

Integrated modelling of climate change effects - **Nitrogen from mountains to fjord**

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Objective of study

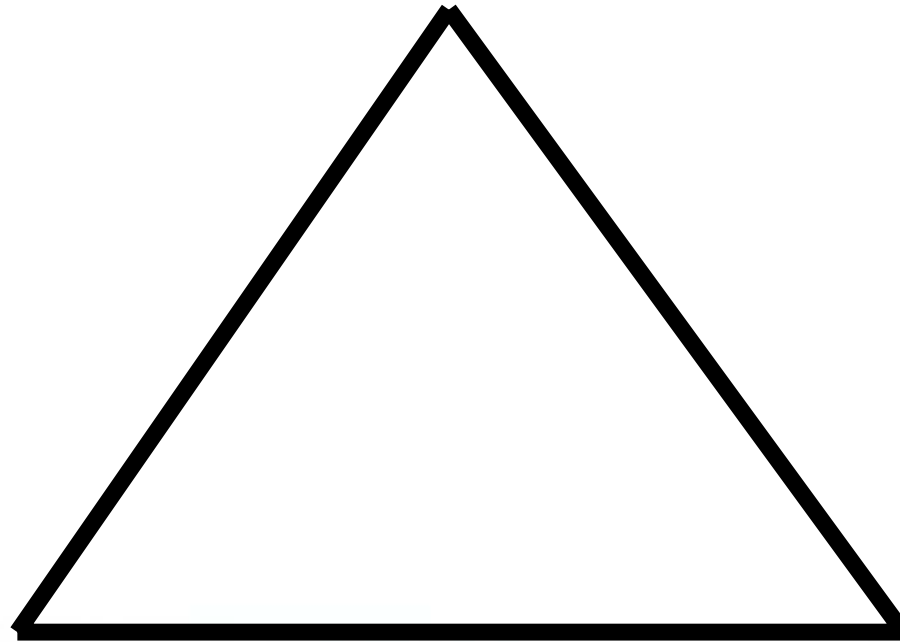


- Simulate possible impacts of future climate change on **hydrology** and **N export** in a river and its estuary
- ... by means of four linked effect models

(Kaste et al. 2006; Sci. Tot. Environ.)

