# Major uncertainties in scenarios of Baltic Sea eutrophication – response to changes in the drainage basin

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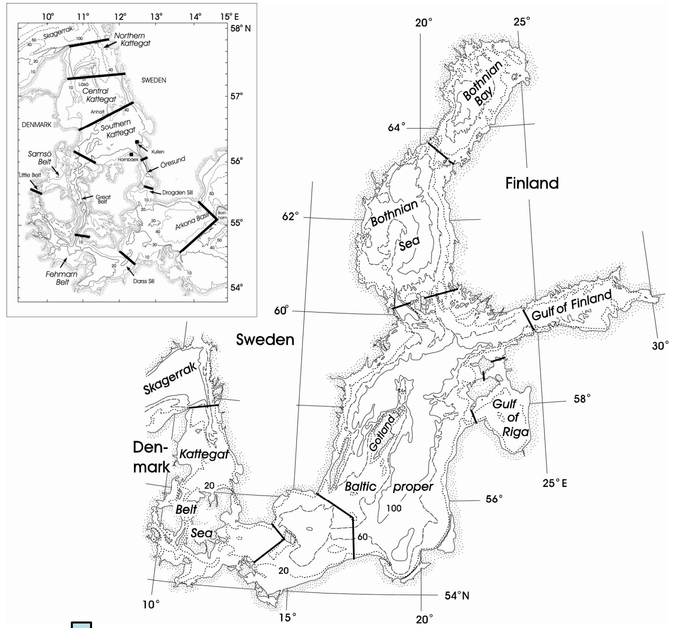
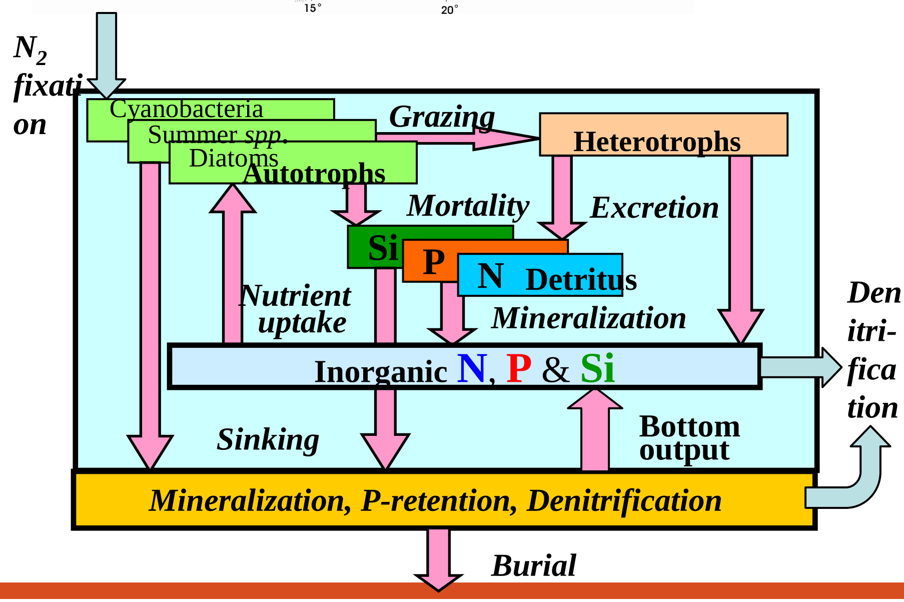
# BAltic sea Long-Term large-Scale Eutrophication Model

Main characteristics:

- 13 sub-basins
- High vertical resolution
- Full air-sea exchange including sea ice
- Water exchange from well-founded steady state dynamics
- Wind and buoyancy forced mixed-layer dynamics and wind-forced deep-water mixing
- Dense gravity current mixing sub-models
- Typical simulation times on 8 core MacPro:
  - with only physics 1.6 sec/year
  - with BGC ~14 sec/year

