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Water quality modelling in a highly regulated lowland river catchment

Outline

- **Objectives**
- **Study area**
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  - The Rhin catchment: natural environment
  - The Rhin catchment: anthropogenic influences
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  - Output parameters
- **Results (hydrology and nitrogen)**
  - Calibration
  - Validation
  - Analyses
- **Conclusions and outlook**

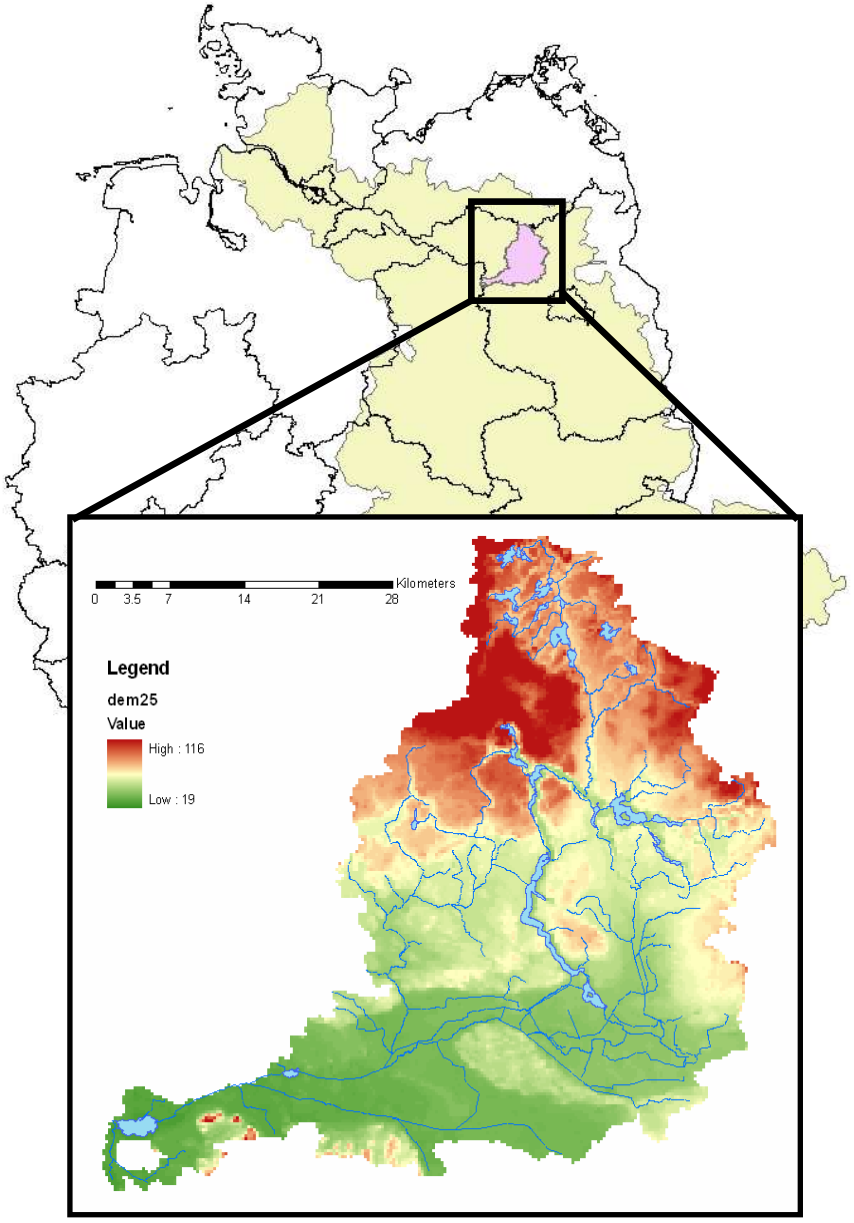
Objectives

- Water quality modelling in the Rhin catchment to identify point and diffuse sources of nutrient pollution and to test feasible measures to improve water quality for implementation of the WFD
- Scenario analysis considering possible climate and land use changes in the Rhin basin
- Stakeholder involvement (LUA) in the Elbe basin (NeWater project)

Study area

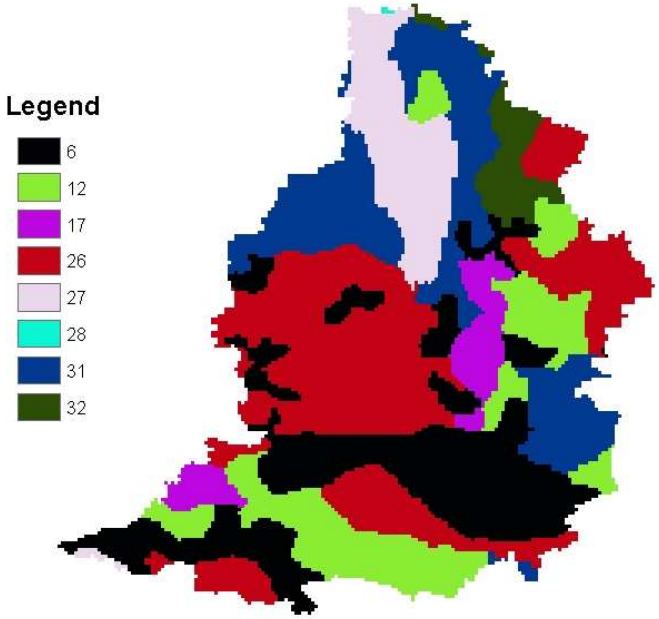
The Rhin catchment

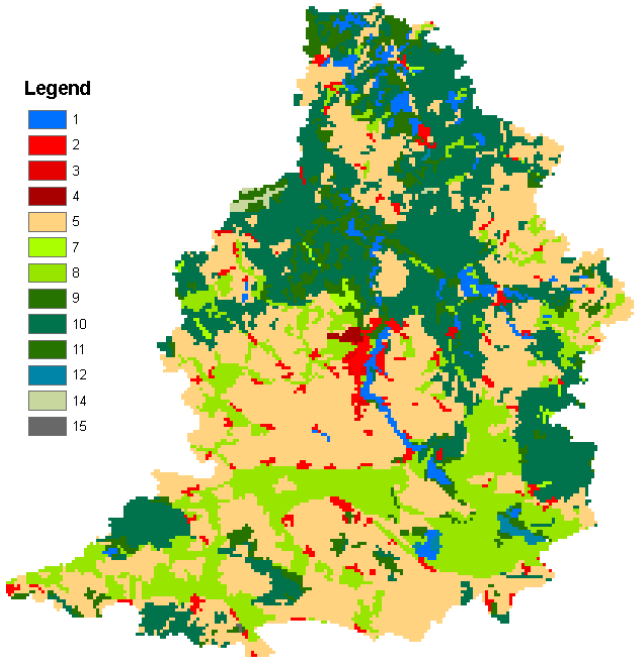
- part of the Elbe basin
- federal state of Brandenburg
- 1716 km²
- 19 - 116 m above sea level
- slowly flowing river with a lot of lakes within the river course
- high amount of fens and wetlands
- annual precipitation 524 mm/a
- mean temperature 9.4 ℃
- mean discharge 3.7 m³/s



Study area

The Rhin basin: natural environment





Soils:

- 40% wet soils (gley) and fens
- 28% Fahlerde (sand over loam)
- 30% brown soils and derivates

