Climate of the Baltic Sea Region

Regional climate system modeling - reconstruction of past climate and future projections

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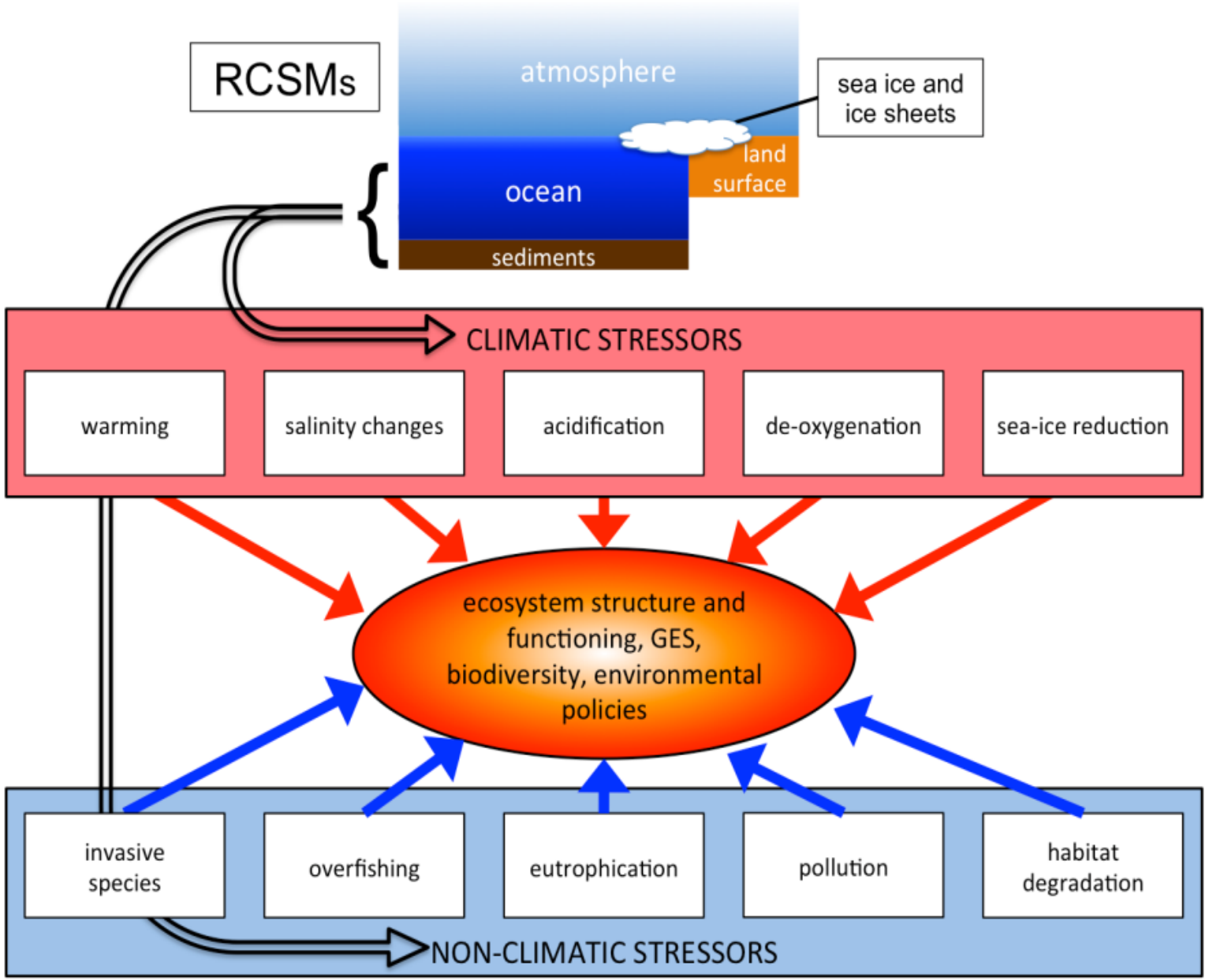
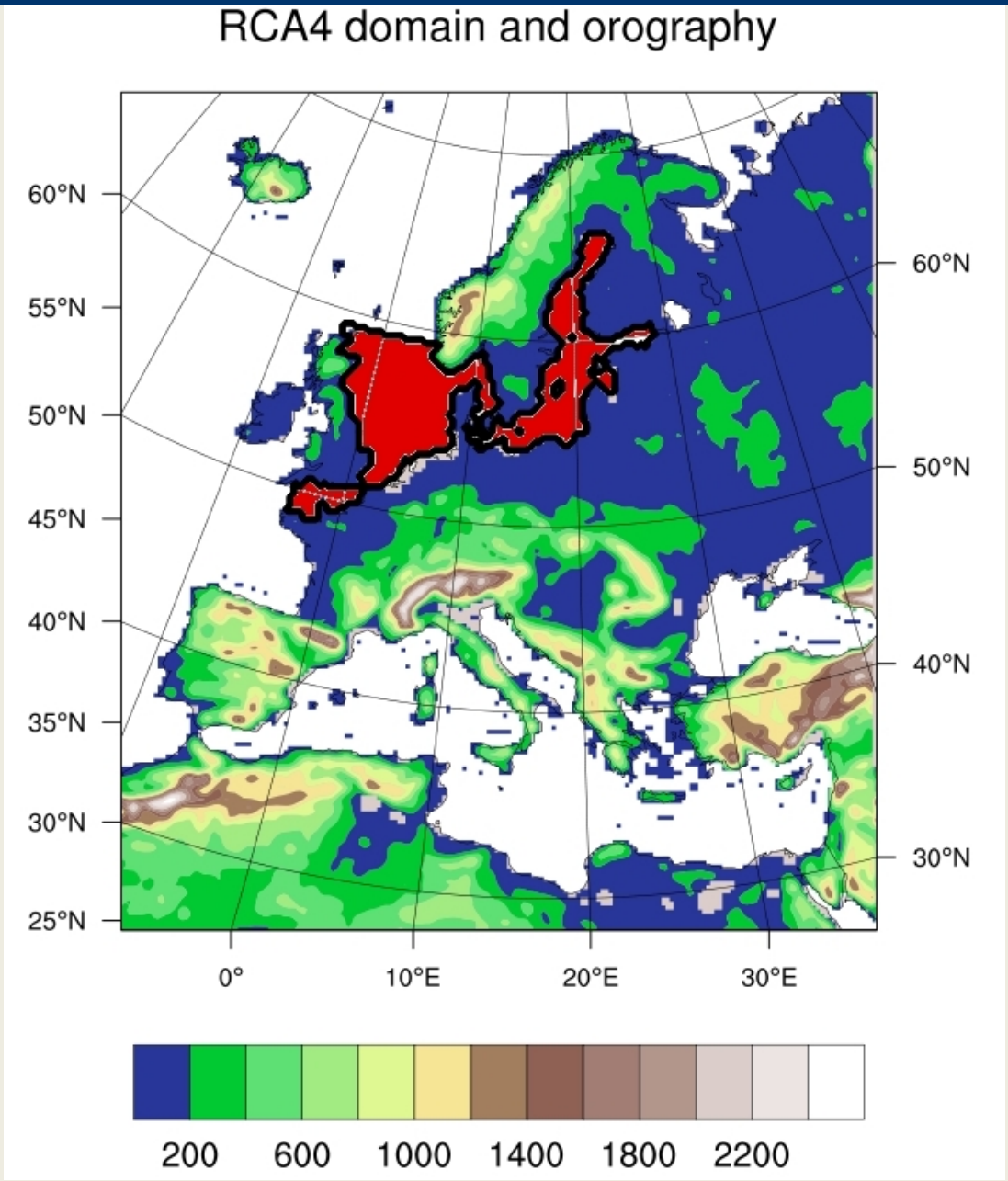


