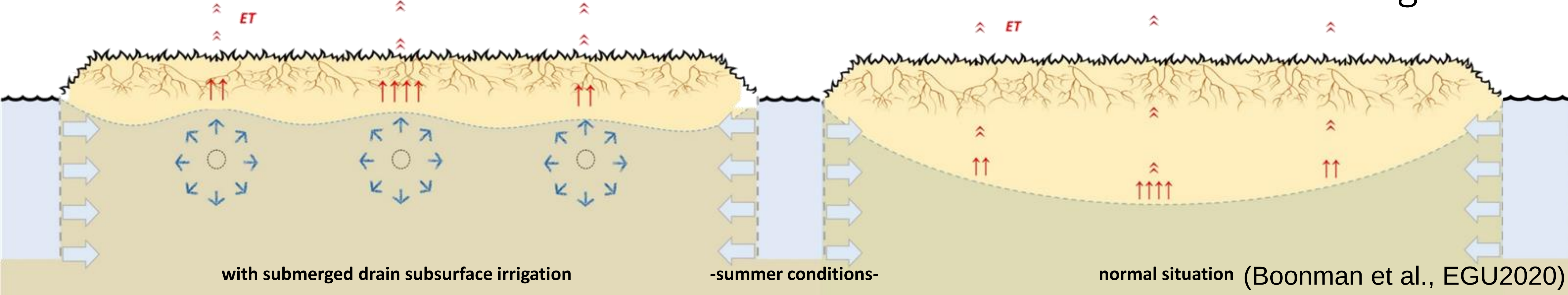


(Boonman et al., EGU2020)



Submerged drain subsurface irrigation
(SDSI)

Background



(Boonman et al., EGU2020)

Part I - **Hydrological modelling**

Model illustration

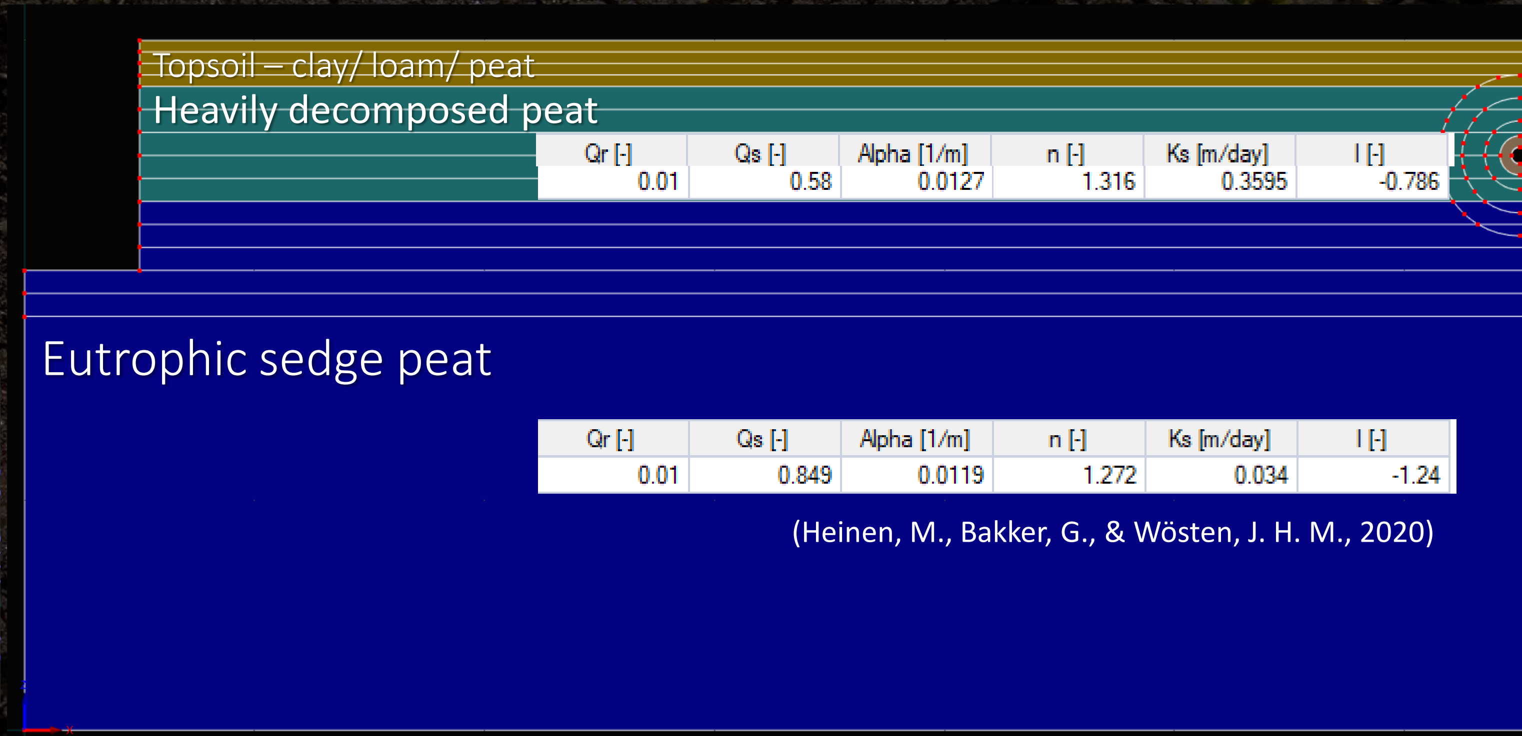
2D cross-sectional HYDRUS FEM

(Šimůnek et al. 2018)

