DTU Environment
Department of Environmental Engineering

SDC Sino-Danish Center

Nutrient exchange between surface water and shallow groundwater and **degradation pathways** of nitrogen species in the North China Plain

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LuWQ 2015 - 21 September 2015

Chinese Academy of Sciences
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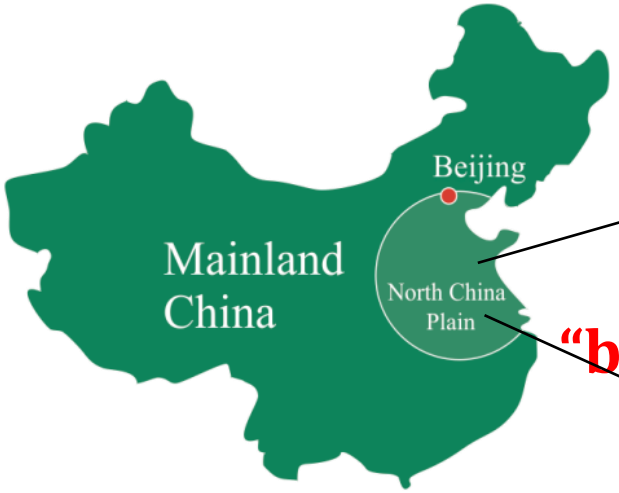
1.1 Introduction: Agriculture in the North China Plain (NCP)



China's "bread basket"

Conditions:

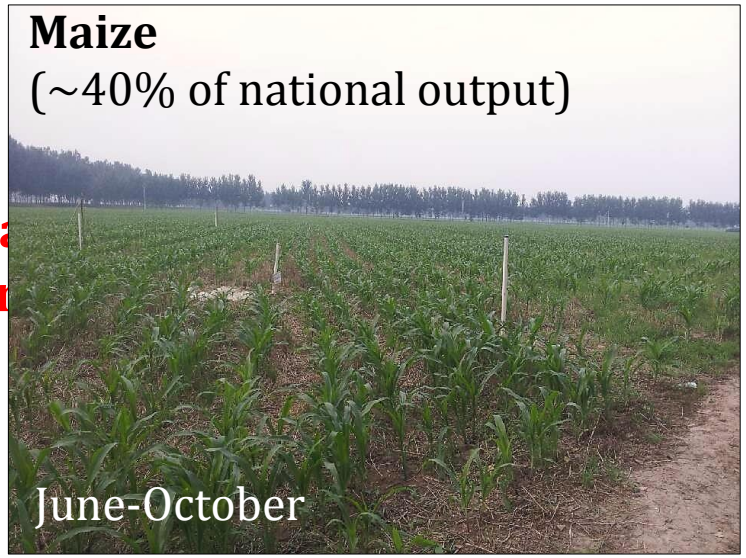
- Suitable temperature for double-cropping
- Much rainfall in summer (annual P 500-600mm)
- Many rivers and lakes
- Relatively fertile land

Pressures:

- High population density
- High industrial use
- Competing land use
- Maintaining food production by
  - increase in irrigation
  - increase in nutrient input

Needed: Understa and degr

Maize
(~40% of national output)



Result: **Water scarcity and pollution in surface water (SW) and groundwater (GW)**

