

What happened outside the Baltic Sea ?

The next neighbor is the North Sea with strong exchange with the open Atlantic

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with contributions from

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Climate models predict

Atlantic SST may increase by up to 4.5 °C at the end of the century

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- Freshwater input to the North Atlantic may increase by 15%
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- Ice free Arctic during summer $p\text{CO}_2 > 500\text{ppm}$
-
- open ocean productivity may decrease by 20%
-
- Ocean acidity has already increased by 30%
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- ...
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- **How do the basin scale climate signals propagate**
- **on the NW European shelf?**
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1.5 degree

0.4 degree

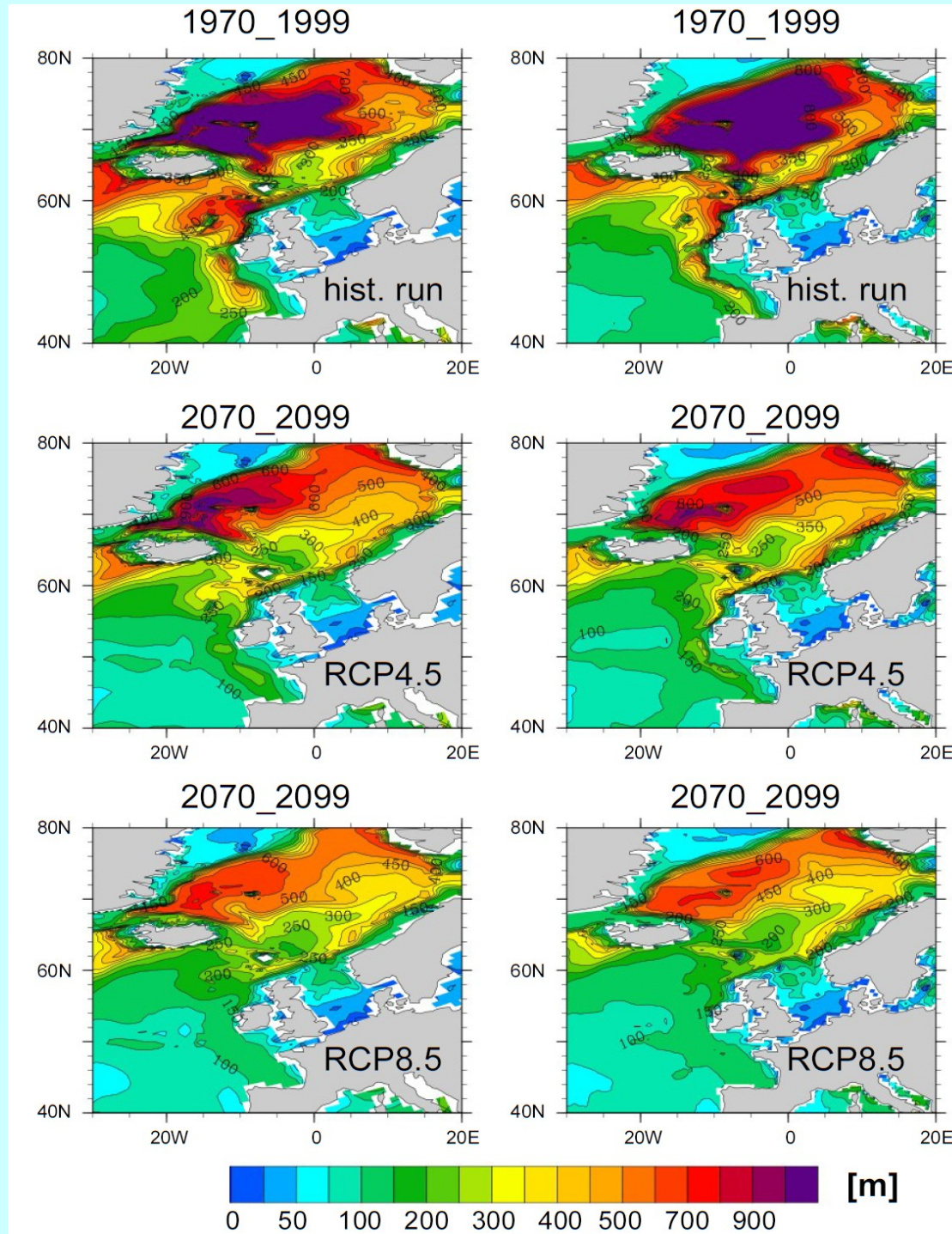
Max mixed layer depth

simulated by the Max-Planck-Institute Earth System Model in different resolutions and different scenarios

Robust feature of reduced MLD in warming scenarios (in agreement with many other global models, e.g. Steinacher et al., 2010).

