# Using current hydrological conditions to better understand paleoecological dynamics in oligotrophic peatlands of north-central Quebec, Canada

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# Context

- Peatlands in north-central Quebec are characterized by high dominance of aquatic microforms such as pools and wet hollows suggesting present-day or historical water table rise expressed by tree mortality, physical degradation of strings, and pool expansion.

- Ecohydrological disequilibrium of peatlands may have major consequences for their ecological functions including and carbon sequestration.

# Goal and objectives

**Goal**

Identify the most important ***processes that influenced the ecohydrological disequilibrium in the peatlands*** where terrestrial vegetated microforms shifted into wet hollows and pools that modified their ecosystem functions throughout the Holocene.

**Specific objectives**

1) Reconstruct the ***paleohydrological and paleoecological conditions*** that influenced peat accumulation and carbon dynamics throughout the ***Holocene***;

2) Reconstruct the ***Holocene regional vegetation and related climate variations*** in terms of temperature and precipitation;

3) Document the ***present-day hydrological dynamics and groundwater exchanges*** within the peatland watersheds;

4) ***Simulate*** the effect of different ***forcings on the peatlands ecohydrological functioning*** over the last 6000 years obtained by the results of specific objectives 1, 2 and 3.

**Size**
- 10 ha (Misask)
- 14 ha (Cheinu)

# Study sites

**Peat depth**
- 2.1 m (Misask)
- 3.2 m (Cheinu)

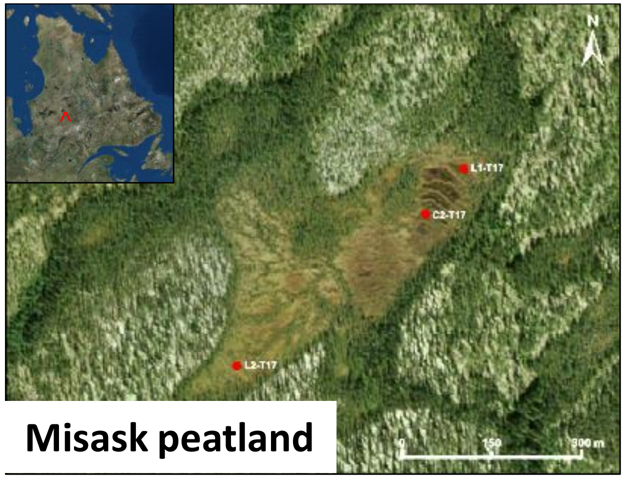
**Precipitation**: 800 mm/yr

**Temperature**
- Dec-Jan-Feb: -17°C
- Jun-Jul-Aug: 15°C

**Potential ET**: 450 mm/yr

**Geology**: Highly permeable till over low-permeability bedrock

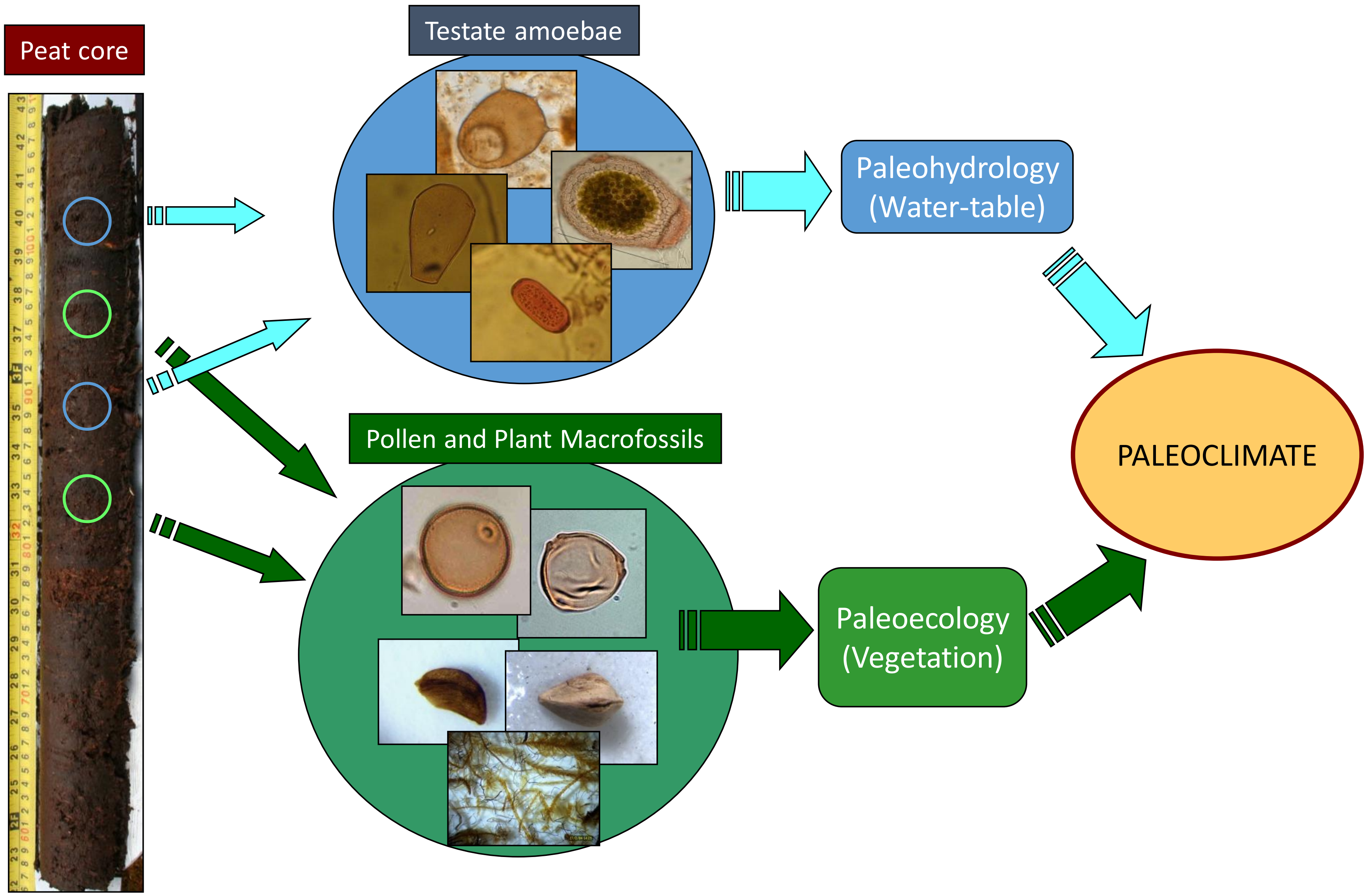
**Surface ecology**
- Subarctic poor fens
- Presence of elongated pools
- Signs of aqualysis



Misask peatland

Cheinu peatland

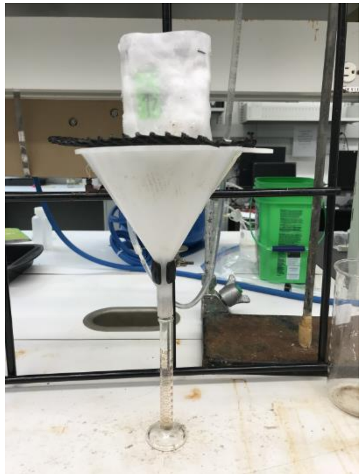
# Methods for paleoecology (Objectives 1 and 2)