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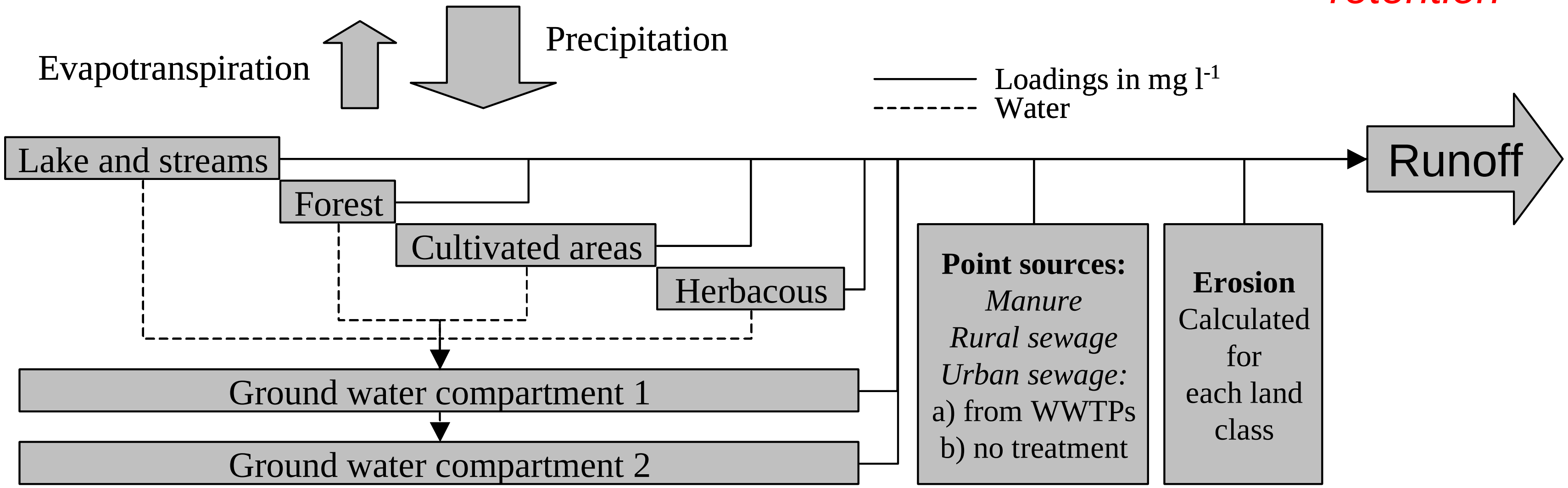
# CSIM
## (Catchment Simulation)