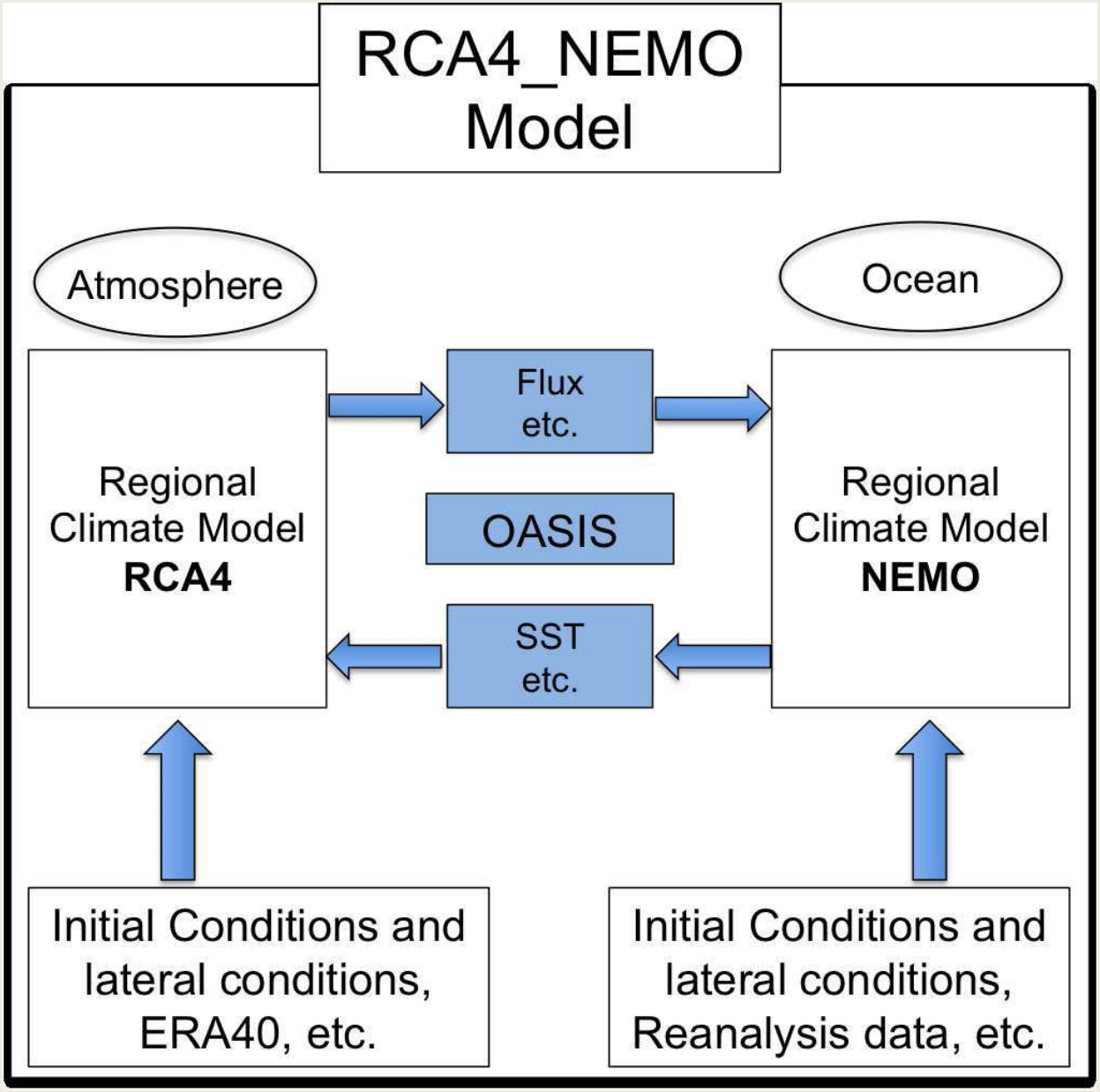
(Source: S. Schimanke, IMPROVE)

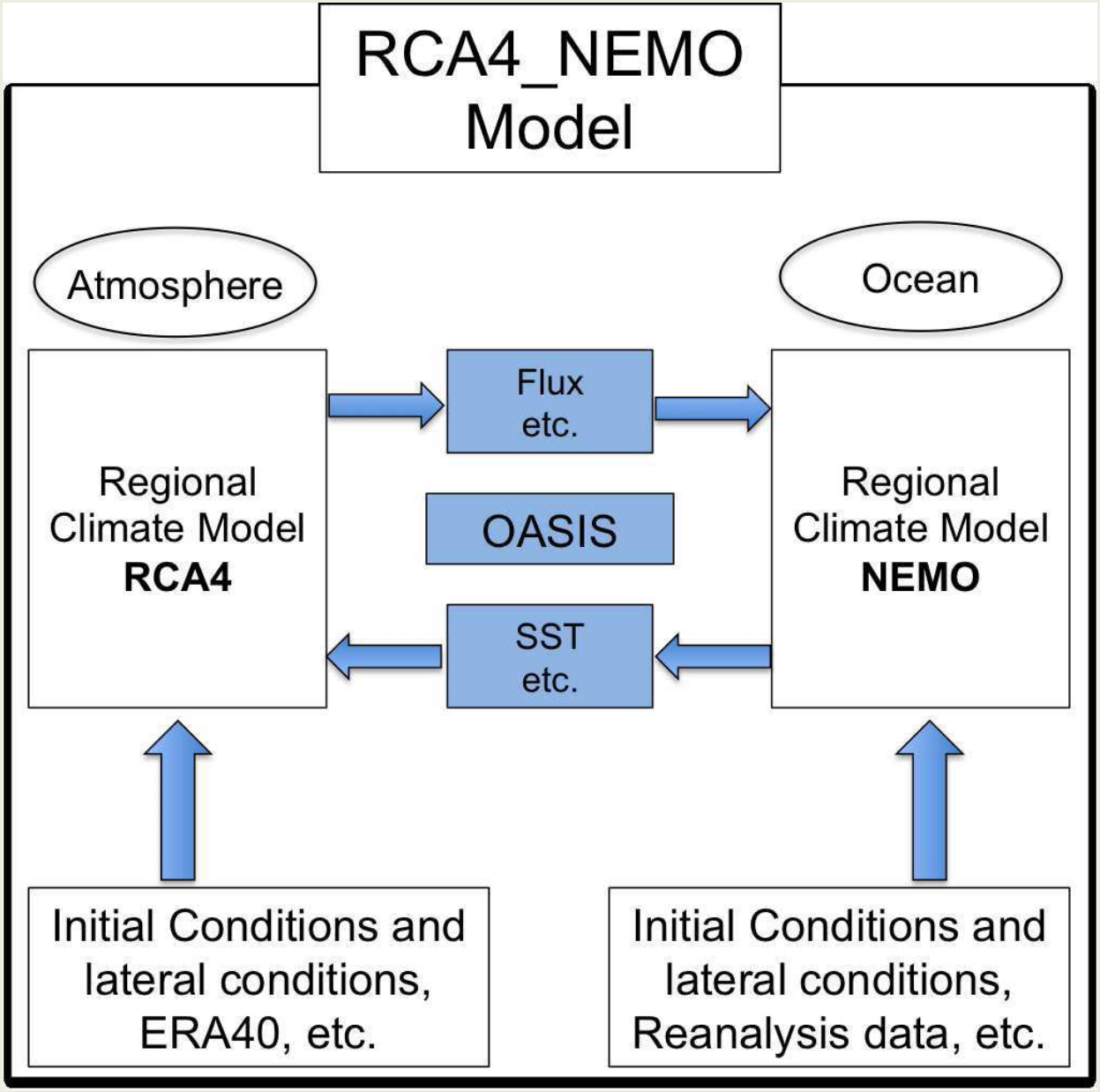
SMHI's regional climate models:

RCAO (Source: Döscher et al., 2002)

RCA-NEMO (Source: Wang et al., 2015)




RCA4_NEMO Model
Atmosphere
Ocean
Regional Climate Model RCA4
Flux etc.
OASIS
SST etc.
Regional Climate Model NEMO
Initial Conditions and lateral conditions, ERA40, etc.
Initial Conditions and lateral conditions, Reanalysis data, etc.

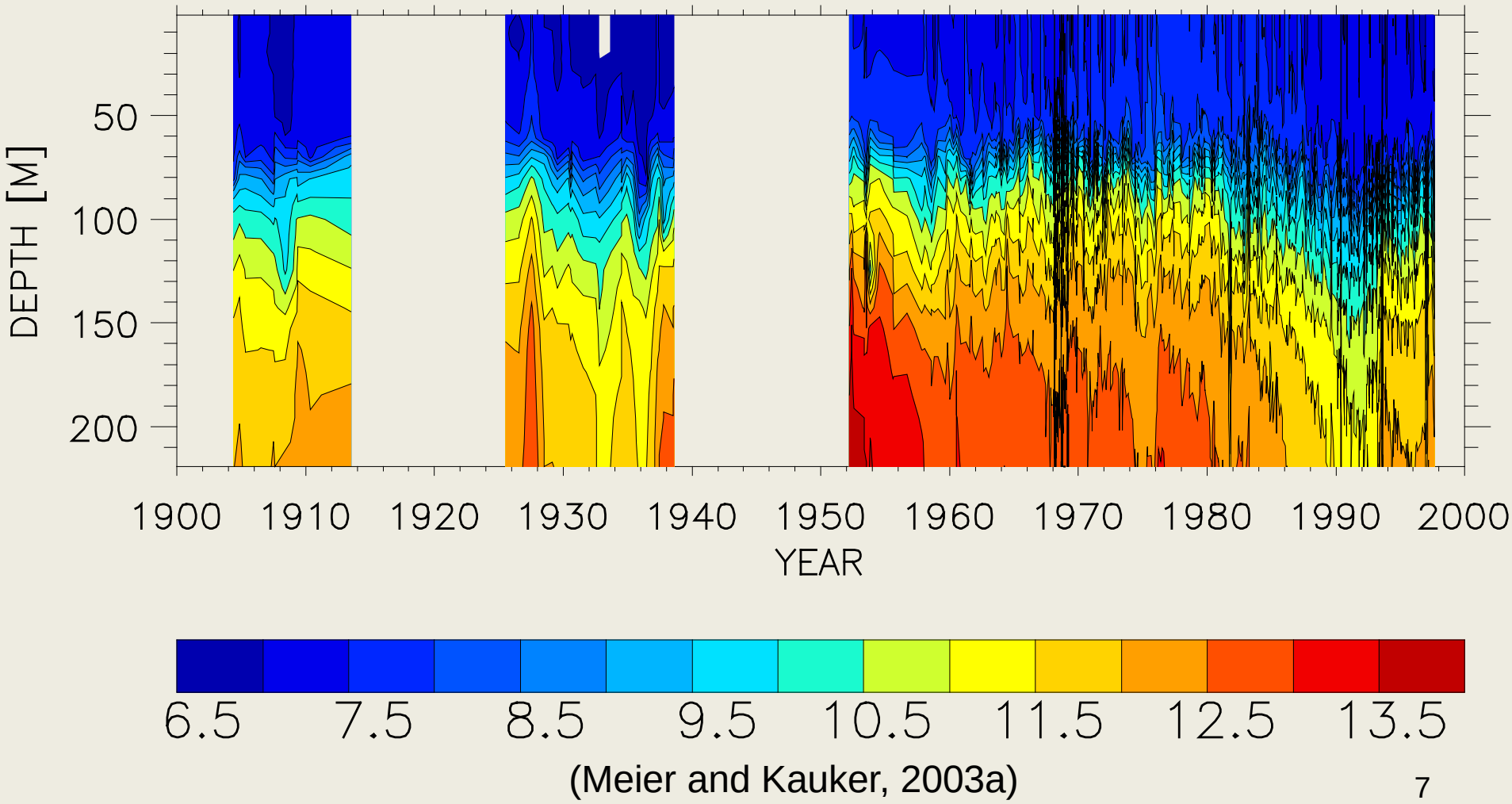


Additional components:

- sea ice
- waves
- marine biogeochemistry
- (marine food web)
- sediments
- land surface and hydrology
- lakes
- (dynamic land vegetation)
- (atmospheric chemistry)

Causes of decadal variability during the 20th century

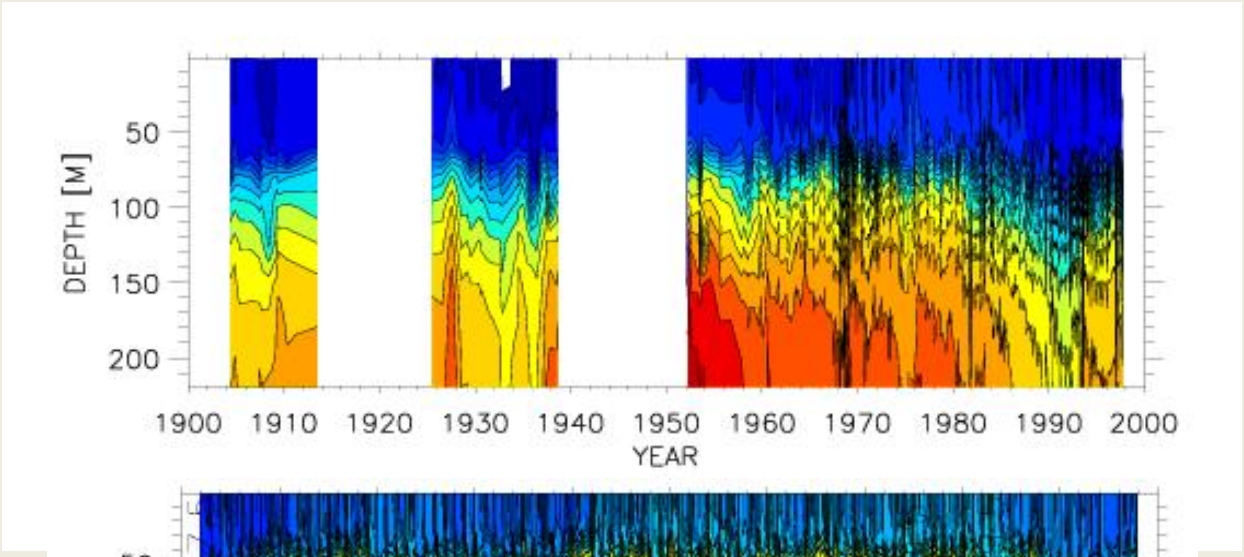
Salinity as function of time and depth at Gotland Deep



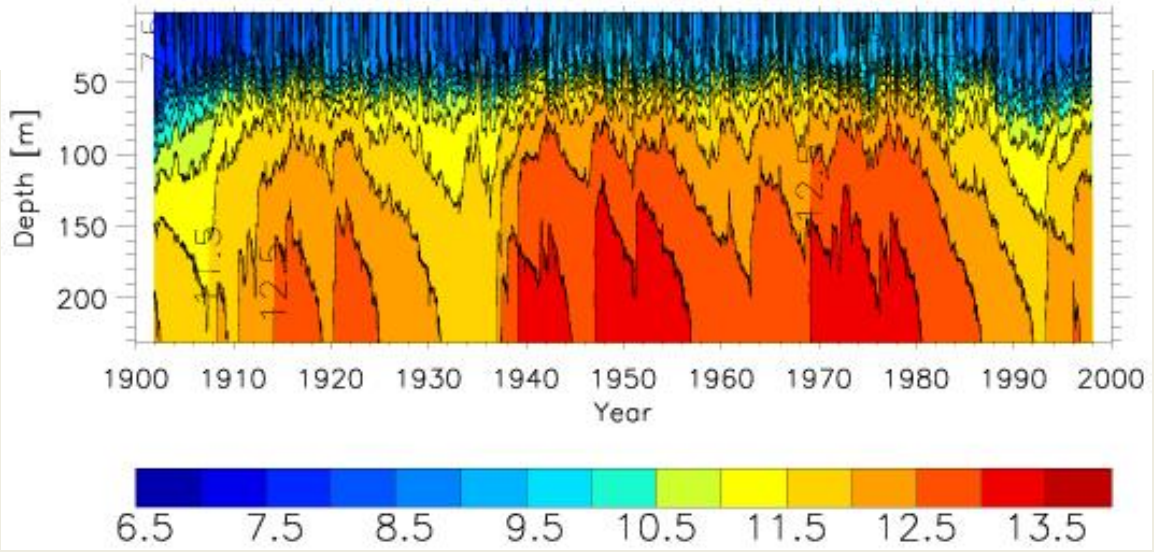
(Meier and Kauker, 2003a)

Salinity Gotland Deep

Data



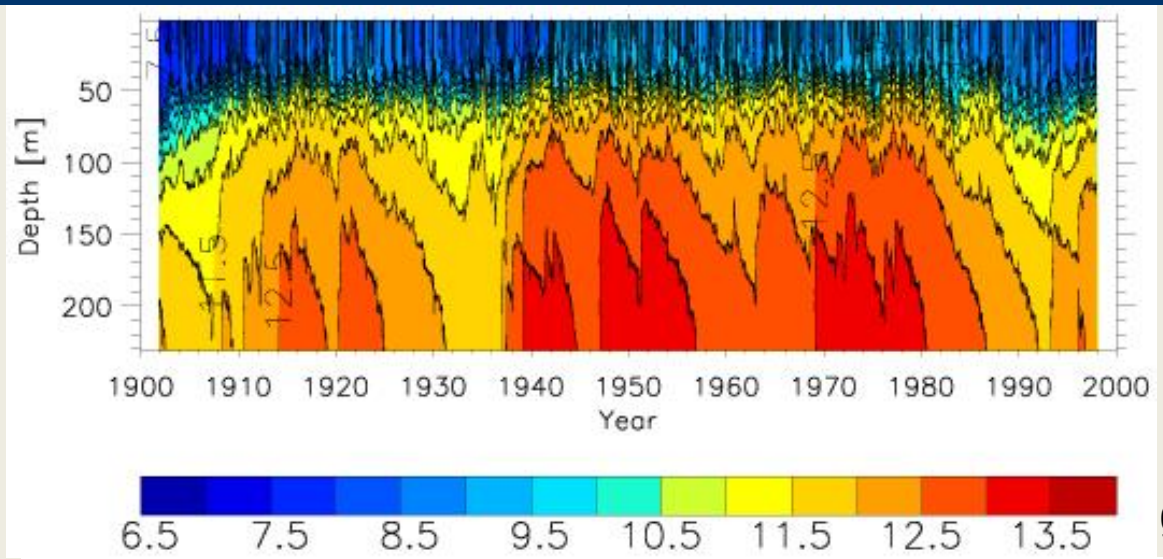
Model



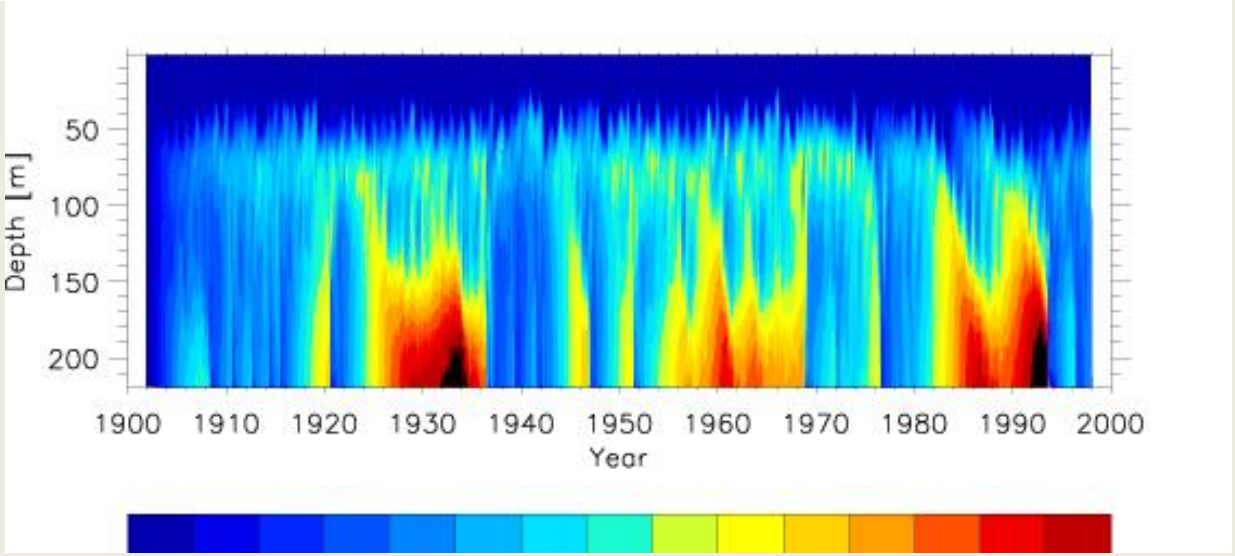
(Meier, 2005)