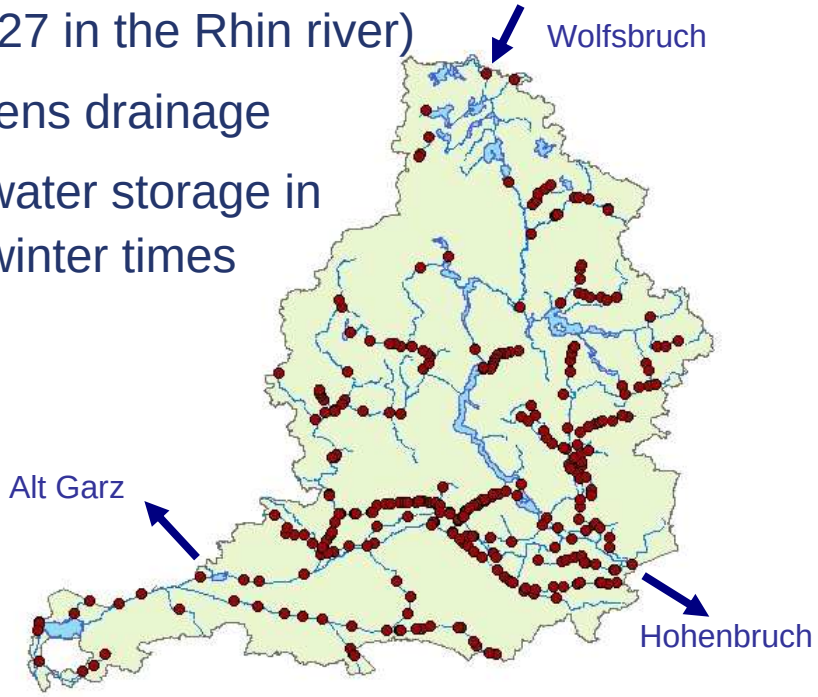
Land use:

- 41% agriculture
- 34% forests (mainly evergreen)
- 19% intensively used pastures
- 3% surface water bodies
- 3.5% settlements

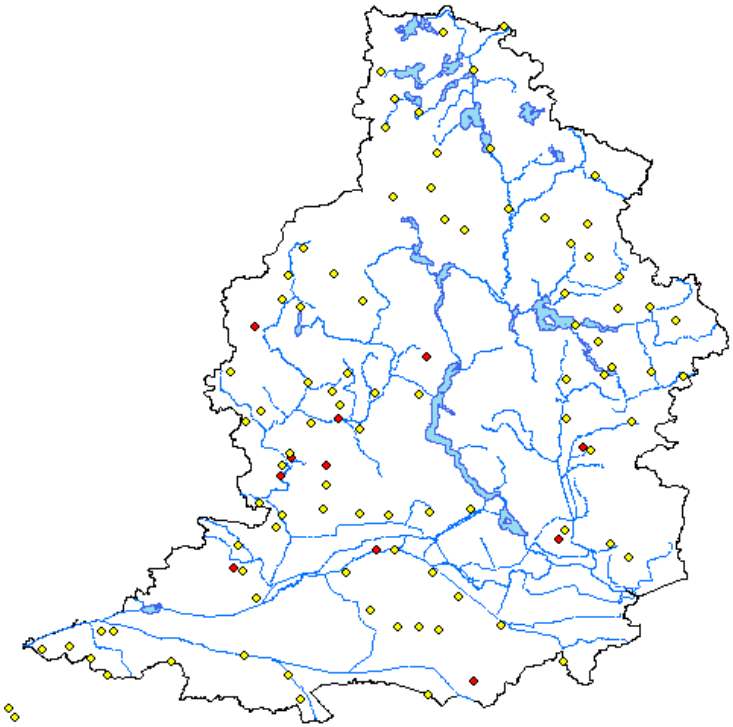
The Rhin basin: anthropogenic influences

Water management

- three water transfer points from or to adjacent catchments
- more than 300 small dams and weirs within the catchment (27 in the Rhin river)
- fens drainage
- water storage in winter times



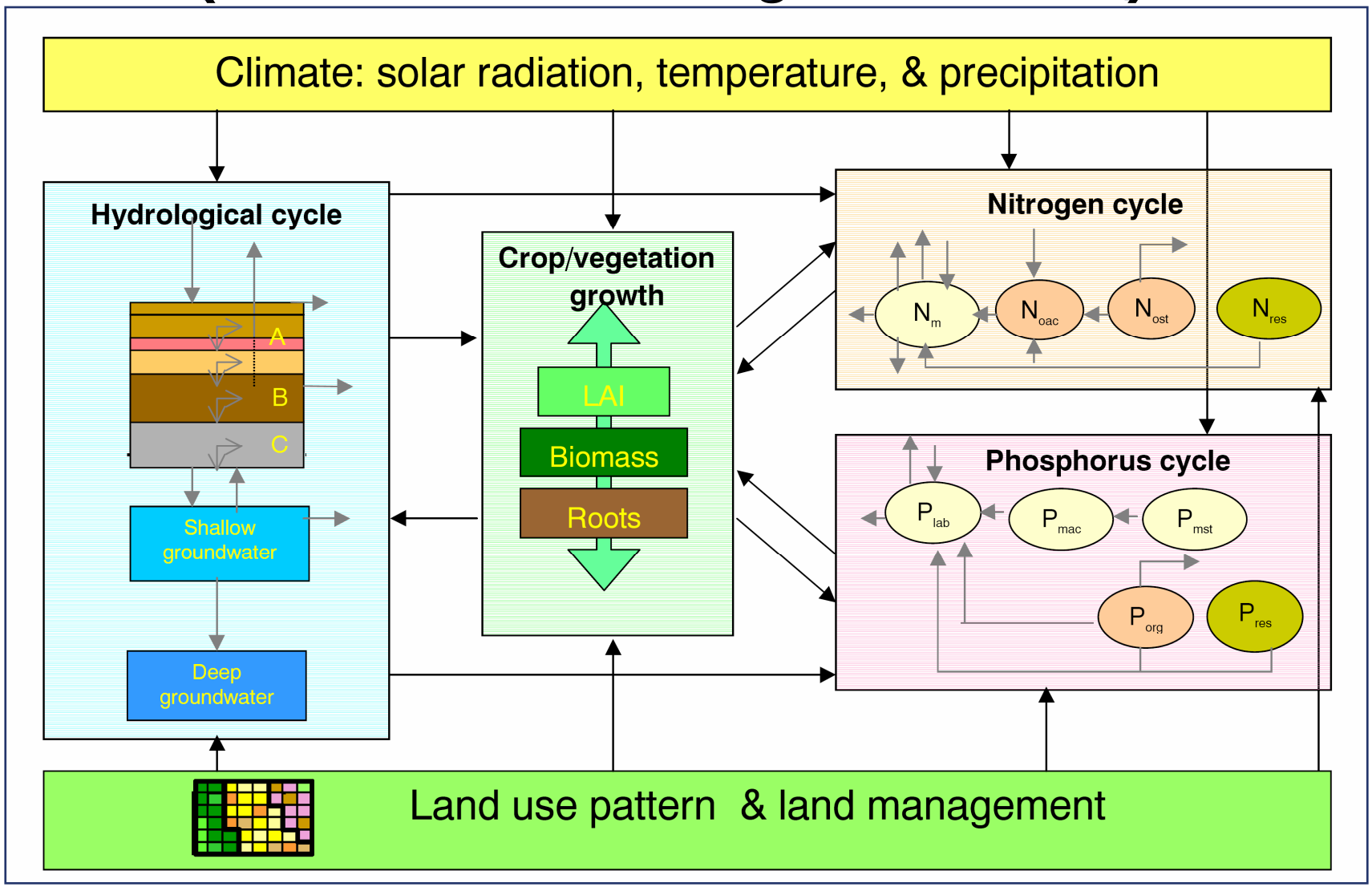
→ **no natural discharge behaviour**



Point sources

- 10 large (red) and 46 small (yellow) sewage water treatment plants within the catchment