1.2 Study aims

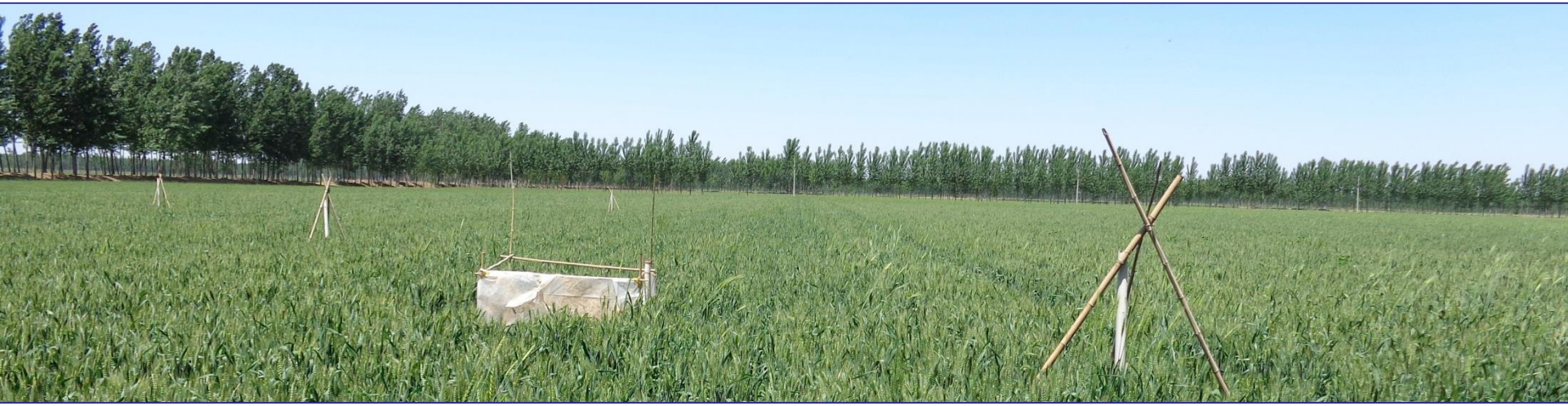
Study area: Typical wheat-maize field with SW-GW interaction

Study aims:

1) Describe local **flow dynamics and solute transport**

2) Assess **temporal water quality changes** regarding inorganic water chemistry and nitrogen

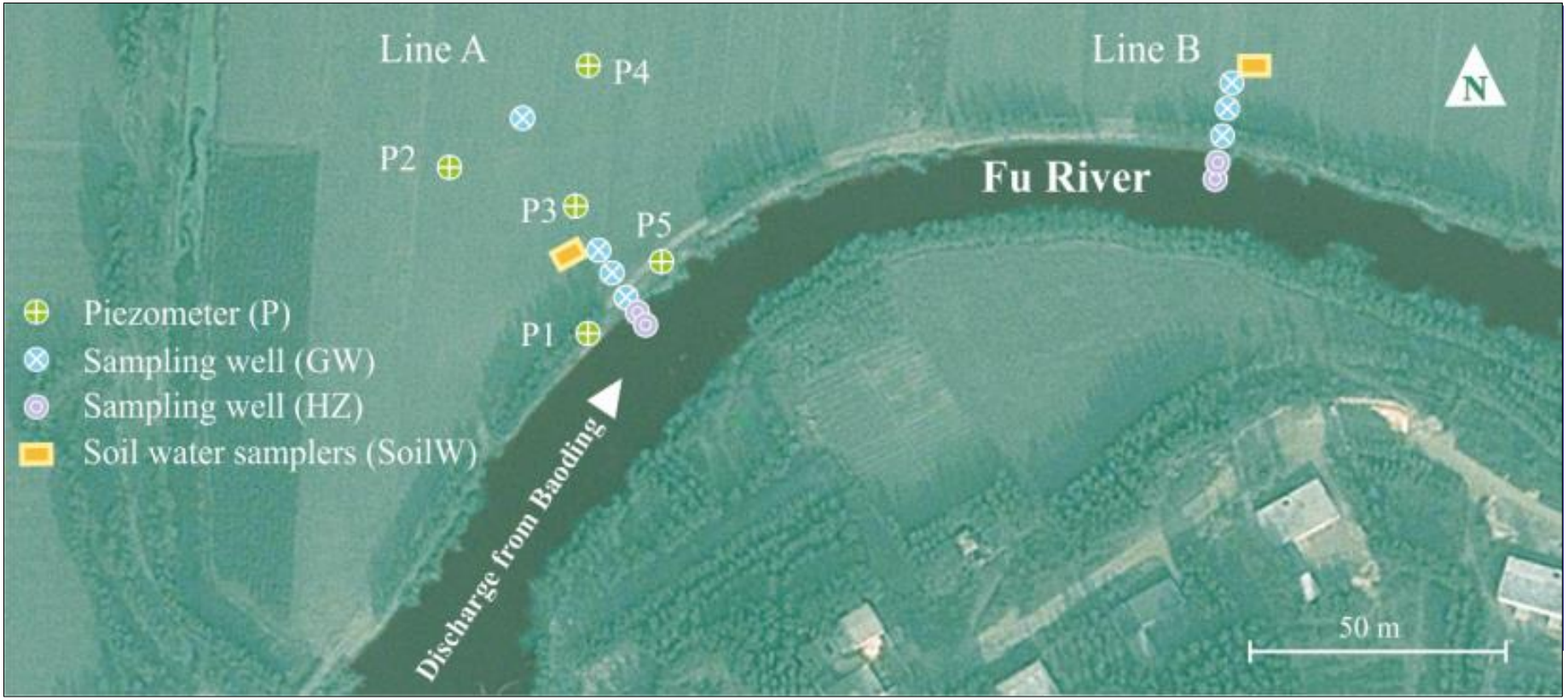
3) Evaluate **dominant processes of nutrient removal**, using geochemical modelling with **PHREEQC**