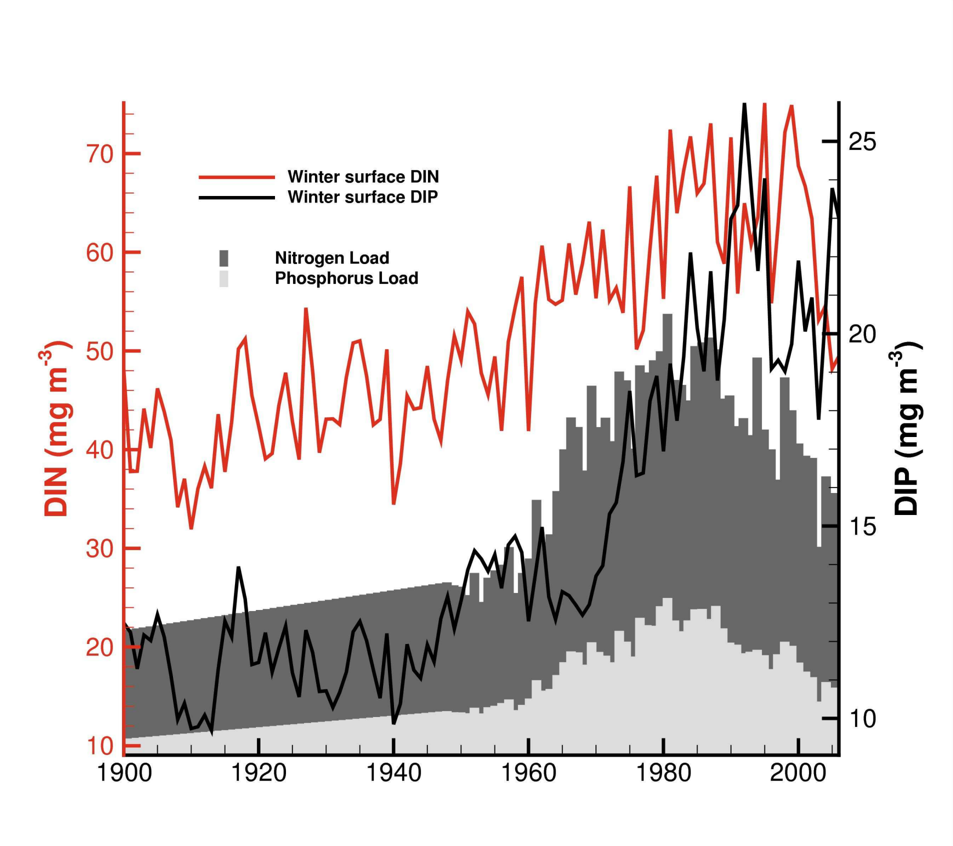
*Future: dynamic Riverine retention*




*Now: fixed type concentrations*
*Future: Type concentrations =f(land use)*

Mörth et al. 2007

# Long-term hindcast




- Shows non-linear and delayed response to load increase
- Qualitative correct development
- Accurate for validation period (1970-2006)

Shortcomings:

- Still not “real” weather before 1961
- Probably too high DIP concentrations before 1970 or so – correction of loads?

# Scenarios

**Climate scenarios 1961-2099**

RCAO – ECHAM5 A1B
RCAO – HadCM3 A1B

Sealevel forcing and runoff from statistical downscaling (by SMHI)

"Real" nutrient loads 1961-2006, thereafter according to load scenarios (not coupled to runoff)

Initial condition from hindcast

**Load scenarios**

Implemented 2007, constant thereafter

Reference – average loads 1997-2003

BSAP – reduction with 135 kT N and 15 kT P

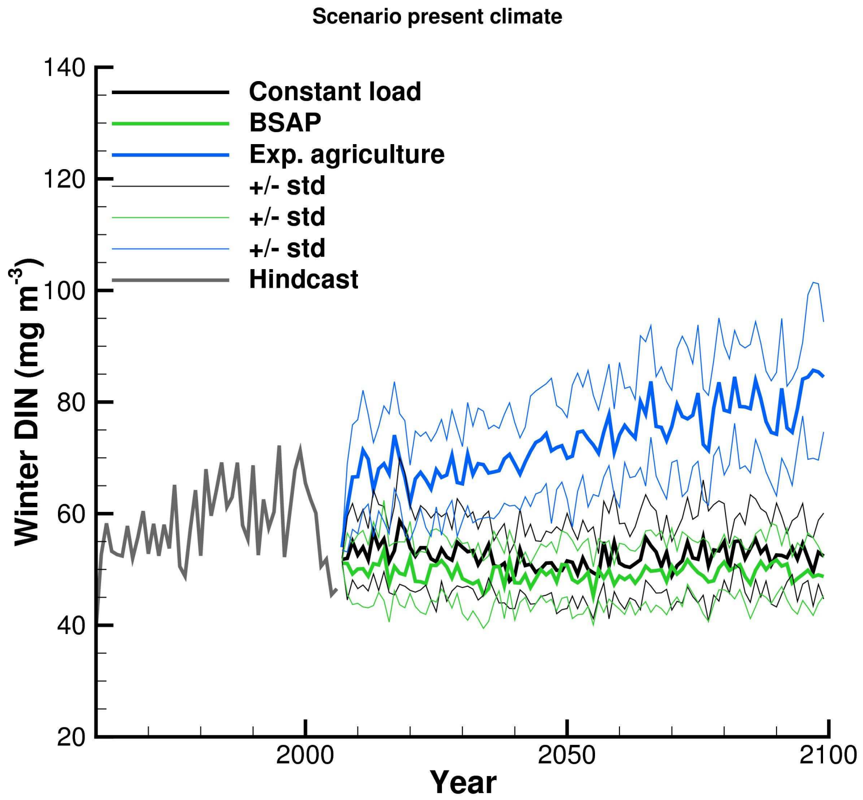
Intensive agricultural development around the Baltic (Humborg et al, 2009) – increase with 341 kT N and 16 kT P