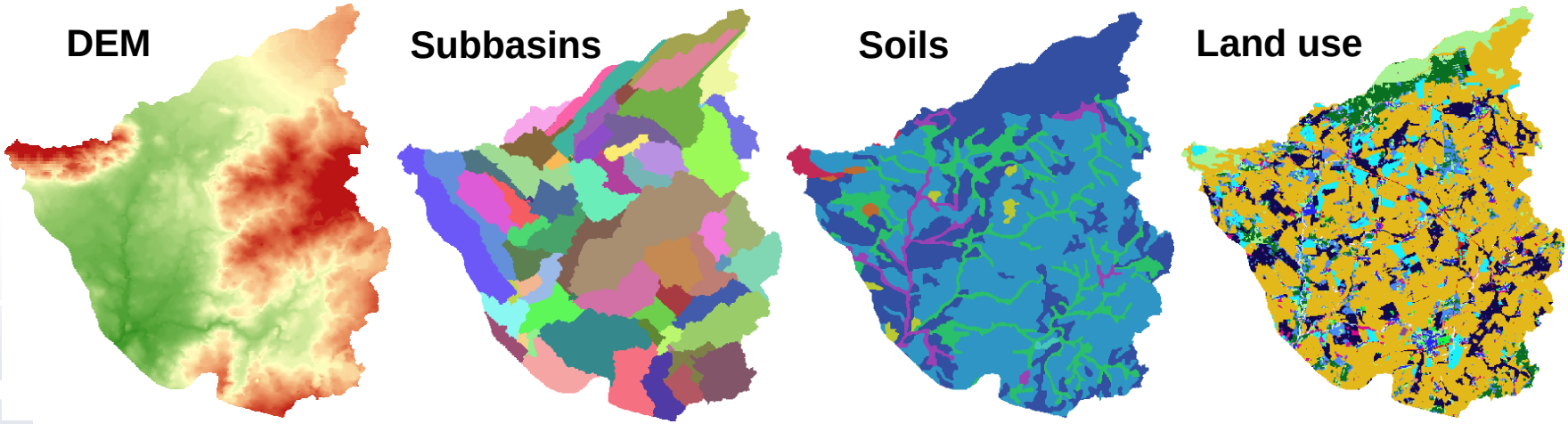
SWIM (Soil and Water Integrated Model)



Krysanova et al., 1998

Data needed for modelling

- **For preparing the model:**

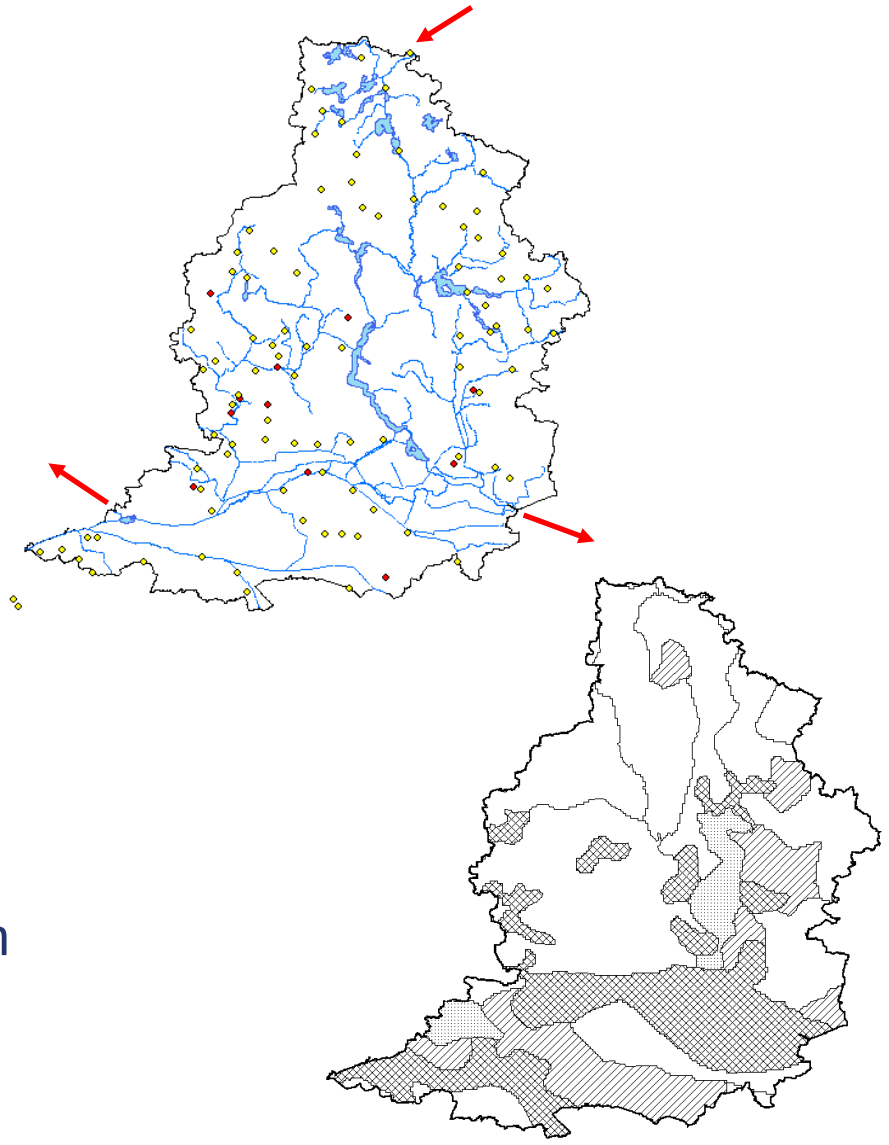


  + climate data (temperature, precipitation, radiation, humidity)
  + soil parameters; vegetation parameters
  + point sources; water management and use; fertilization

- **For interpreting the results:**
  + water discharge
  + water quality measurements
  + crop yield

SWIM code modifications for the Rhin

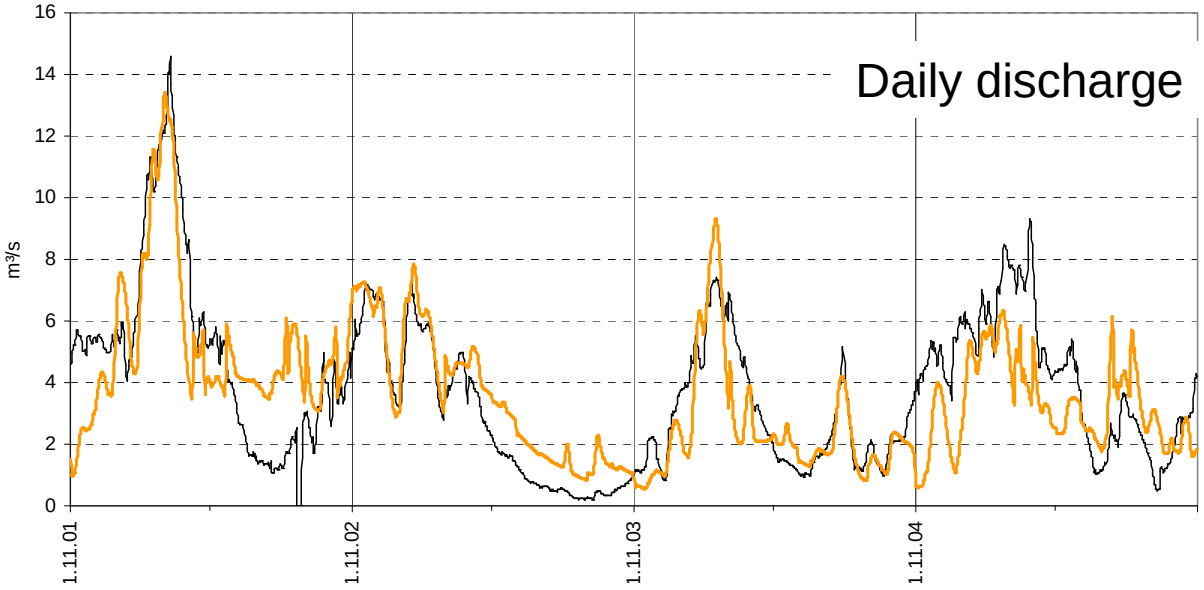
- Definition of subbasins and constraints for water input or water output from or to adjacent catchments
- Implementation of point sources for nutrients
- Simple wetland method to increase water and nutrient uptake by plants on fens and ground water influenced soils (ca. 40% of the whole area) in times when supply is limited