Basis for the modelling

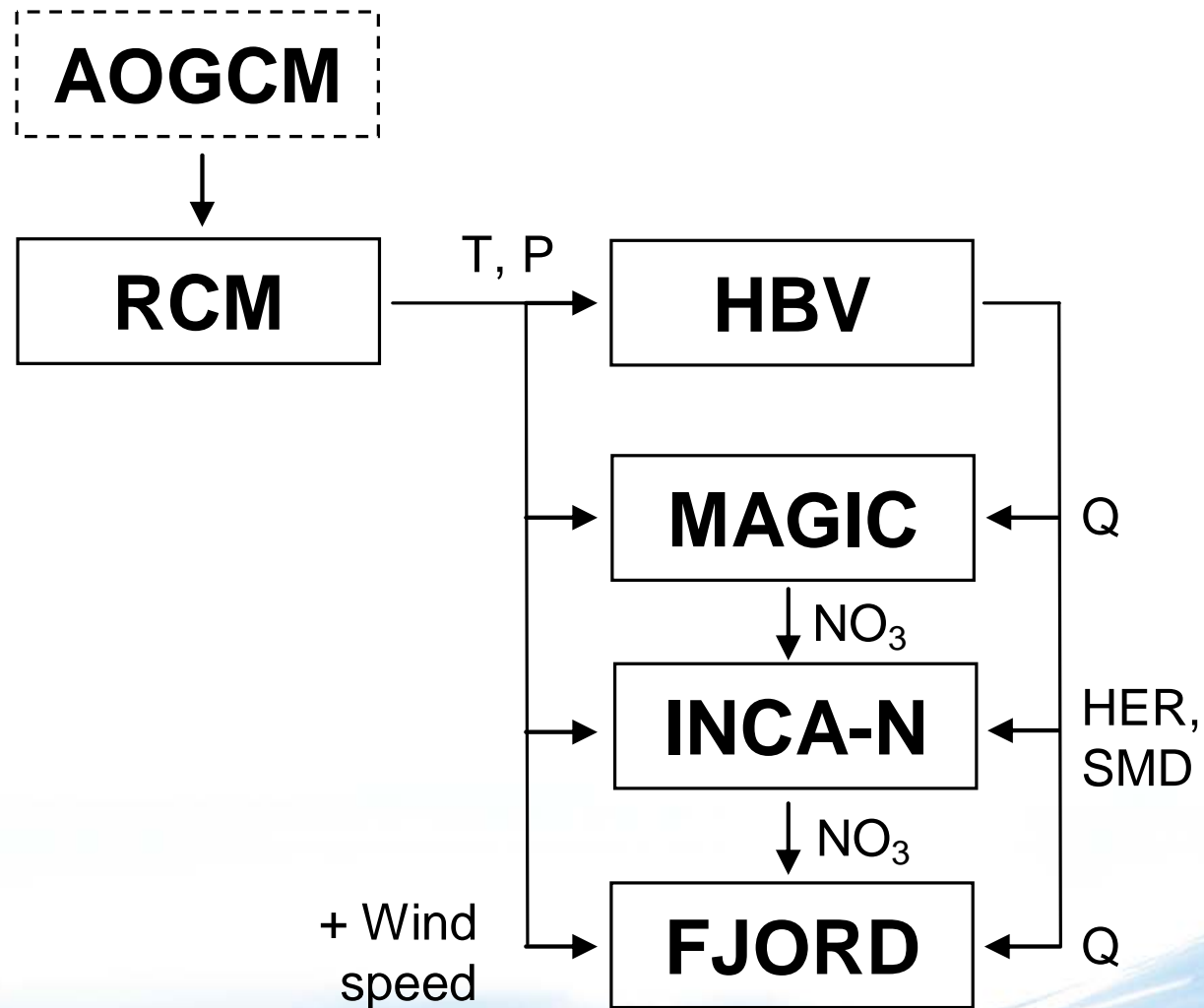
Model



**Long-term
data**

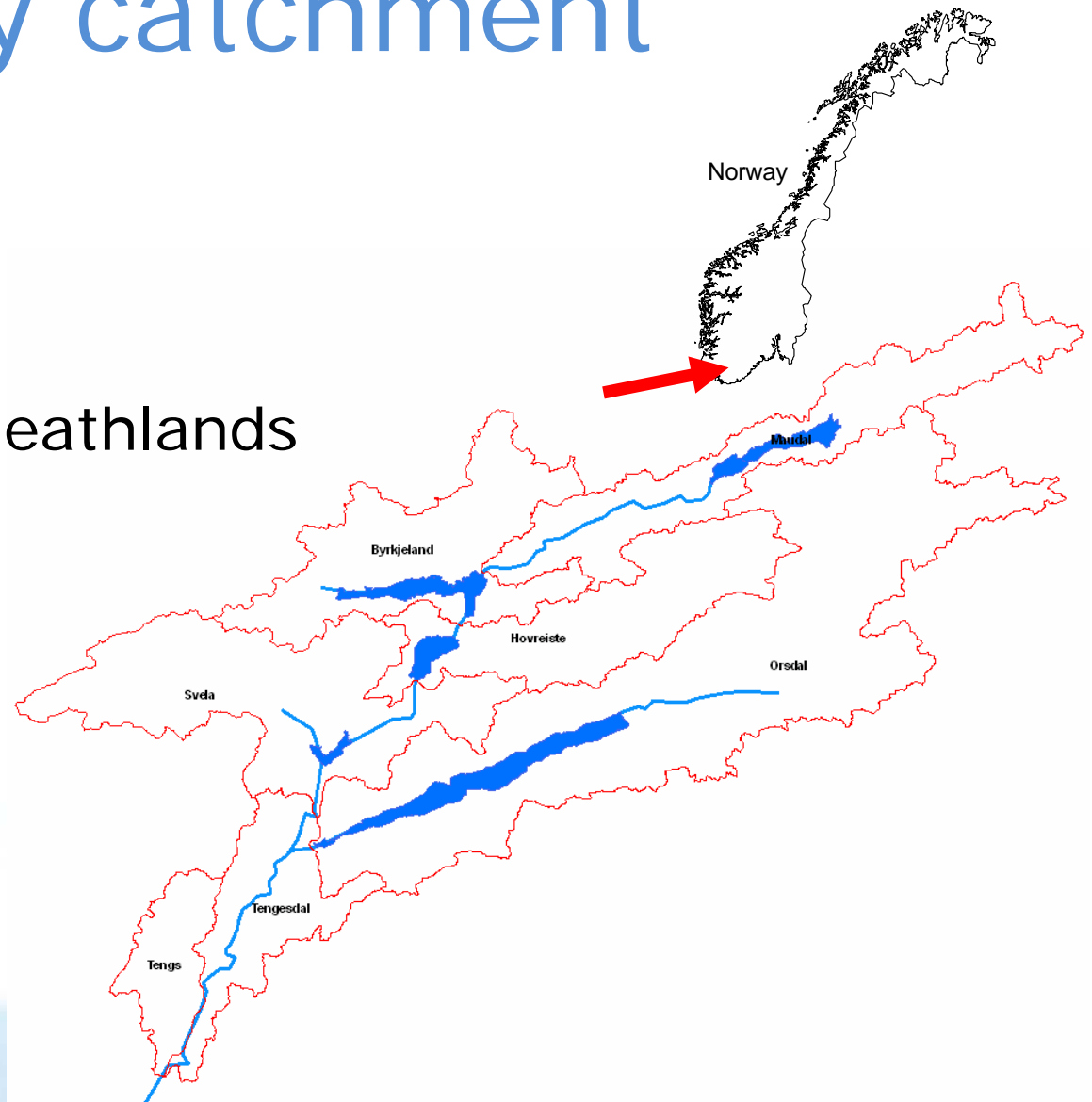
Experiments

The model chain



Study catchment

- Bjerkreim River
- 685 km²
- 0-1000 m.a.s.l.
- 65% mountains/heathlands
- Main pressures:
 - Acid deposition
 - Agricultural runoff



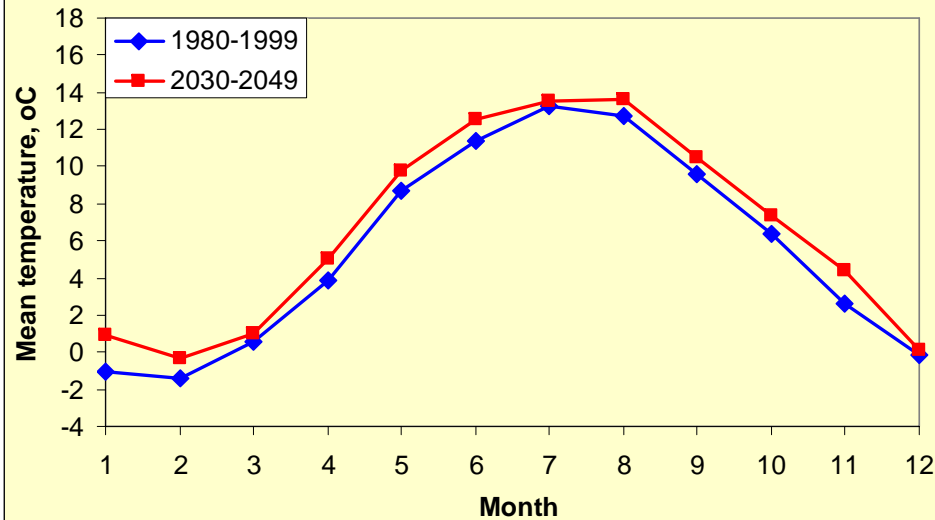
Climate scenarios used

- **IS92a emission scenario**
 - ECHAM4 (Max Planck Institute)
 - Scenario period: 2030-2049
- **A2 emission scenario**
 - HadAM3 (Hadley Centre)
 - Scenario period: 2071-2100