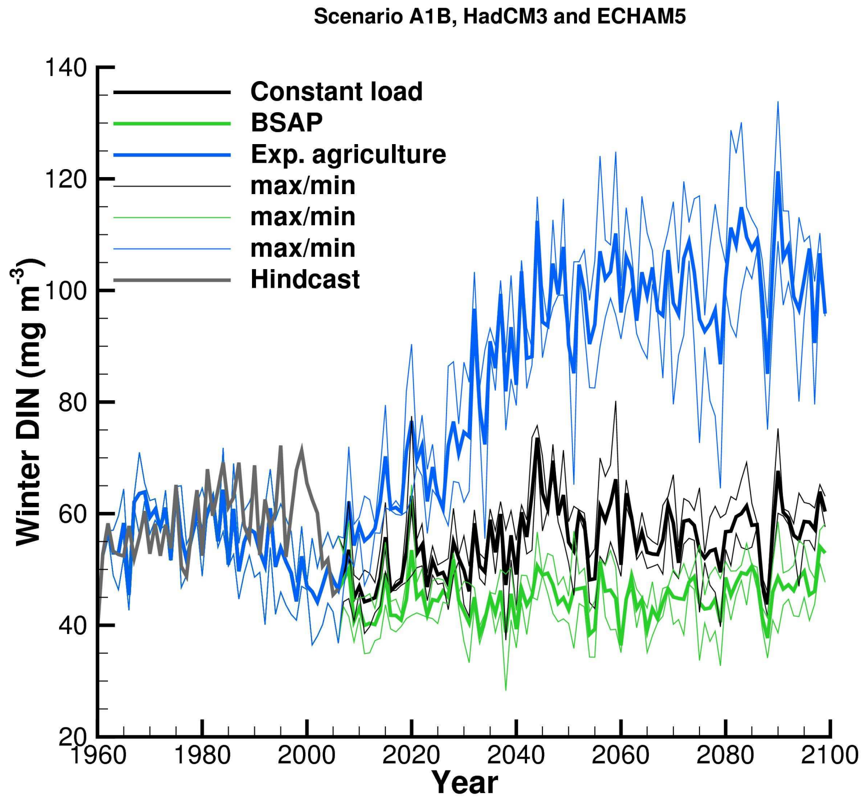
**Present climate met. forcing**

Statistically generated, only small variations in river runoff