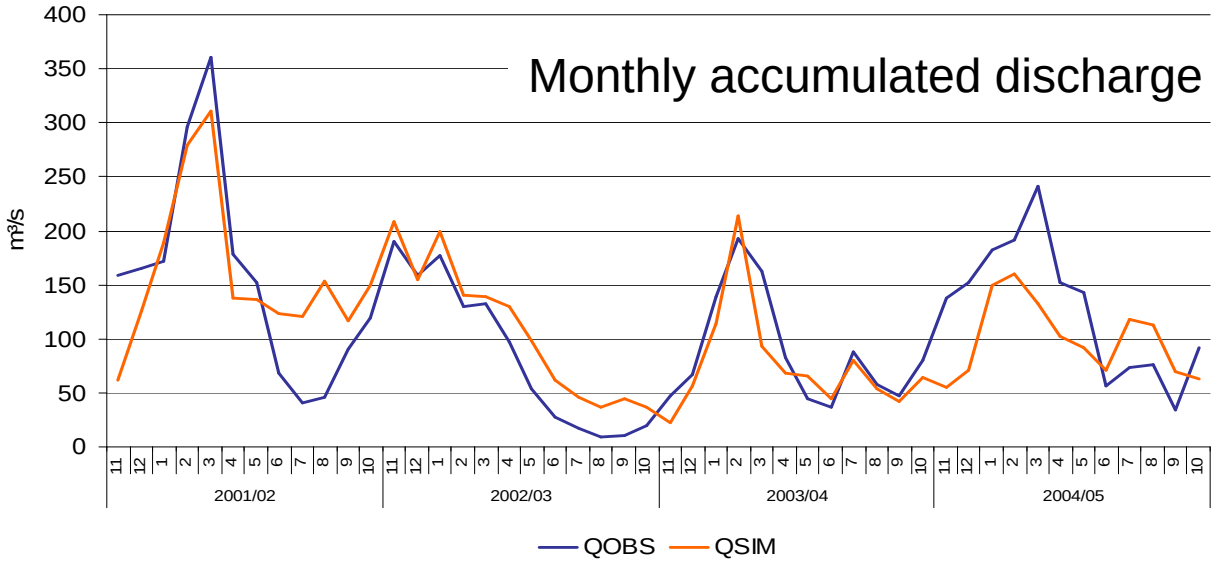


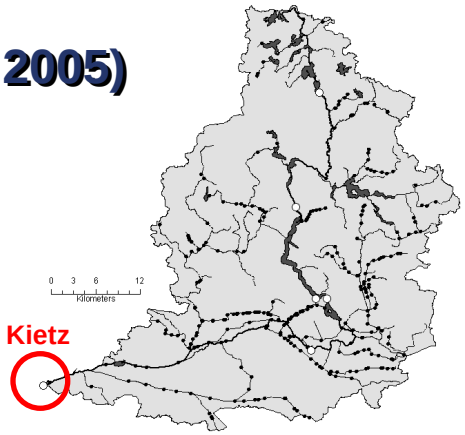
Model outputs

- water discharge at the basin outlet and in several subbasins
- Nutrient concentrations:
  - Nitrogen
  - Phosphorous
- GIS-Outputs of water and nutrient cycle components and of agricultural yields per hydrotope

Calibration: Hydrology (Nov. 2001 – Oct. 2005)







Efficiency:

- daily 0.6
- monthly acc. 0.59

Deviation in balance:

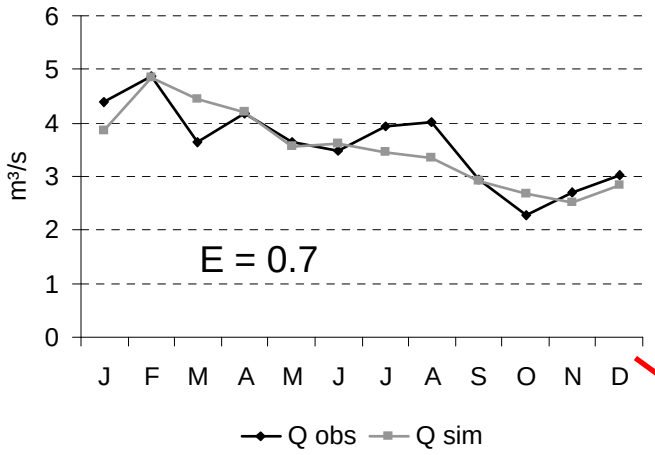
- -2.48%

Results

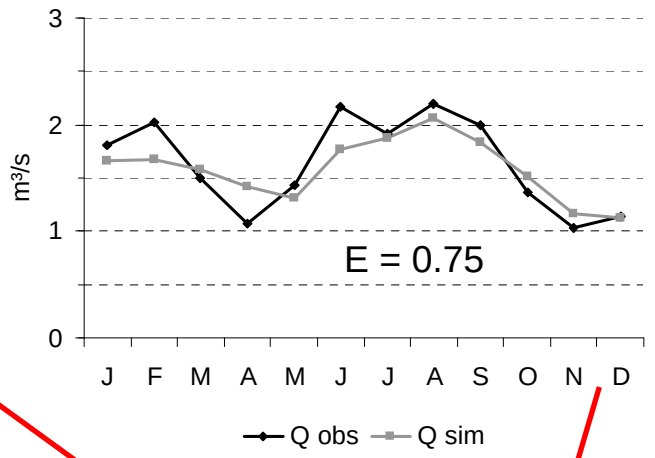
Hydrological calibration along the river

Results

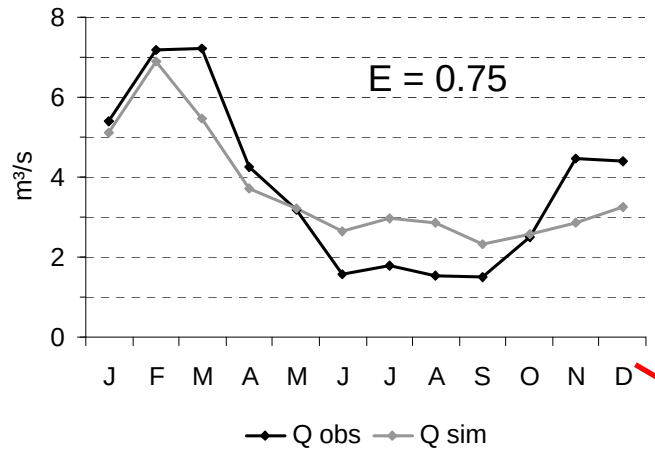
Alt Ruppin (1981 – 1985)