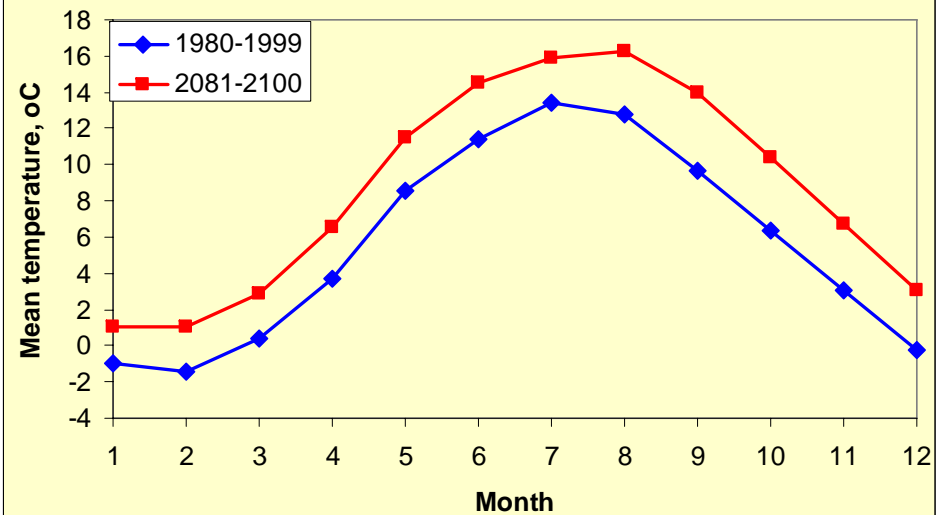


After downscaling

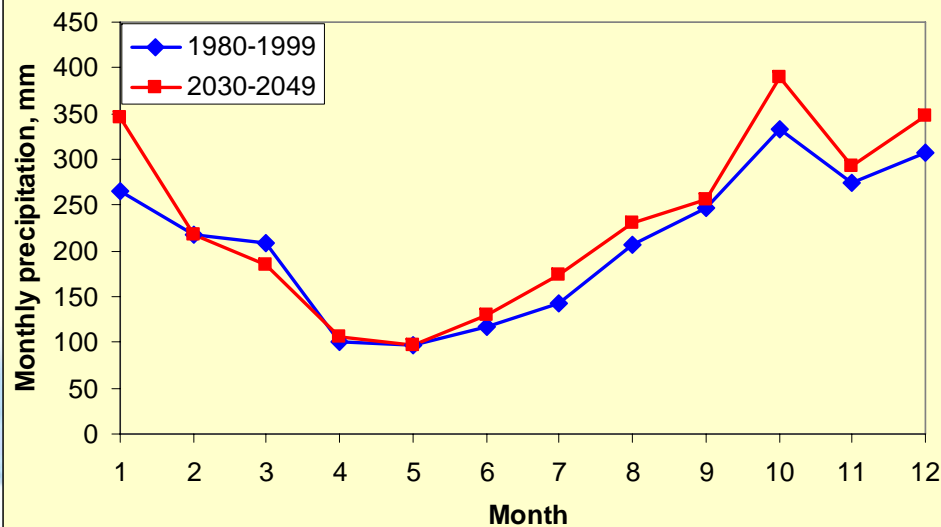
Temperature scenario 2030-2049 vs. 1980-1999 (MPI)



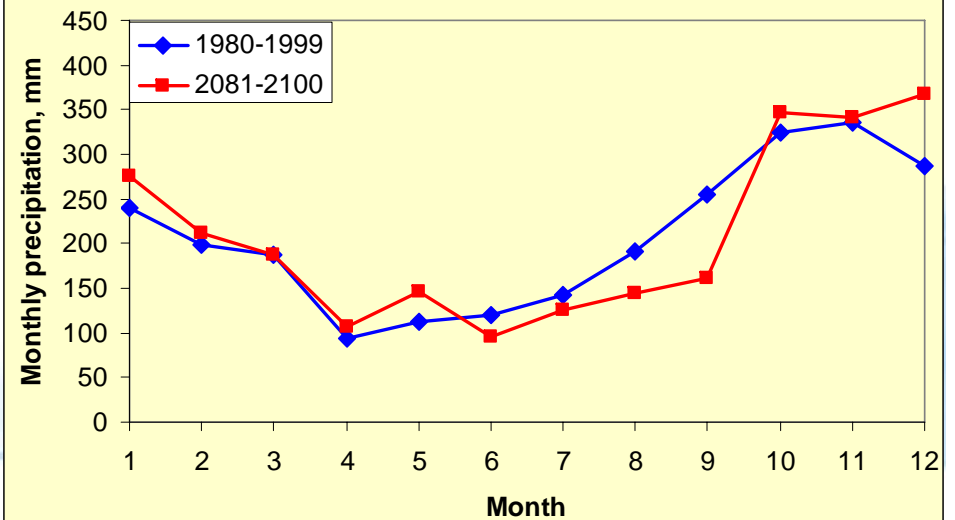
Temperature scenario 2081-2100 vs. 1980-1999 (Hadley)



Precipitation scenario 2030-2049 vs. 1980-1999 (MPI)



