ESA-Baltic Earth Workshop
Earth Observation in the Baltic Sea Region
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Salinity dynamics of the Baltic Sea

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Salinity dynamics

BEAR – Baltic Earth Assessment Report

Baltic Earth Assessment Reports

Assessment of the current state of science in different research fields in the Baltic Earth context

BEAR for each of the Baltic Earth Grand Challenges (GC) will be published in a special issue in an Open Access scientific Journal, sometime in 2021

Grand Challenges – GC

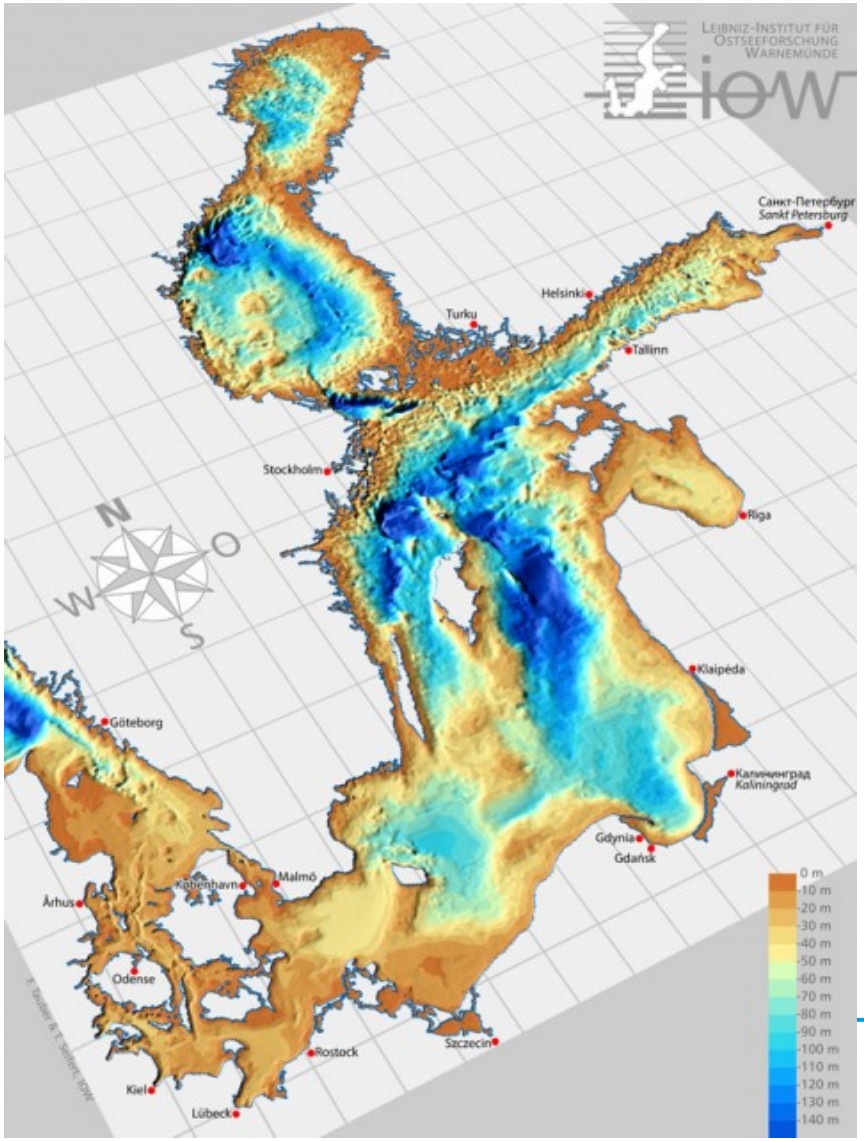
- **Salinity dynamics in the Baltic Sea**
- **Land-Sea biogeochemical linkages in the Baltic Sea region**
- **Natural hazards and extreme events in the Baltic Sea region**
- **Sea level dynamics in the Baltic Sea**
- **Regional variability of water and energy exchanges**
- **Multiple drivers for regional Earth system changes**

Baltic Earth Assessment Reports

BEAR on Salinity dynamics in the Baltic Sea

- Salinity dynamics of different space and time scales – knowledge from BACC I and BACC II
- Atmospheric forcing driving salinity dynamics
- Large volume changes & MBIs
- Cold intermediate layer and mixing
- Regional salinity dynamics (GoF, GoR, GoB, Lagoons)
- Climate variability and change – impact on salinity dynamics
  - The role of net precipitation and river runoff
  - Change of stratification
  - The role of sea level change due to global warming
- Impact of salinity dynamics on environmental conditions
  - Oxygen conditions
  - Environmental interaction between fish/larvae and salinity
- Knowledge gaps and outlook
- Conclusions and key messages