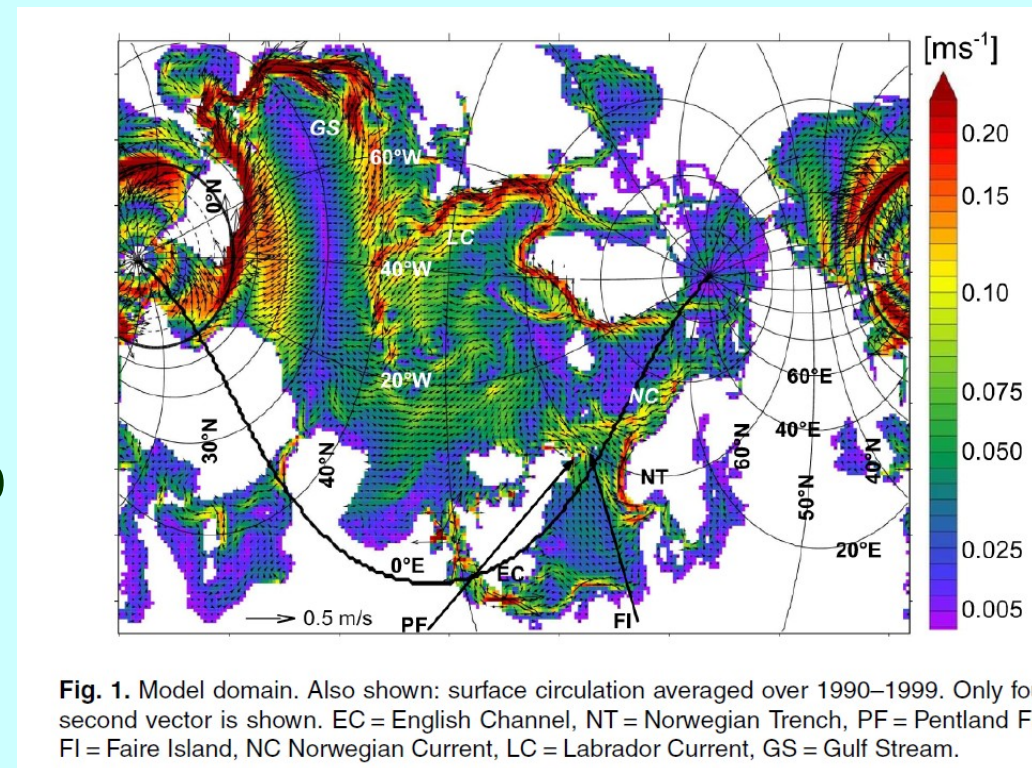
stronger warming – stronger effect

resolution – less important



Models

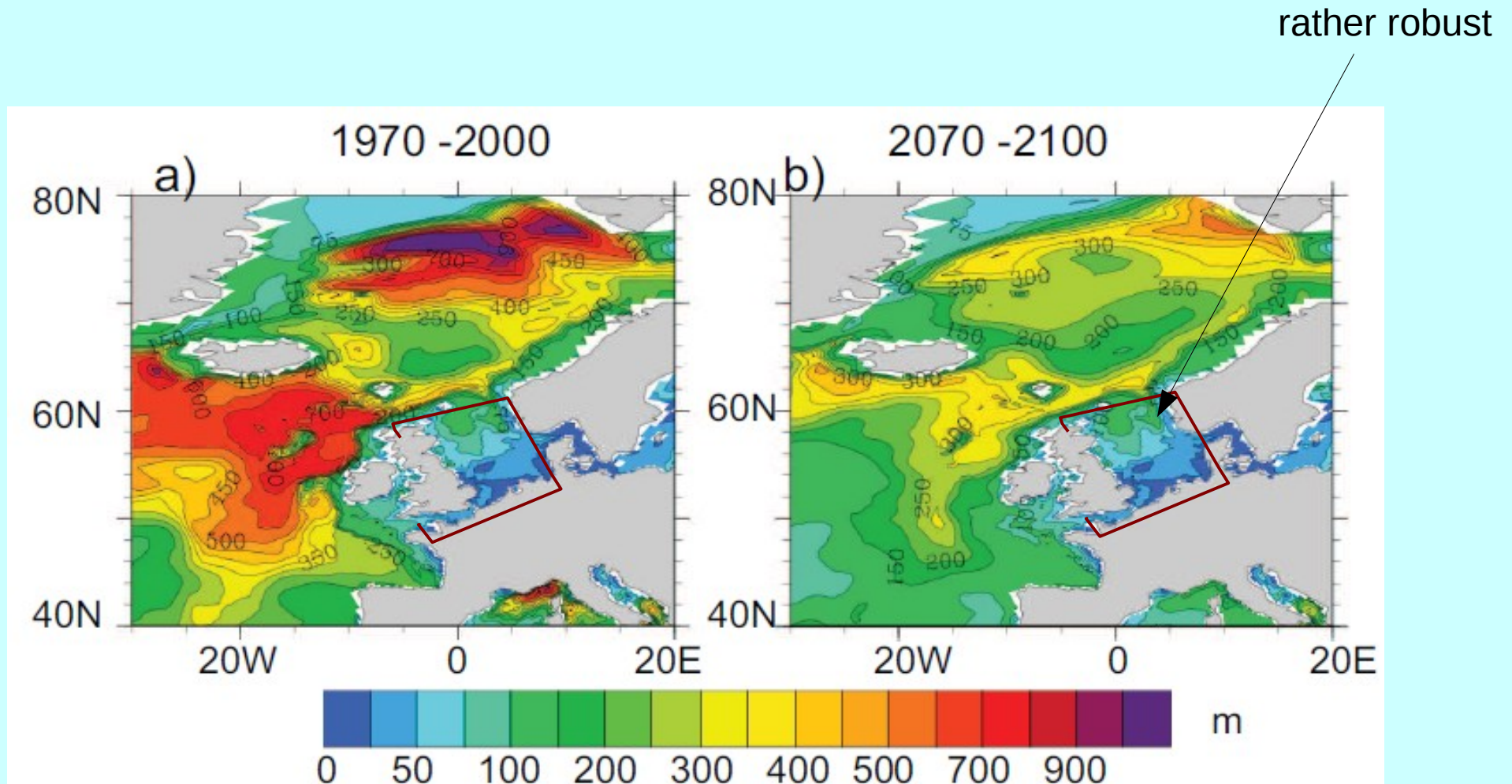
- **Ocean GCM** including dynamic thermodynamic sea ice (Hibbler, 1979)
- 1.5° (10 km), 0.6° (4 km), free surface
- 30 vertical z levels
- no SST restoring
no SSS restoring in the Baltic
- **Regional Atmosphere REMO**
37 km 27 vertical levels
- **Biogeochemistry model**
(modified NPZD model
including sediment model)