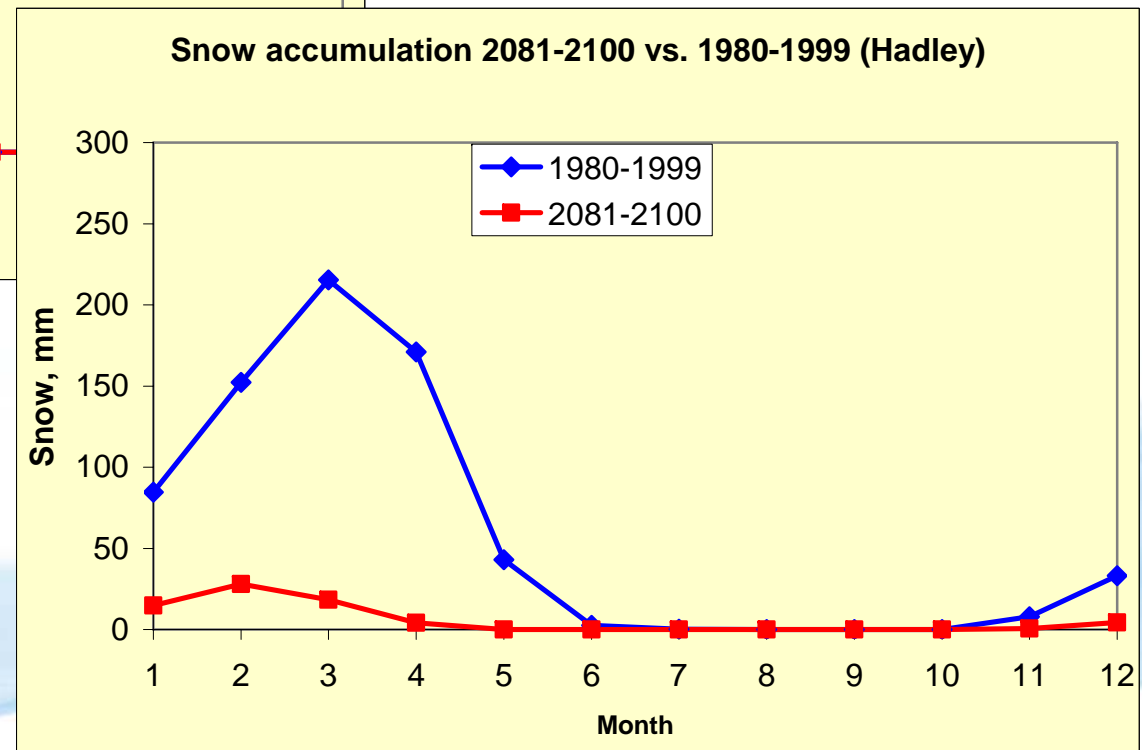
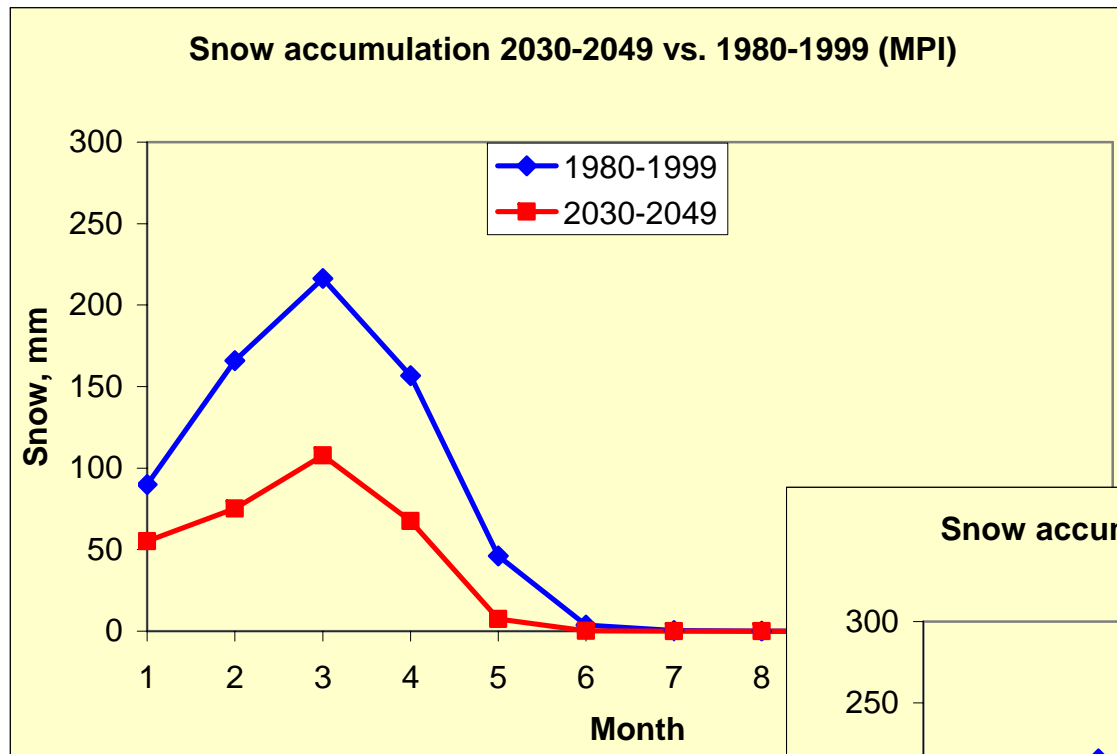
Precipitation scenario 2081-2100 vs. 1980-1999 (Hadley)



The HBV model

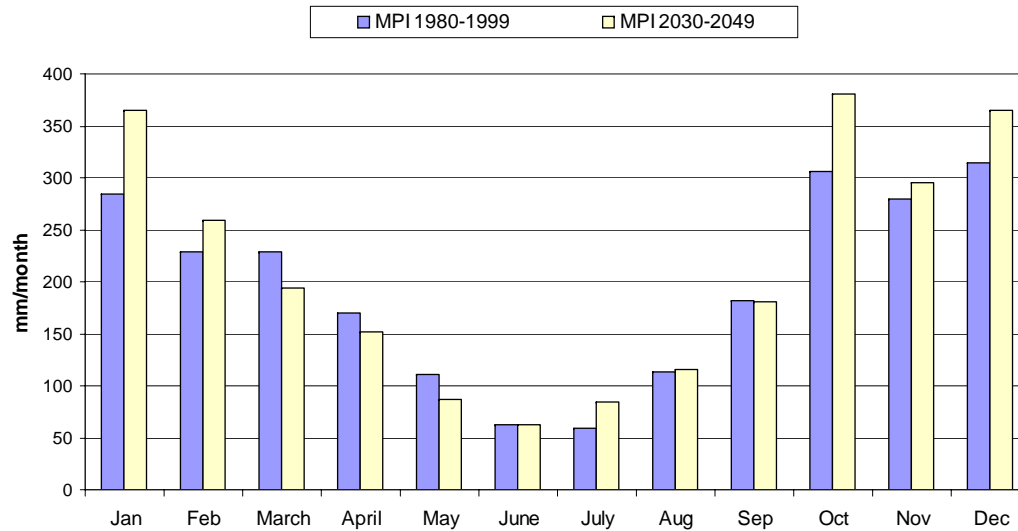
- Semi-distributed (sub-catchment level)
- Simulates hydrological inputs to the other models (water flow, snow depth, soil moisture)
- Daily time-step

Snow accumulation (upper sub-basin)

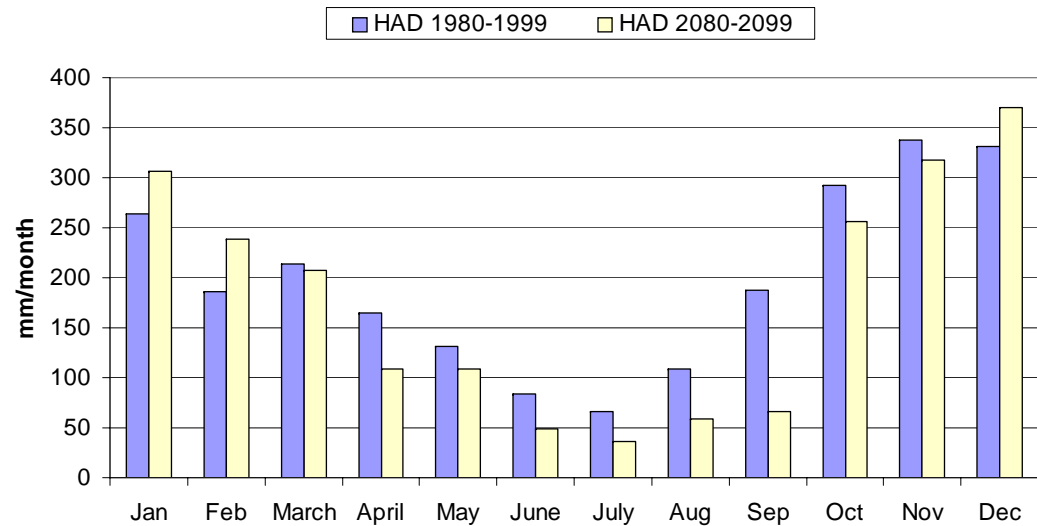


Flow at outlet

Bjerkreim River Basin, monthly runoff (MPI)