g kg^{-1}

Salinity



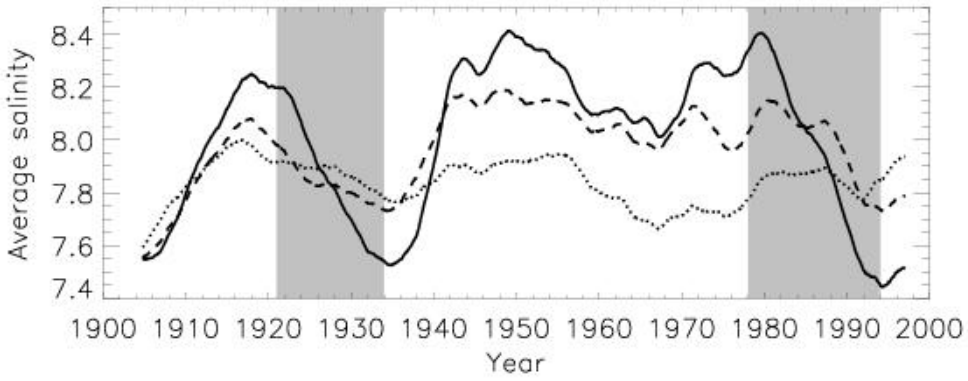
Age



(Meier, 2005)

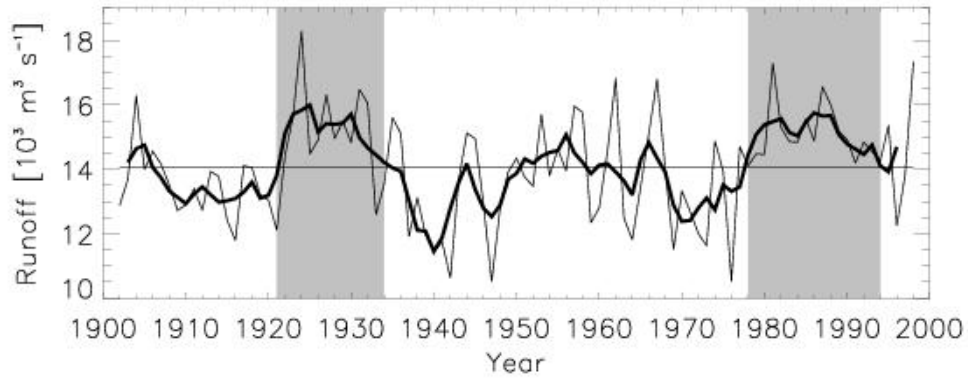
Stagnation periods

Salinity



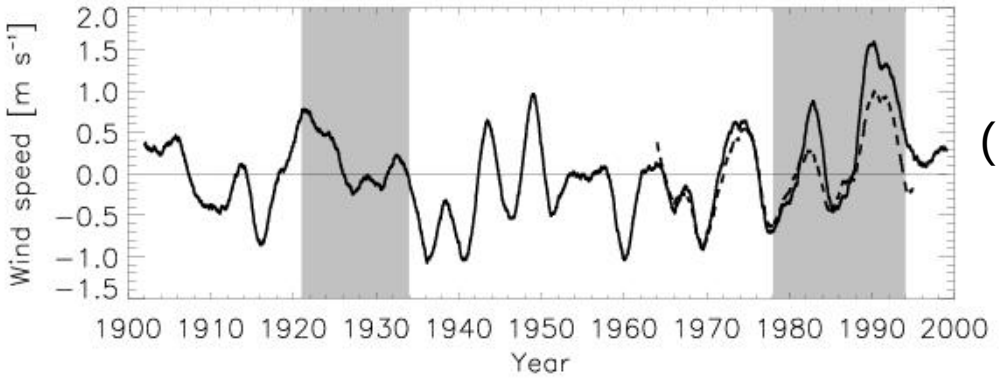
— 4-yr running mean

Runoff



Stagnation periods are shaded

Wind



(Meier and Kauker, 2003a)

Summary of decadal variability

- half of the decadal variability of salinity is explained by accumulated freshwater inflow variations (Meier and Kauker, 2003a)
- another significant part is caused by the low-frequency variability of the wind (Meier and Kauker, 2003a)
- remainder might be caused by the high-frequency wind anomaly, i.e. specific atmospheric conditions causing major saltwater inflows (Lass and Matthäus, 1996)
- no impact of river regulation, sea ice (air temperature), sea level in Kattegat on decadal time scale