# Methods for hydrology (Objective 3)

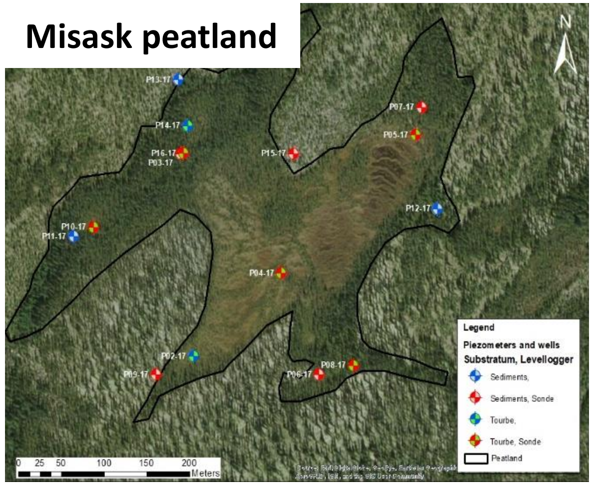
**Peat cores**
**(3 cores/peatland)**

**Hydraulic conductivity**
**(MCM method)**

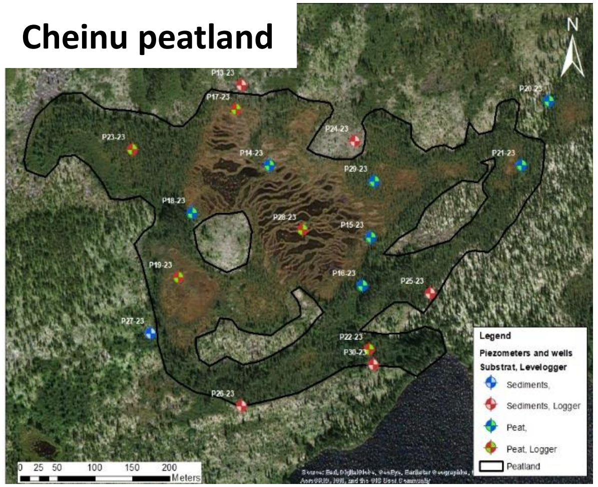


**Peatland instrumentation**
**(piezometers + loggers)**

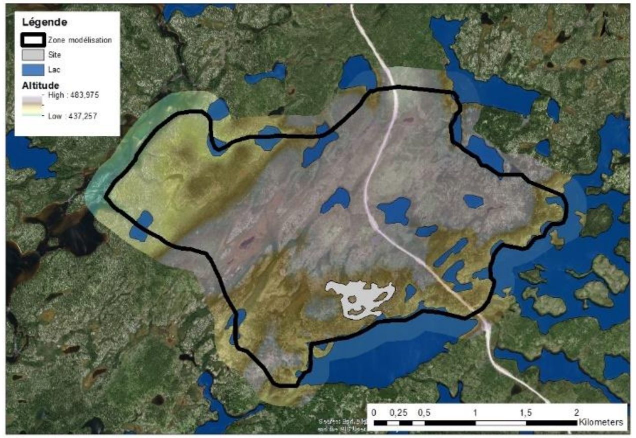
**Misask peatland**



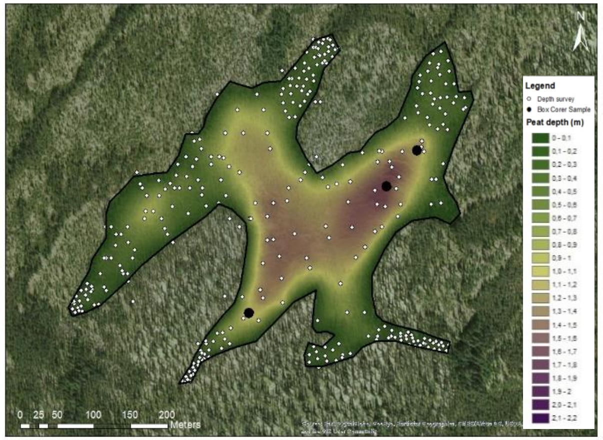