Model validation of is available at:
Gröger et al. (2013): NW European shelf under climate warming: Implications for open ocean – shelf exchange, primary production, and carbon absorption (Biogeosciences, accepted).

IPCC SRES A1B downscaled to NW European shelf

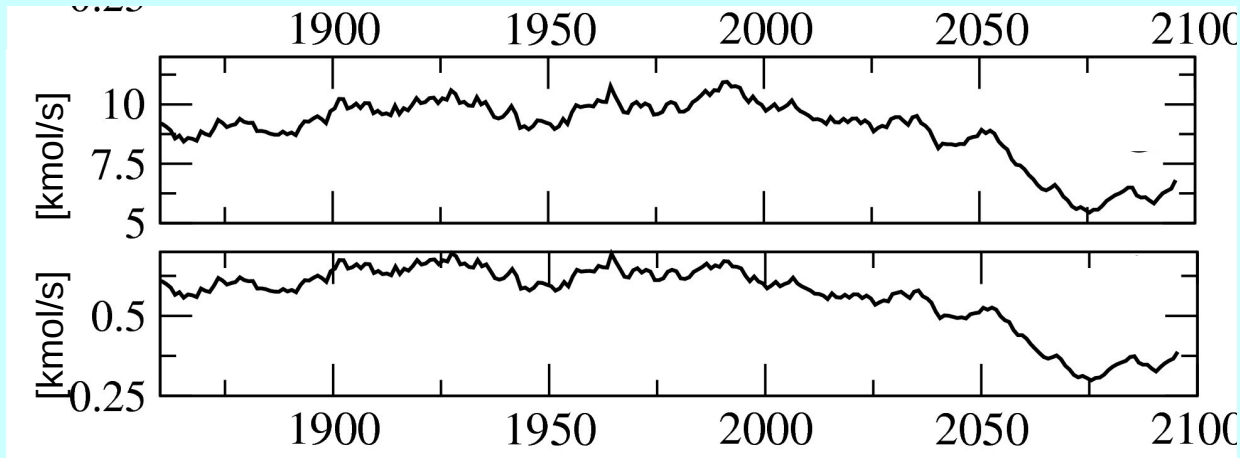
- *Slope hydrography* Winter mixed layer depth



IPCC SRES A1B downscaled to NW European shelf

Integrated biogeochemical Parameters of the North Sea

thanks to J. Paetsch for providing
riverine nutrient loads



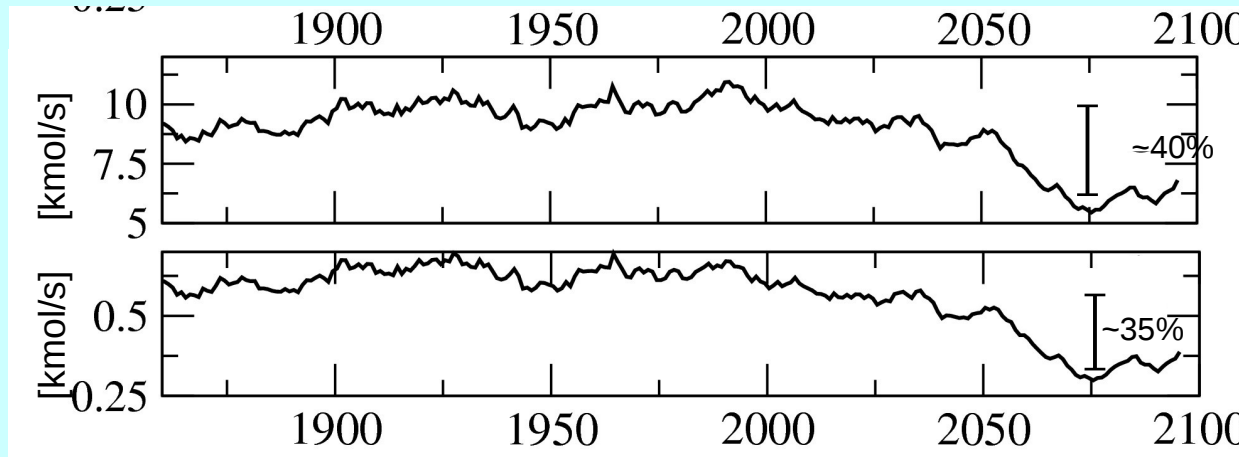
Transport of nitrate
into the North Sea across
the shelf break