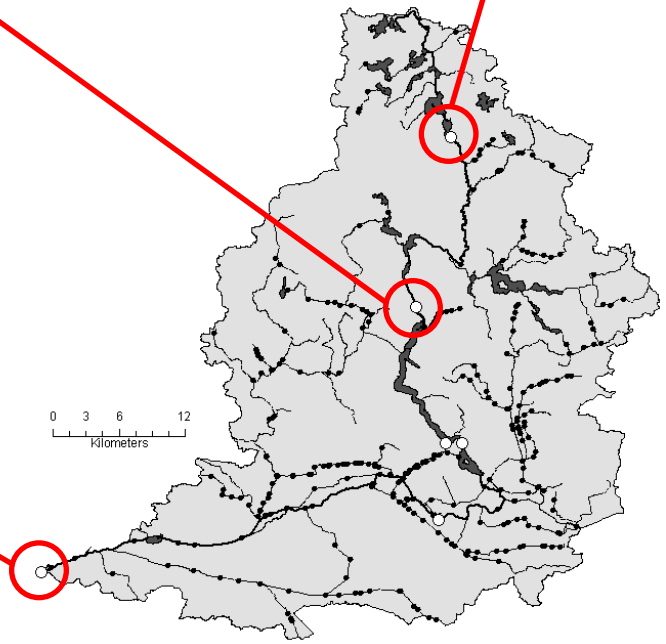


Rheinsberg (1981 – 1985)

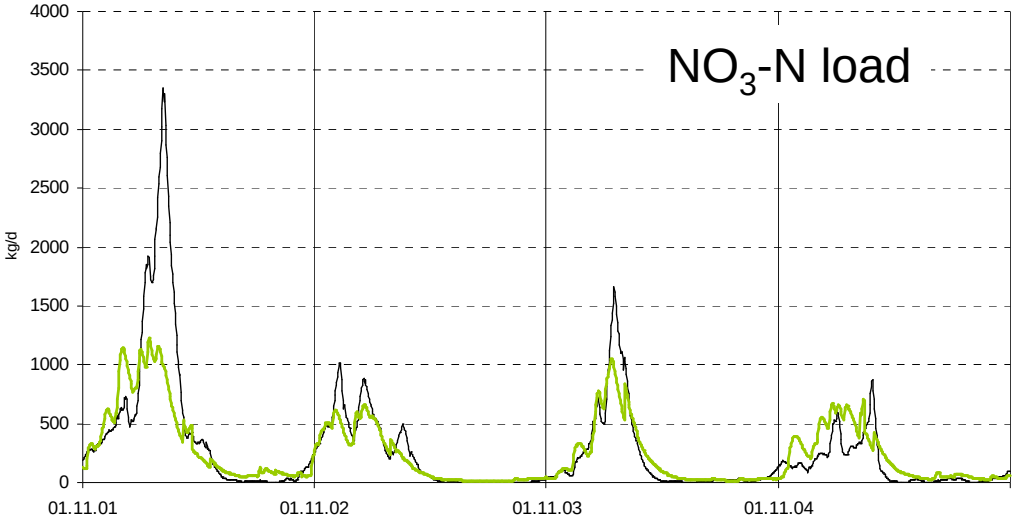


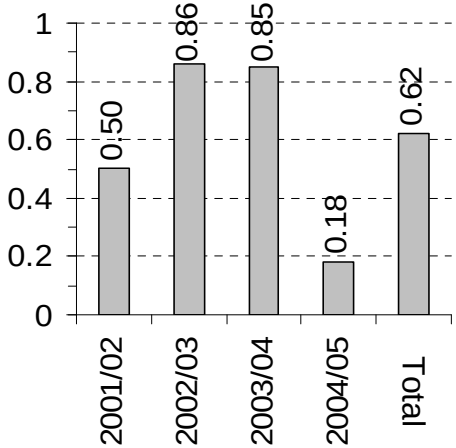
Kietz (2001 – 2005)