**Cheinu peatland**

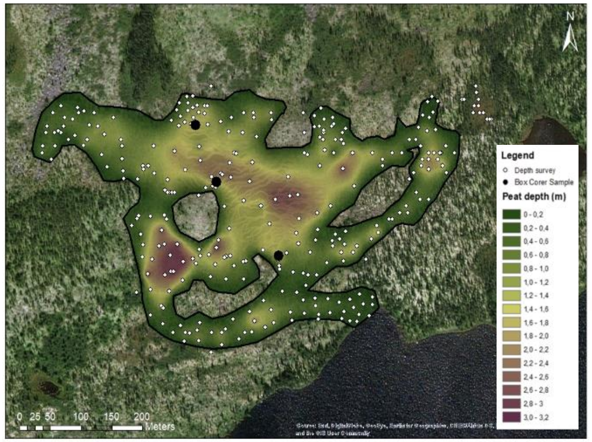



**Steady-state Modflow model**

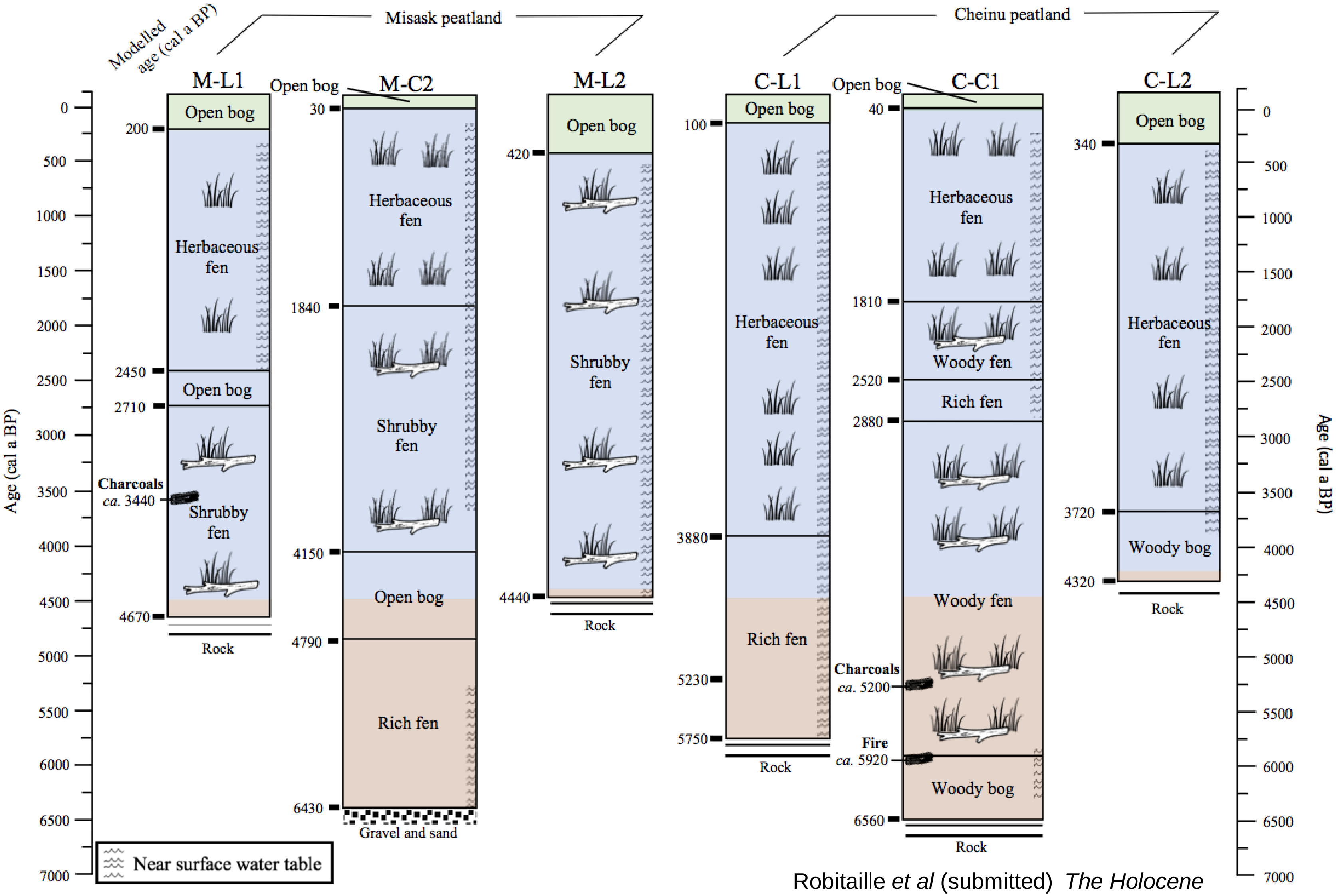



**Basin morphology**



# Results paleoecology – Cheinu peatland




Robitaille *et al* (submitted) *The Holocene*

Recent ecosytem state shift with the 20th century warming

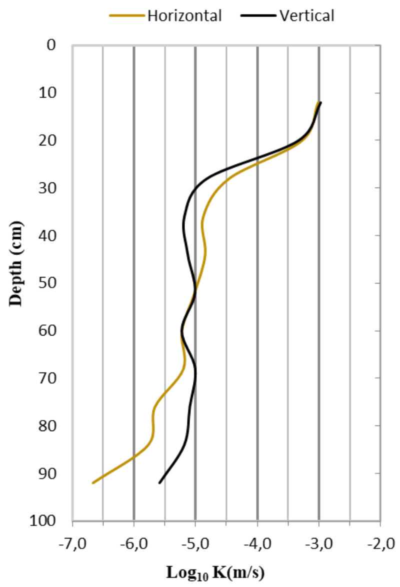
