Simulations of eutrophication scenarios with and an improved version of ERGOM

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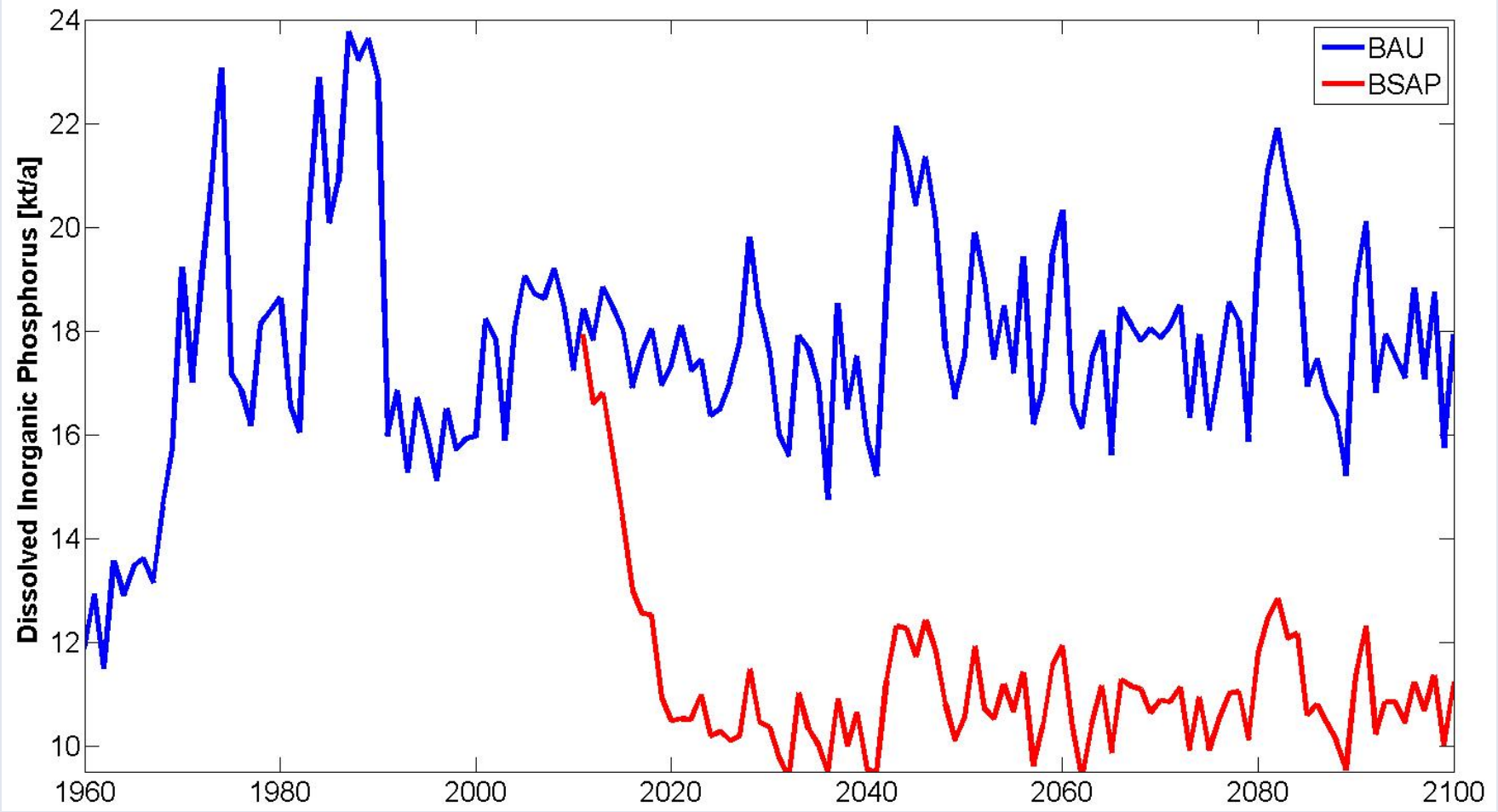
Matrix of simulations

- Climate Change (IPCC-Szenarios):
  - A1B & B1

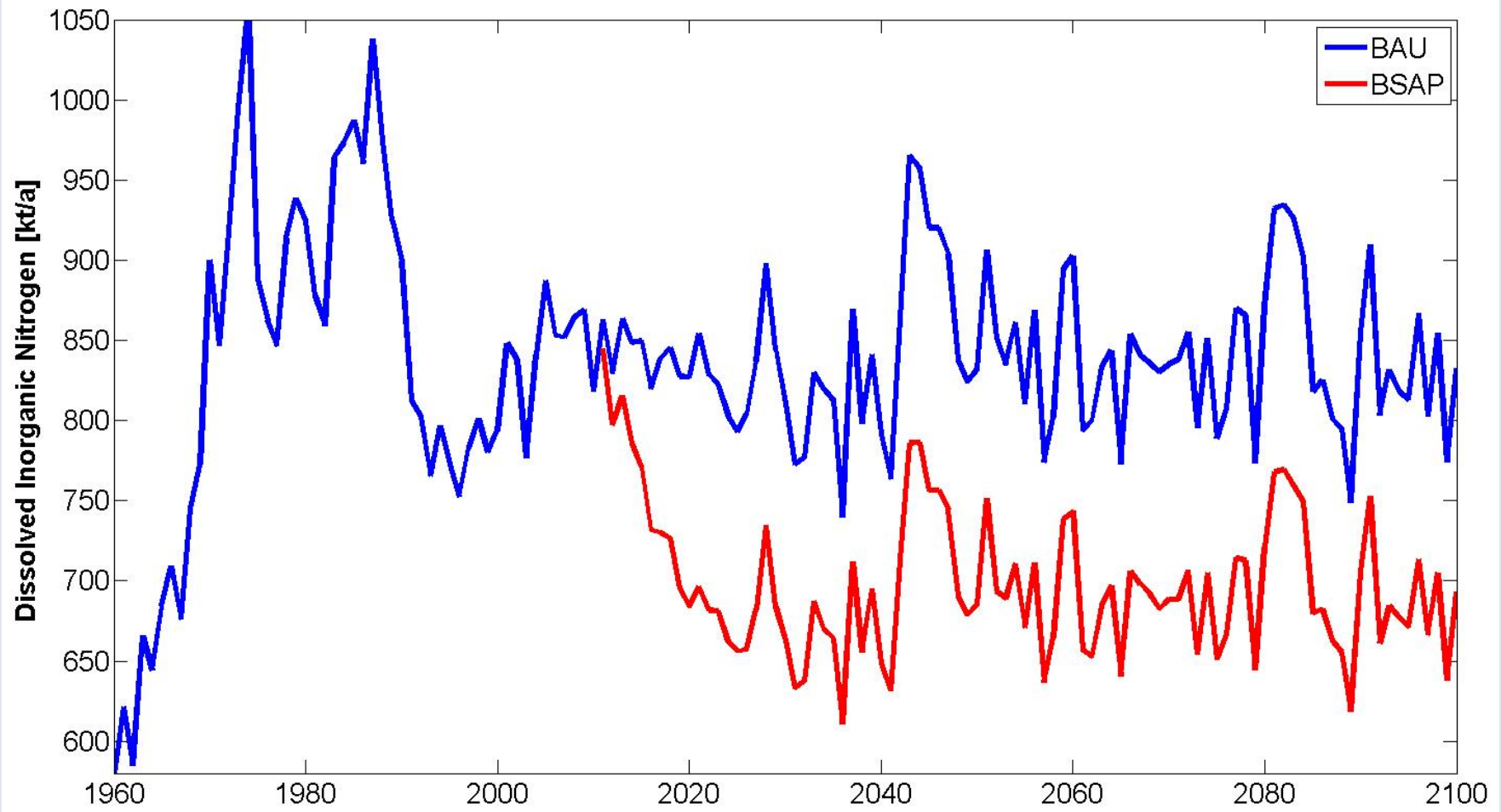
    regional climate model provided by the CLM-community (1960-2100)

- Eutrophication
  - High nutrient inputs (BAU=REF at SMHI)
  - Reduction according to the Baltic Sea Action Plan (strong decline of the P input in the Baltic Proper, in the western part stronger N input reduction)