Climate reconstruction of the Baltic Sea region during the past 1000 years

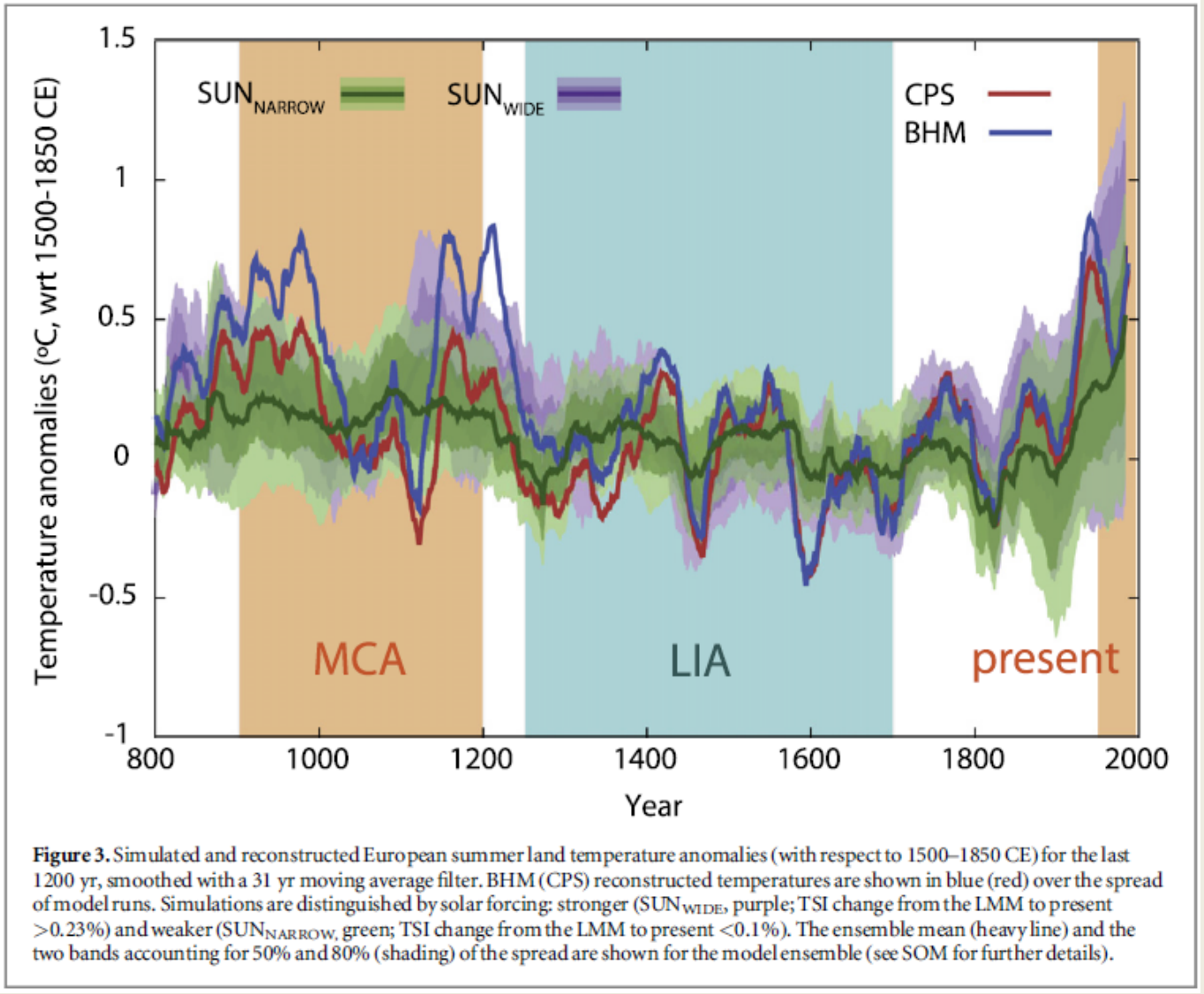


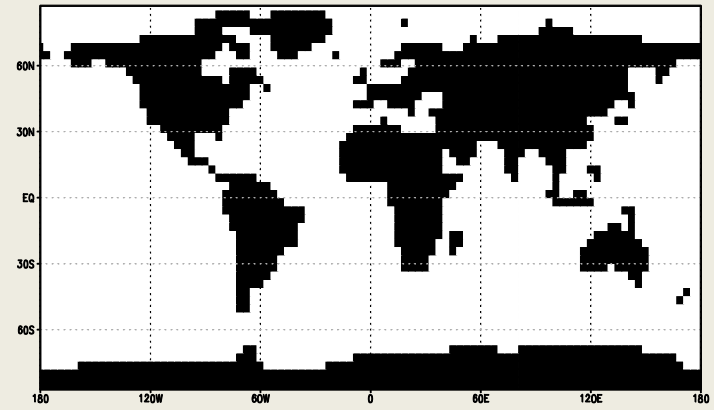
Figure 3. Simulated and reconstructed European summer land temperature anomalies (with respect to 1500–1850 CE) for the last 1200 yr, smoothed with a 31 yr moving average filter. BHM (CPS) reconstructed temperatures are shown in blue (red) over the spread of model runs. Simulations are distinguished by solar forcing: stronger (SUN_{WIDE}, purple; TSI change from the LMM to present >0.23%) and weaker (SUN_{NARROW}, green; TSI change from the LMM to present <0.1%). The ensemble mean (heavy line) and the two bands accounting for 50% and 80% (shading) of the spread are shown for the model ensemble (see SOM for further details).

(Source: Luterbacher et al. 2016)

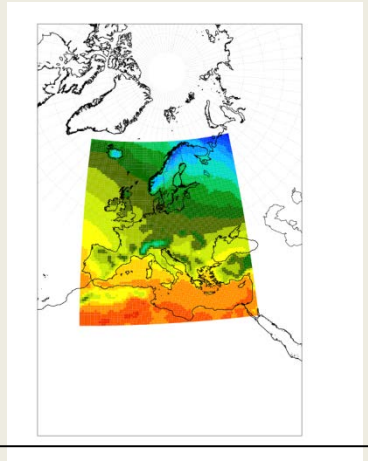
- Transient simulations of the last millennium (950-1997) with the global model and RCA3
- Solar variability, orbital parameters and GHG as forcing parameters
- 2 times 50 years sensitivity studies with RCO for selected time periods

(Source: Schimanke et al., 2012; Clim. Past)

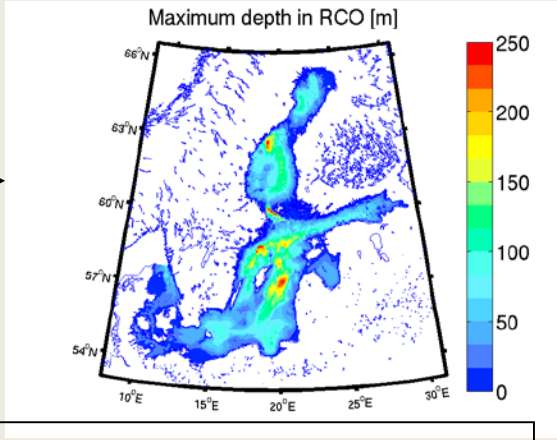
ECHO-G



RCA3



RCO



T30 ≈ 3.75° x 3.75°
19 vertical levels
HOPE-G (2.8°x2.8°)

0.44°x0.44° (~50km)
24 vertical levels

2nm (3.7km x 3.7km)
83 vertical levels
+ Biogeochemical model SCOBI

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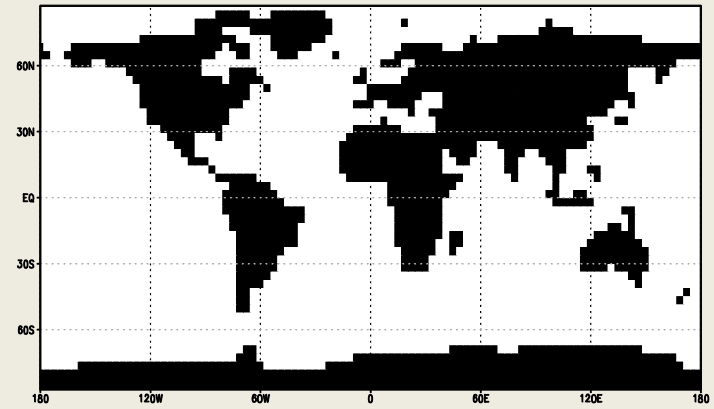

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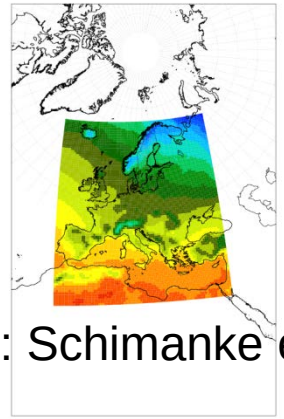
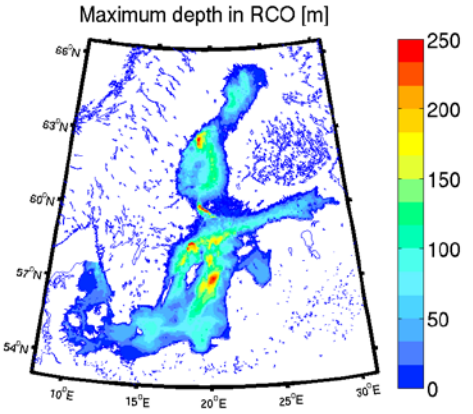


RCO



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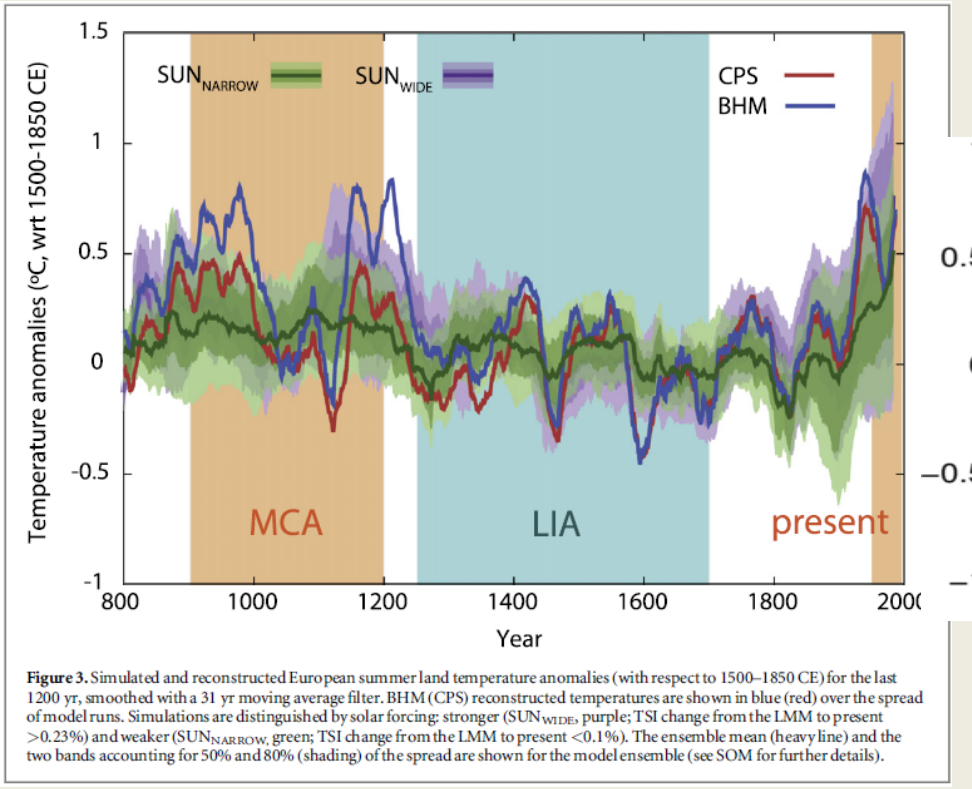