1.3 Setup and sampling

Study area: Typical wheat-maize field with SW-GW interaction

⇒ near Baiyangdian Lake, Hebei Province



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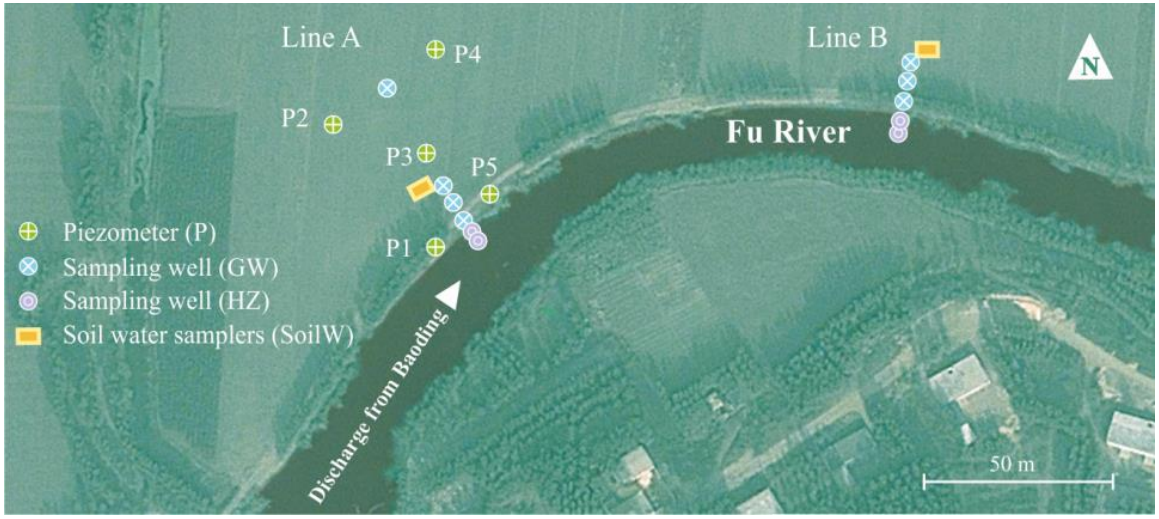
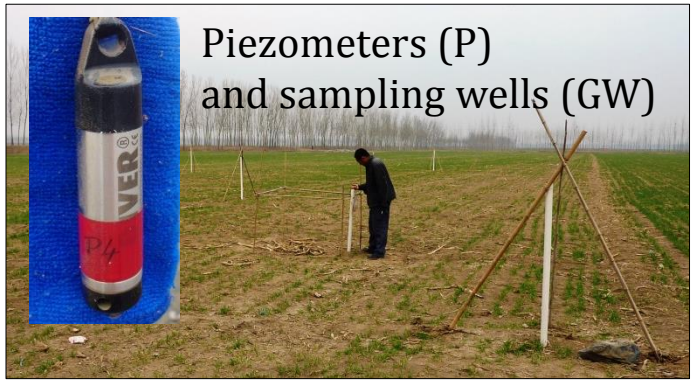


Soil water samplers (SoilW)



Piezometers (P) and sampling wells (GW)

Sampling wells (HZ)

1.3 Setup and sampling

Sampling period: April 2013 to April 2014 (9 sampling campaigns)