Dimensions: 25 m x 3 m

Submerged drain subsurface irrigation included

Soil material



Heavily decomposed peat:

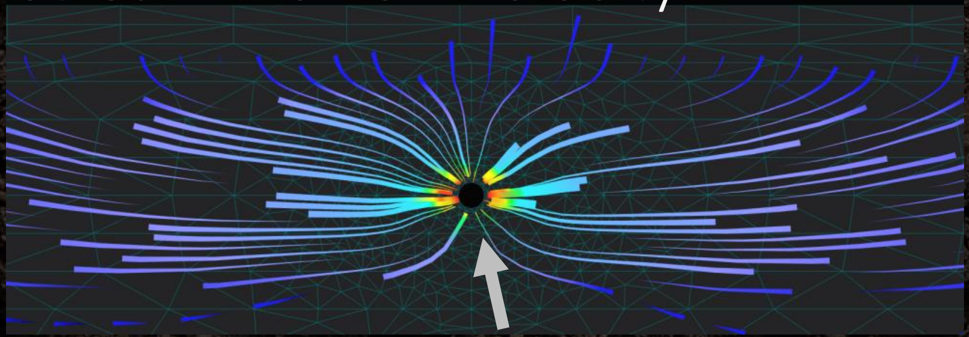
Qr [-]	Qs [-]	Alpha [1/m]	n [-]	Ks [m/day]	l [-]
0.01	0.58	0.0127	1.316	0.3595	-0.786

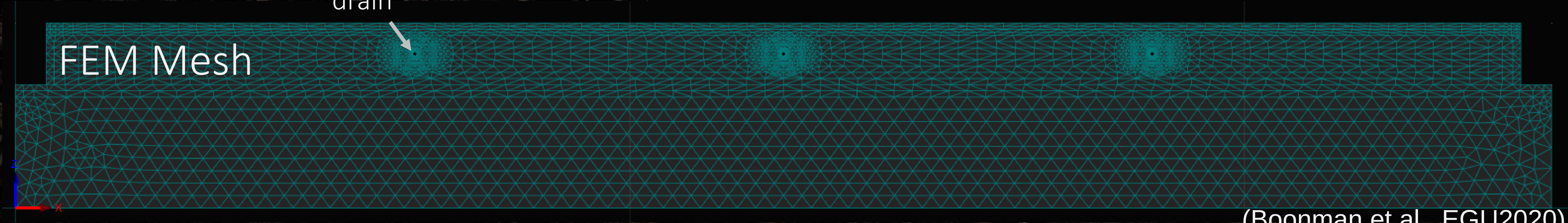
Eutrophic sedge peat:

Qr [-]	Qs [-]	Alpha [1/m]	n [-]	Ks [m/day]	l [-]
0.01	0.849	0.0119	1.272	0.034	-1.24

(Heinen, M., Bakker, G., & Wösten, J. H. M., 2020)

Streamline flow velocity





(Boonman et al., EGU2020)

Model variations

Soil
- Profile
- Clay cover

SDSI
- Drain depth
- Drain distance
- Drain pressure

Ditch/trench
- Water level

Deep groundwater
- No flow
- Seepage
- Infiltration

Hydraulic model
- Hysteresis
- Dual porosity
- Anisotropy

Model constants

Dimensions

Climate

2012 (warm up)
2013 (normal)
2018 (dry)

Root parameters

Soil layer parameters

Tracer transport parameters

Many variations:

Which hydraulic parameters?

How to deal with uncertainty?

Parameters not available

→ to what extent can we simplify complexity?