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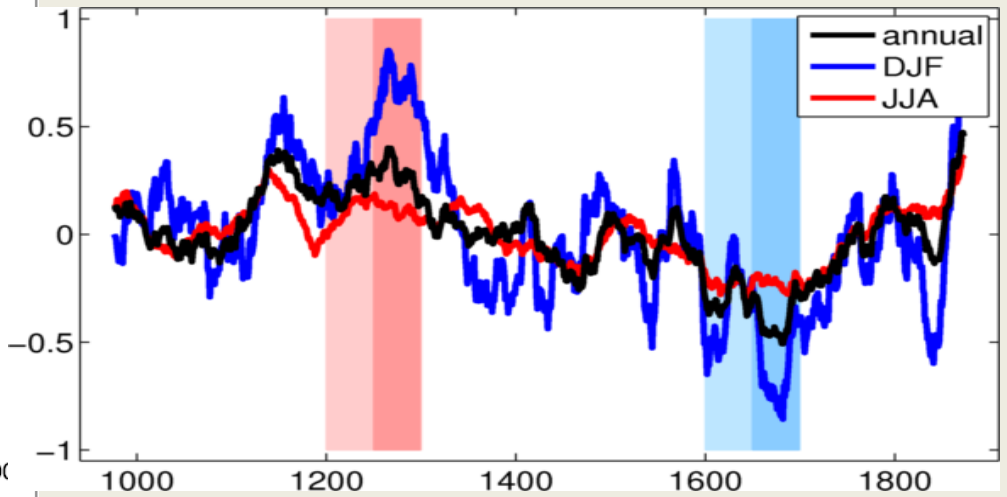
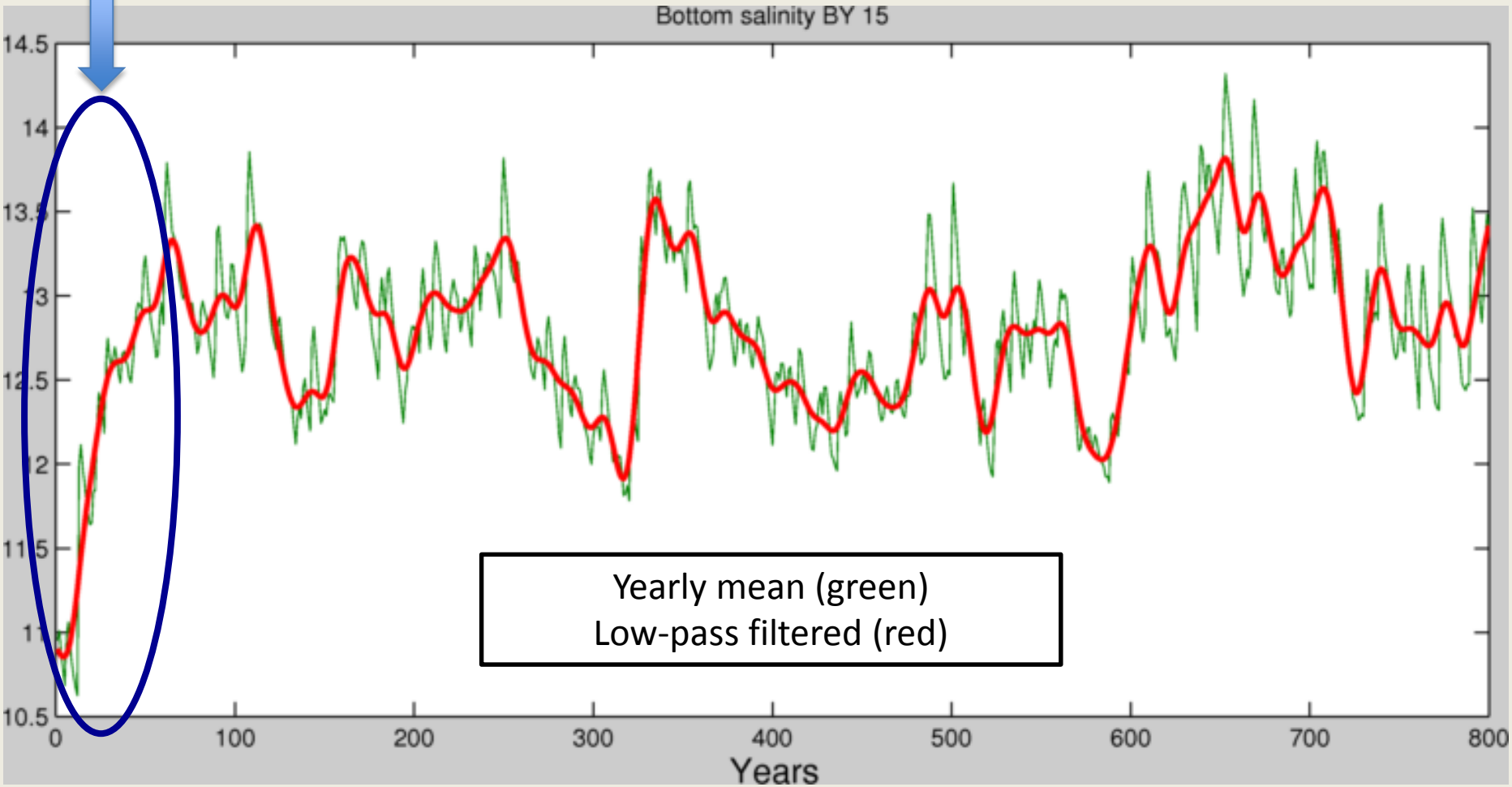


2 m-temperature anomaly w.r.t. the pre-industrial mean (950–1900) averaged over the Baltic Sea region

(Source: Schimanke et al., 2012)

Modeled salinity

Spin-up



(Schimanke and Meier, 2016)

How exceptional are long lasting stagnation periods in the Baltic Sea from a model perspective?

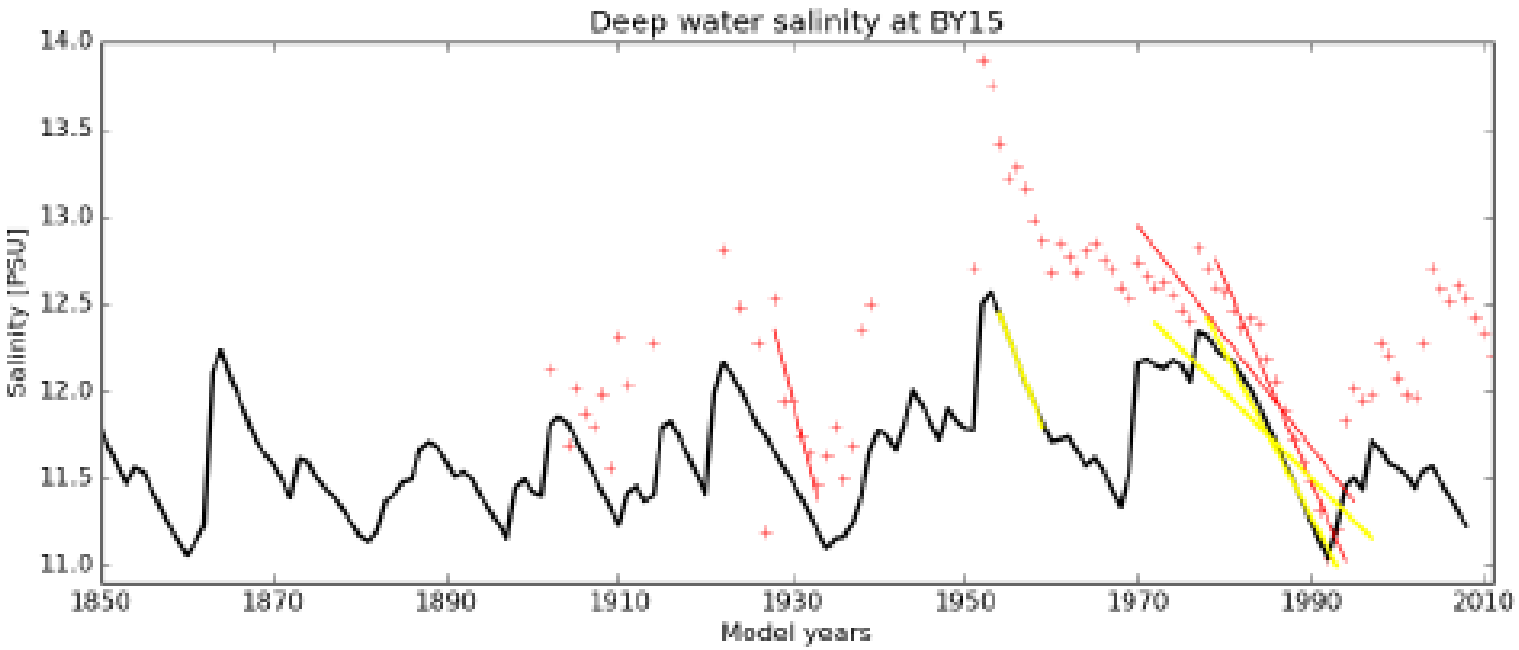


FIG. 2: Annual mean salinity of the hindcast simulation at BY15 in 200 m and strongest linear reductions in salinity (yellow lines) for periods of 5, 15, and 25 years. Observations based on BED and SHARK data are shown as red crosses, and corresponding maximum negative trends as red lines.