Transport of phosphate
into the North Sea across
the shelf break

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Winter transport of nitrate
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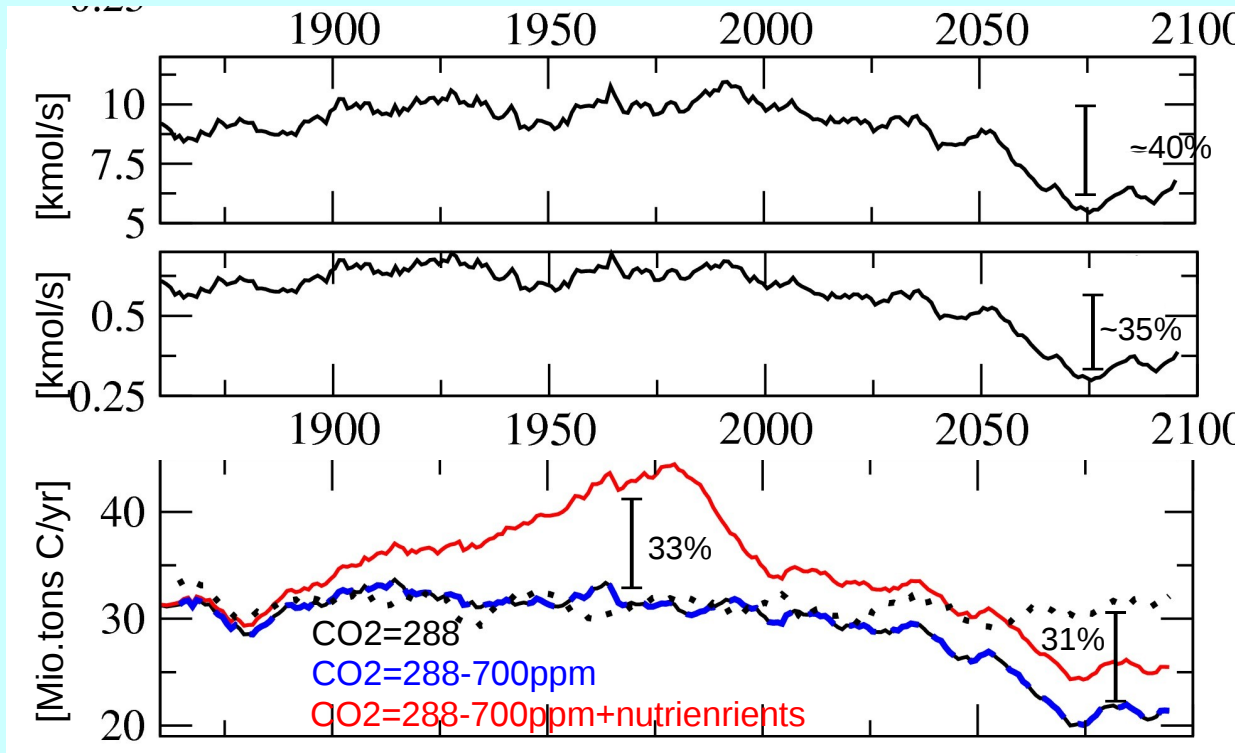
The downscaled simulations predict a decrease of > 40 %

in qualitative agreement with other models (Holt et al. 2012: ~20 % reduction)