Analysis:

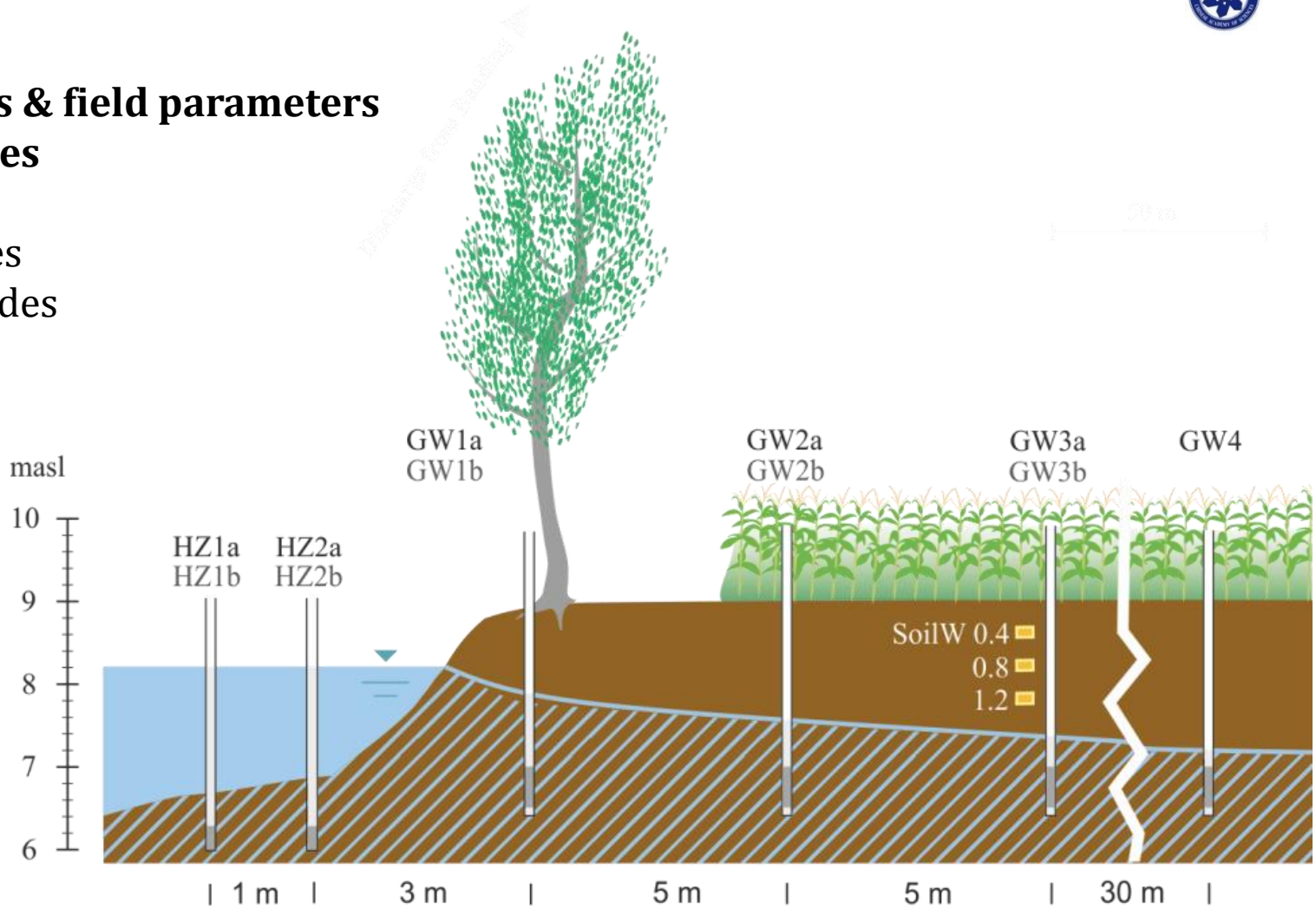
Cations, anions & field parameters

Nitrogen species

Bromide tracer

H and O isotopes

Selected pesticides



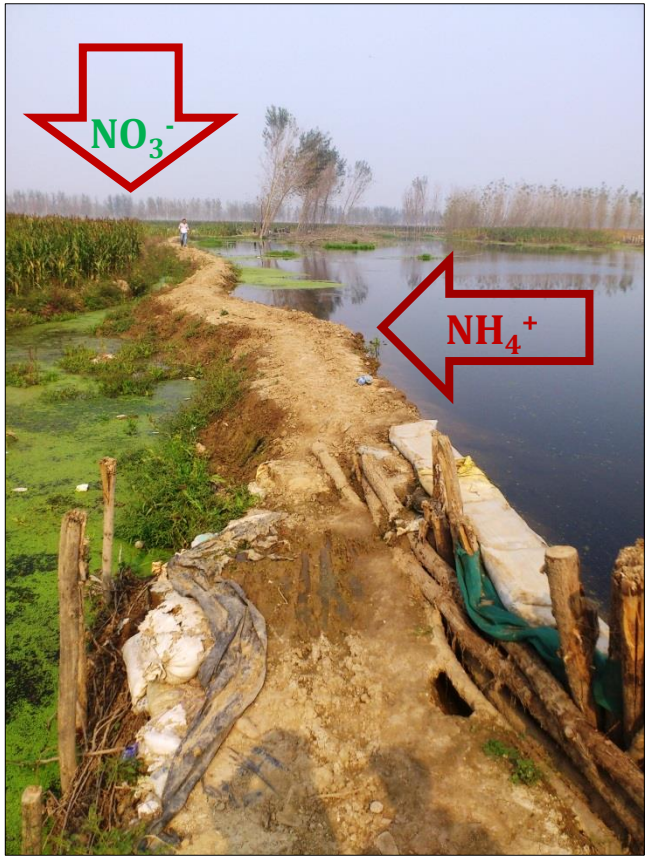
2.1 Water flow and contaminant mass transfer

Horizontal flow

- Hydraulic heads
- Movement of Br-tracer into the field