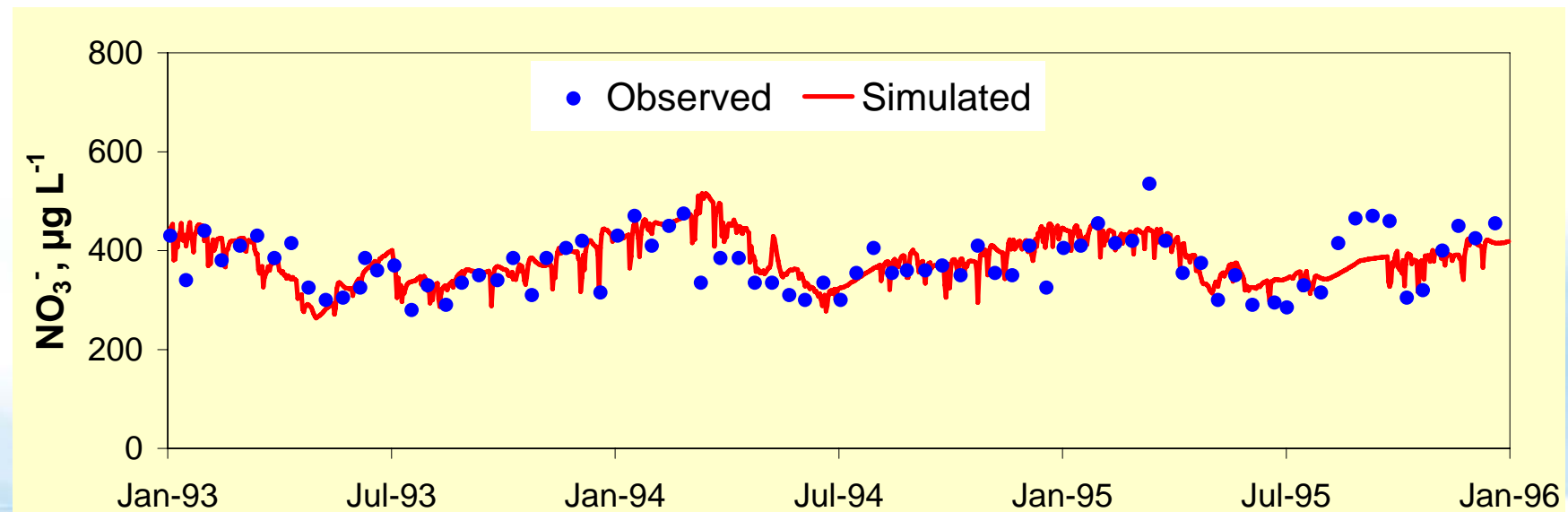
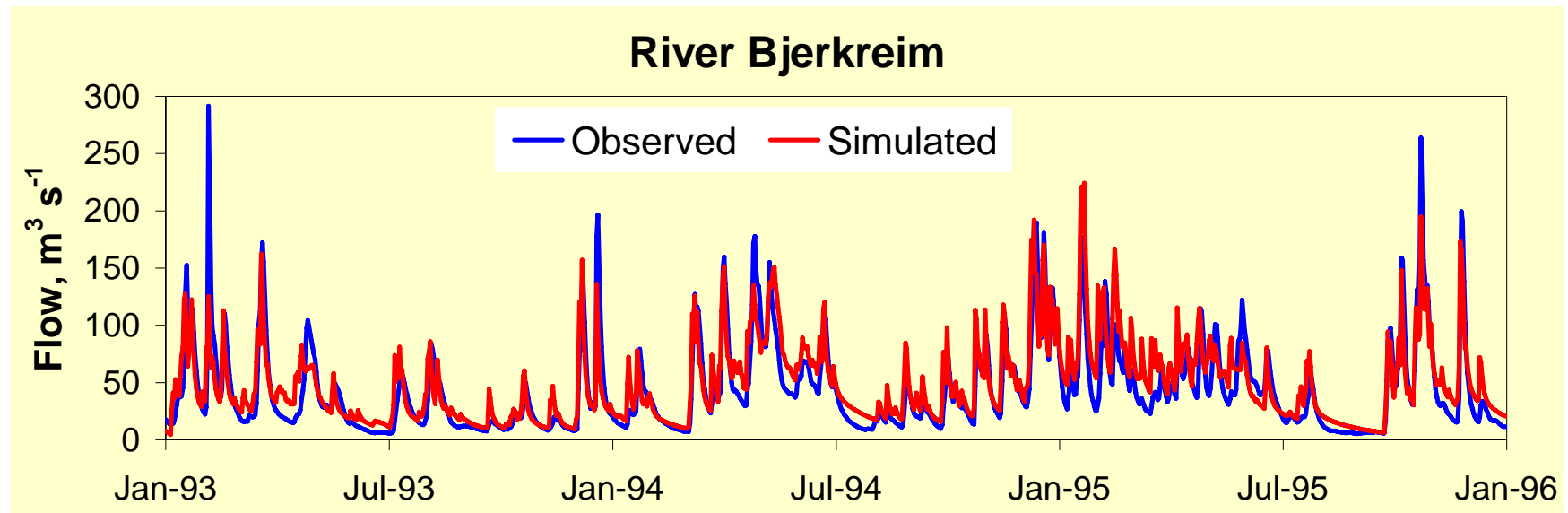
Bjerkreim River Basin, monthly runoff (Hadley)