Output analysis

Source tracer distribution

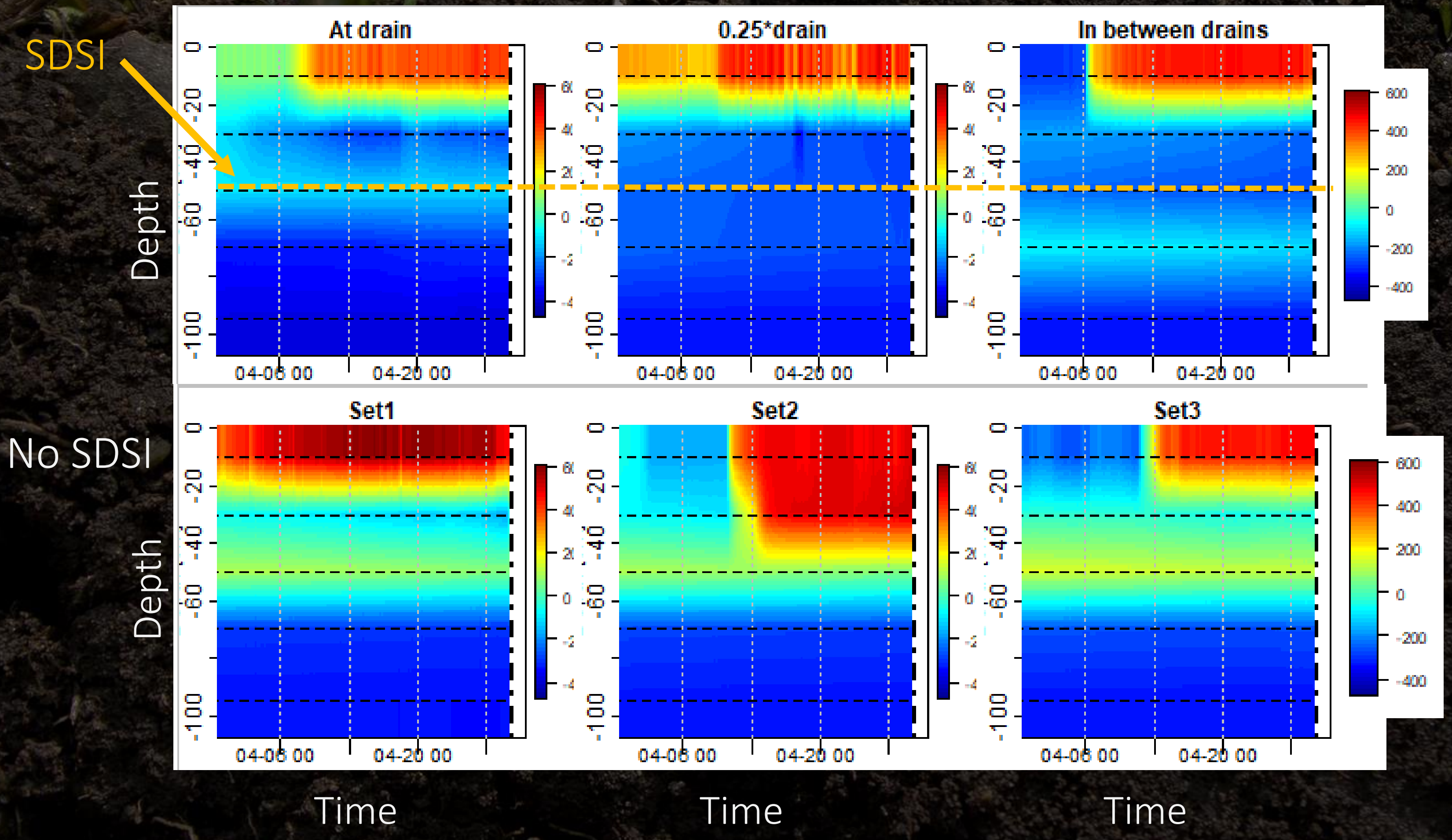
Cumulative absolute pore velocity

2D cross-sectional HYDRUS FEM

(Šimůnek et al. 2018)

(Boonman et al., EGU2020)

Part II – Electron acceptor availability
Preliminary results



Redox (Eh) results from a lowland sedge peat meadow in Assendelft (Noord-Holland) during previous dry and warm April are presented. The conditions are measured at five depths at two parcels, with and without SDSI. Please note that the values have not yet been corrected for temperature and pH. The color gradient provides information on raw redox measurements, from 600 mV (red) to -400 mV (blue). With SDSI systems (top plots), oxidative conditions seem to remain more at the surface compared to reference situations (lower plots).

(Boonman et al., EGU2020)

Discussion

Part I

- Which hydraulic parameters to chose?
- To what extent can we simplify the pore system?
  - How to obtain representative estimates of parameters?

Part II

- Could a low electron acceptor availability mean that there is high decomposition rate?
- How are the micro and macro pore redox states/electron acceptor availabilities related to the measurements?


(Boonman et al., EGU2020)
Thank you!

References

Heinen, M., Bakker, G., & Wösten, J. H. M. (2020). Waterretentie-en doorlatendheidskarakteristieken van boven-en ondergronden in Nederland: de Staringreeks: Update 2018 (No. 2978). Wageningen Environmental Research.

Liu, H., Janssen, M., & Lennartz, B. (2016). Changes in flow and transport patterns in fen peat following soil degradation. European journal of soil science, 67(6), 763-772.

Rezanezhad, F., Price, J. S., Quinton, W. L., Lennartz, B., Milojevic, T., & Van Cappellen, P. (2016). Structure of peat soils and implications for water storage, flow and solute transport: A review update for geochemists. *Chemical Geology*, *429*, 75-84.

Šimůnek, J., M. Th. van Genuchten, and M. Šejna, The HYDRUS Software Package for Simulating Two- and Three-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media, Technical Manual, Version 3.0, PC Progress, Prague, Czech Republic, pp. 274, 2018.