(Schimanke and Meier, 2016)

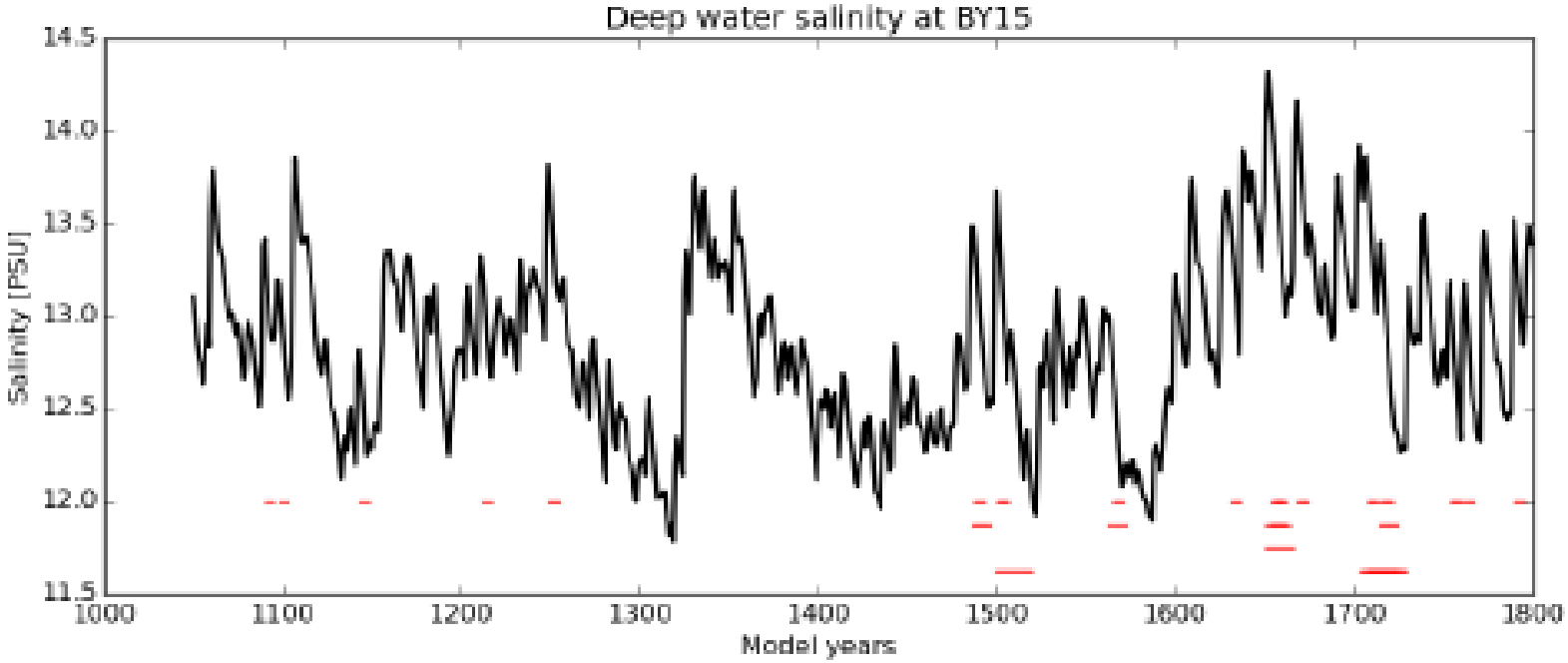


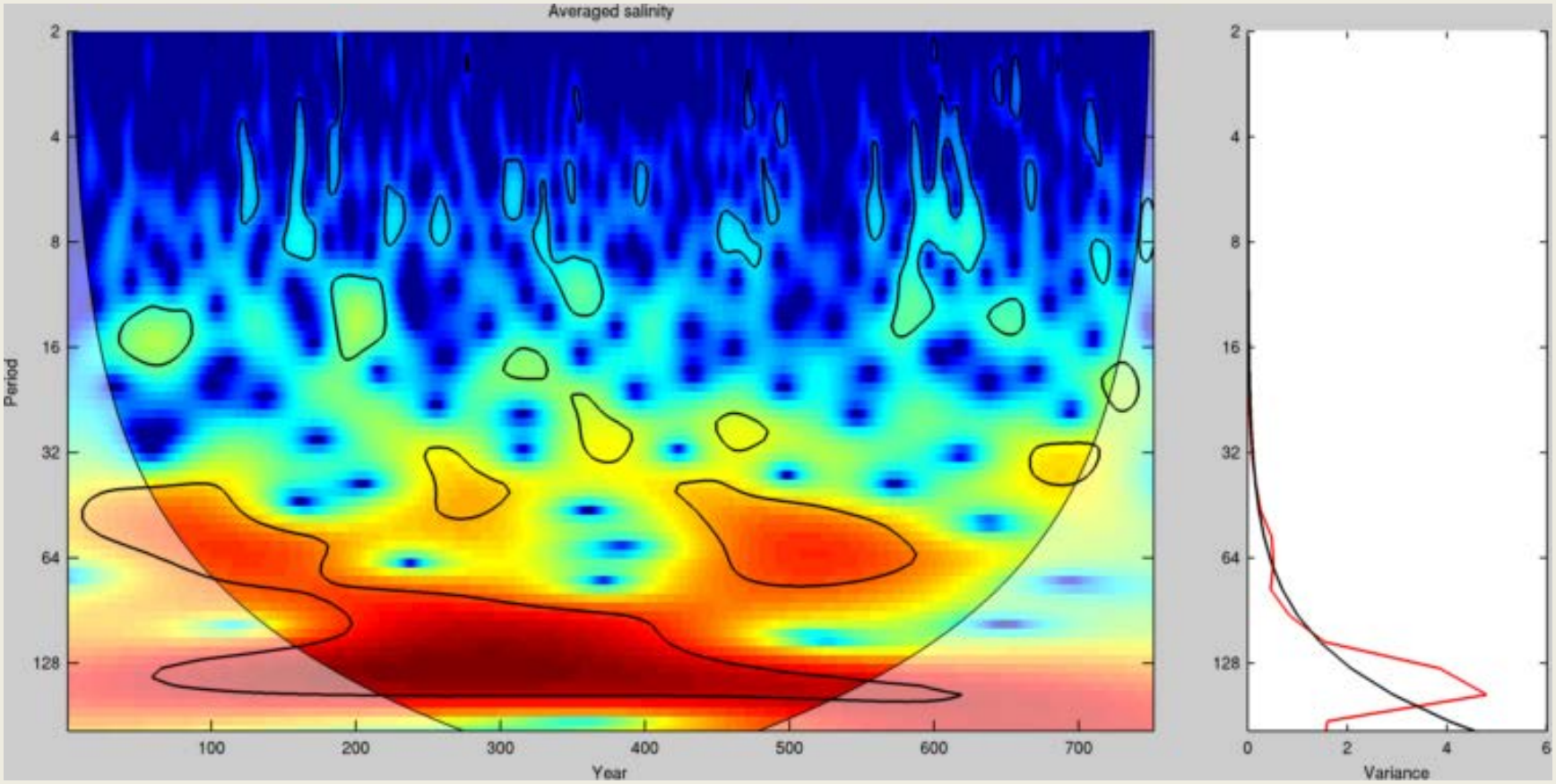
FIG. 3: Deep water salinity at BY15 in the long climate simulation (black line). The red lines indicate time slices with a reduction in salinity with a regression at least as big as in the hindcast simulation for 5-, 10-, 15- and 20-year periods of decrease.

(Schimanke and Meier, 2016)

- Stagnation periods over 10 years are not exceptional
- Longer lasting freshening periods (16 years) are unlikely from the model perspective
- 62% of the long-term salinity variability can be explained by runoff, temperature, wind and NAO fluctuations

Wavelet analysis

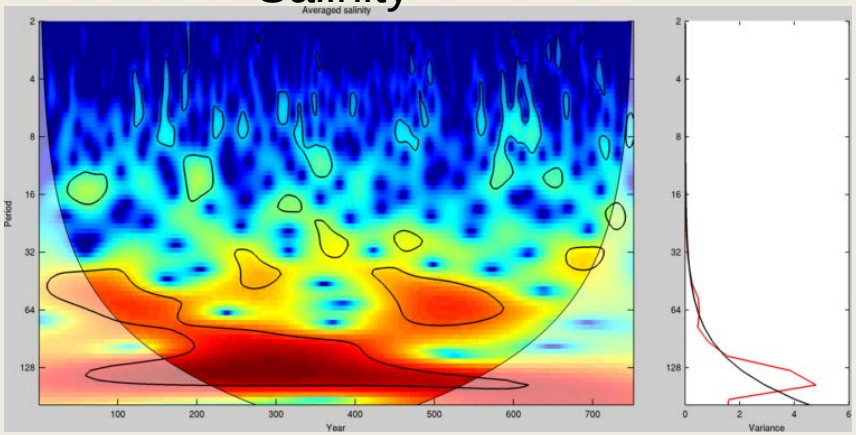
Time series analysis to detect power on different periods which can be non-stationary. Reddish means more power, black line indicates 95% significant level. Outside the cone of influence results are not reliable.