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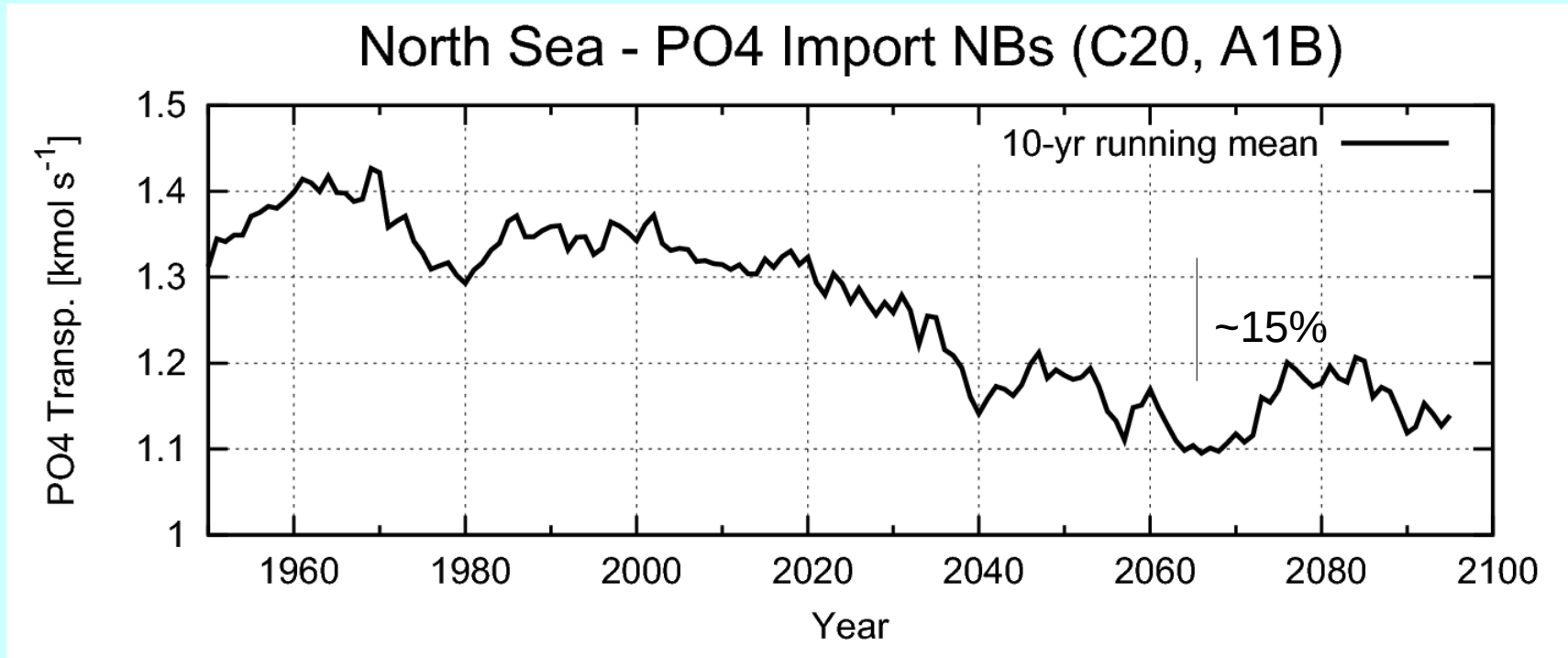
Transport of nitrate
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Transport of phosphate
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- Yearly integrated
primary production

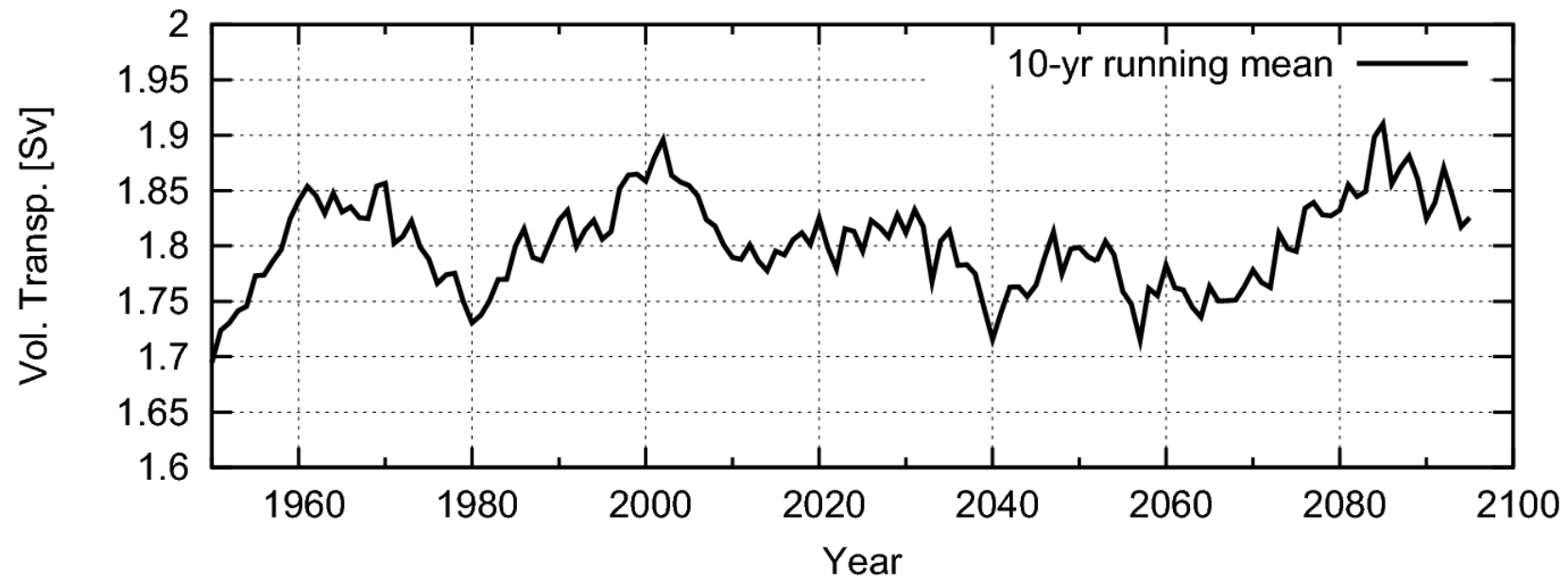
However, Holt et al., 2012 found a reduction of only 5% at the end of the 21th century
(despite 20% reduction in nutrient imports)