Salinity dynamics
Bottom topography



Area: 412560 km²

Volume: 21631 km³

South-North-Extension:
~1300 km (54°-66°N)

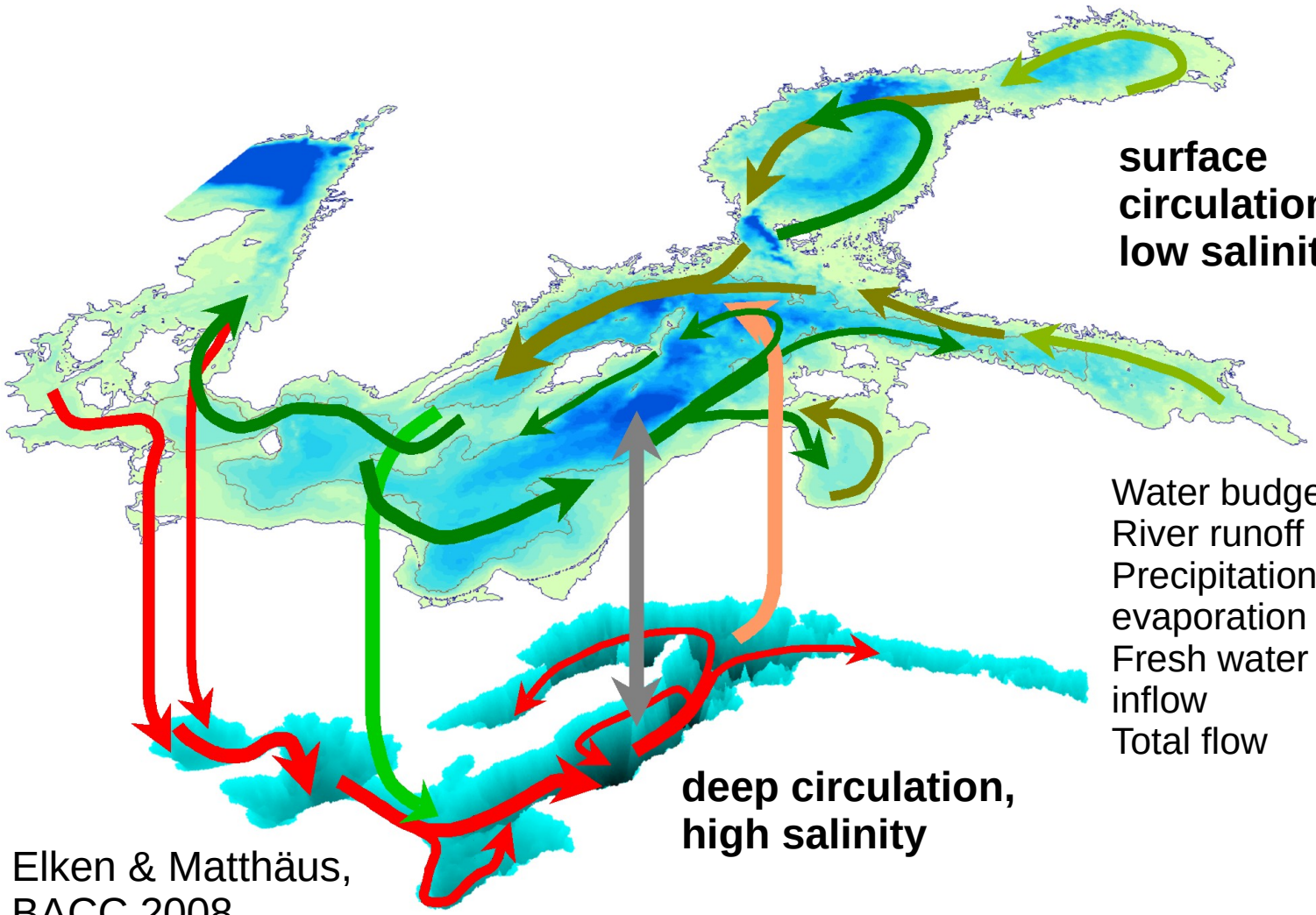
West-East-Extension:
~ 1000km (10°-30°E)

Mean depth: 52 m

Maximum depth: 459 m

www.io-warnemuende.de/steckbrief-der-ostsee.html

Salinity dynamics
Surface and deep circulation



Water budget:

River runoff	440 km³/Jahr
Precipitation	225 km³/Jahr
evaporation	185 km³/Jahr
Fresh water	480 km³/Jahr
inflow	470 km³/Jahr
Total flow	950 km³/Jahr