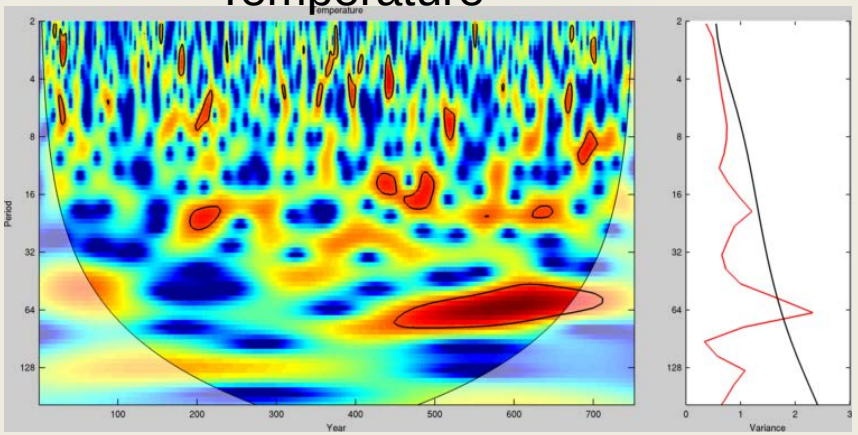
(Schimanke and Meier, 2016)

Wavelets

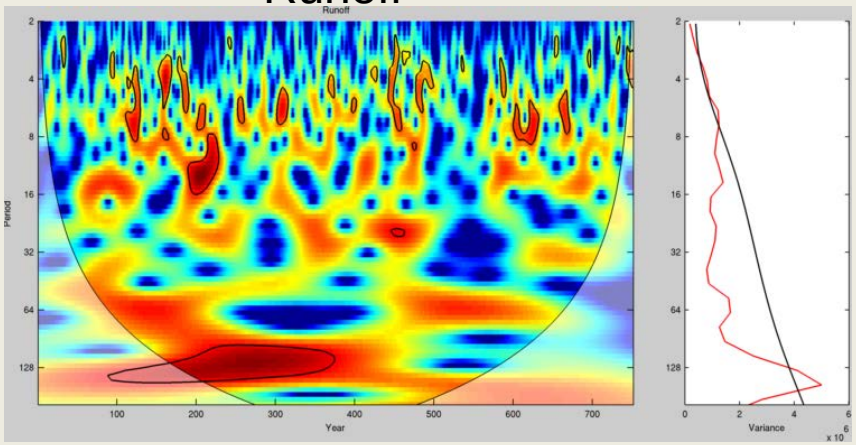
Salinity



Temperature



Runoff

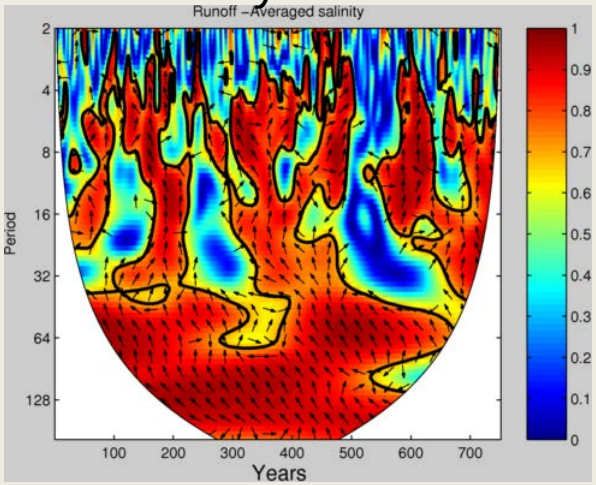


- Parameters have power on similar periods and time slices

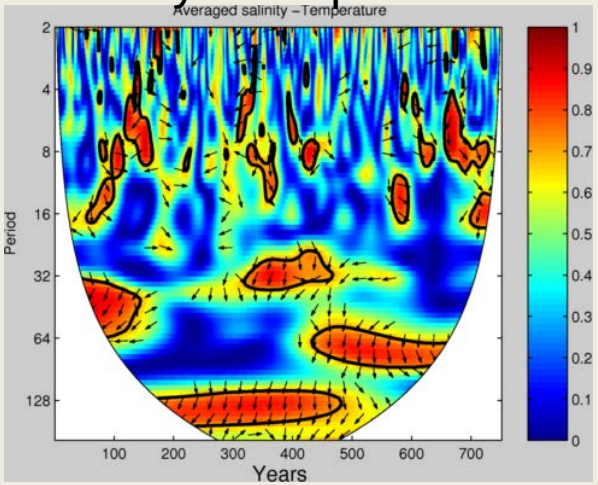
(Schimanke and Meier, 2016)

Wavelet coherence

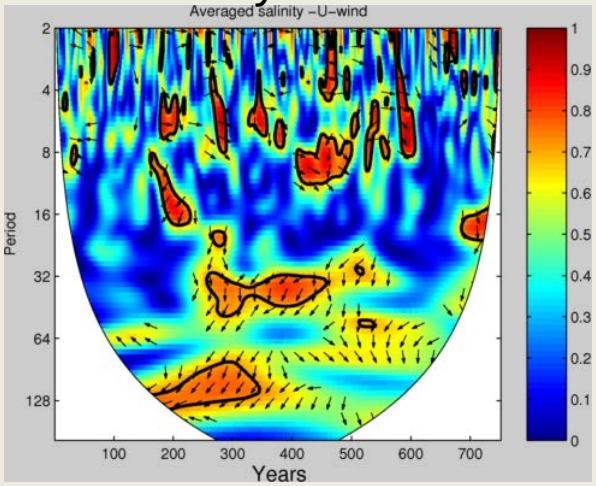
salinity – runoff



salinity – temperature

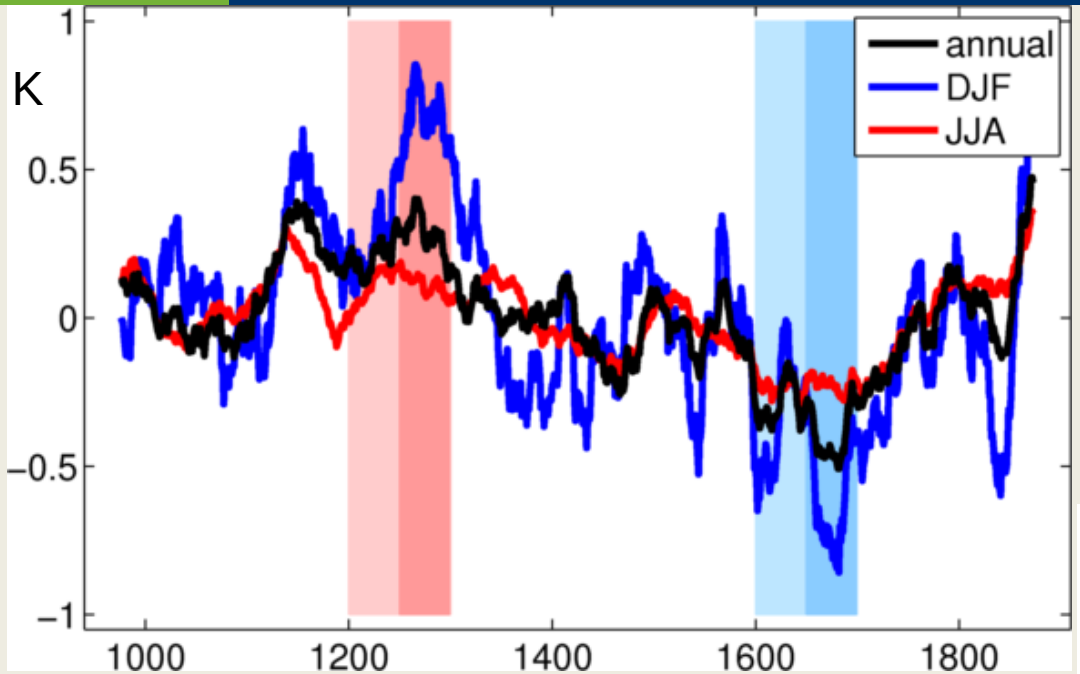


salinity – u-wind



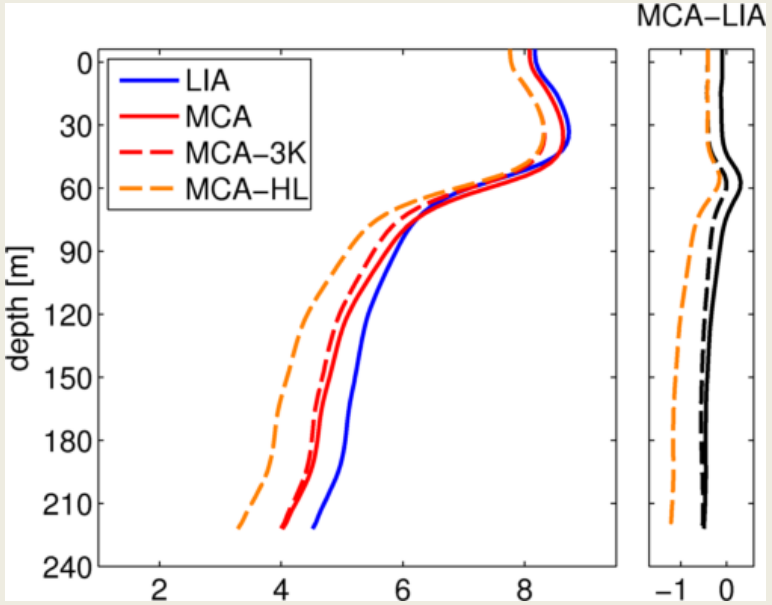
- no coherence for periods shorter than 4 years
- significant correlation of salinity and runoff for all periods larger than 4 years
- weaker coherence with temperature and u-wind
- enhanced power and coherence for frequencies larger 50 years must be investigated in more detail

(Schimanke and Meier, 2016)



2 m-temperature anomaly w.r.t. the pre-industrial mean (950–1900) averaged over the Baltic Sea region

50-year mean vertical oxygen concentration profiles at Gotland Deep



(Source: Schimanke et al., 2012; Clim. Past)

Thank you very much for your attention!