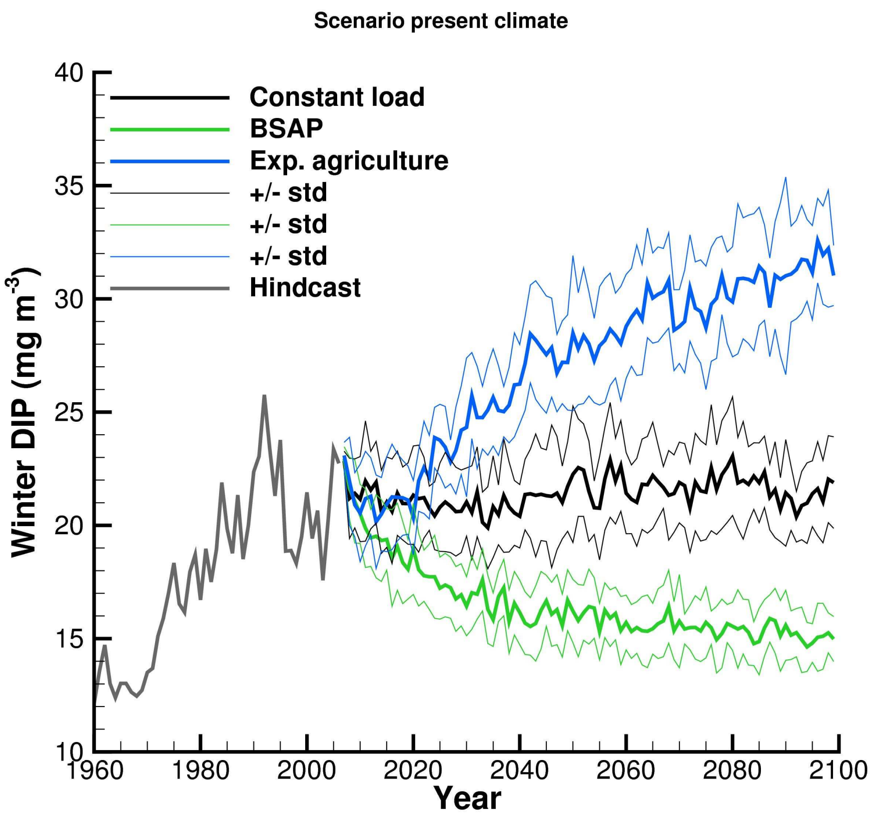
12 simulations 2007-- 2099

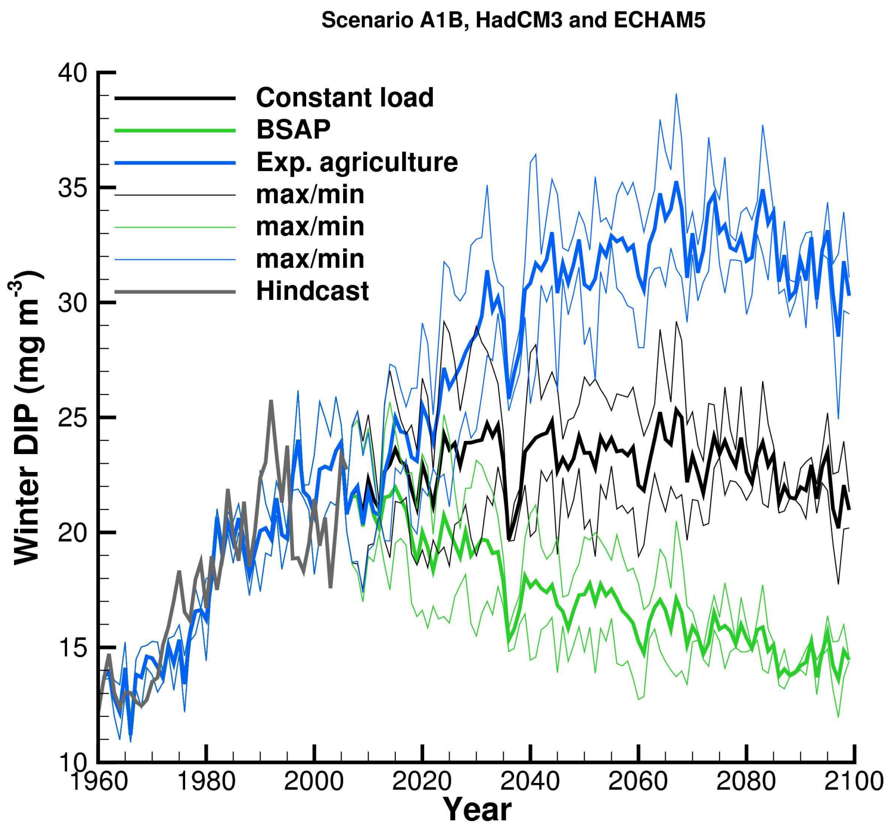