Elken & Matthäus,
BACC 2008

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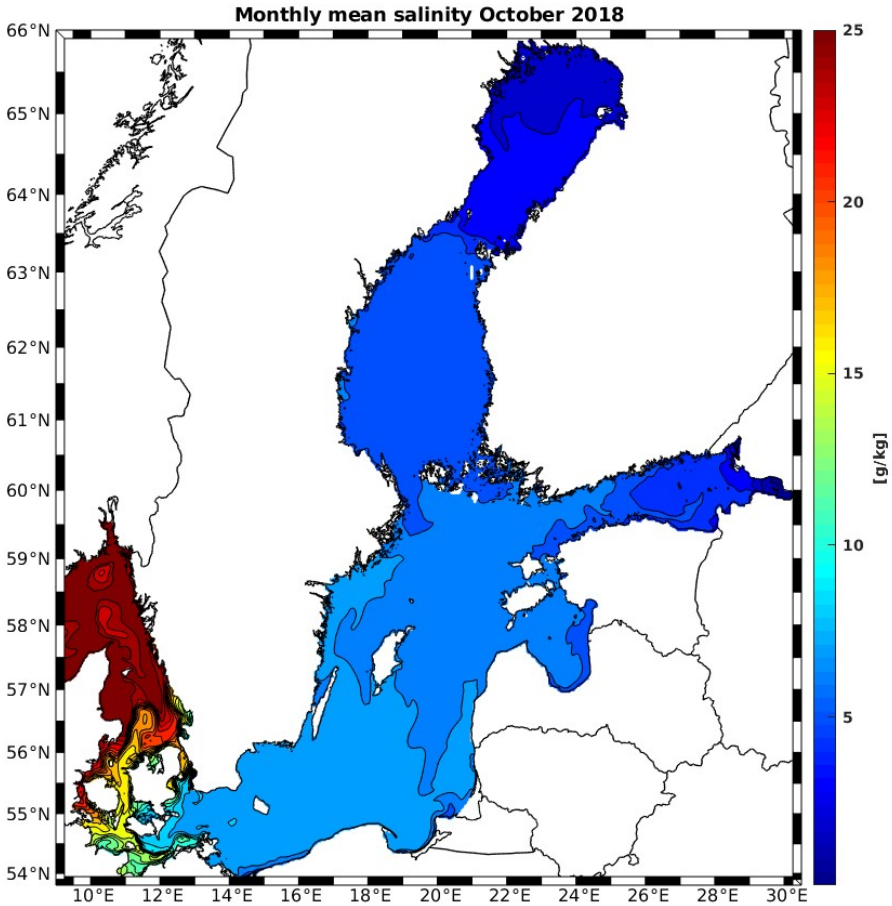
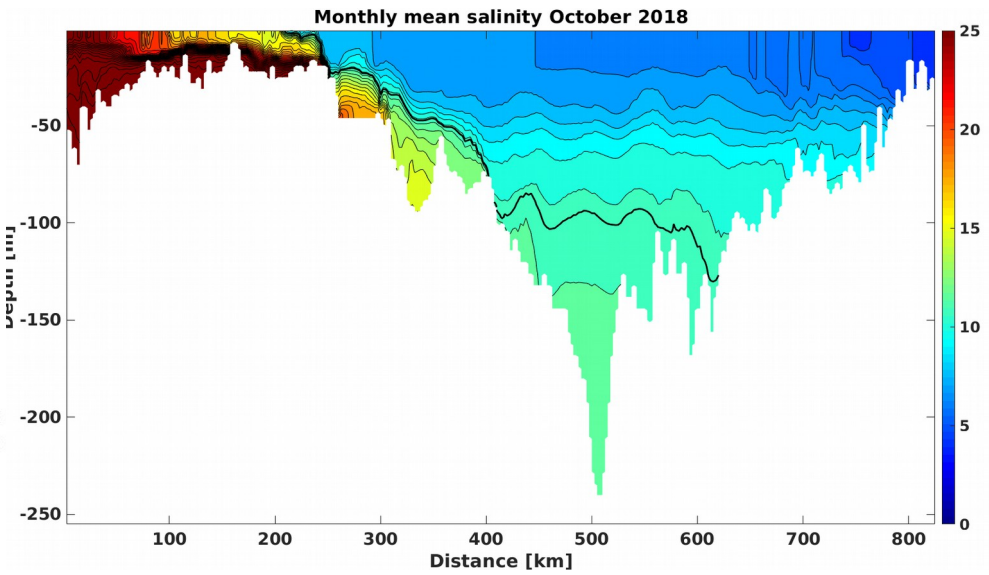
Salinity dynamics
Salinity (surface, section)