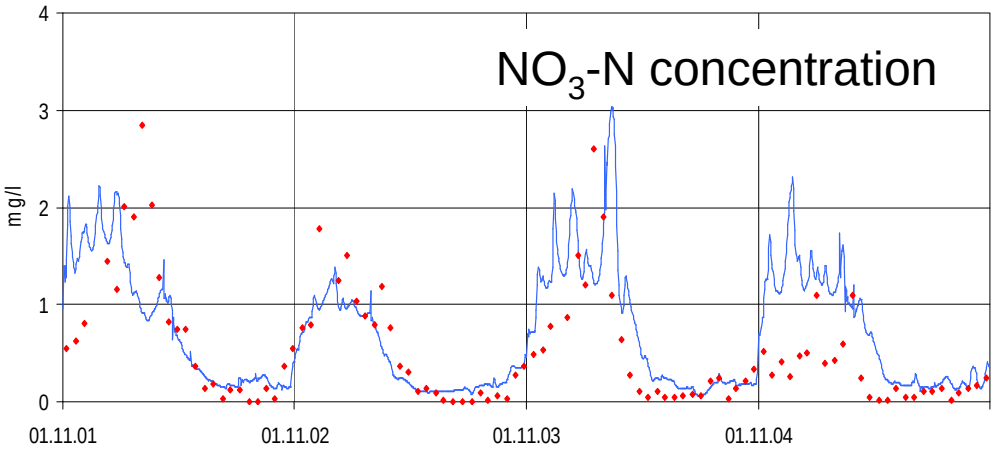


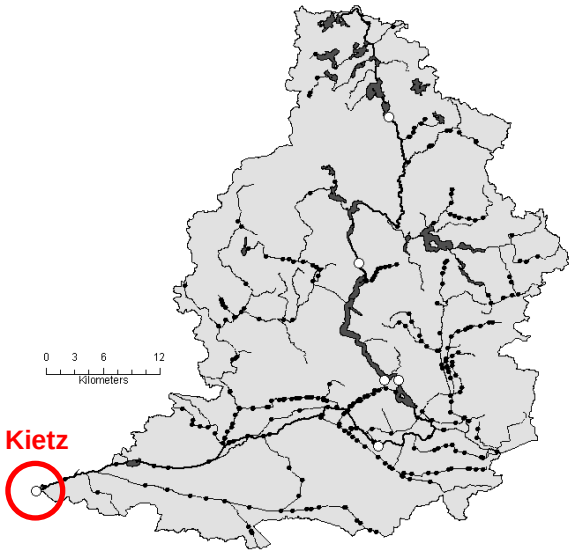


Calibration: Nitrate nitrogen







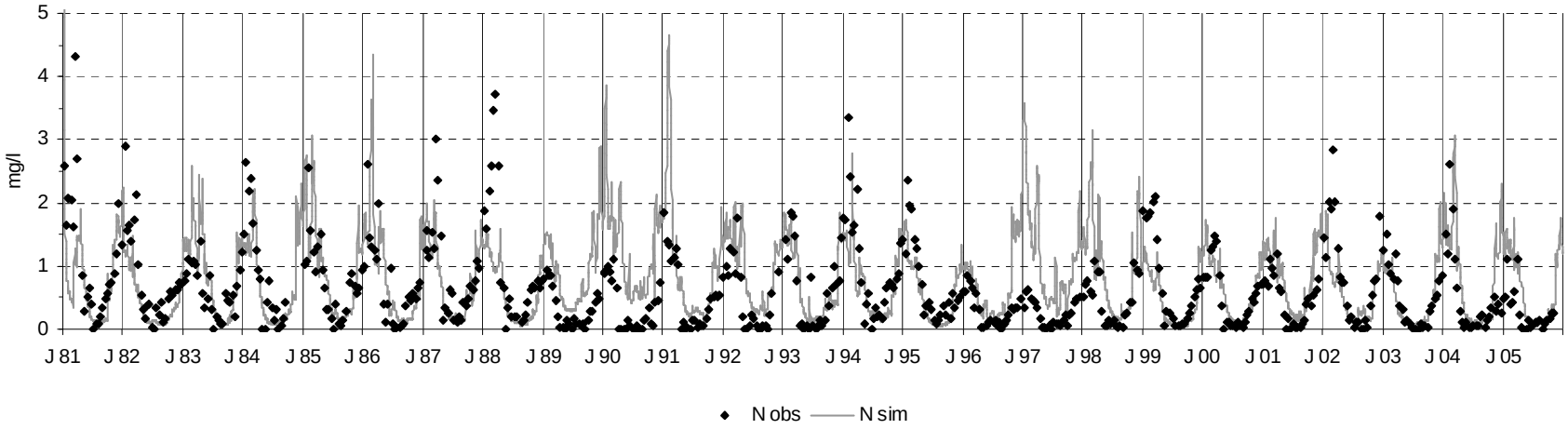


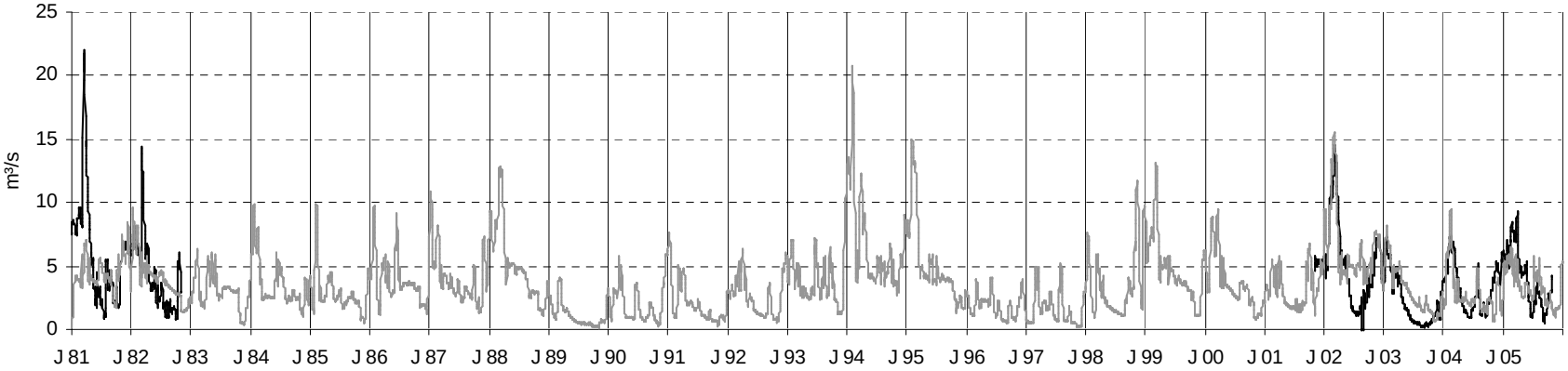
Results

Model validation (Kietz 1981 – 2005)