The INCA-N model

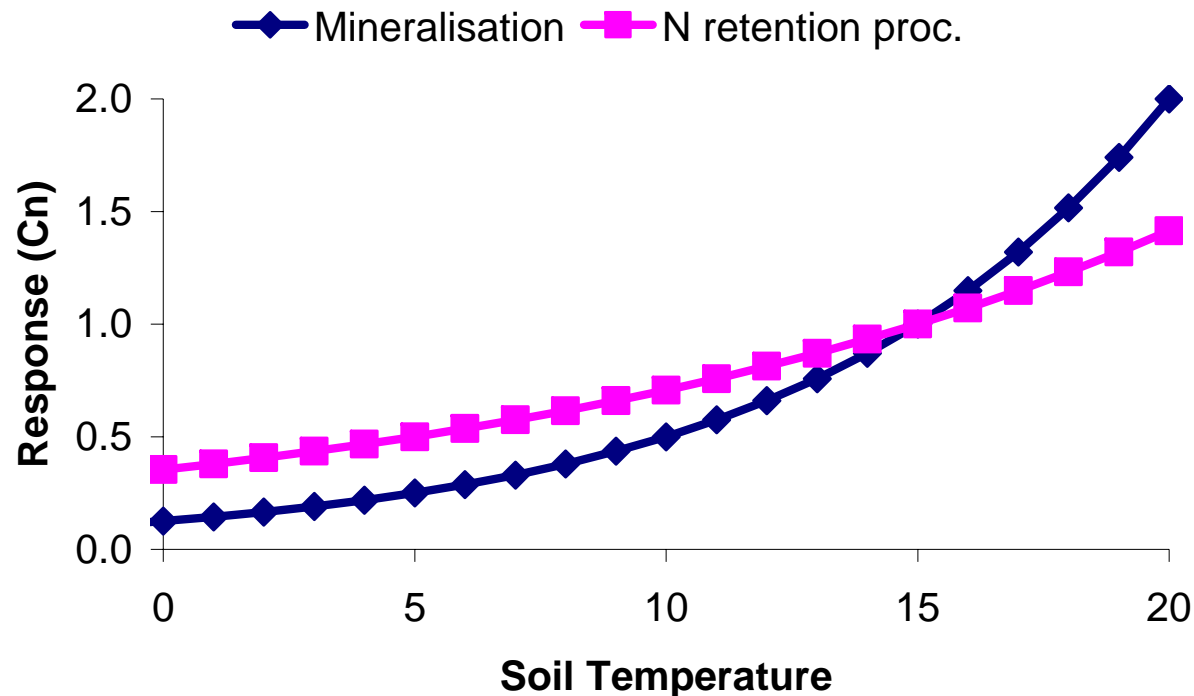
- Coupled catchment-river model
- Same spatial distribution as HBV
- Integrates hydrology and nitrogen processes – simulates concentrations of NO_3 and NH_4
- Daily time step

Calibration 1993-95



Major uncertainty (1): Effects of changed climate on N processes

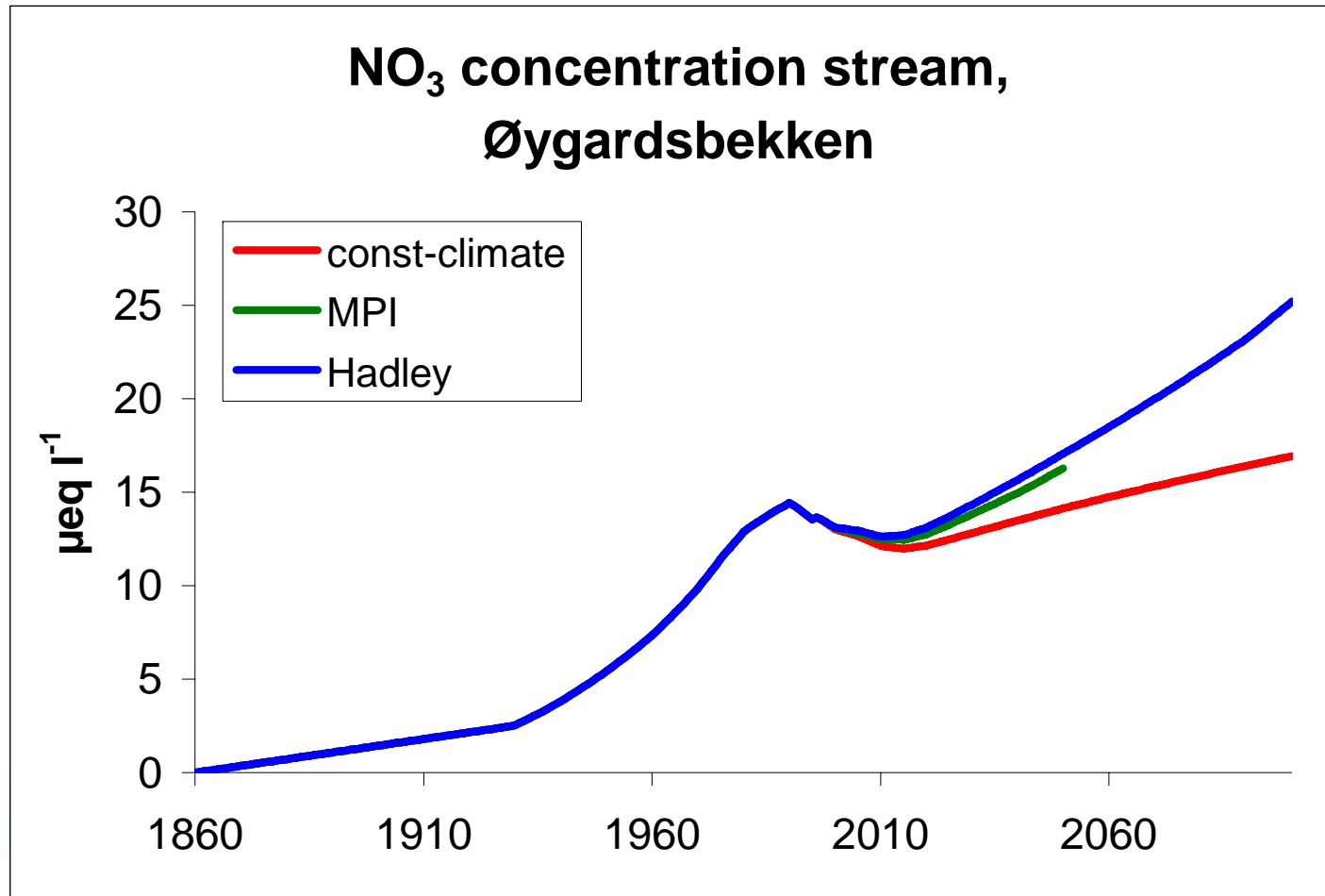
- All N processes are positively correlated with T
- ..., but N mineralisation seems to be slightly more temp-sensitive than most N consuming processes
(from CLIMEX; Van Breemen et al. 1998)