Monthly mean of salinity [g/kg], October 2018
(BSIOM – Kiel Baltic Sea Ice-Ocean Model)

Salinity dynamics
Long-term changes

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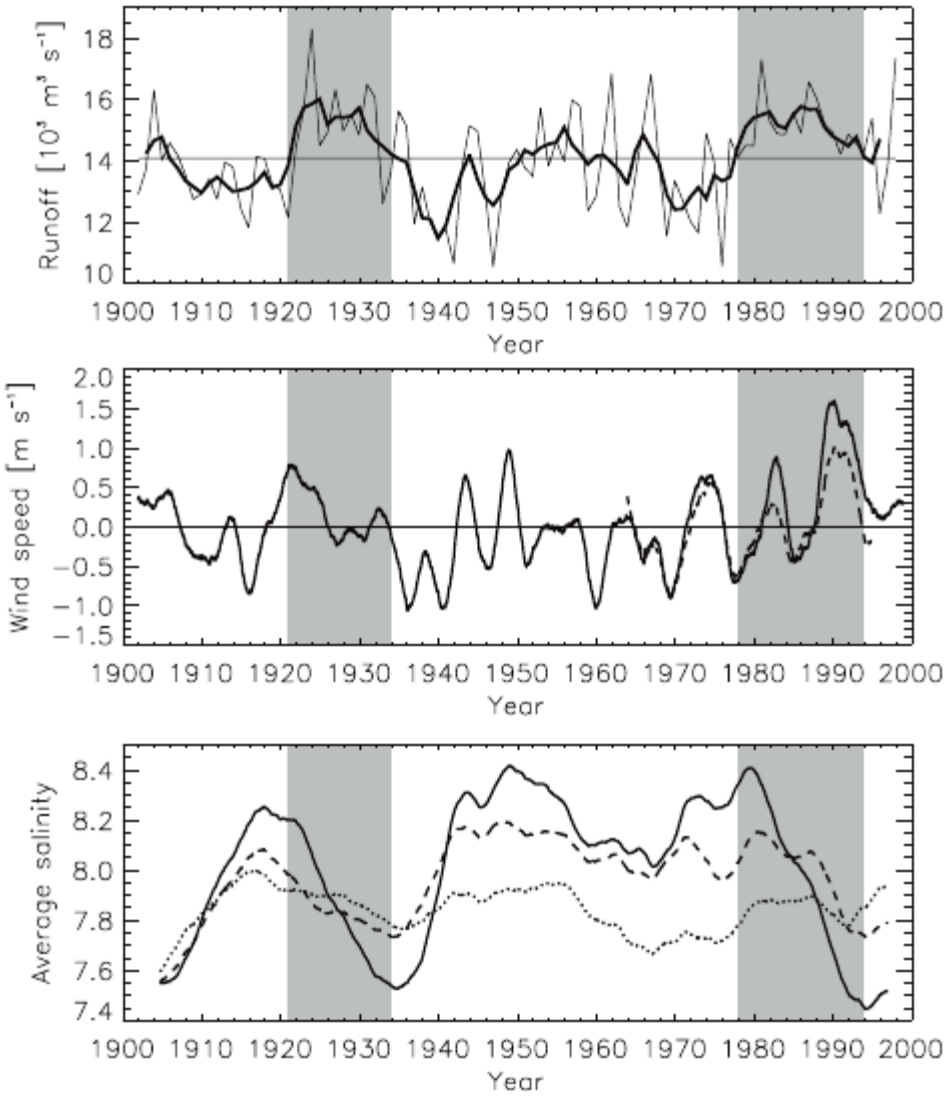

Salinity is an elementary factor Controlling the ecosystem of the Baltic Sea

BACC 2008 (Meier & Kauker, 2003):

- no long-term trend in the mean salinity for the 20th century
- half of the decadal variability is explained by the accumulated river runoff
- the remaining decadal variability is explained by the zonal wind fluctuations