Lateral expansion (4500 cal. a BP) and Neoglacial cooling (2000 cal. a BP)

**Colder and wetter conditions influenced** productivity. The **size of the watershed and groundwater inflows** may have enhanced increase in minerotrophic conditions.

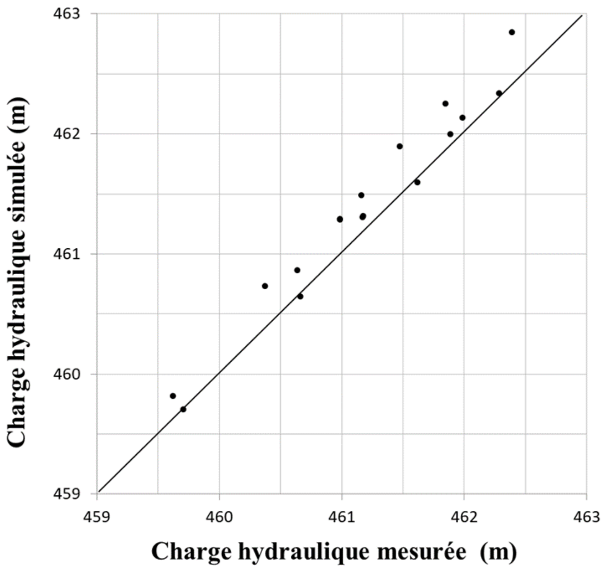
Peatland initiation under warm and dry climatic conditions (from 6500 cal. a BP)