- Temperature gradient
- Similarity of H and O isotopic signature
- Same water type in SW, HZ, GW

⇒ **SW and GW are very well connected**

⇒ **Contaminants are transferred from SW into GW**



Vertical flow

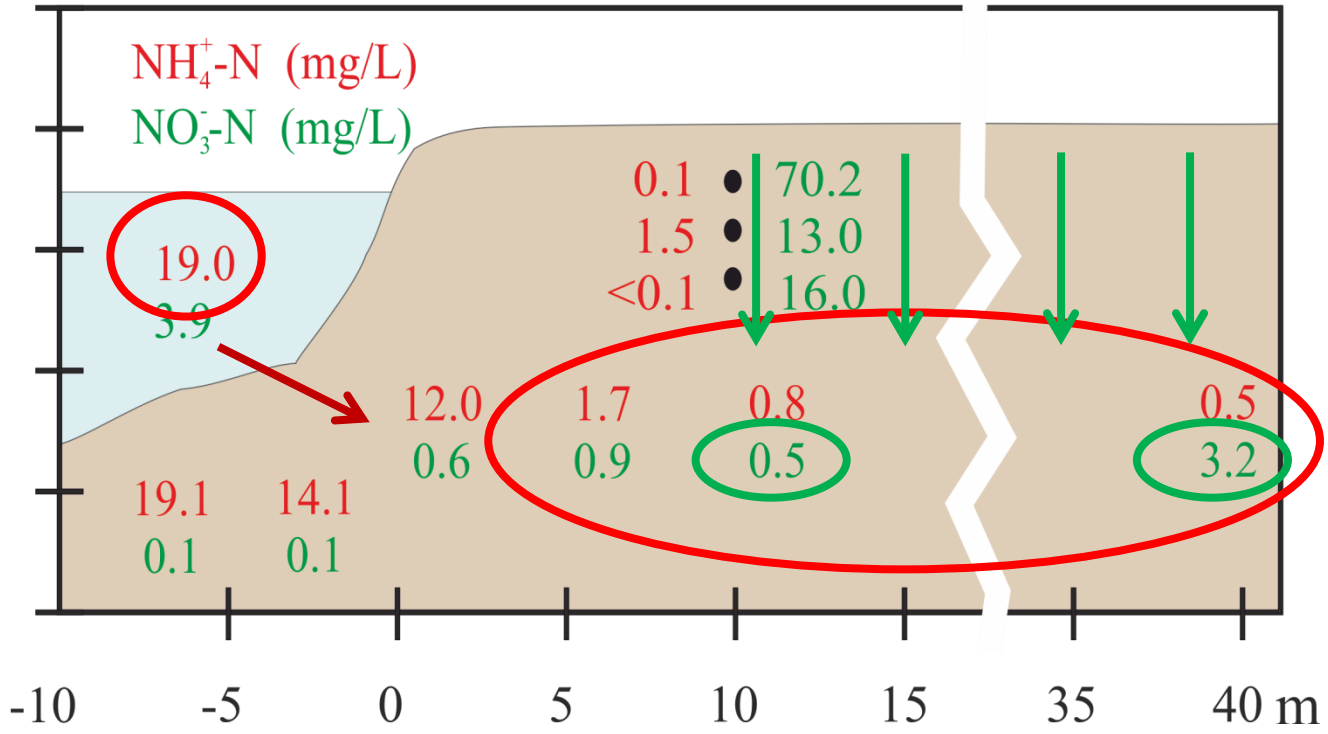
Br applied on surface reaches GW after few months