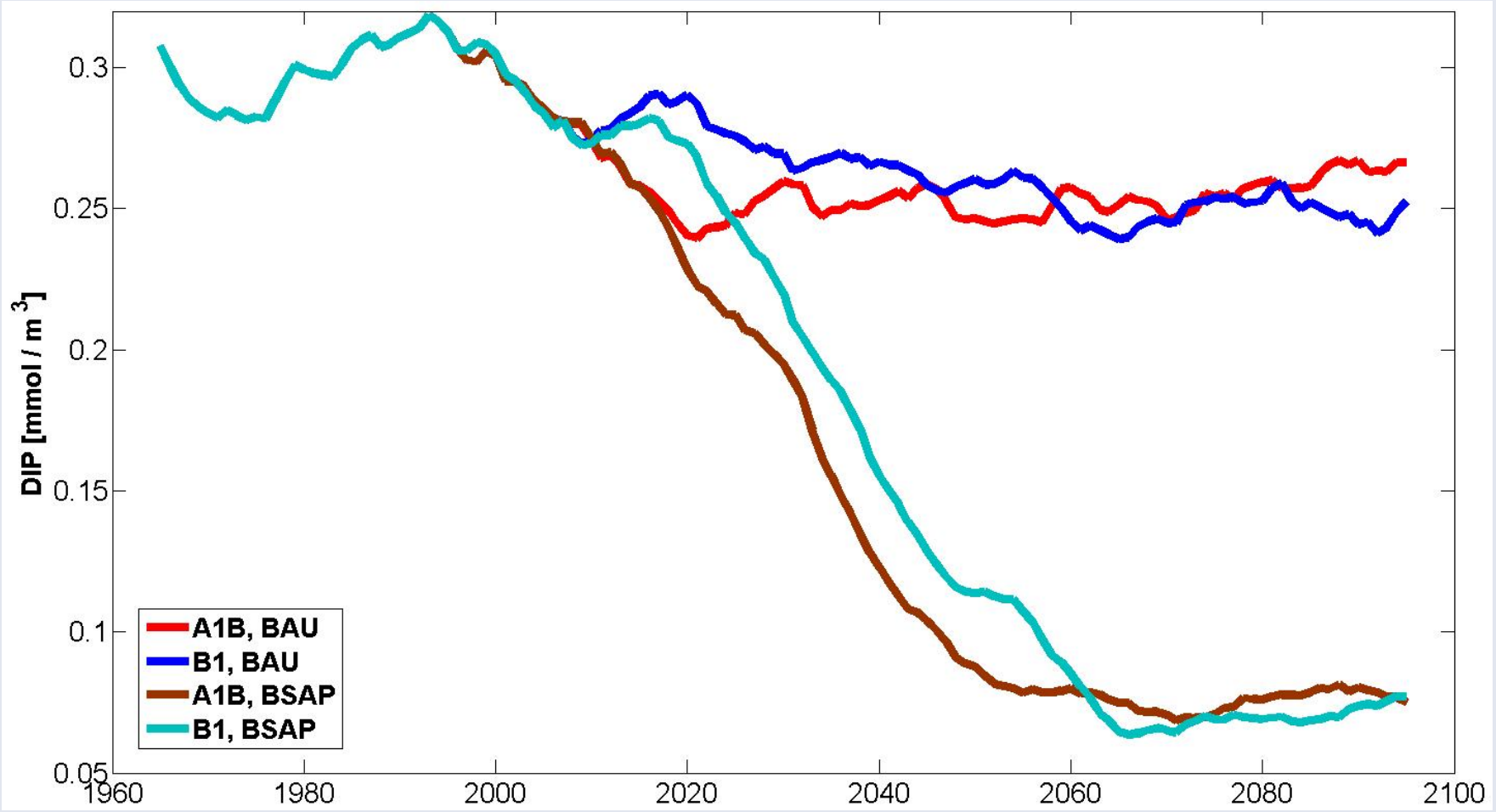
Reduction of the DIP input to 60%



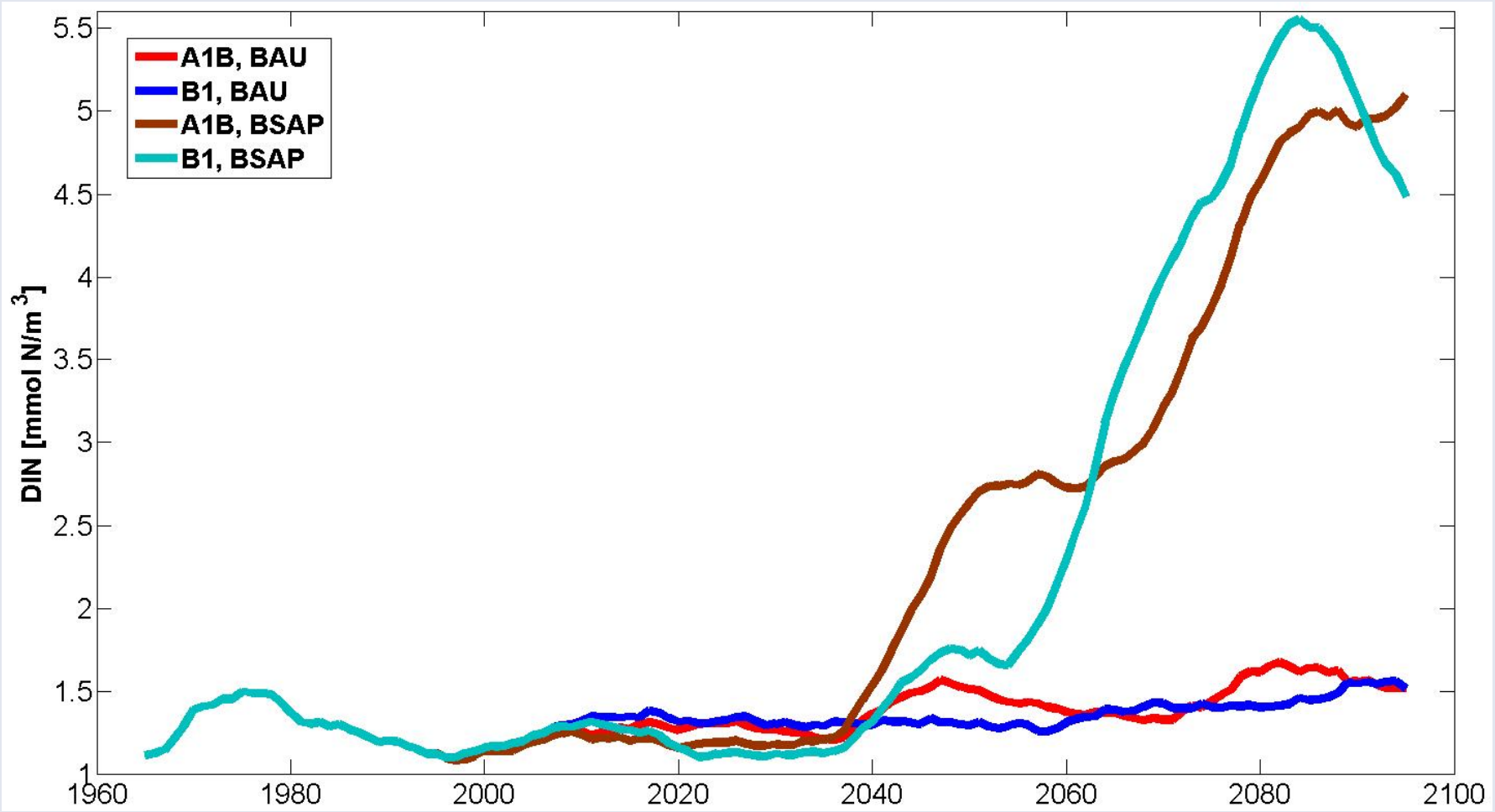
Reduction of the DIN input to 82%



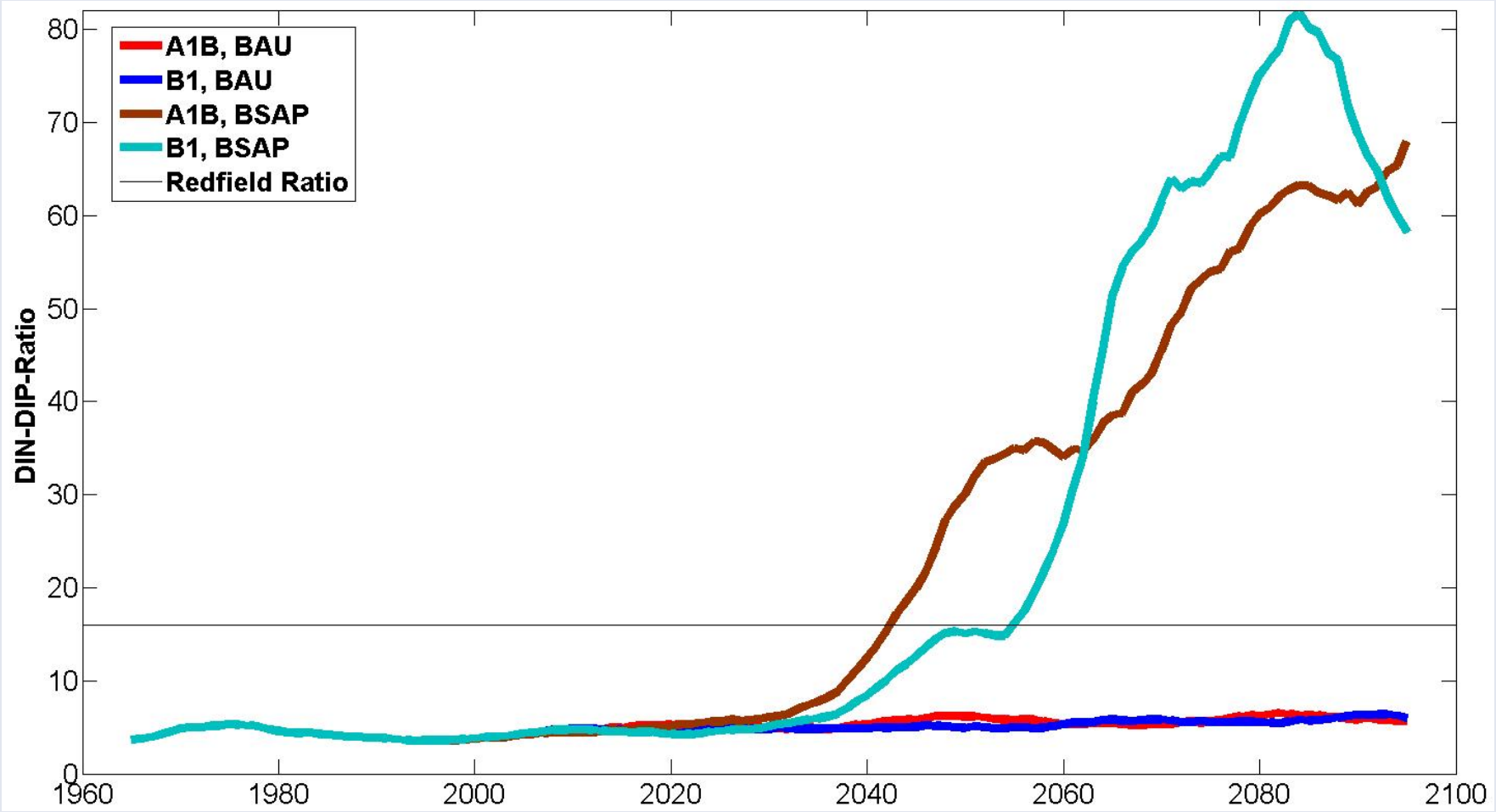
Strong decline of the available DIP (14-22˚E, 54-60˚N, 0-50m, summer)



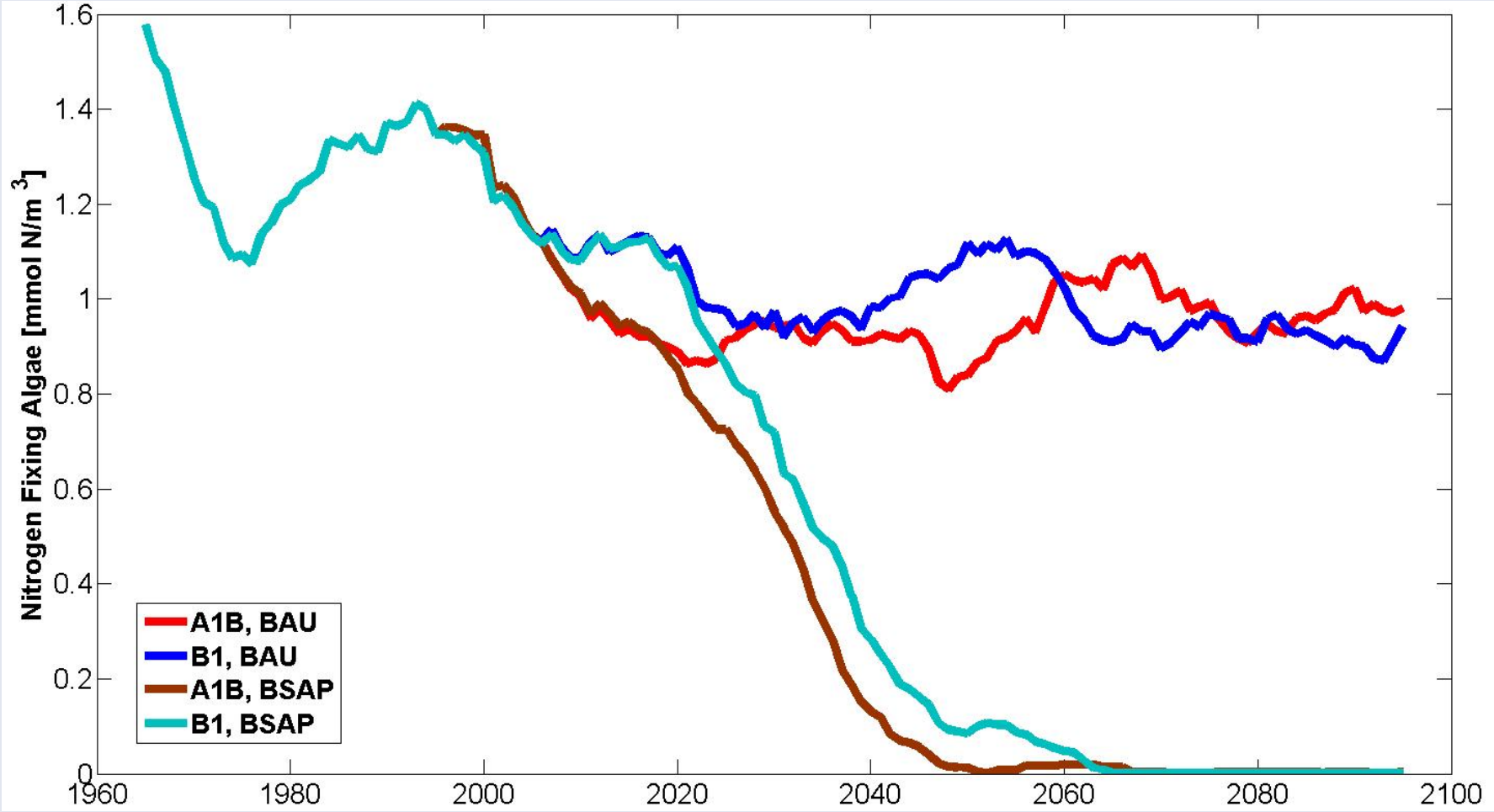
Accumulation of DIN (14-22˚E, 54-60˚N, 0-50m, summer)