Coupled Atmosphere-Ocean downscaling REMO-MPIOM



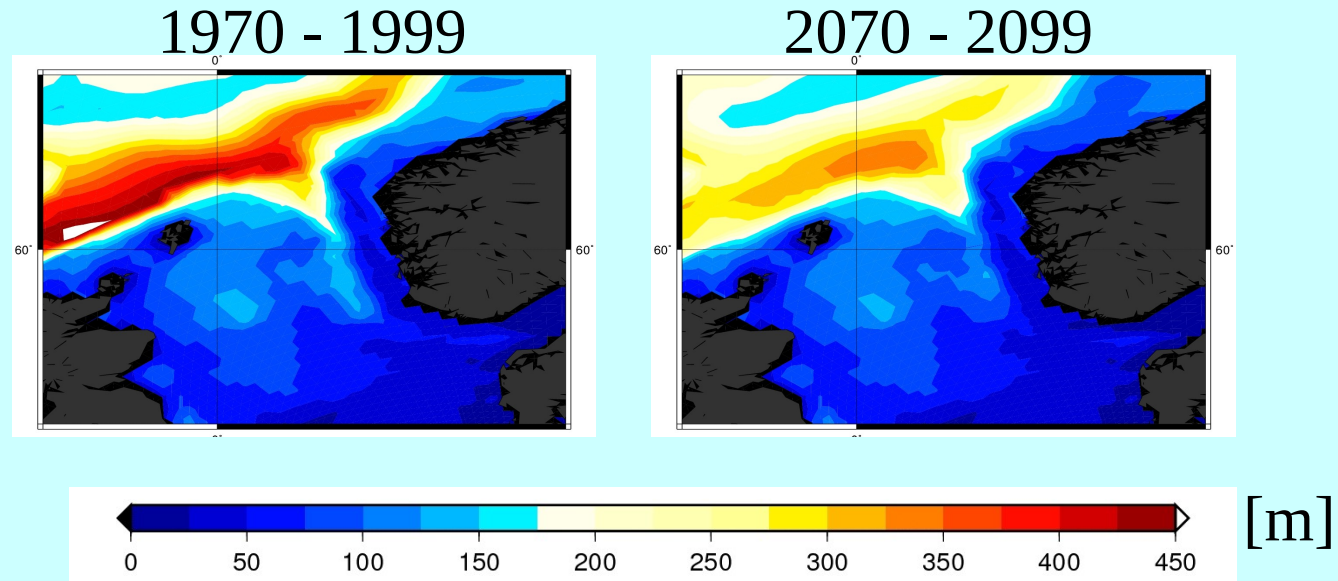
Remo winds are stronger and enhance upward vertical mixing compared to the uncoupled case

North Sea - NBs Inward Vol. Transport (C20, A1B)