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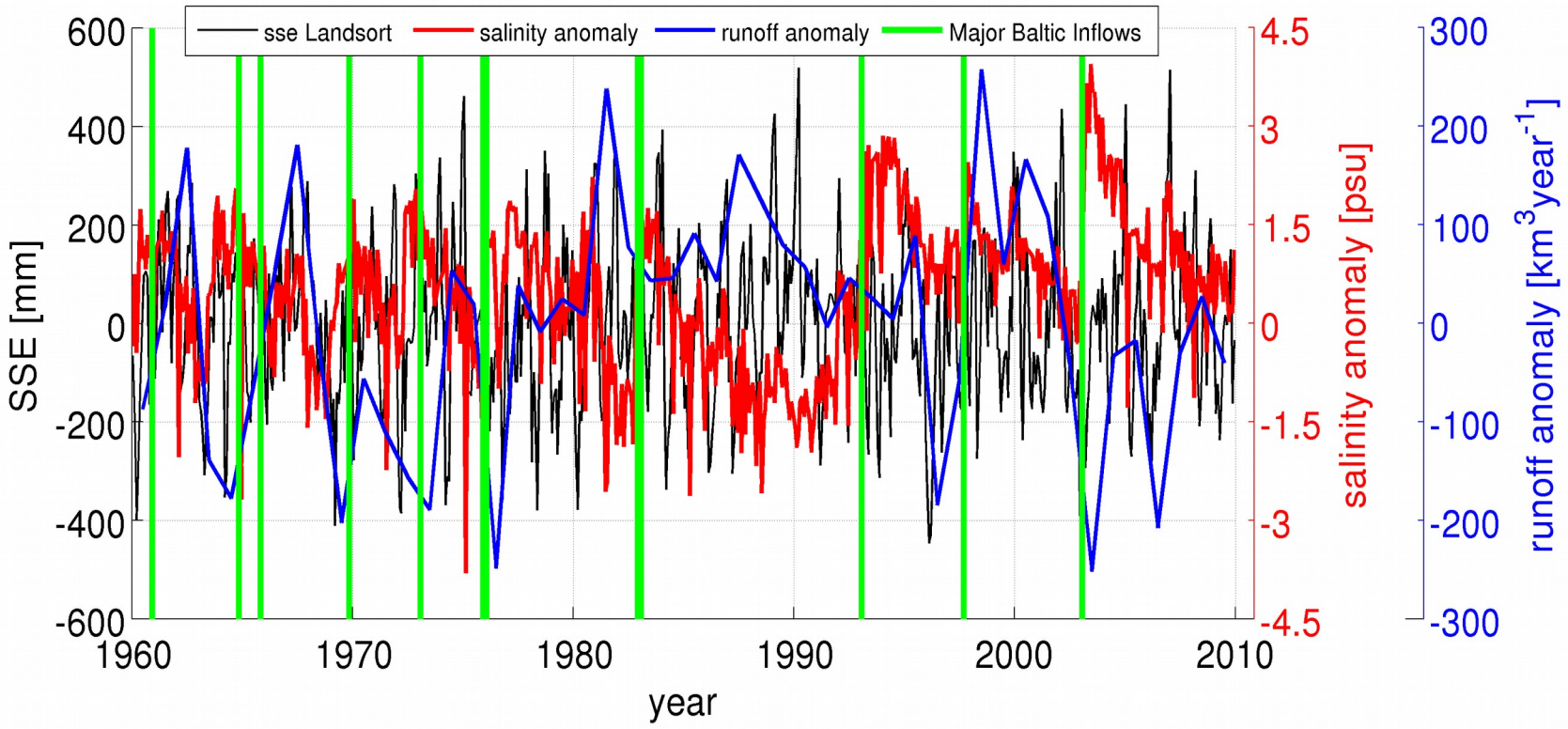
Salinity dynamics
Annual/decadal variability



SSE Landsort (black), Bornholm Basin deep salinity (red), runoff (blue), MBI (green)

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Salinity dynamics Arkona Basin
Annual/decadal variability, 1979-2018