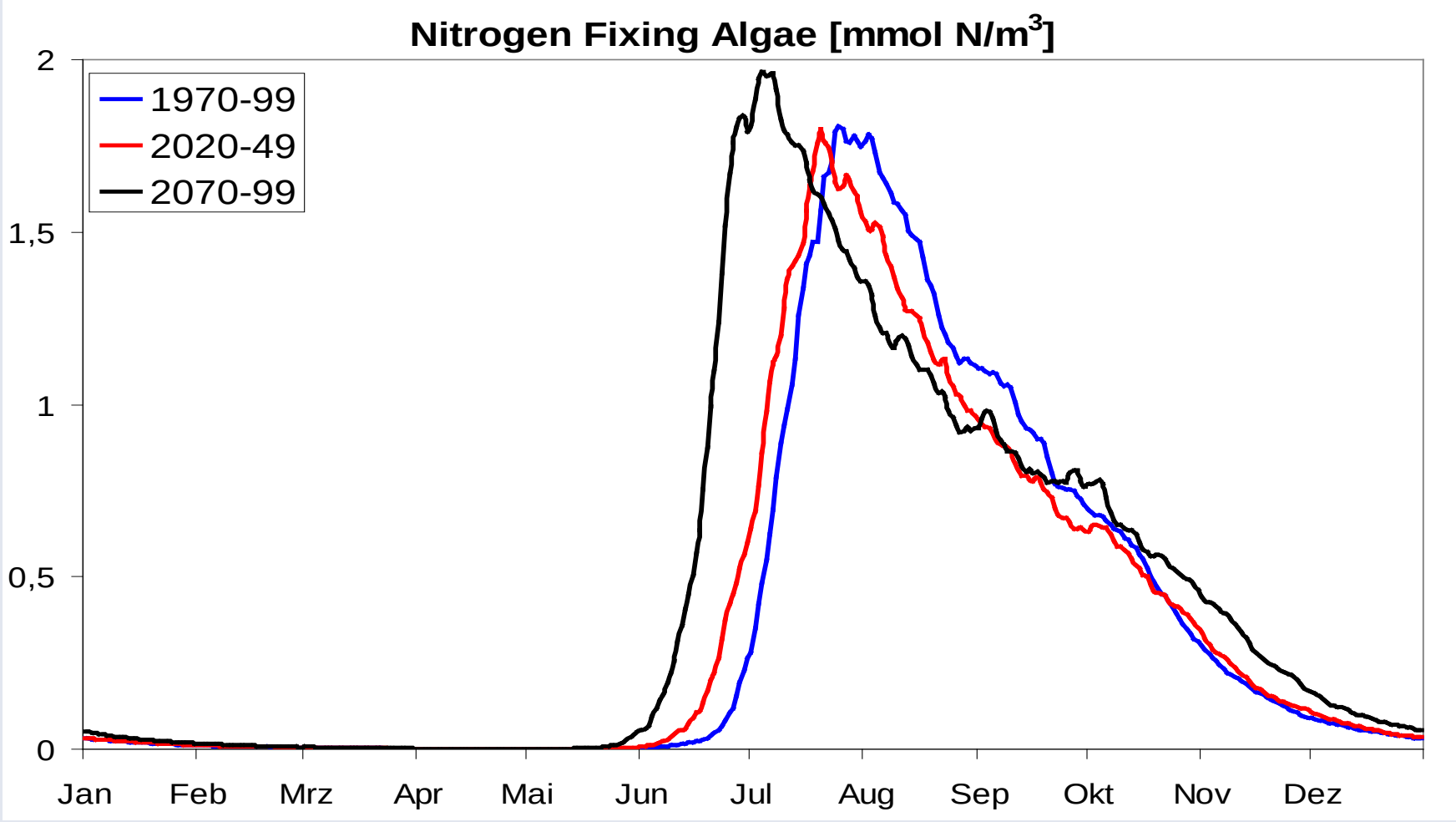
Shift from N to P limitation



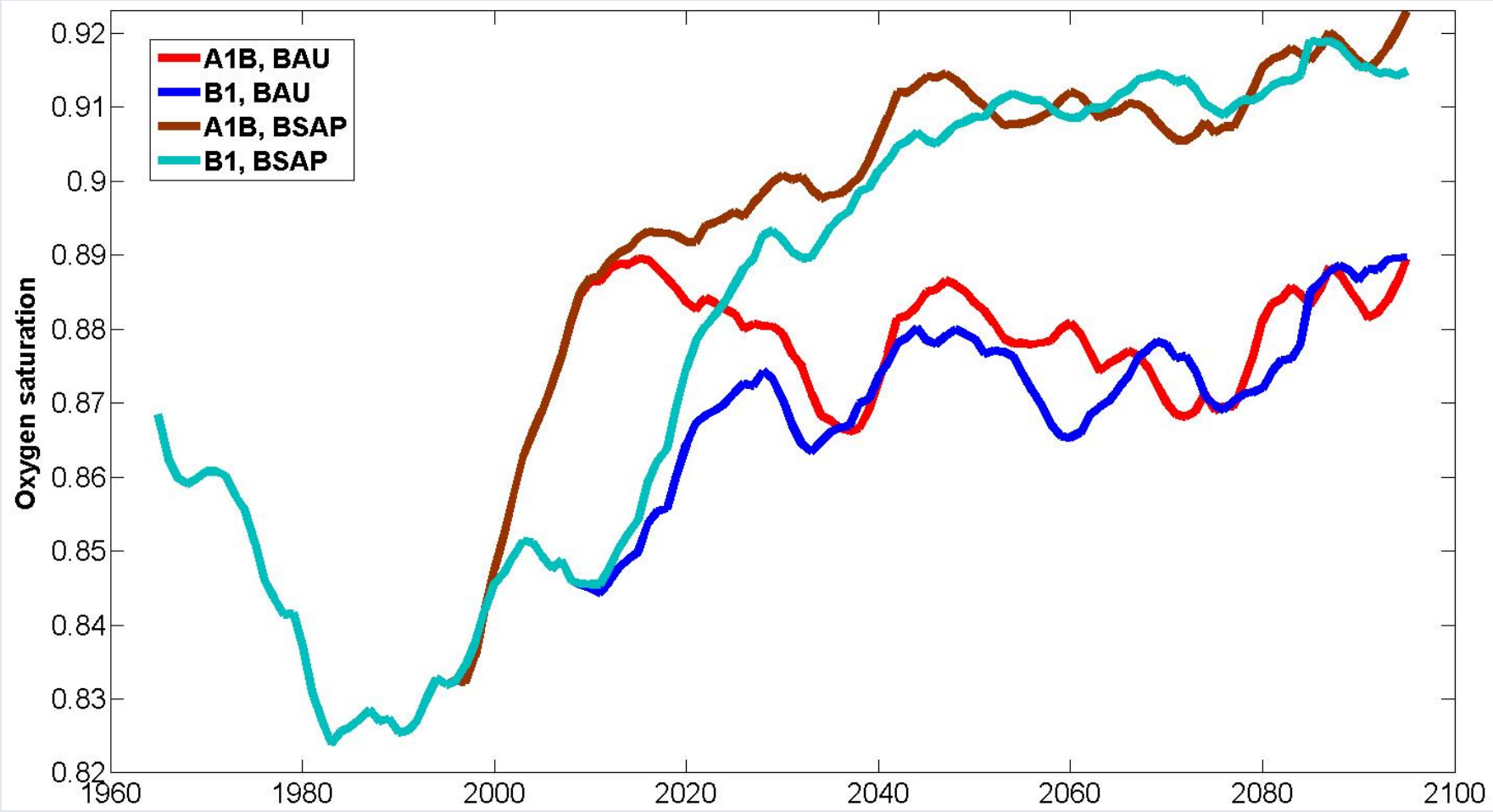
Strong decline of nitrogen fixing algae (14-22˚E, 54-60˚N, annual maximum)