# Winter DIN - Baltic proper



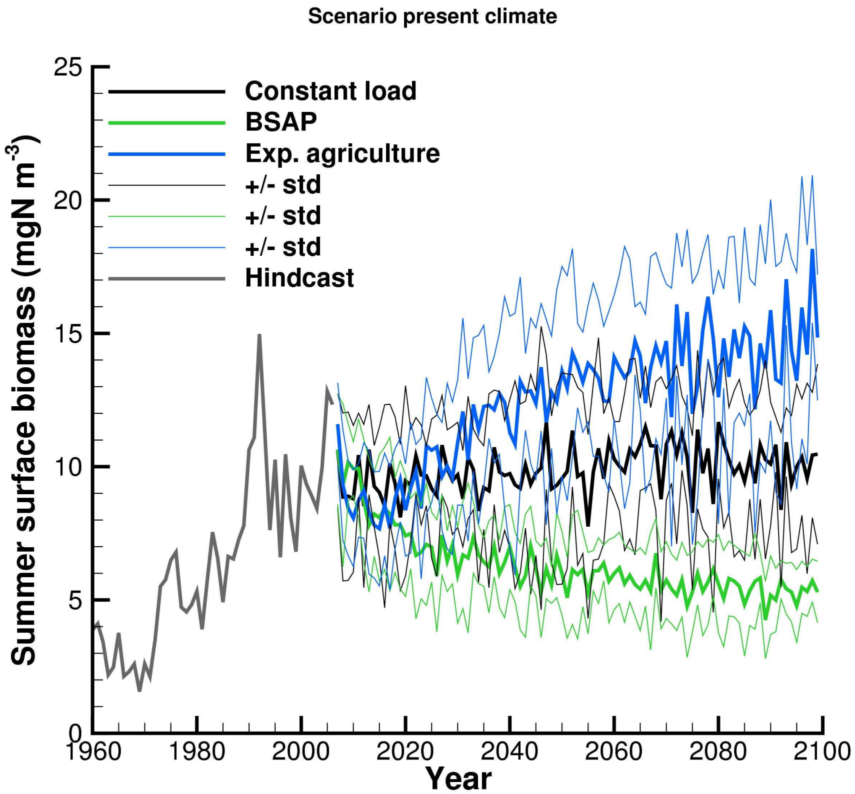



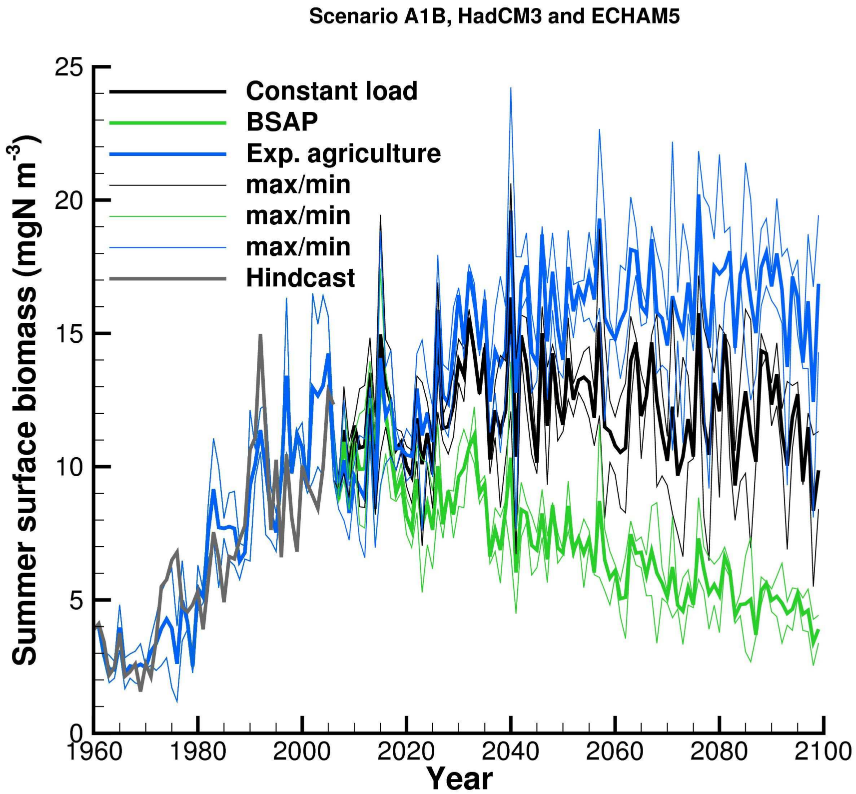
# Winter DIP – Baltic proper