High nitrate concentrations in SoilW after fertilization

- Much faster than expected for silty clay loam
- Macropore flow must take place

⇒ **Nitrate leaching from the field into GW**

2.2 Nitrogen species – Distribution

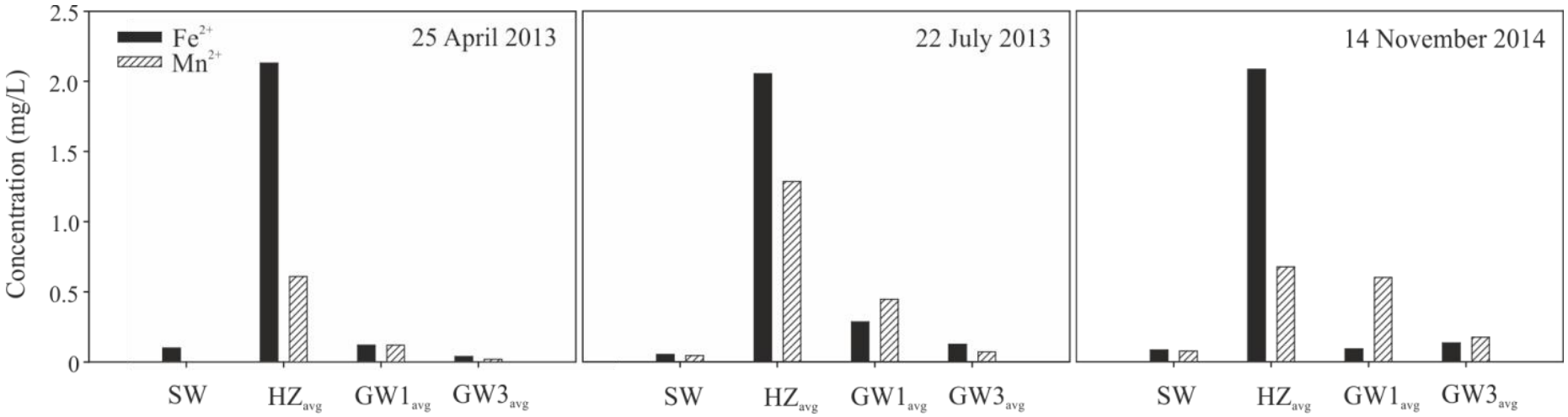


Nitrate: SoilW up to 134.8 mg/L NO_3-N **=> indicates leaching, most NO_3 at GW4**

Ammonium: High in SW, low in GW **=> effective ammonium removal in GW!**

2.3 Redox conditions and suggested removal pathways for nitrogen

- **HZ strongly reducing**
- **GW slightly reducing**



Suggested removal mechanisms:

Nitrate: Denitrification (slightly reducing conditions, OM), DNRA, anammox?

Ammonium: Cation exchange (CE) with clay minerals, anammox?