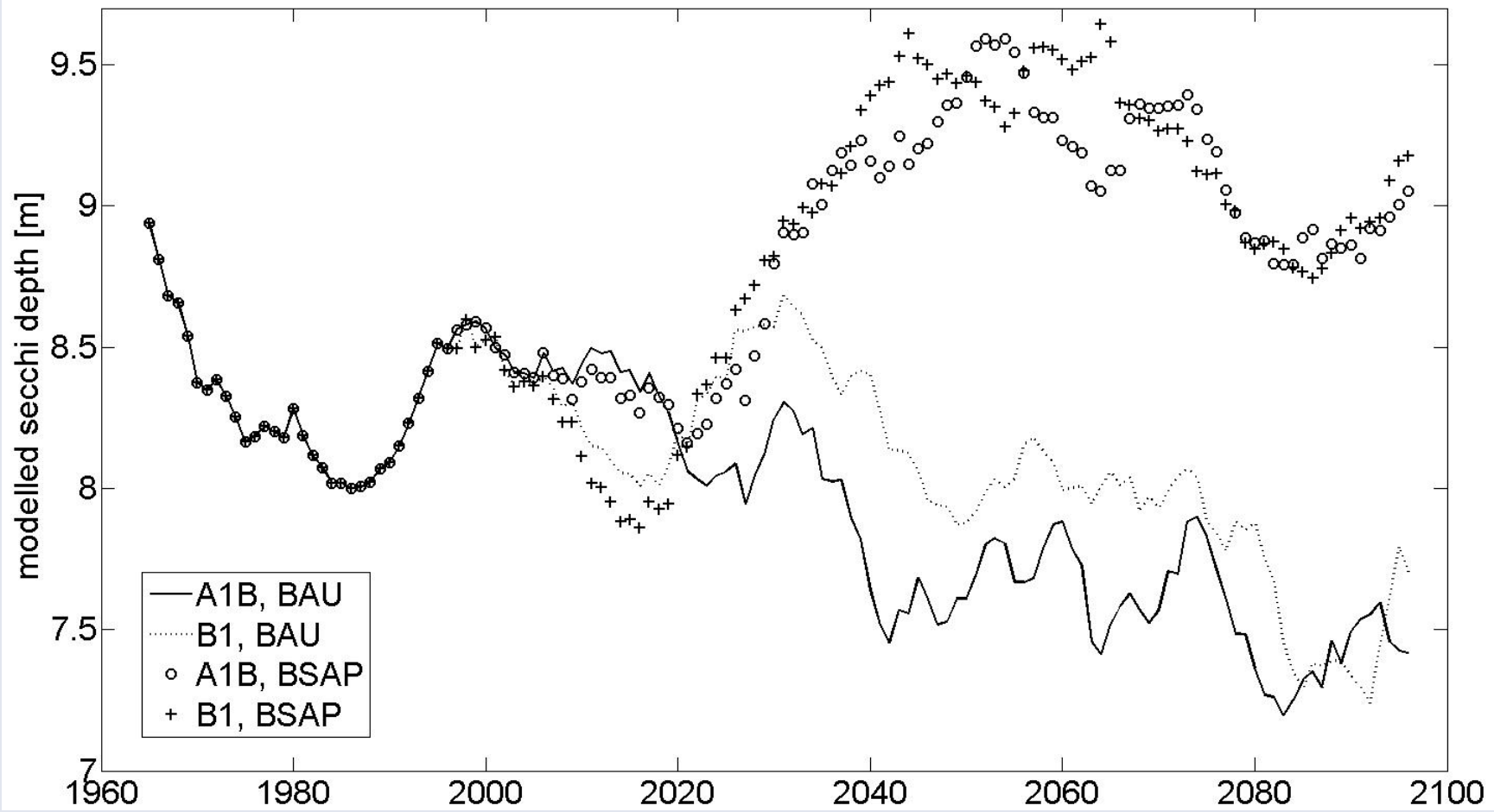
Increase of Nitrogen Fixers bloom at BAU-scenario (Arkona Sea, A1B-forcing)



Higher oxygen saturation at BSAP (14-22˚E, 54-60˚N, summer)



Increase of Secchi Depth (Mecklenburg Bight, averaged for June to September)



Simulations of eutrophication scenarios

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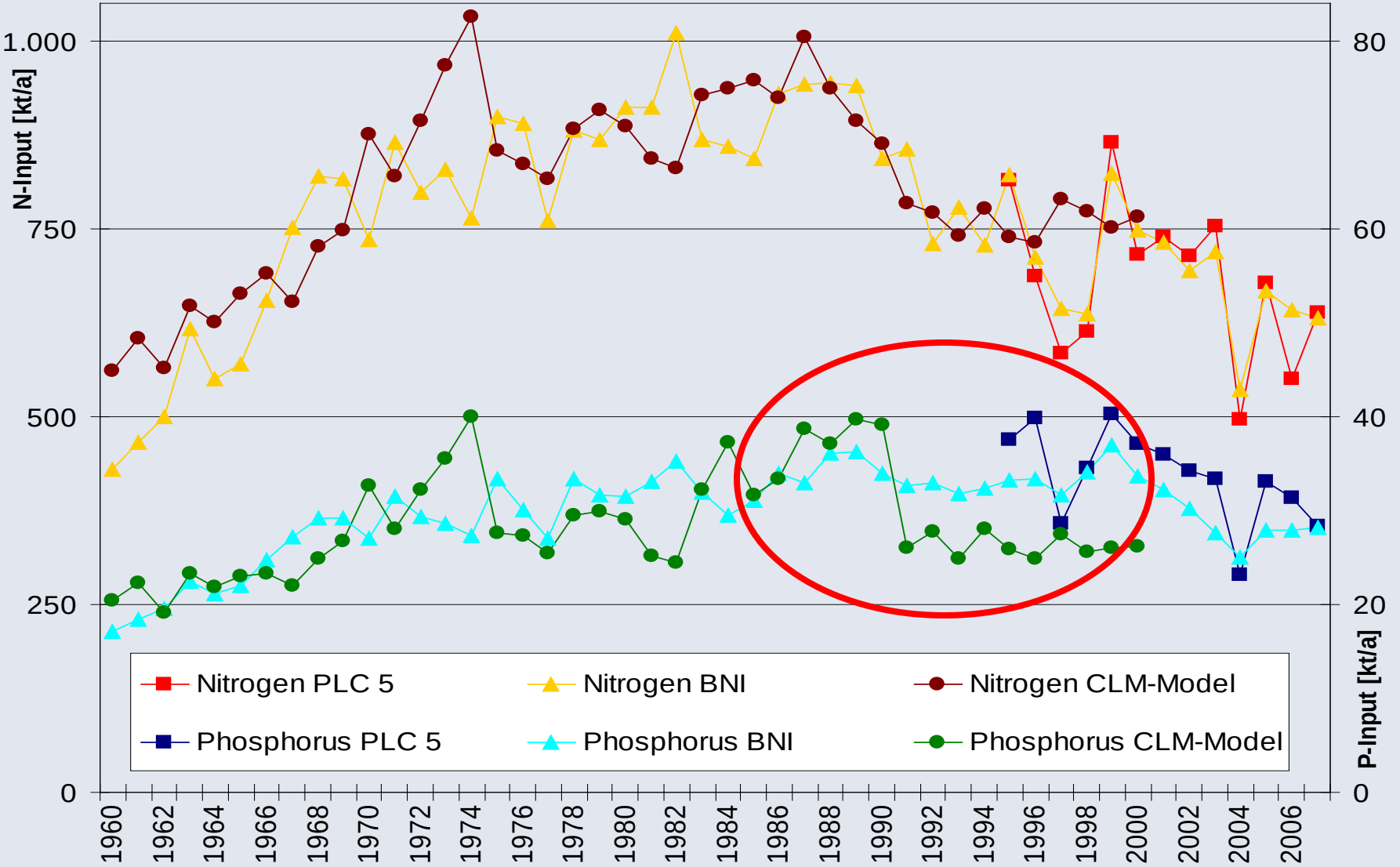
Parameter	Climate Change	CC & BSAP
Water transparency	↔	↑
Oxygen	↓	↔
DIP	↔	↓↓
DIN	↔	↑↑
Nitrogen Fixing Algae	↑	↓↓
Chlorophyll a	↑	↓↓
Detritus	↑	↓↓
Zooplankton	↑	↓
Denitrification	↑	↓↓
N-Fixation	↑	↓↓

Friedland et al. (2012, JMS): „Climate change and the Baltic Sea action plan: Model simulations on the future of the western Baltic Sea“

Meier et al. (2012, AMBIO):
"Impact of Climate Change on Ecological Quality Indicators and Biogeochemical Fluxes in the Baltic Sea: A Multi-Model Ensemble Study"

BSAP implementation would only stabilize nitrogen fixation on a high level of twice the flux in 1971 - 2000. (p. 567)

Decrease of riverine P-load after 1990 too strong?



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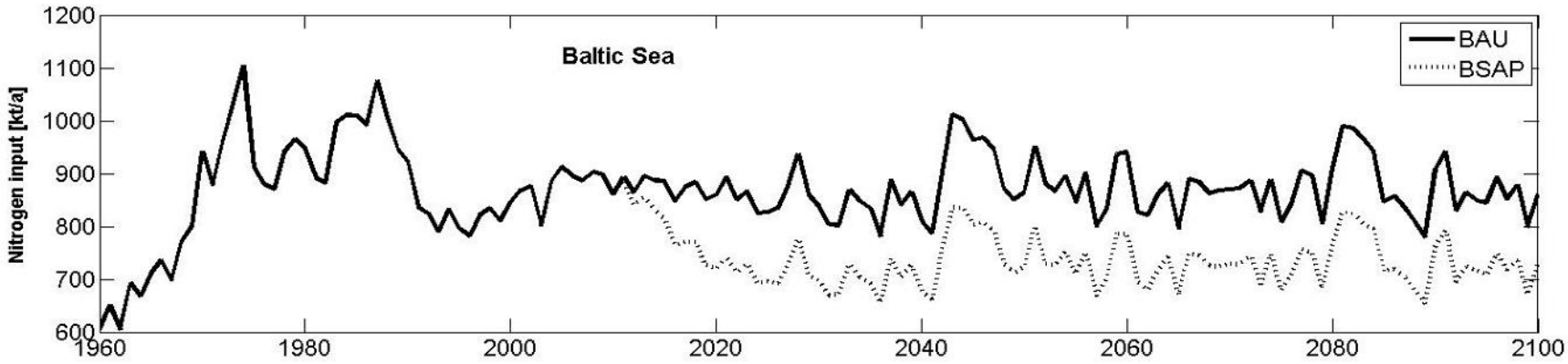
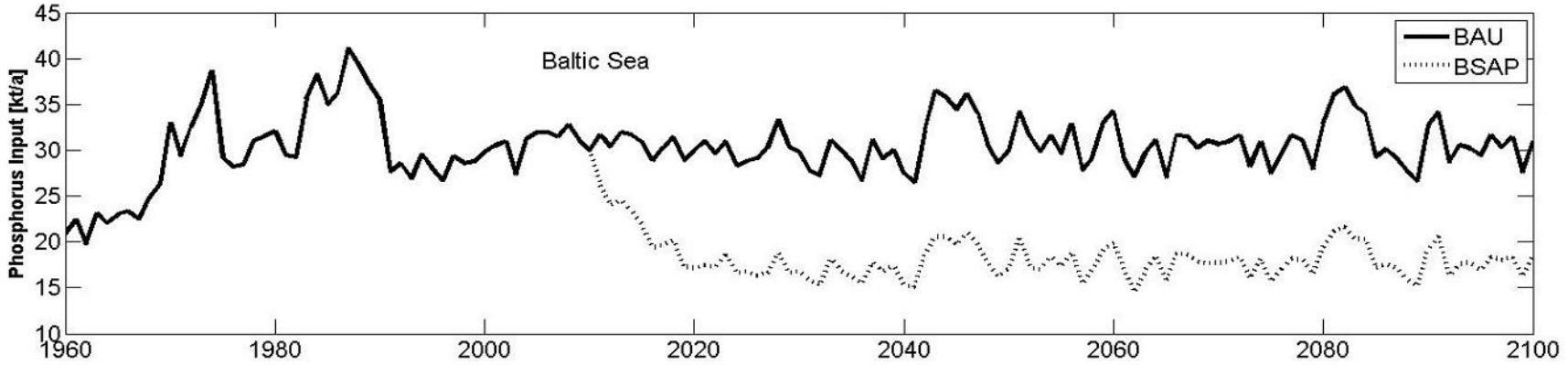
Waterborne nutrient loads	N [t/a]	P [t/a]	N/P
1997-2003	736.720	36.310	≈ 20,3
BSAP (from 2021)	601.720	21.060	≈ 28,6





Savchuk et al. (2008, JMS): "The Baltic Sea a century ago – a reconstruction from model simulations, verified by observations"

	Contemporary	Pre-industrial
N-loads [kt/year]	1015.1	391.4
P-loads [kt/year]	42.2	11.4
N/P-ratio of input	≈ 24	≈ 34
N-Fixation [kt N/year]	366	14 (44)

improved oxygen conditions:

- enhanced P removal
- reduced denitrification

⇒ higher N/P-ratios

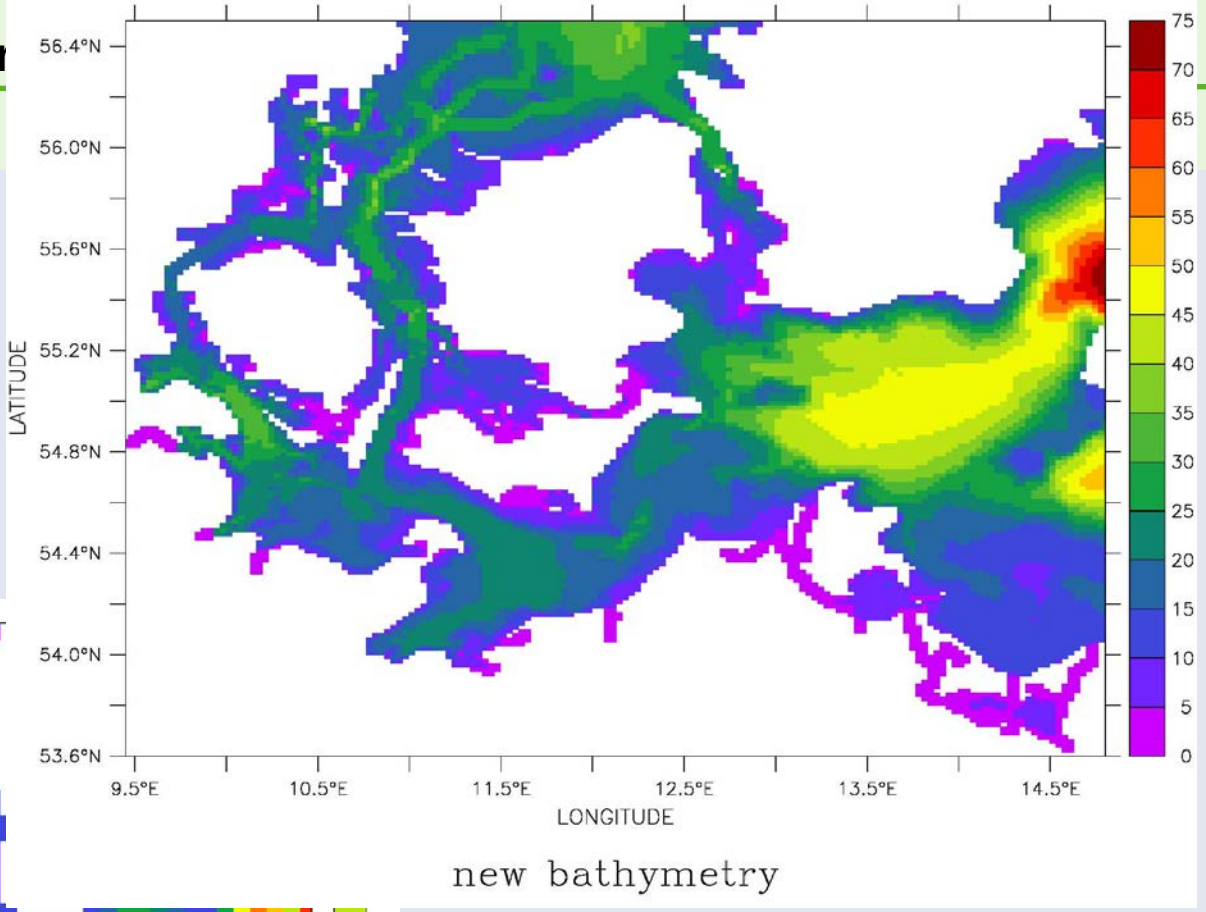
⇒ less N-Fixation

Model improvements necessary

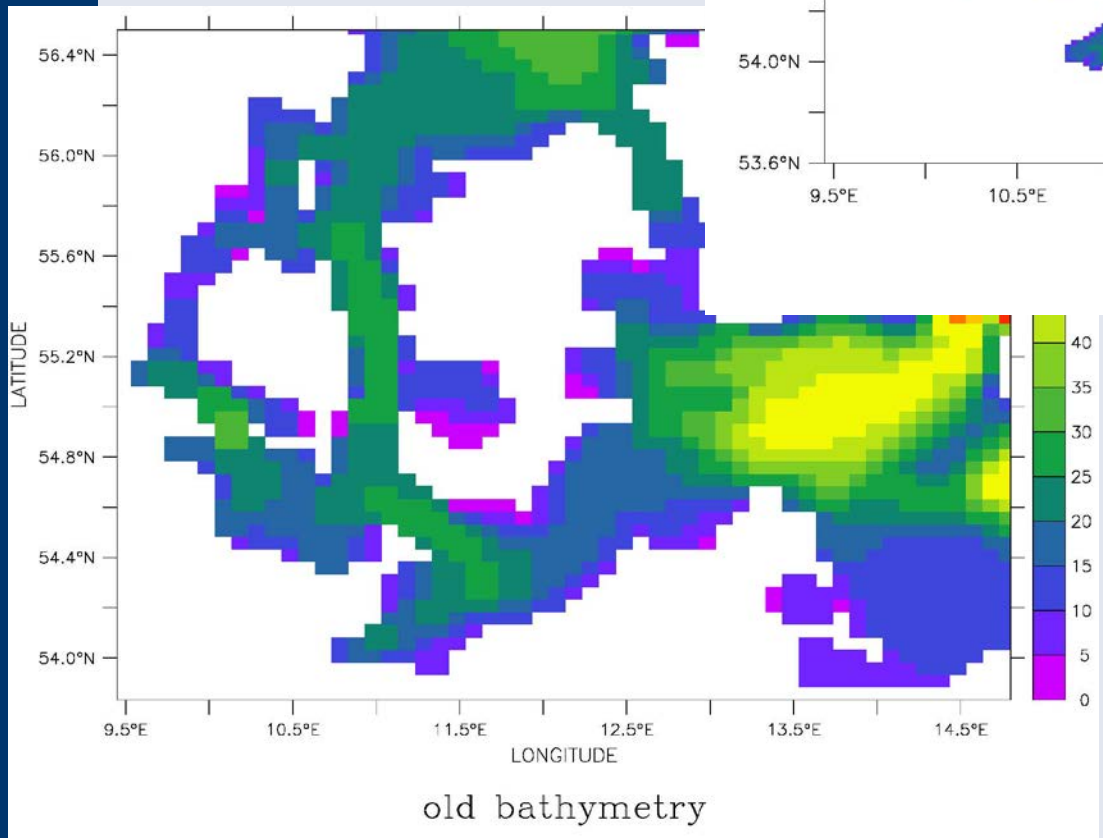
- finer horizontal grid

Bathymetry:

finer resolution in the western Baltic Sea



new bathymetry

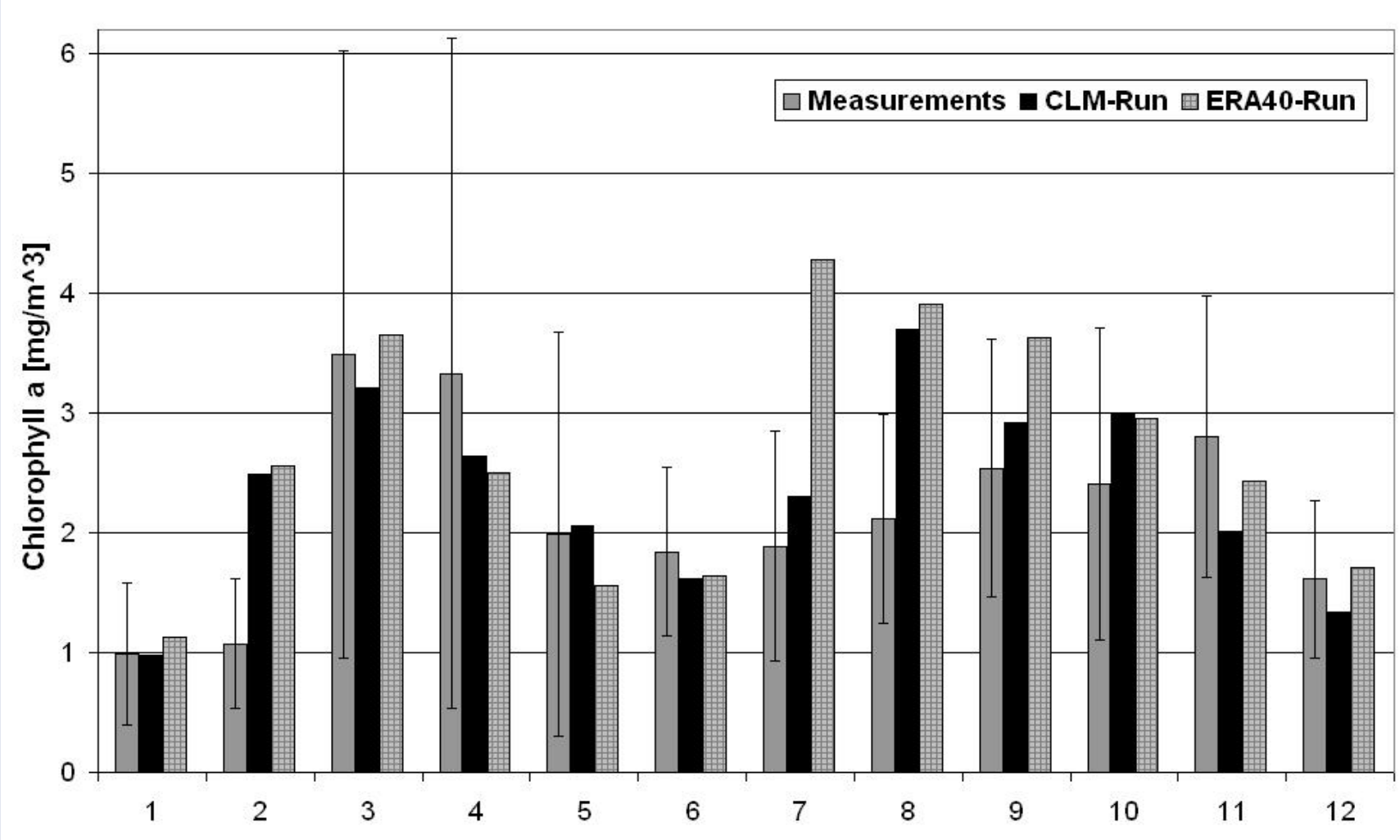


old bathymetry

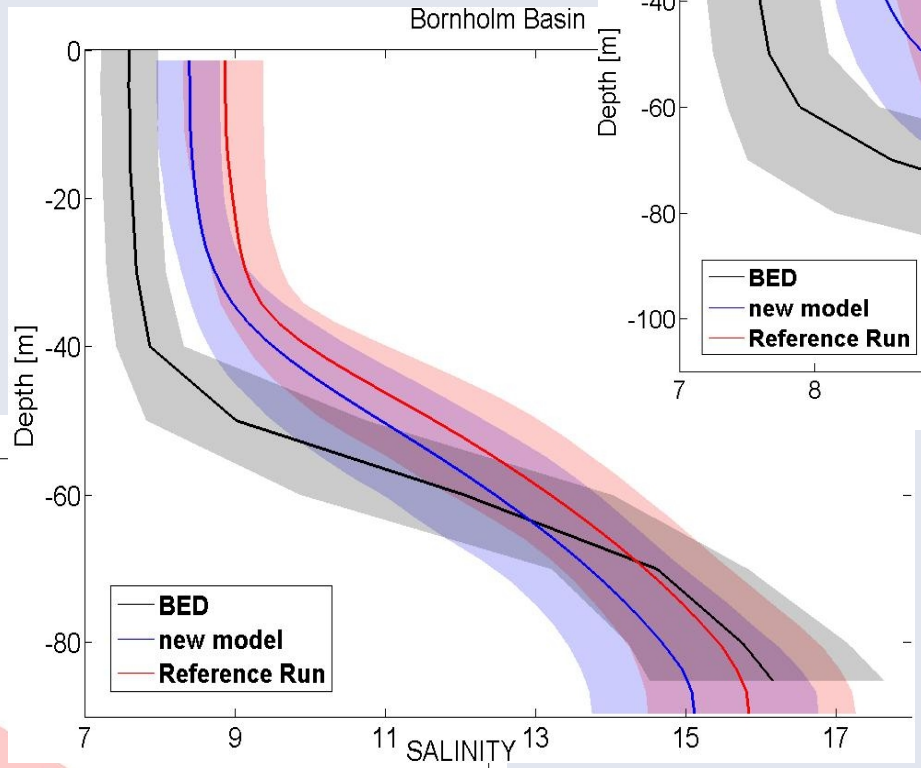
Model improvements necessary

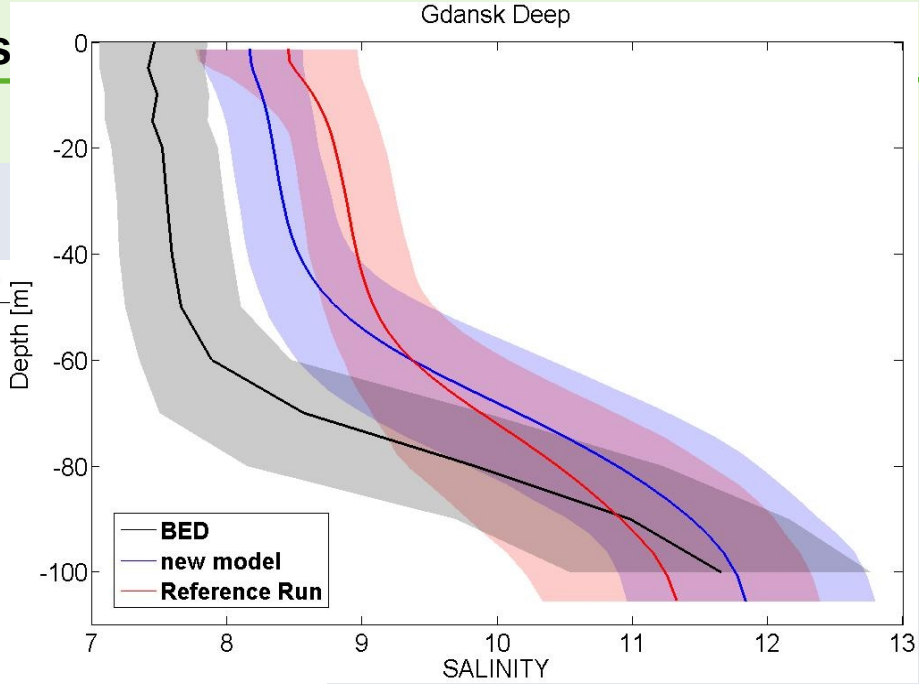
- finer horizontal grid
- more detailed allocation of freshwater and nutrient inputs (according to riverine database of BNI and MONERIS for the german rivers)
- improved modeling of sedimentary fluxes (within the BMBF-project SECOS)
- handling of higher trophic levels
- some more fine tuning (e.g. start of the spring bloom)

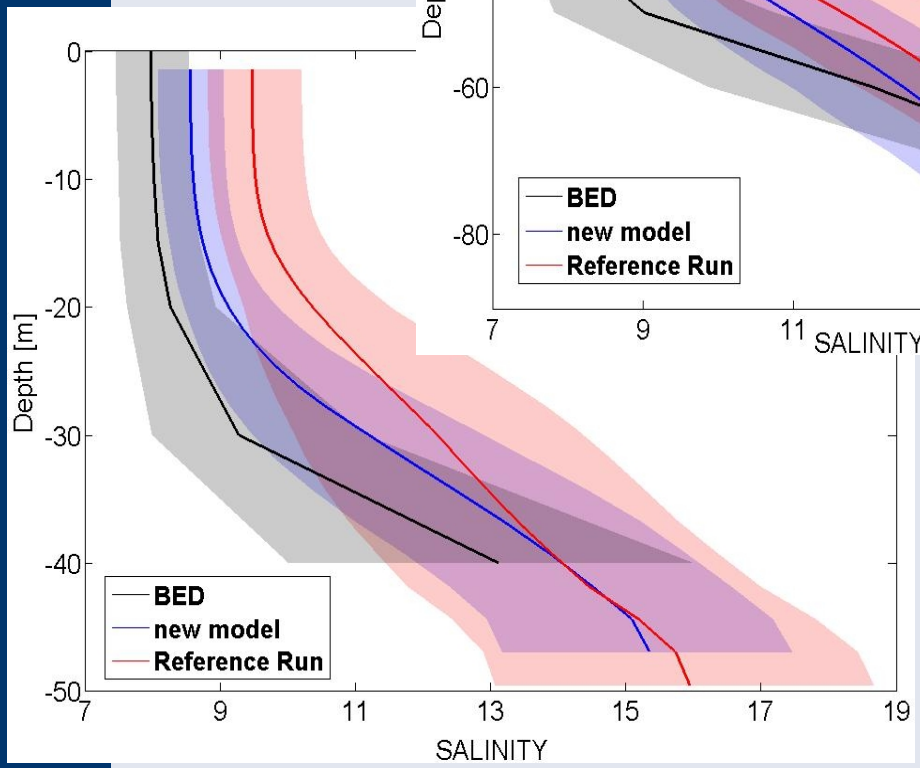
Climatology of Chlorophyll at Arkona Sea



Salinity profiles get better (mostly)

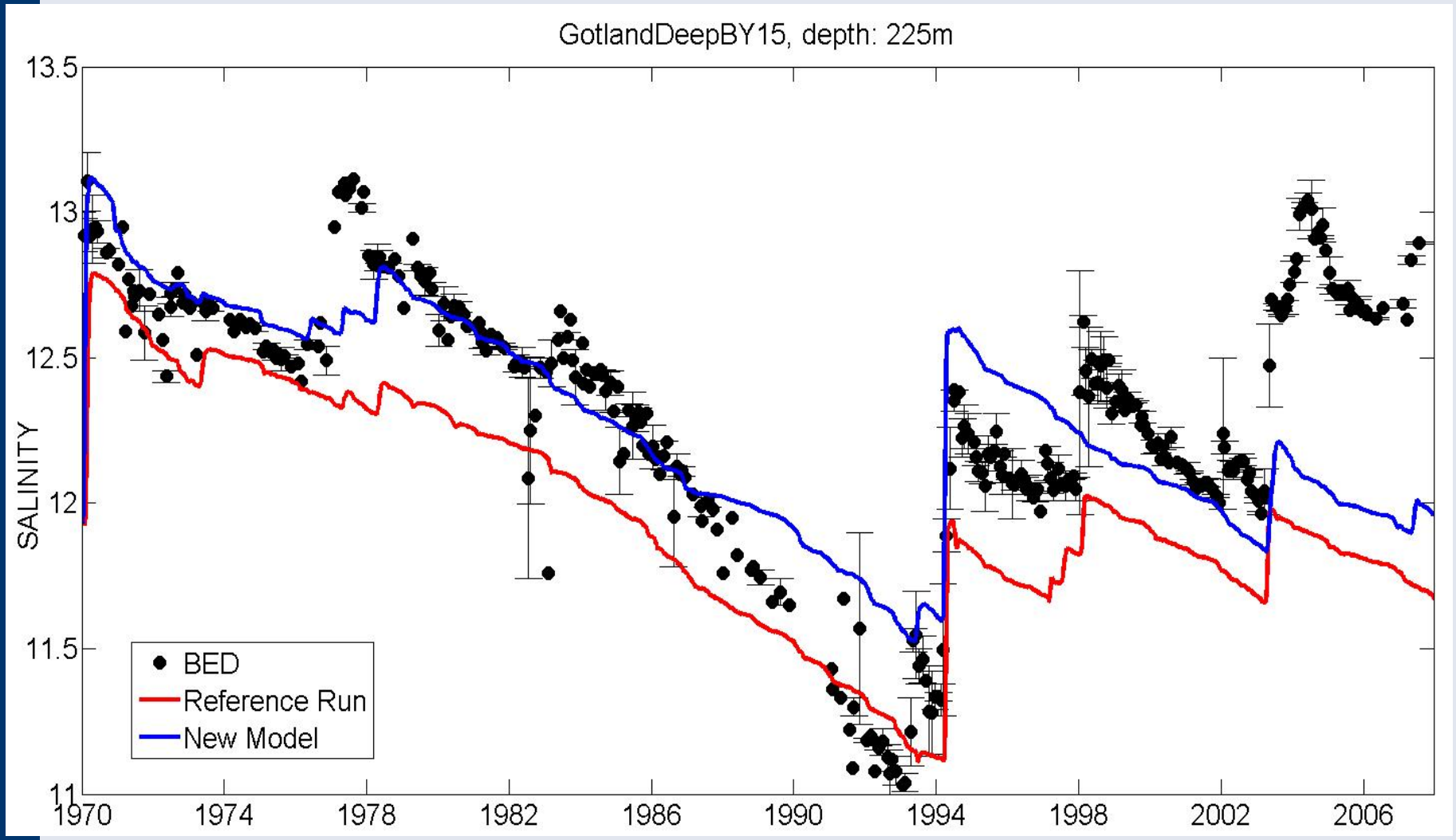






new model compared with the 3n.m.-model and the Validation data set compiled from BED [both used at Eilola et al. (2011)]

Inflows get better (mostly)