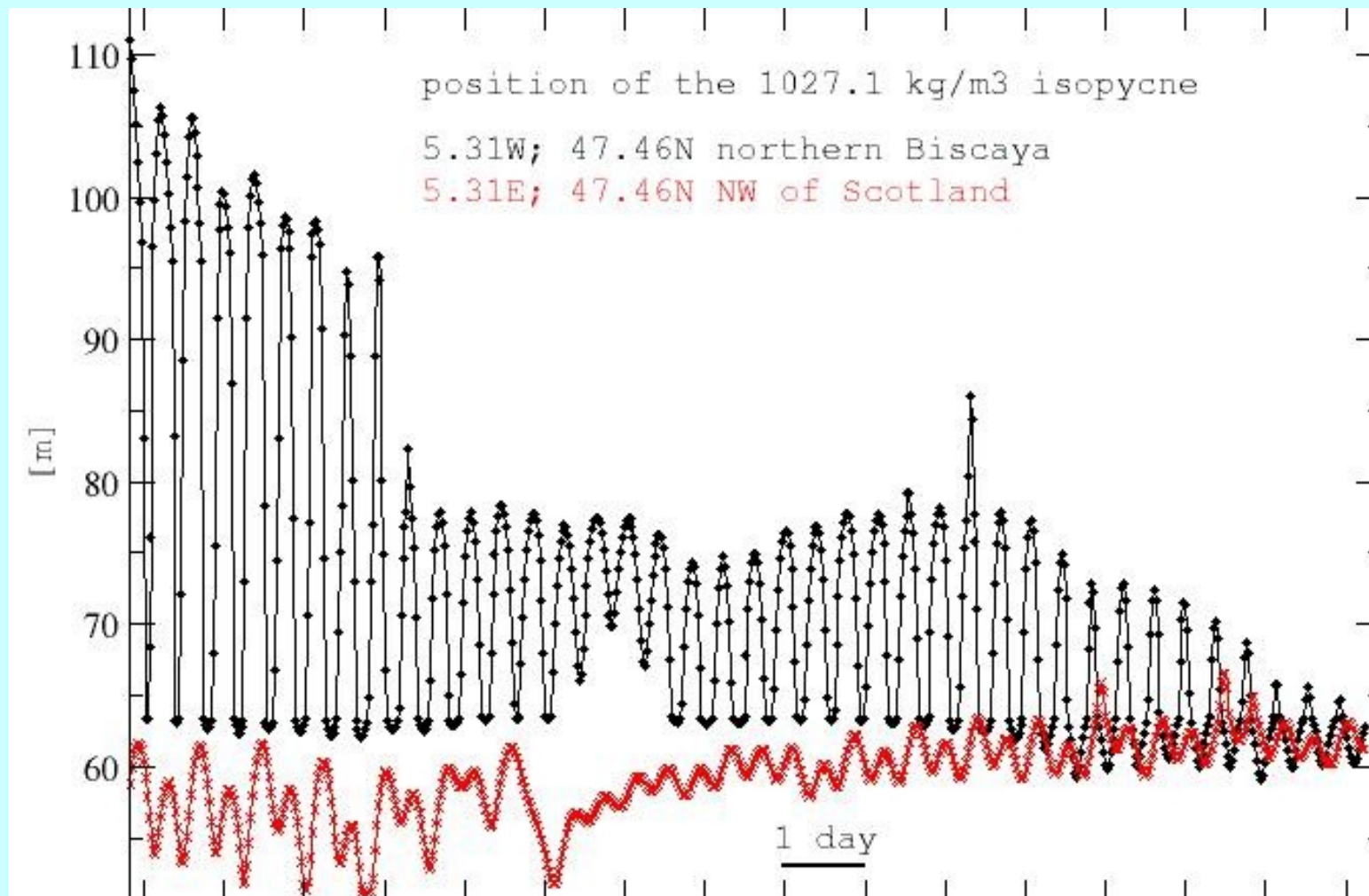


Another source of uncertainty – the shelf edge

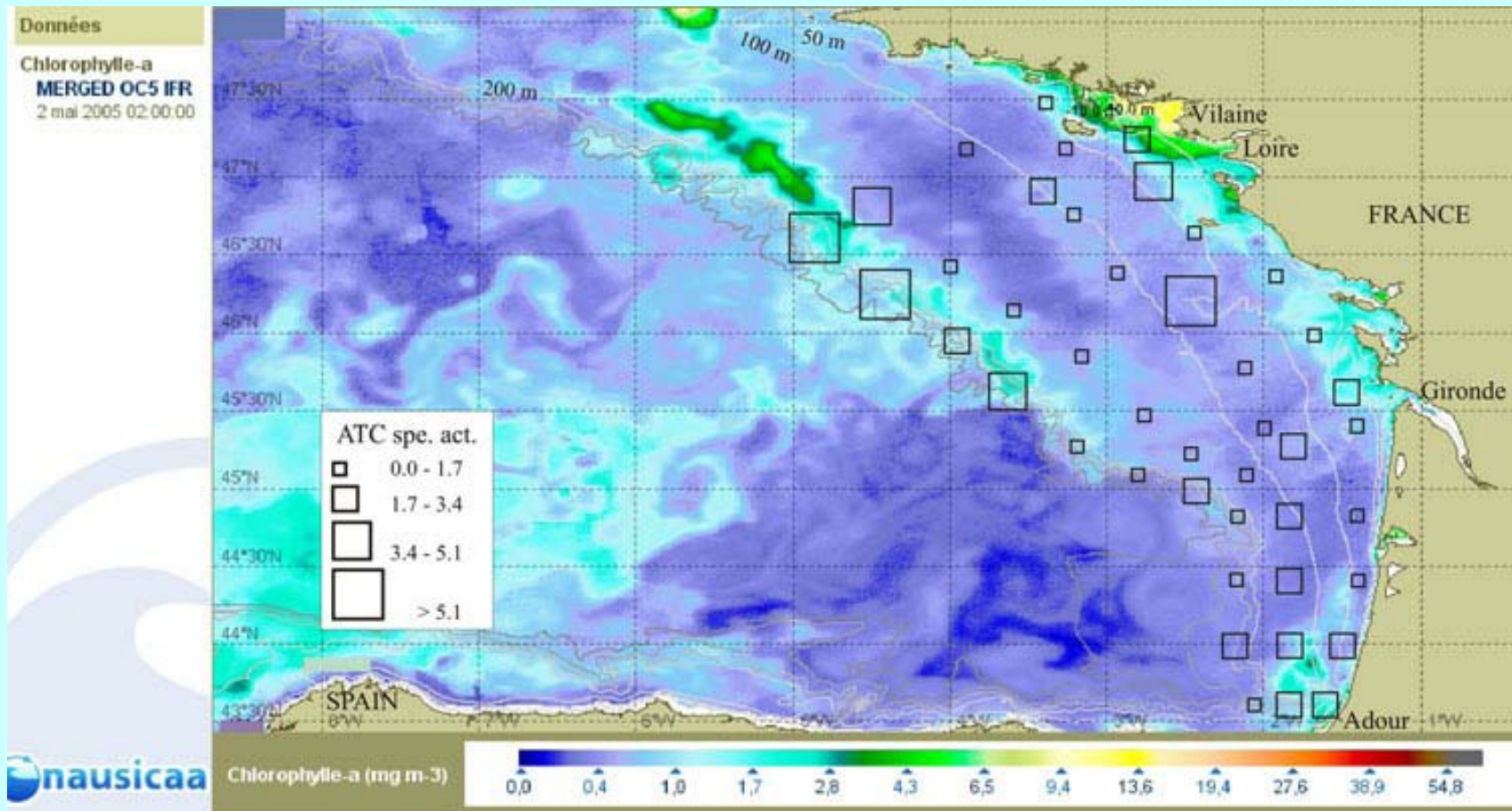
Winter mixed layer depth



Vertical movement of the 1027.1 kg/m³ isopycne at two stations along the NW European shelf. The timeseries was extracted from a model experiment and covers the period from the 16th to 31st of August in 1995



mixing induced biological production along the shelf break



Questions and Conclusions !?

Global models agree that the North Atlantic will warm, freshen and become more stratified

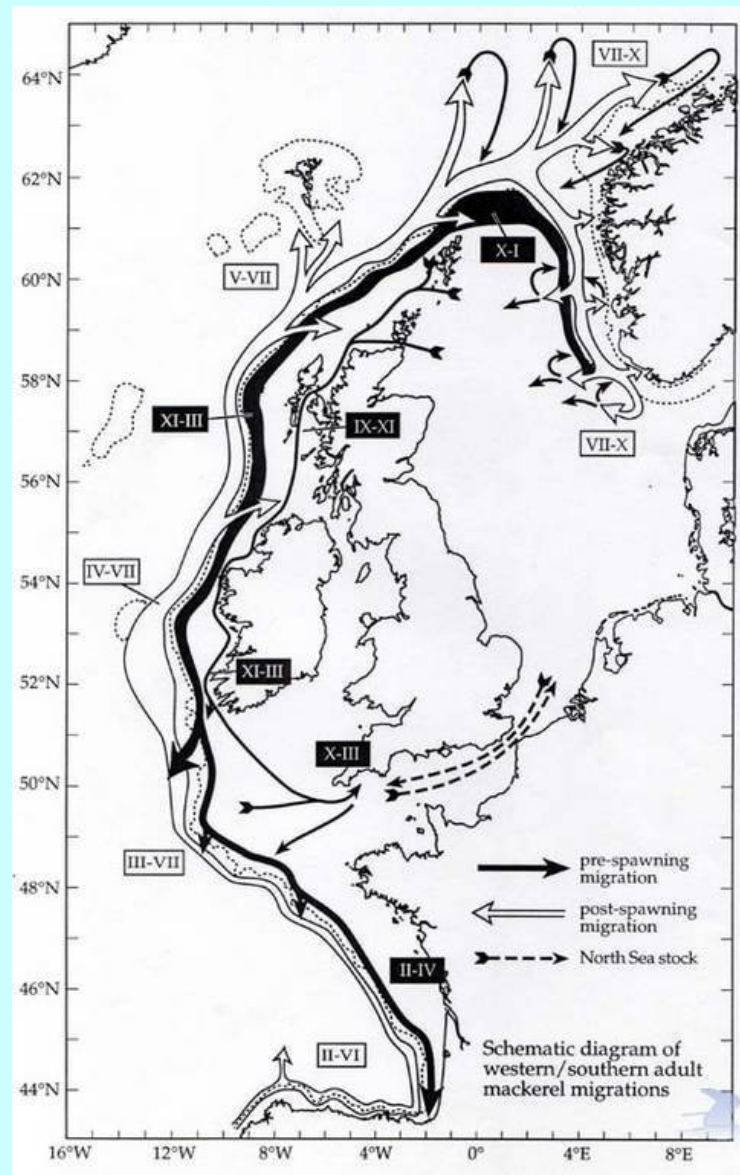
This will likely reduce the nutrient import from the Atlantic (into the North Sea).

BUT

How sensitive/robust is primary production to varying external nutrient sources?

Main processes determining production are highly parameterized. Is there enough empirical evidence for the assumed relationships?

The specific processes at the shelf edge are probably not adequately resolved in current models but may influence the on-shelf nutrient inventory.



The Shelf Seas...

generate ~90% of world fish catches

- (Pauly et al., 2002)

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- may account for 20 to 50% of current oceanic carbon uptake

- (Tsunogai et al., 1999, Thomas et al., 2004)

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- may account for ~30% of total marine primary production

- (Wollast, 1998)

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- **The Problem:**

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Climate models predict substantial changes for mid/high latitudes

- but they do not adequately resolve shelves

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- Regional models have to prescribe mass and energy fluxes at

- their domain boundaries

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- **Therefore...**

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