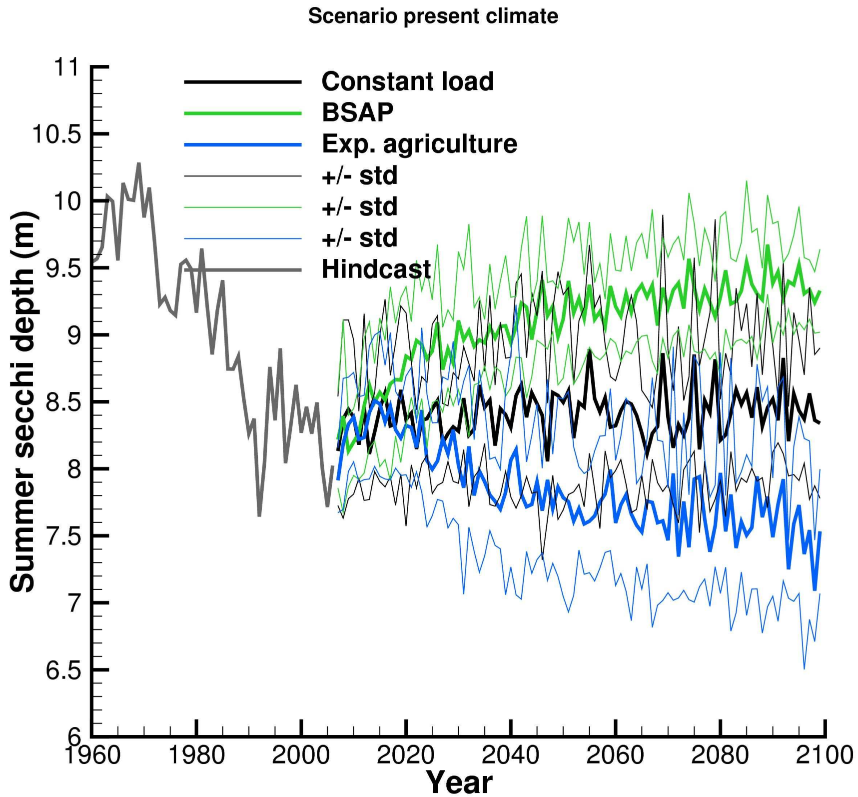



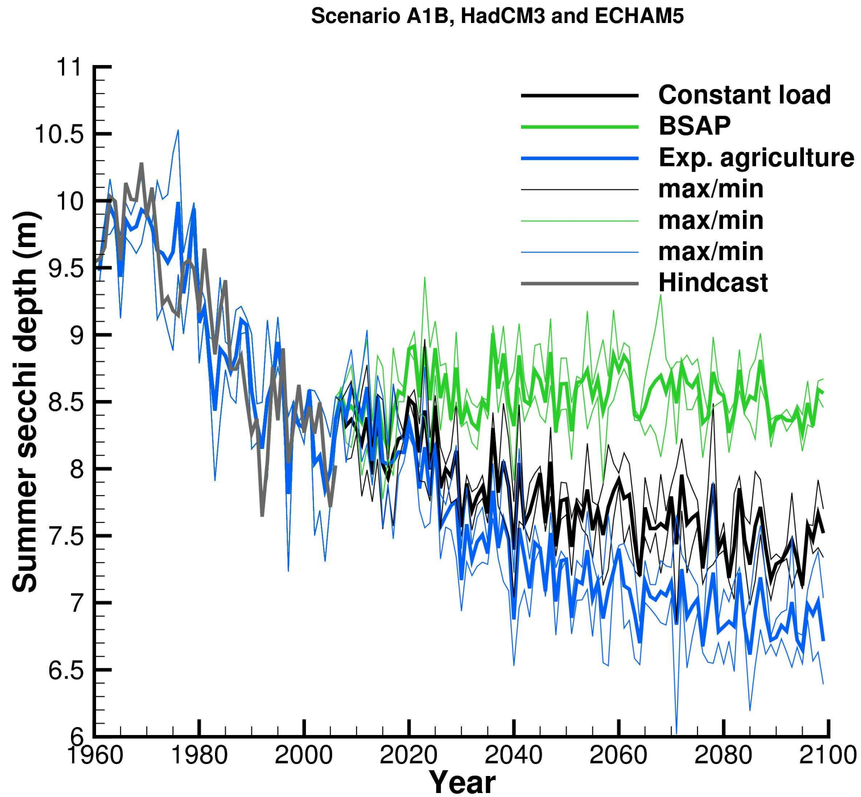
# Summer phytoplankton biomass
# Baltic proper