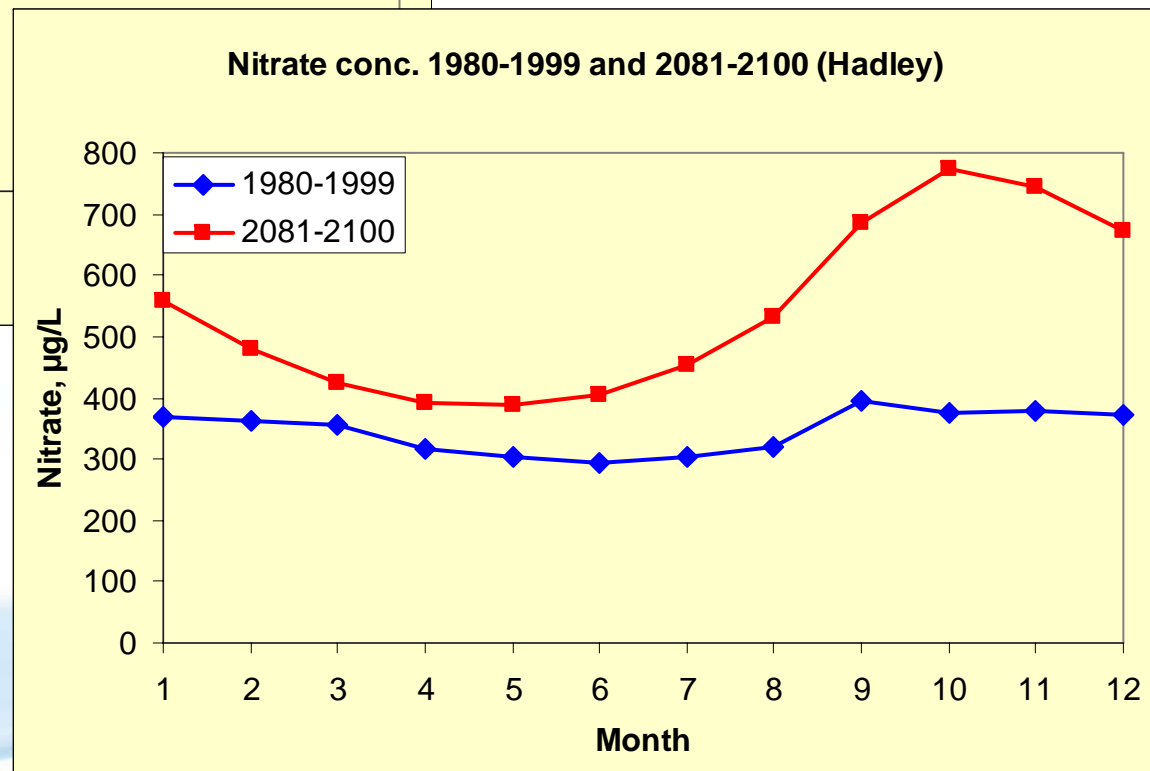
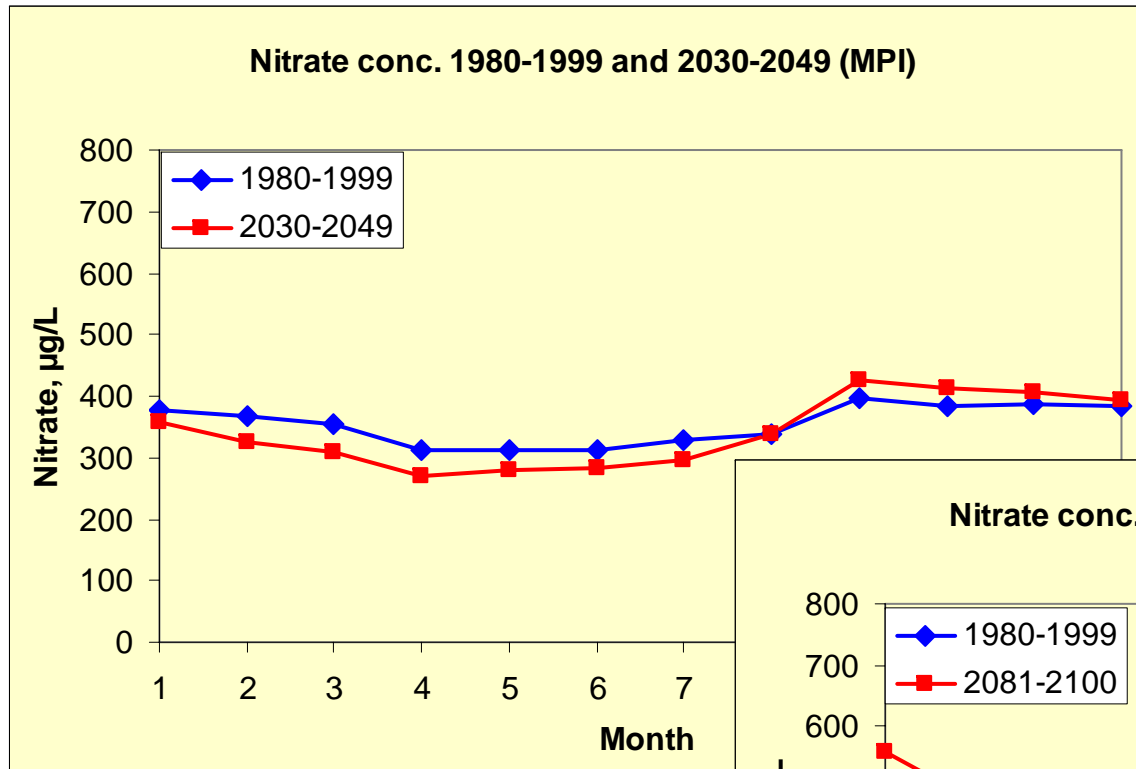
Major uncertainty (2): What happens if the N retention capacity declines over time?

- The soils are constantly enriched with N
- Empirical data show negative relationship between C:N ratio in soils and N leaching (Gundersen *et al.* 1998)
- **Here:** Used the MAGIC model to forecast future C:N ratio and future N immobilisation capacity based on this relationship