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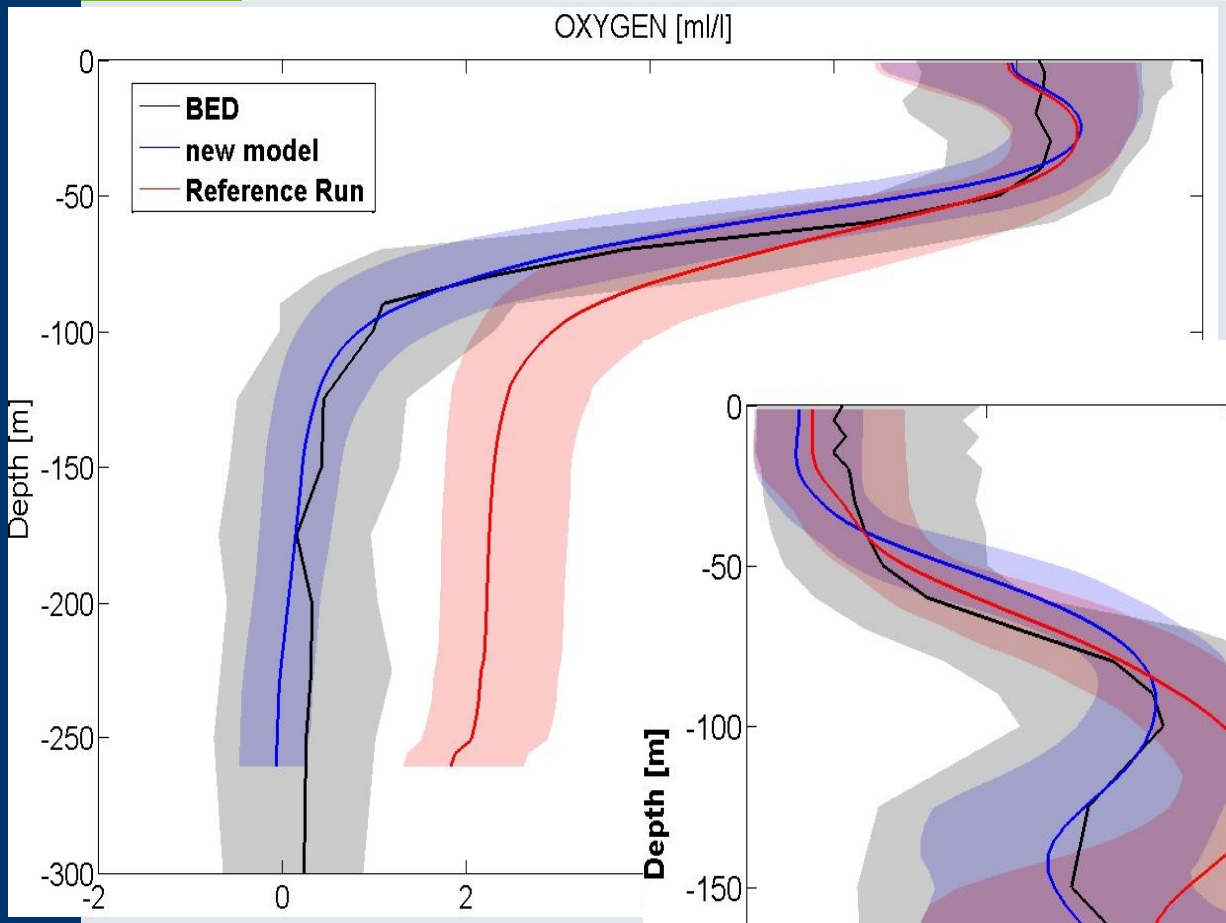
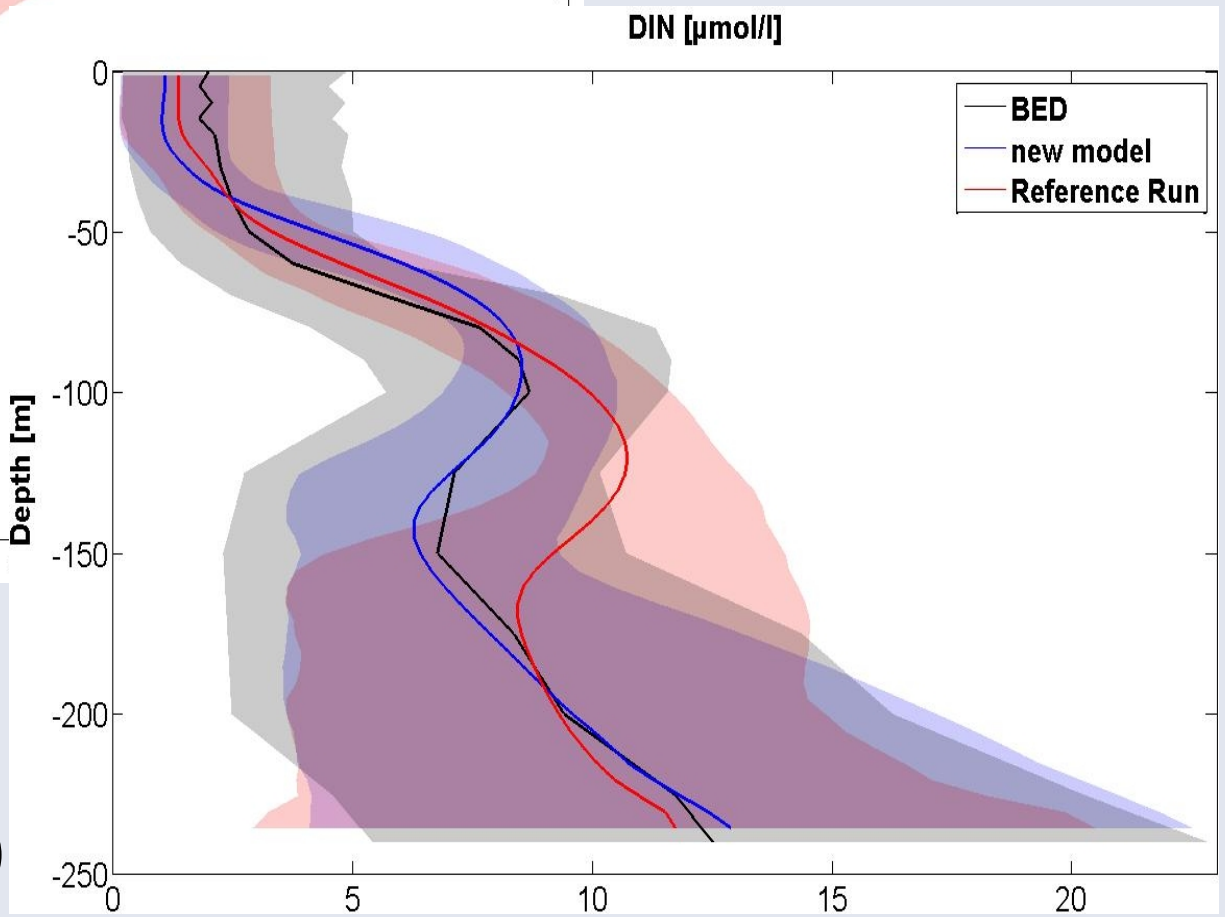


Some promising results



Landsort Deep (Oxygen)

Gotland Deep (DIN)

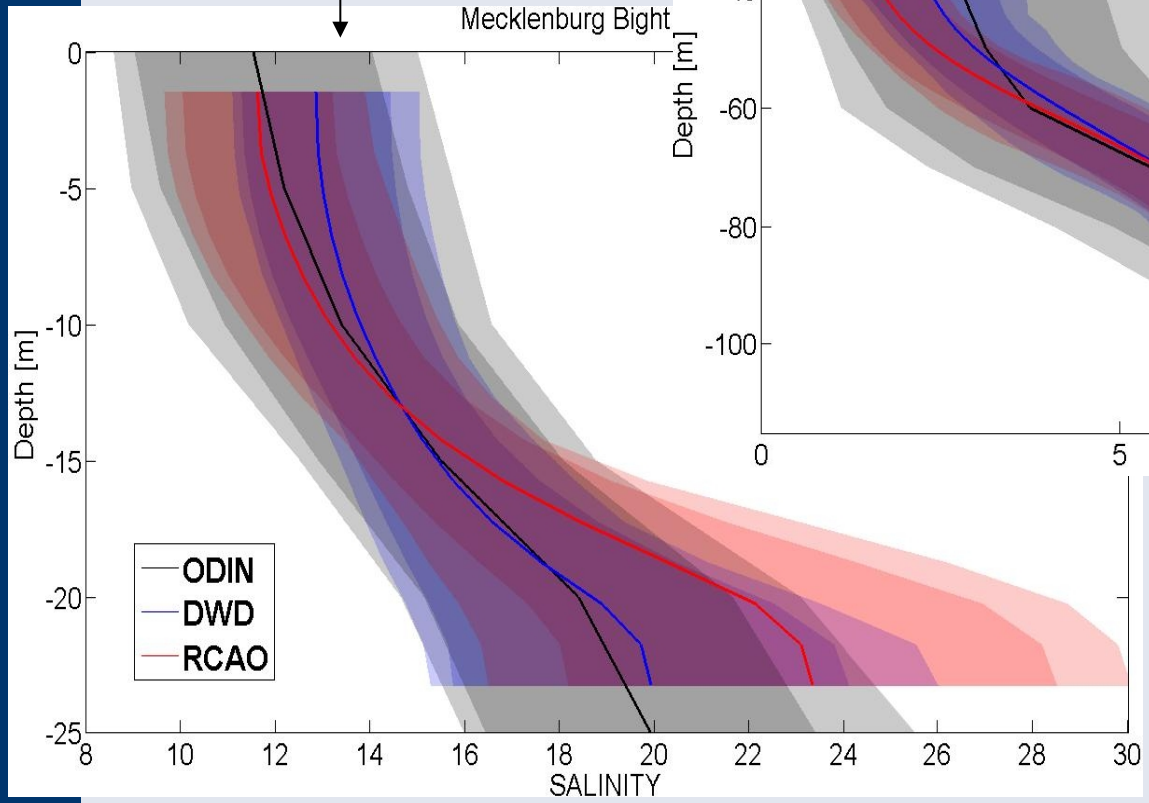
ensemble simulations needed

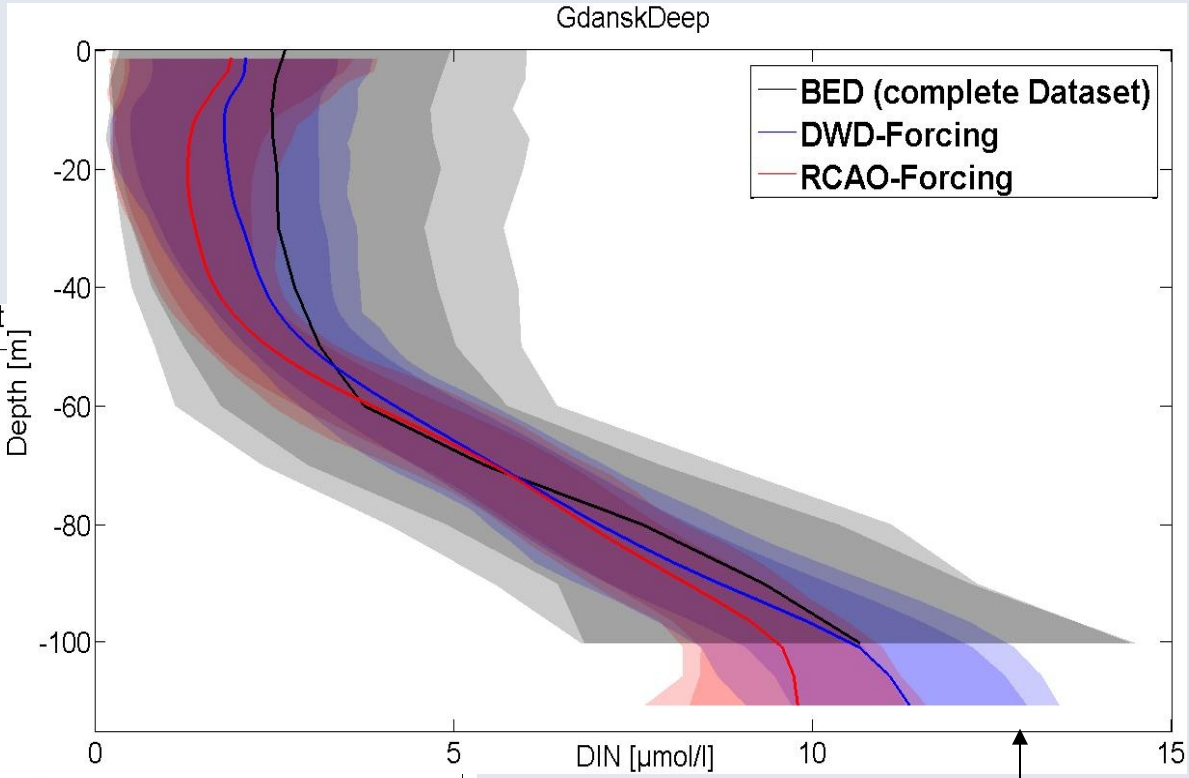
with respect to:

- weather forcing
- nutrient loads (rivers, atmospheric deposition, point sources)
- bioavailability of N & P inputs
- parameterization of biogeochemical components
- …

Influence of DWD-forcing (instead of RCAO)

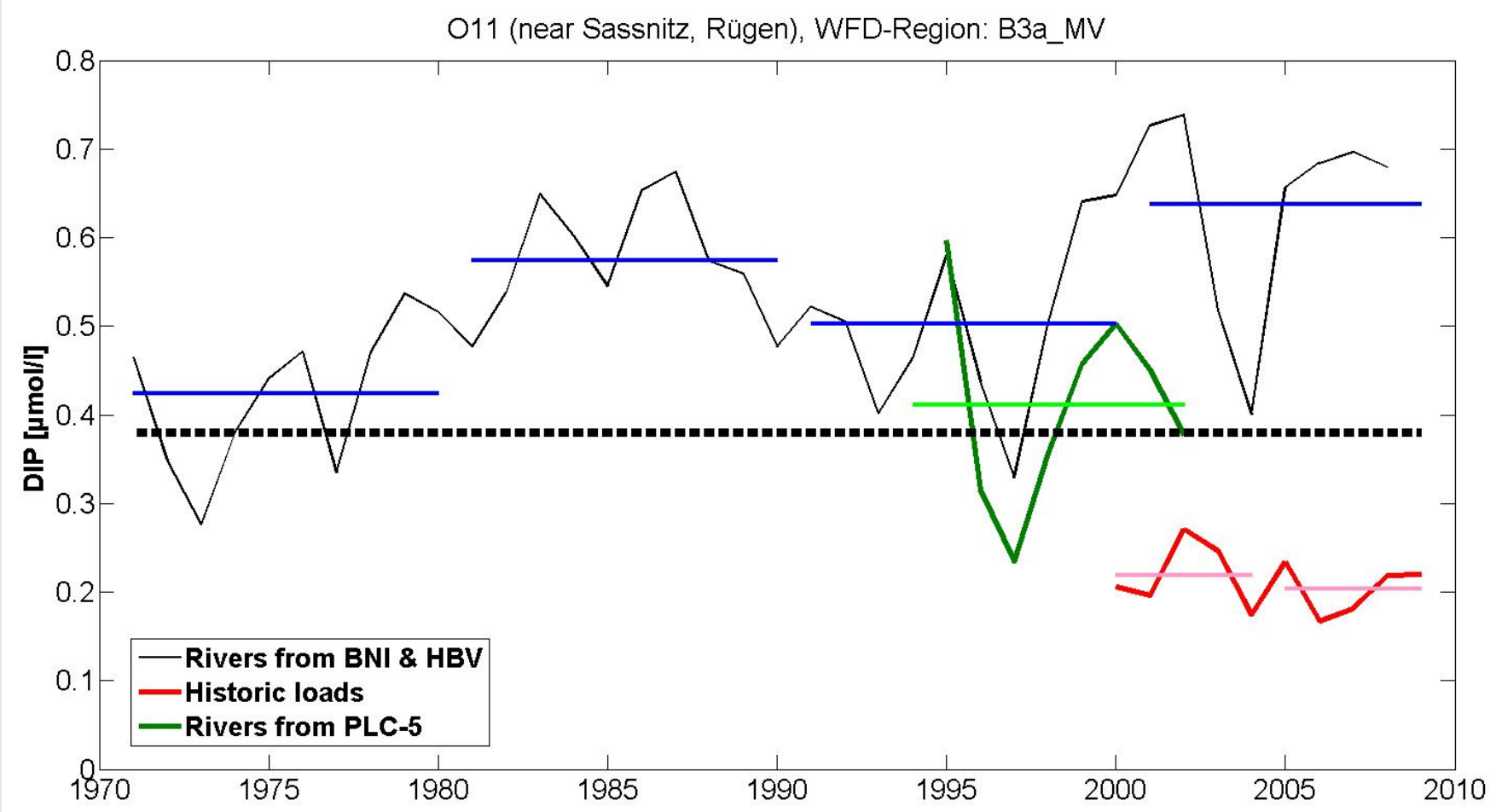
Salinity in the Mecklenburg Bight:





DIN in the Gdansk Deep

Uncertainty due to different riverine datasets



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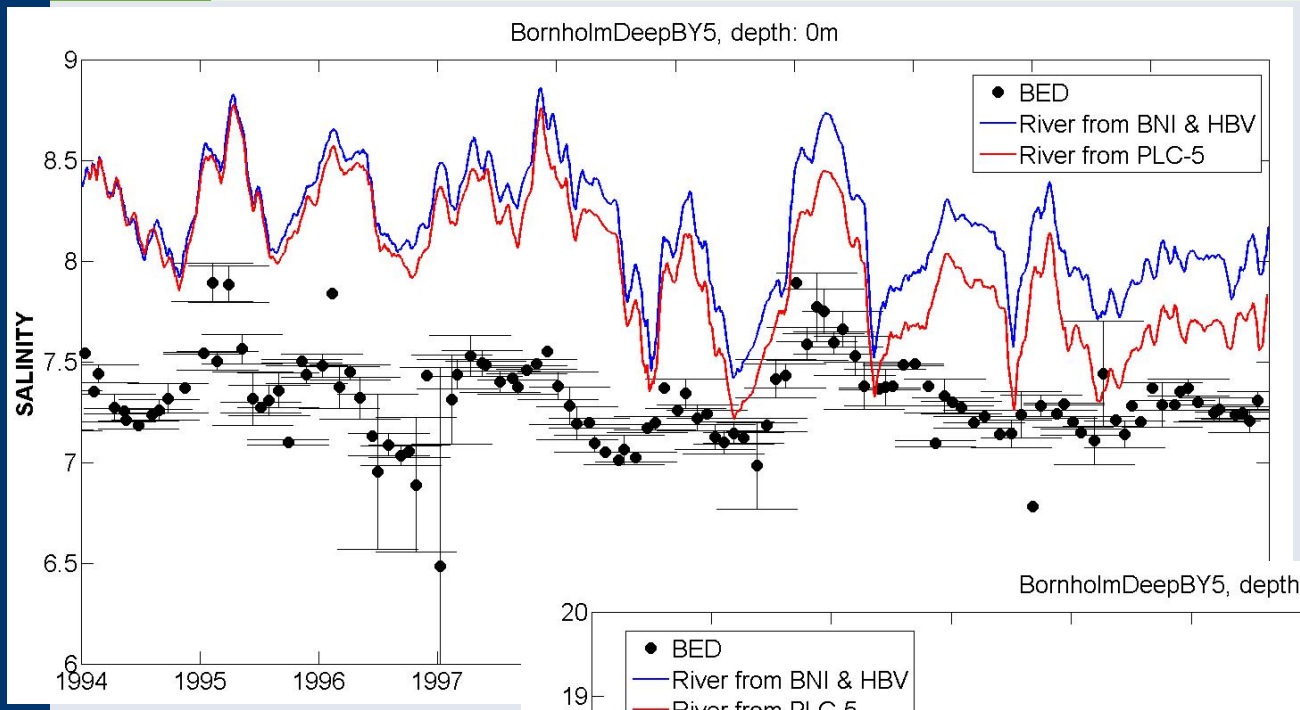
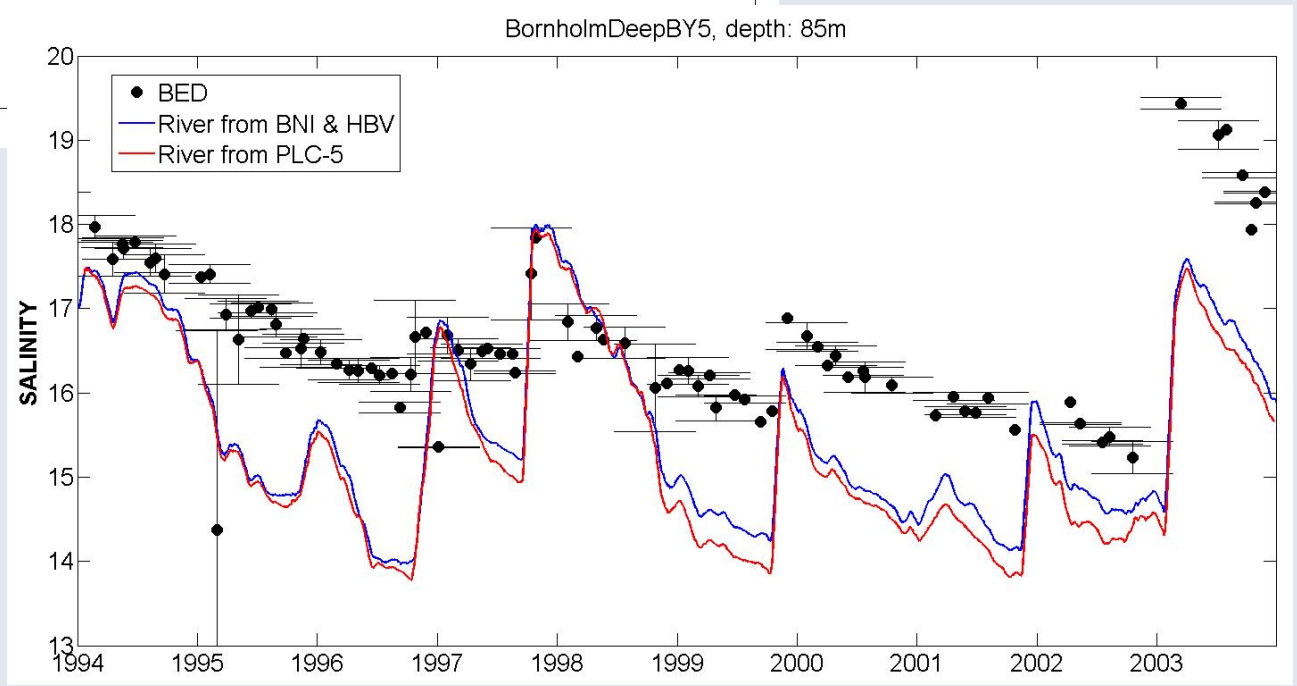


Salinity differs with riverine input



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