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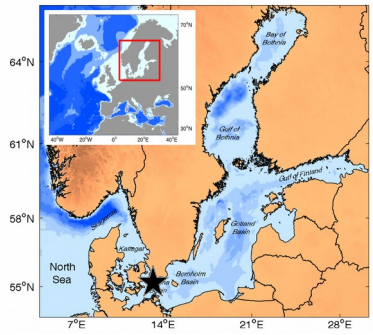
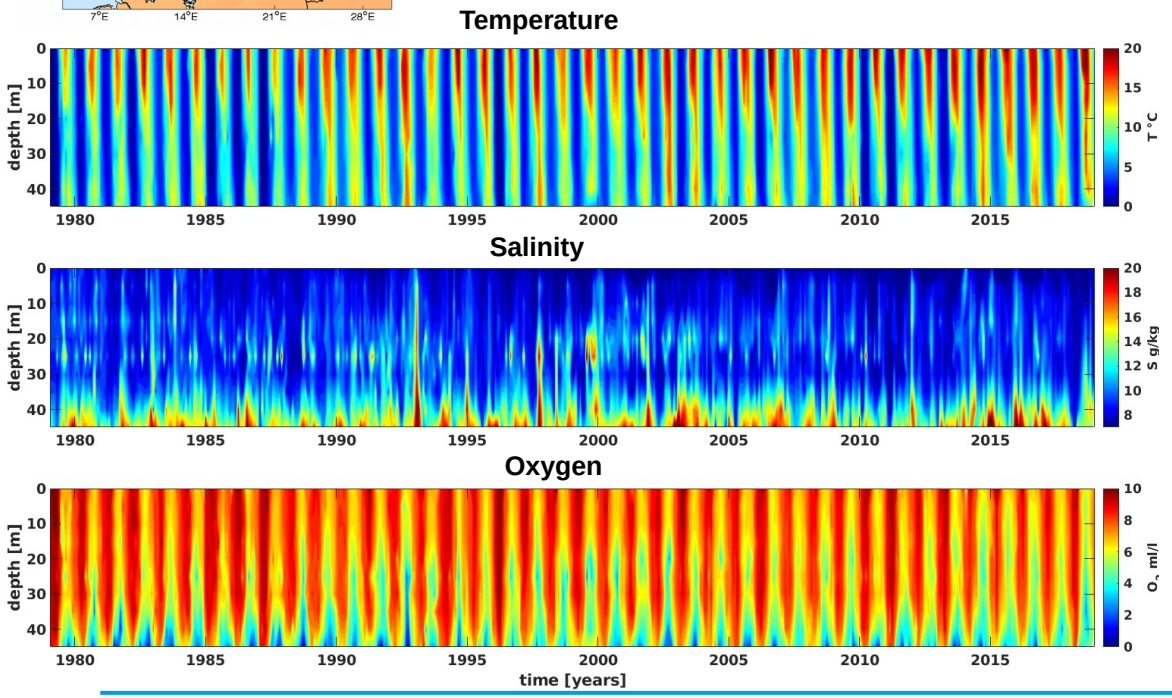


Salinity dynamics in the sub-basins of the Baltic Sea is complex. Inflows from the Skagerrak/Kattegat area can be traced not only by salinity but also by temperature and oxygen changes.



Major drivers are:

- Atmospheric circulation
- Large volume changes/MBIs
- Sub-basin water exchange
- Circulation and advection
- Net precipitation and runoff
- Turbulent mixing

Plot is based on area-averaged monthly T-,S-, O_2-profiles. ICES data set on Ocean Hydrography (2009.)

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Salinity dynamics Bornholm Basin
Annual/decadal variability, 1979-2018

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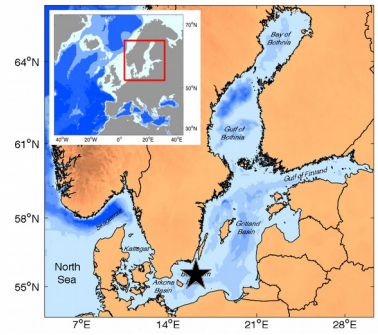

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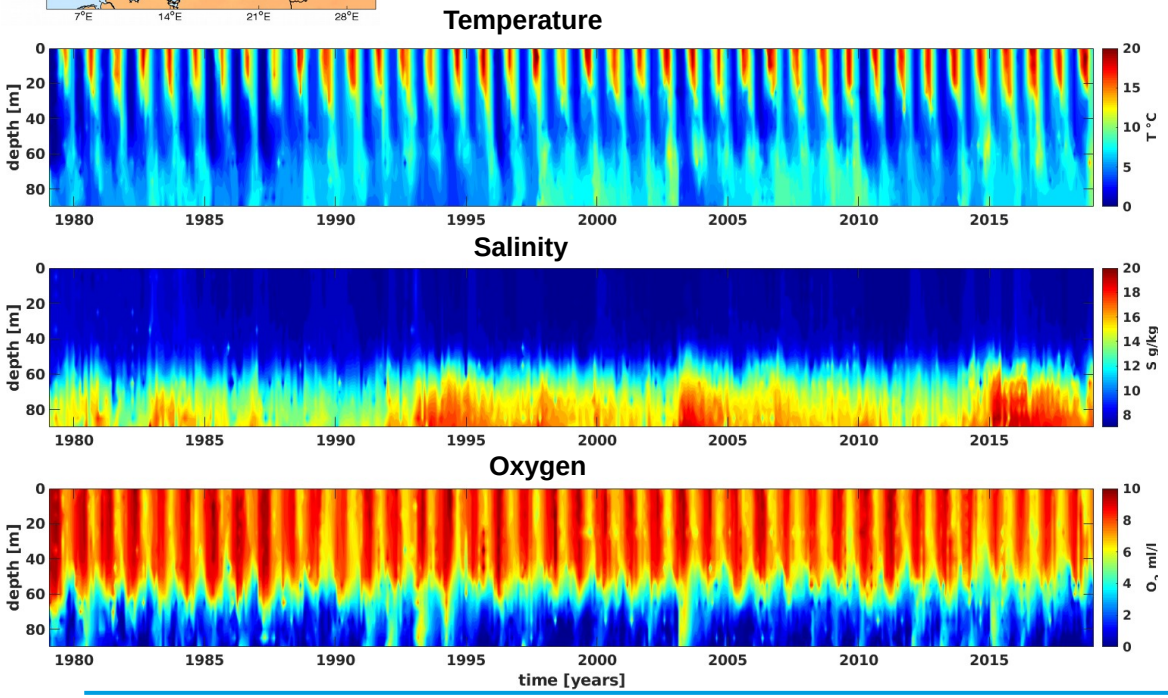