MAGIC - results



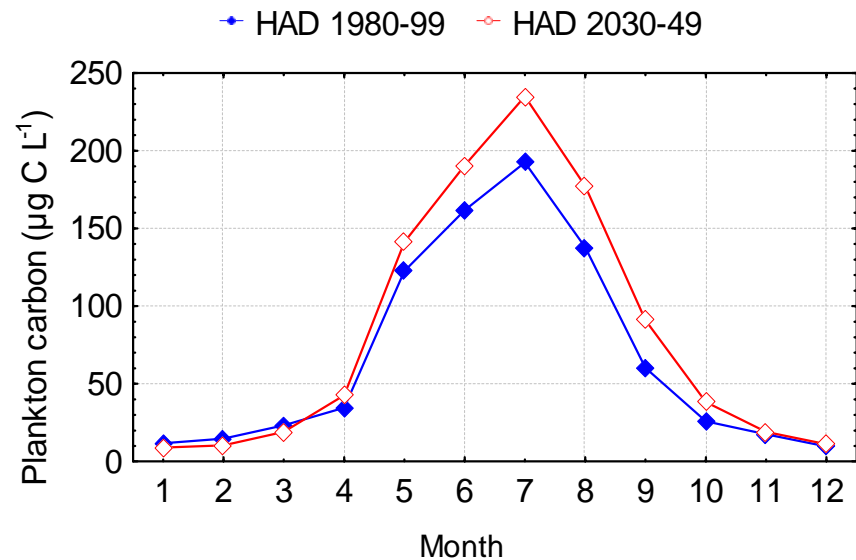
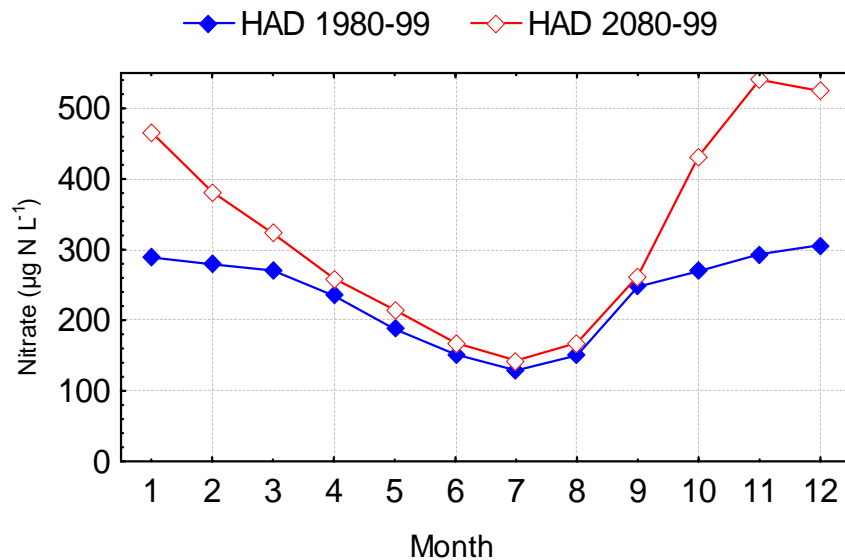
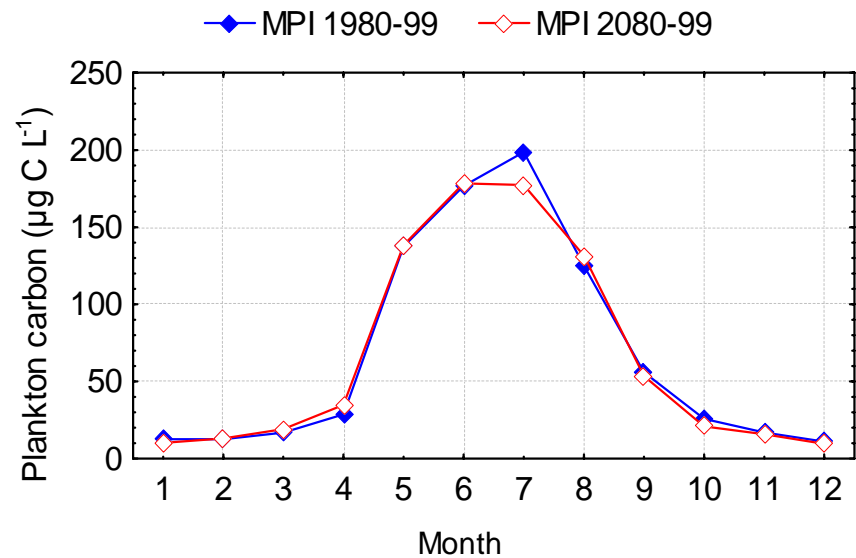
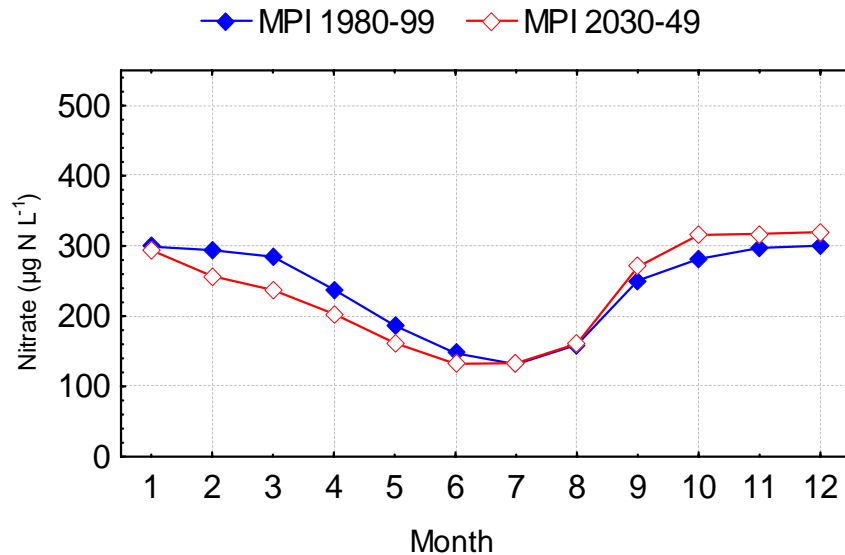
INCA-N scenario results: Nitrate



NIVA Fjord model

- Simulates eutrophication response based on inputs of nutrients and organic matter
- Physically based (mixing of coastal and river water)
- Simulates salinity gradients, nutrient concentrations, and algal biomass in the fjord
- Daily time step

Fjord Model results



Conclusions

- Possible effects on Hydrology:
 - Increased in winter flow,
 - Reduced snowmelt flood
 - Reduced summer flow (Had A2)
- Possible effects on Nitrate:
 - 40-50% increase in riverine export (Had A2)
 - Fjord response: 15-20 % increase in algal biomass
- Climate effects may magnify through the 'effect chain'.
 - Mineralisation increase with T
 - N leaching increases with decreasing C:N ratio in soils
 - Reduced summer flow - reduced dilution capacity

Uncertainties / further work

- Large scatter in climate scenarios
 - Give large uncertainty in effect assessments
 - Should use of multiple climate scenarios to represent uncertainty range
- Major knowledge gaps related to nitrogen:
 - Climate response of various N processes
 - Future N retention capacity
- Next steps
 - Prolong the 'effect chain' with models representing biology and social science