Results

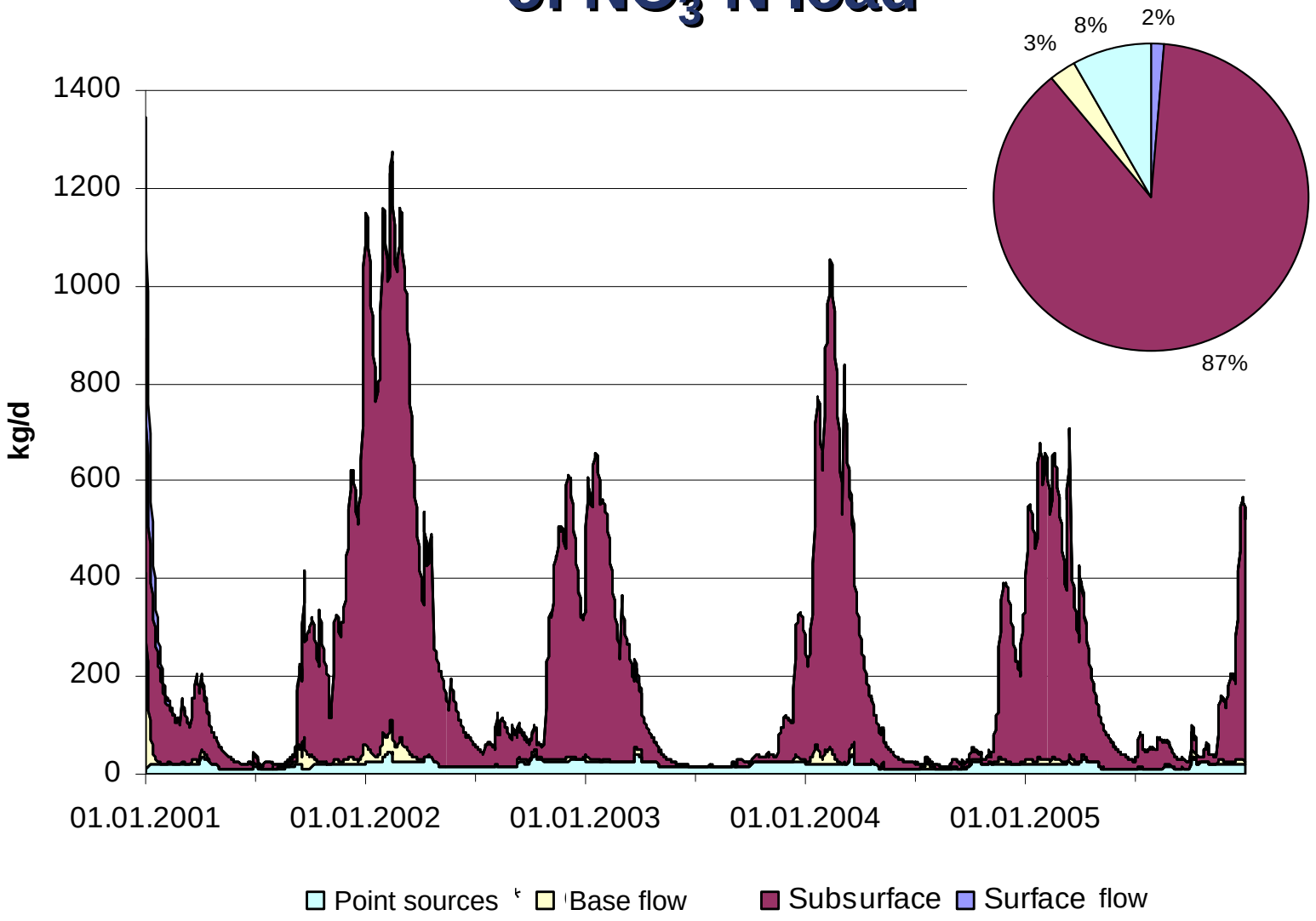
Nitrate nitrogen concentration



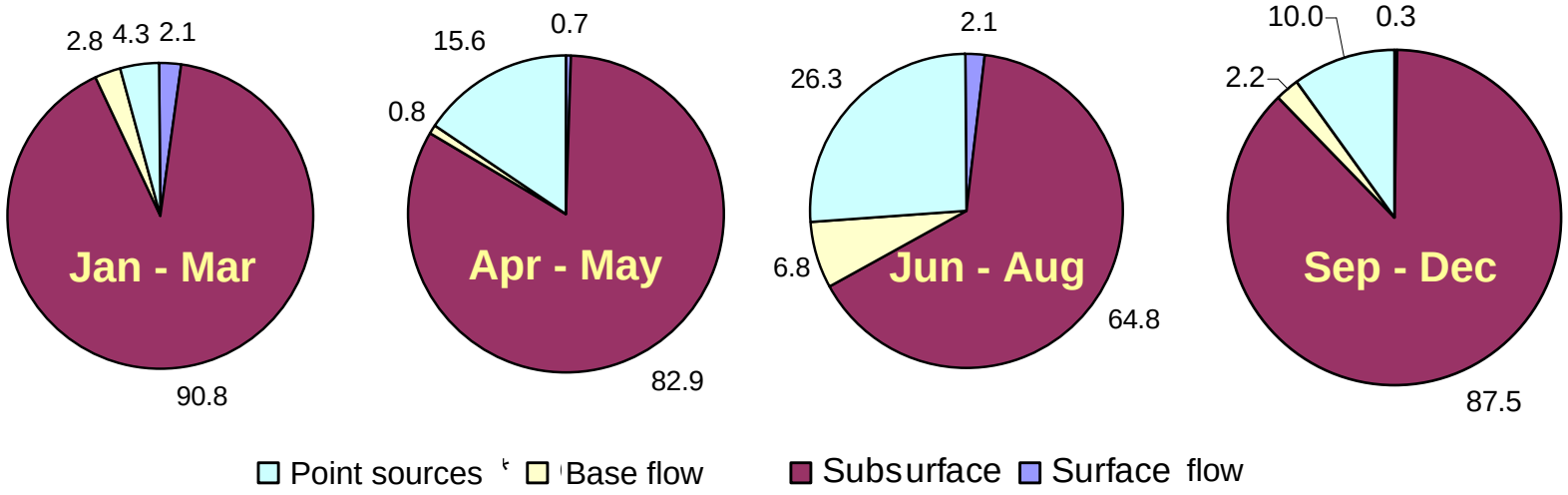


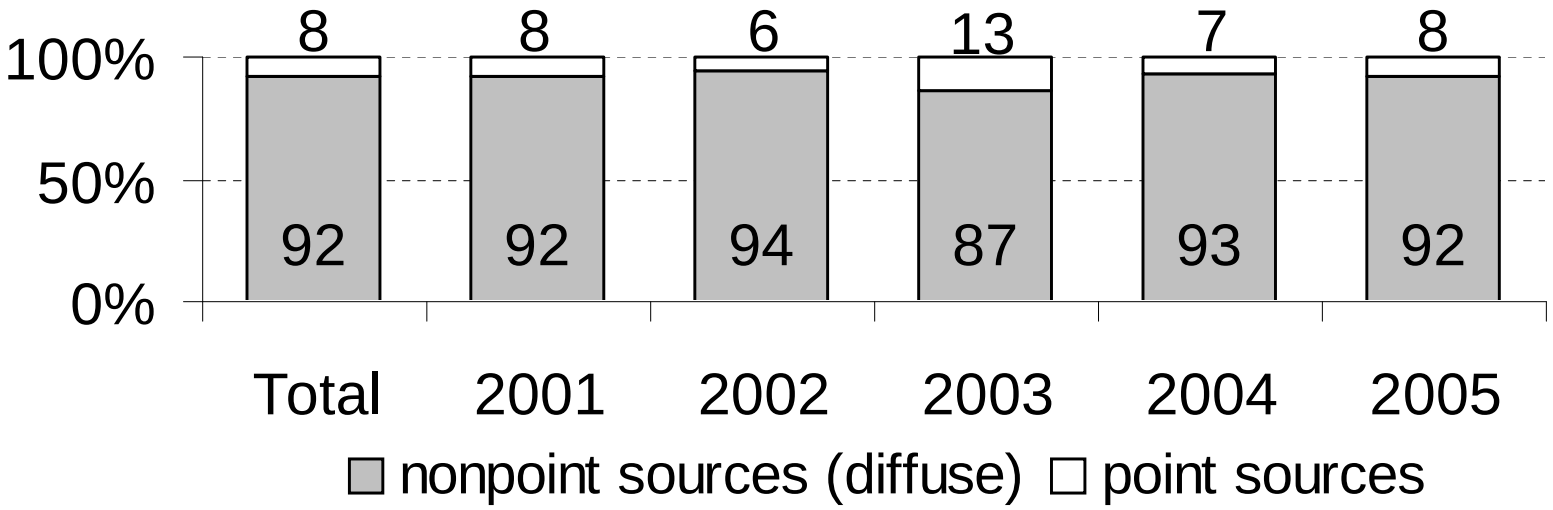
Water discharge

Composition (sources and pathways) of NO_3-N load



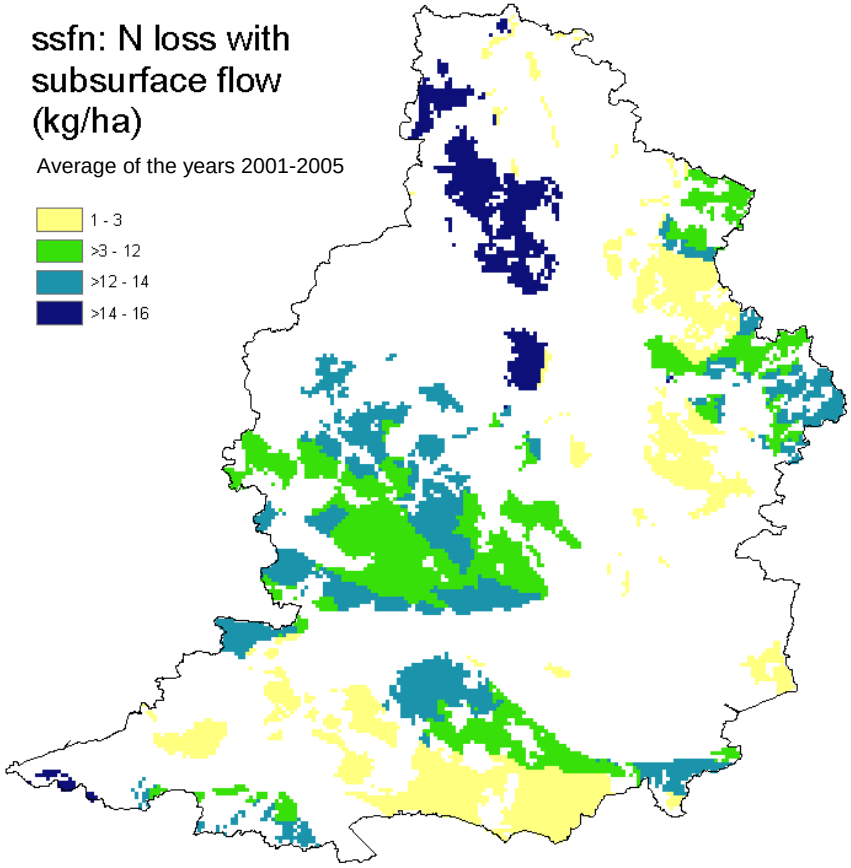
Seasonal and interannual variation in NO3-N composition