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Salinity dynamics e-Gotland Basin
Annual/decadal variability, 1979-2018

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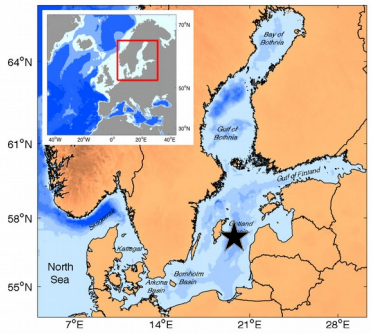

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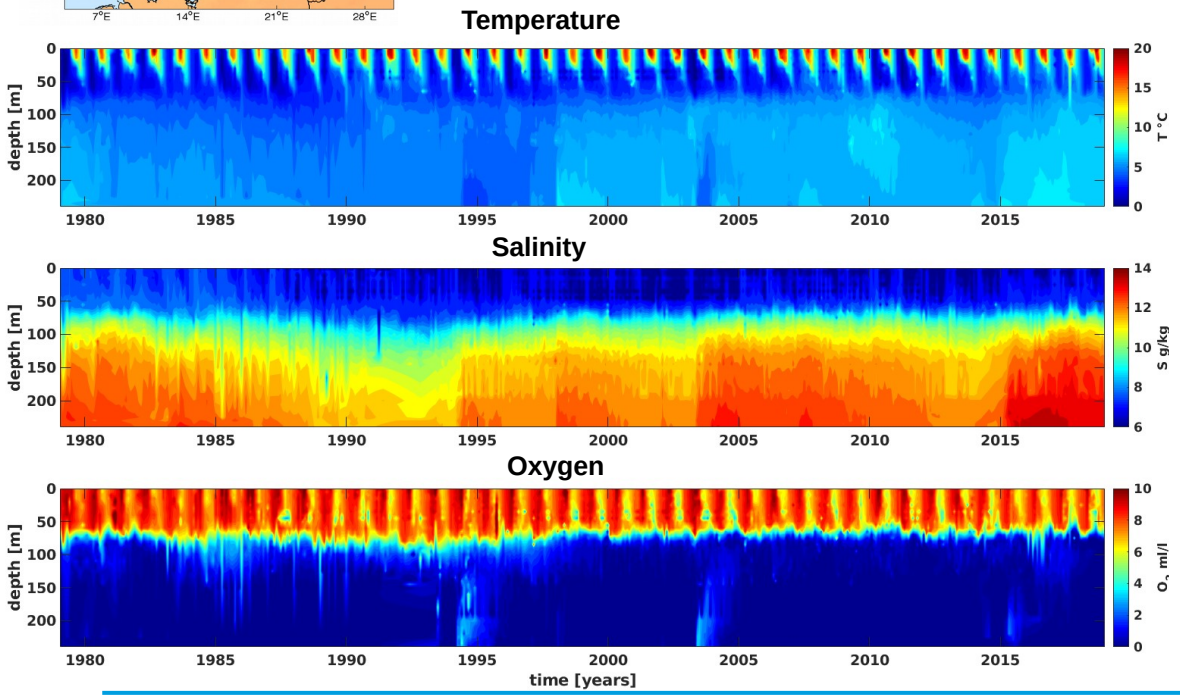

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Salinity dynamics Trends 1979-2018

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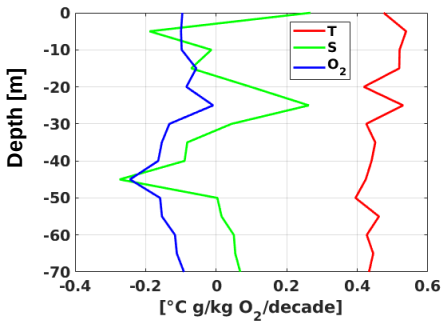
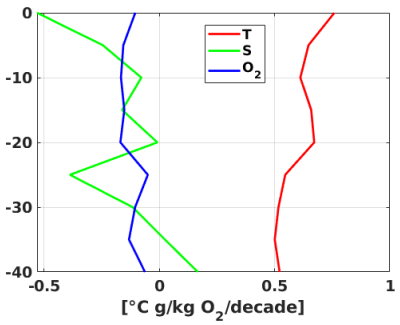
Kattegat