# Summer Secchi depth
# Baltic proper

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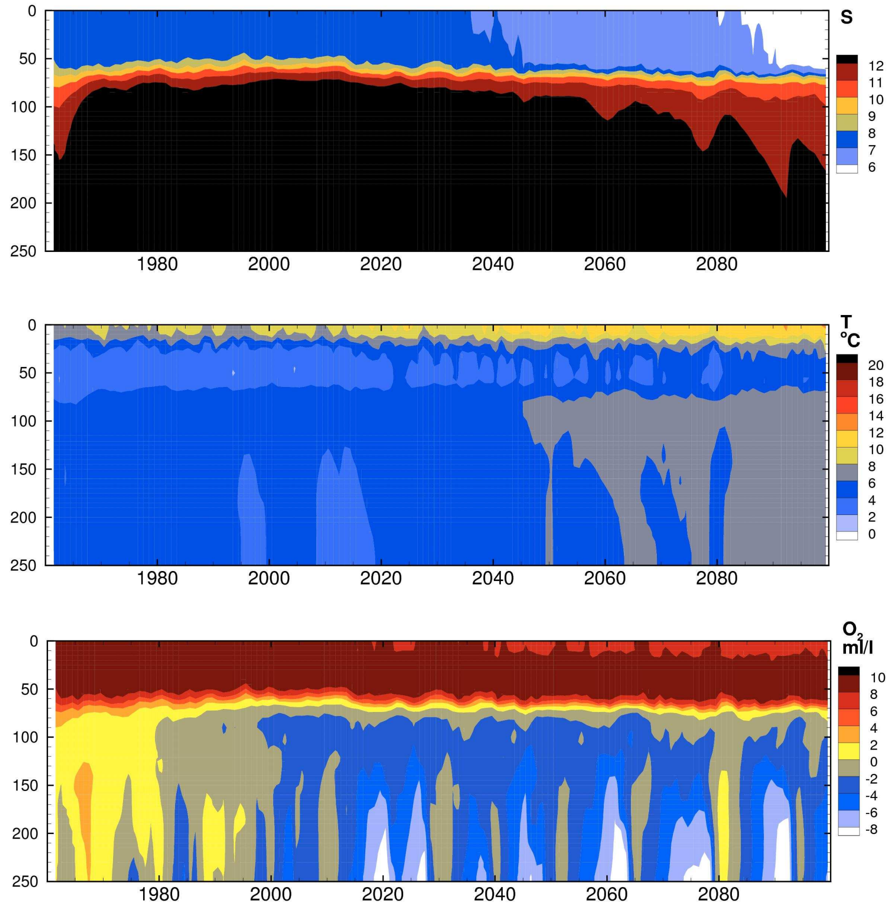
# Problems/uncertainties 1

- How to handle bias in when the coupled system is quite non-linear? Does really “delta-change” work?
- Do the models reproduce the correct responses for large perturbations? Long-term hindcasts necessary, but is it sufficient?
- How to deal with long-term natural variability – non-linear responses and regime shifts




HadCM3 A1B

# Problems/uncertainties 2

- Load scenarios are extremely important, and difficult. Nutrient retention are largely unknown.
- Socioeconomic development and political decisions have large impact.