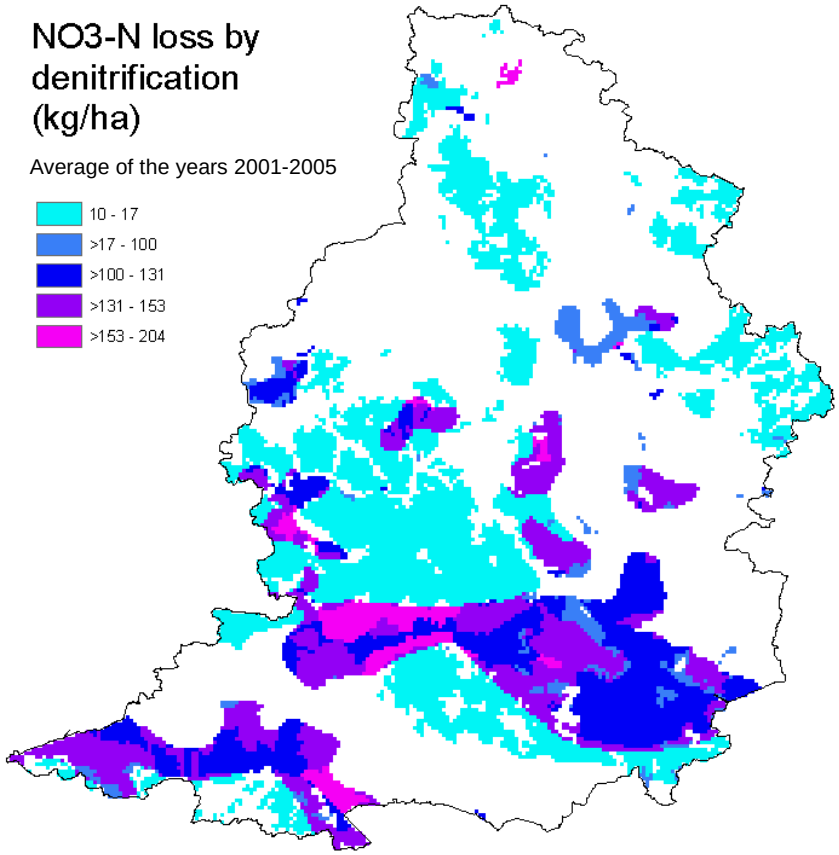




Results

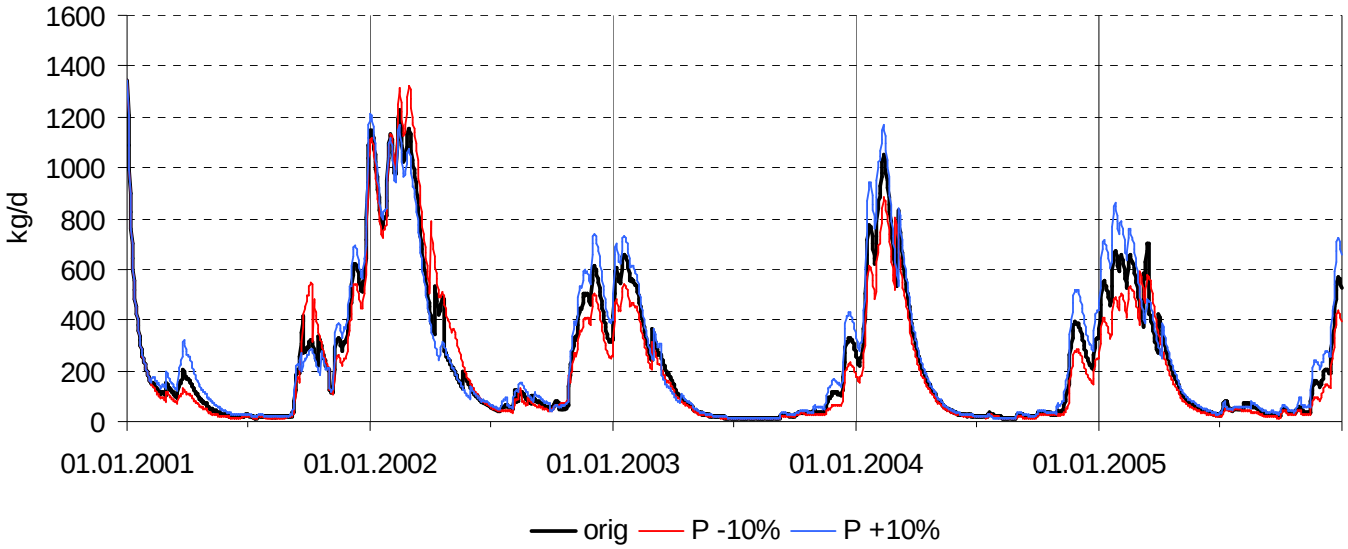
Areas of diffuse N pollution and denitrification



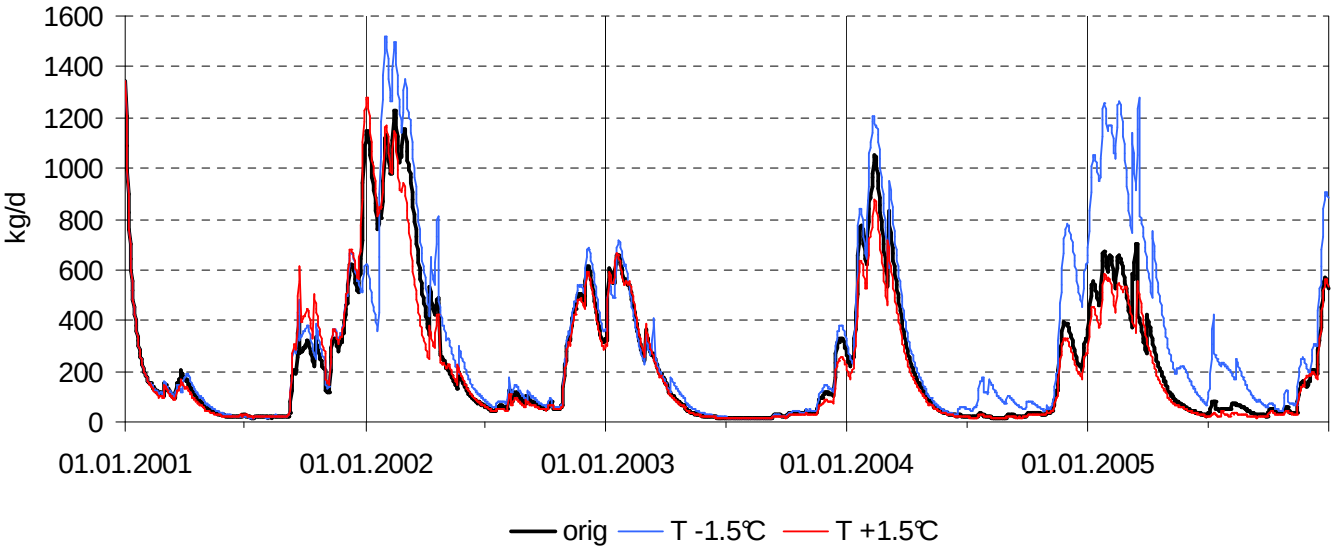


→ corresponds with land use and soil types

Climate sensitivity (N load)



precipitation



temperature

Results

Conclusions and outlook

- Simulation is much more difficult for regulated lowland rivers than for rivers in mountainous areas due their special characteristics and lack of management data
- Modelling helps to understand the river system behaviour and to identify fractions of point and diffuse pollution and areas of the highest diffuse pollution
- Scenarios (possible land use and climate changes) can help to find useful measures for reducing nutrient loads and for implementation of the WFD
- close cooperation of researchers and representatives of the decision-making government is helpful for both sides