# Results hydrology - Cheinu peatland

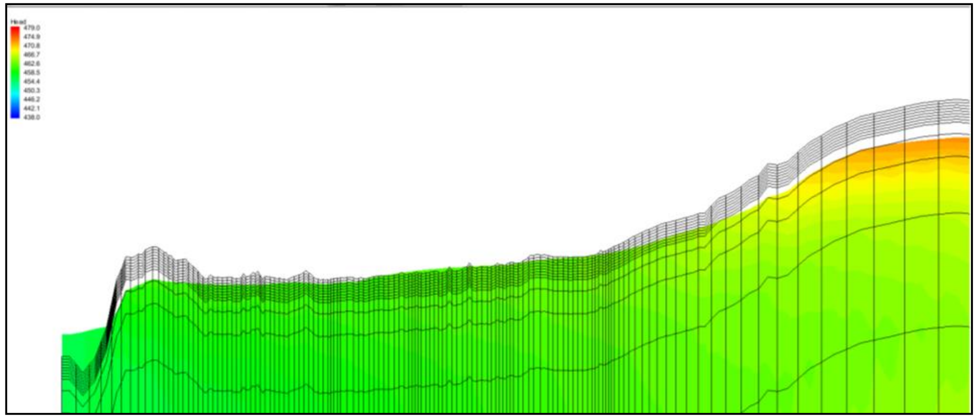
### Peat hydraulic properties



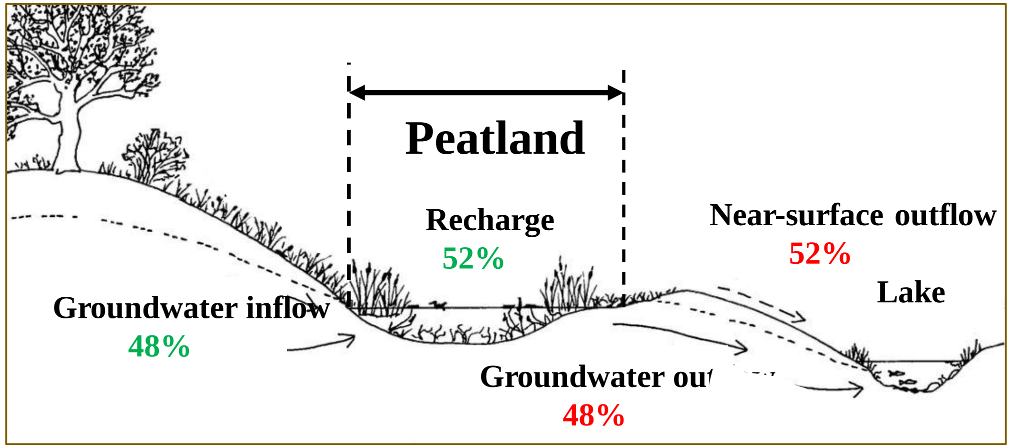

### Measured and simulated heads




### Simulated heads (north-south transect)



### Water budget



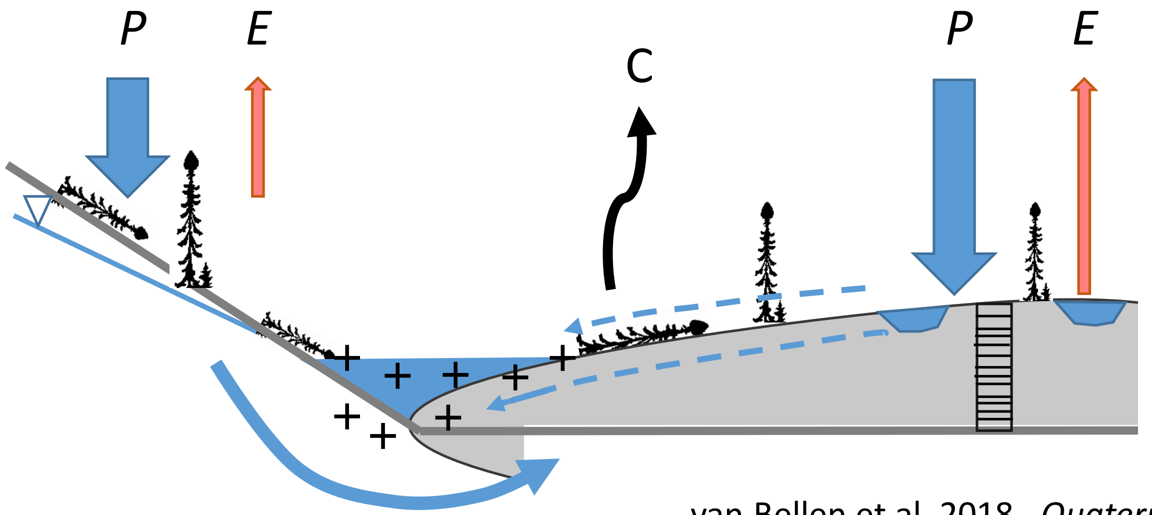

- ➔ The model represents peatland heads satisfactorily.
- ➔ The peatland receives groundwater, and empties via the aquifer and through near-surface runoff.
- ➔ The Cheinu site can been conceptualized as a flow through peatland.

# Testing DigiBog conceptual model with field data

- **Using DigiBog conceptual model, results suggested that hydrological disequilibrium (2200-2000 cal BP) may have been forced by a persisting 20% increase in precipitation, combined with a reduced drainage to the margin and a persisting decrease in temperature reducing plant productivity by 15%**

- **Increased water input to the ecosystem, possibly by increased hillslope contribution (runoff and/or aquifer)**

- **Little Ice Age and Neoglacial cooling negatively affected productivity**




van Bellen et al, 2018 *Quaternary Research*

# Outlook

## Main results

- **Non-negligible groundwater inflow into the peatlands;**
- **Holocene and recent hydroclimatic changes influenced peatlands dynamics.**

## Ongoing work

- **Simulate past and future hydrological conditions in the peatlands using a steady state MODFLOW model;**
- **2-D or 3-D output of the most recent version of the DigiBog model (Morris *et al.*, 2015) to simulate the Holocene development of the study sites, and in particular their response to climate change from the Neoglacial onwards;**
- **Models will be used to study climate change impacts at the sites but also the role of linkages with the wider catchment (e.g. surface and groundwater exchanges).**