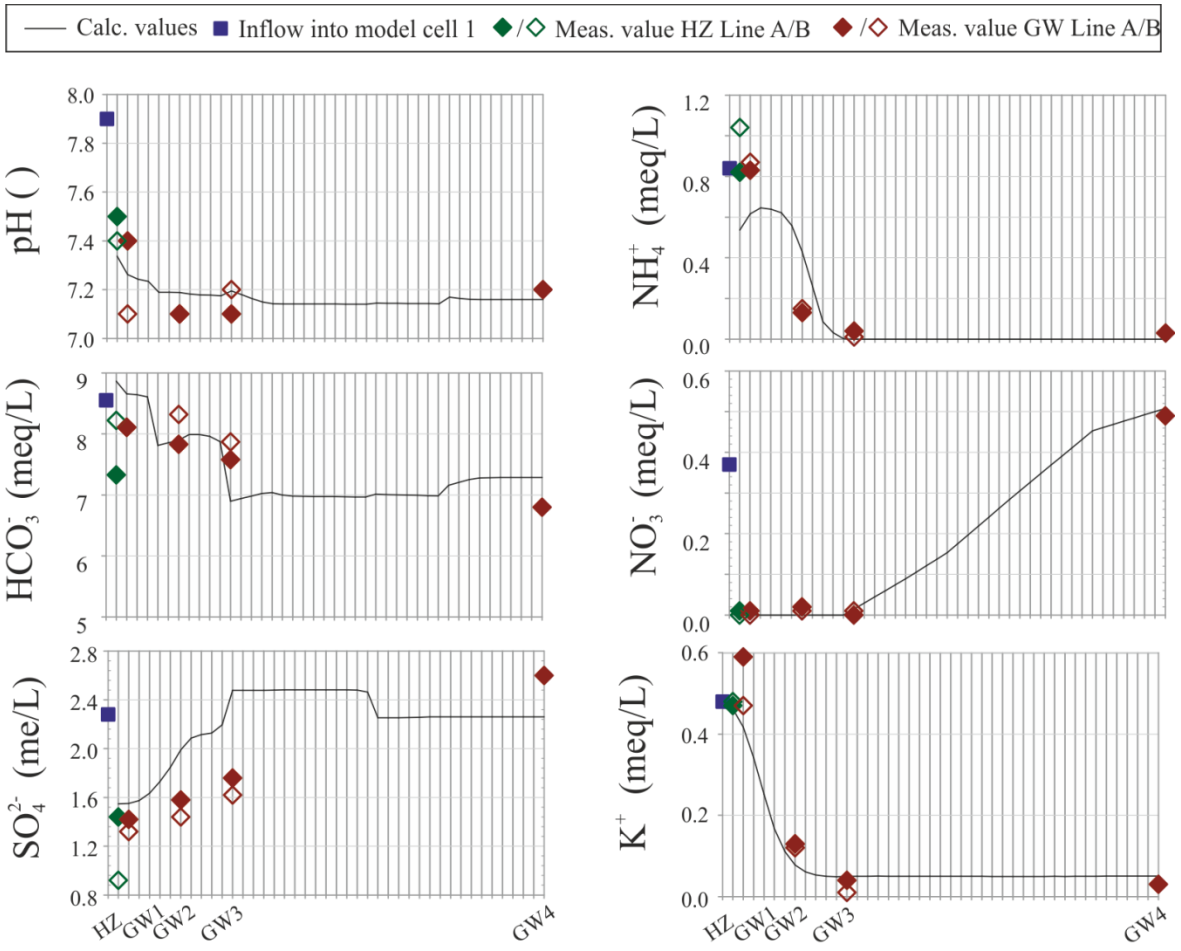
2.4 PHREEQC modelling – part 1

Build up of nitrate along the flow after ammonium is removed
=>Influence of SW quality on nitrate degradation?

<u>Modelled period:</u>
March to September 2013

<u>Included processes:</u>
- Cation exchange
- Equilibrium for calcite, carbon dioxide, and iron(II)sulfide
- Redox processes
- De-/nitrification
- Anammox

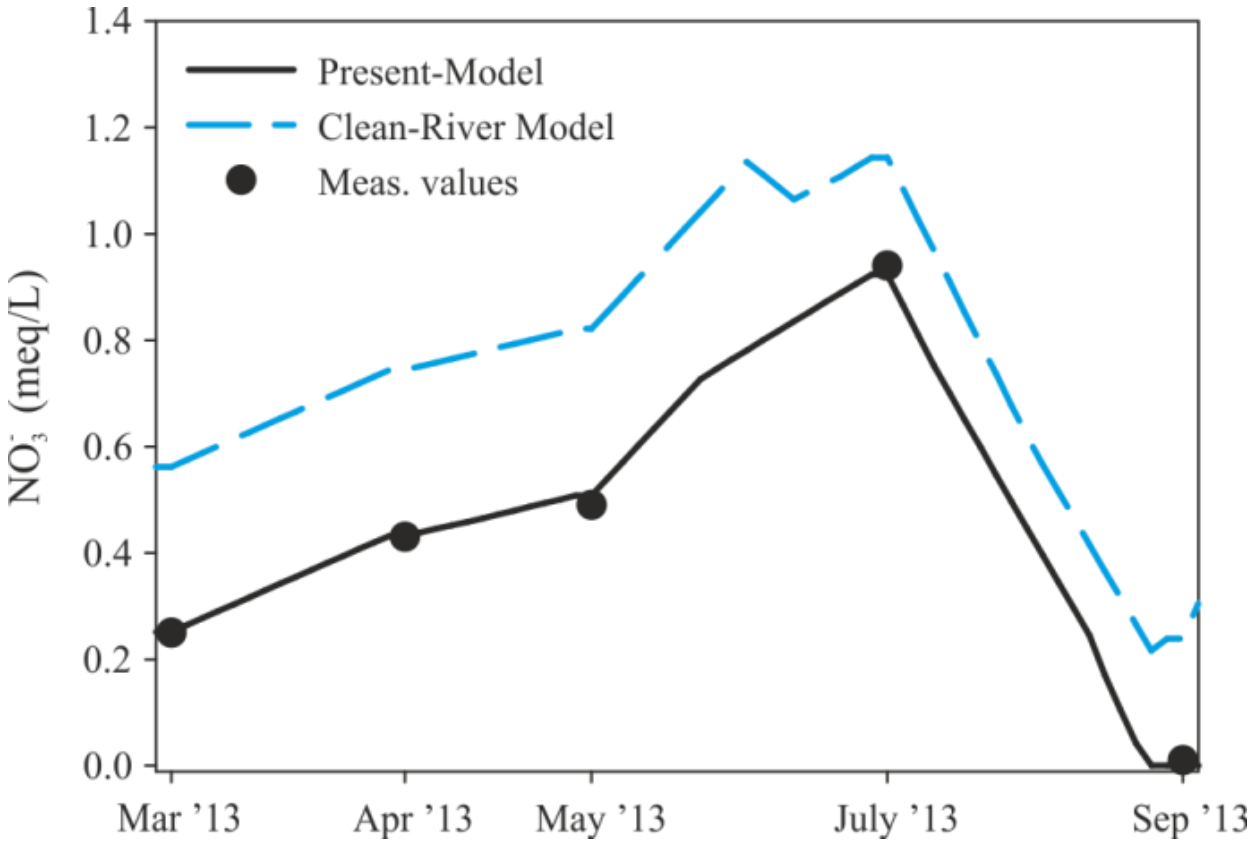
Nitrate pattern well reflected after it was "allowed to react" with ammonium



2.4 PHREEQC modelling – part 2

=>Nitrate levels might increase if ammonium input into the river is reduced

Comparison: Previous model compared to model with reduced ammonium inputs



3 Summary and conclusion

- SW transports pollutants into shallow GW in the BYD area
- The soil system has a good ability to degrade/remove nitrogen, but nitrate is building up at least to some extend
- Nutrient inputs at the field site are excessive
- **Anammox seems to take place not only in the riparian zone**, but also in GW
- **SW and GW should be treated as one resource** and be monitored with the same monitoring scheme to be able to predict changes

THANK YOU FOR YOUR ATTENTION

…QUESTIONS / COMMENTS?

THANKS!!!