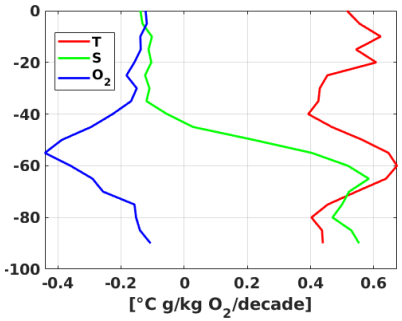
$\Delta\overline{S}$=0.52 g/kg

Arkona Basin



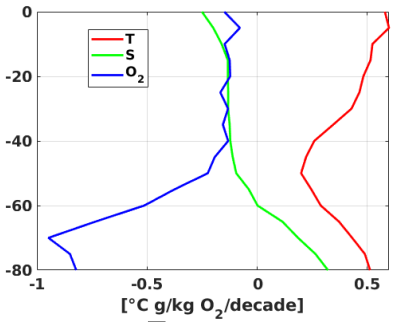
$\Delta\overline{S}$=-1.4 g/kg

Bornholm Basin



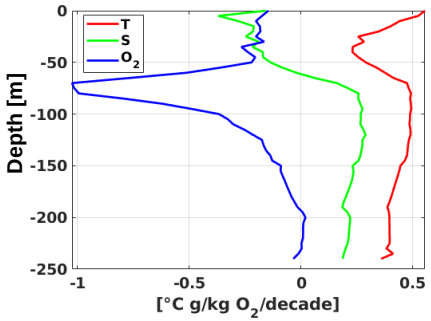
$\Delta\overline{S}$=-0.25 g/kg

Gdansk Basin



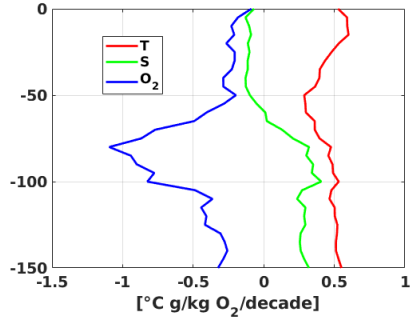
$\Delta\overline{S}$=-0.22 g/kg

E-Gotland Basin



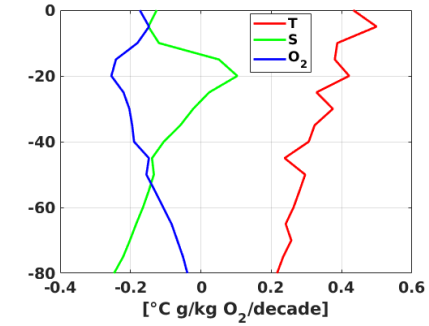
$\Delta\overline{S}$=-0.22 g/kg

N-Gotland Basin



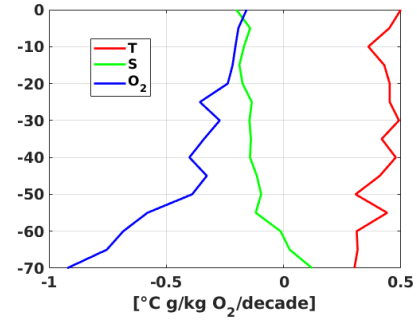
$\Delta\overline{S}$=0.03 g/kg

Bay of Bothnia



$\Delta\overline{S}$=-0.42 g/kg

Gulf of Finland



$\Delta\overline{S}$=-0.6 g/kg

$\Delta\overline{S}$ – difference (2018-1979) of vertically averaged annual mean salinity profiles weighted by the hypsographic curve for each sub-basin

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Conclusions
Salinity dynamics

- Long-term salinity dynamics is controlled by river runoff and net precipitation and the governing east-west wind conditions. However, the recent decrease of surface salinity could not be explained by an increase in annual runoff (Liblik & Lips 2019).
- The mid-term and short term (monthly/annual/decadal) salinity dynamics is much more complex with strong salinity variability also affecting temperature and oxygen
- Over recent decades negative salinity trends of about 0.1-0.2 g/kg/decade appear at the surface, 0.4-0.6 °C/decade for temperature and 0.1-0.2 ml/l/decade for oxygen.
- The temperature trend is about the same as the air temperature trend. The trend in oxygen is strongly related to the increasing temperatures (changing solubility and oxygen depletion rates) with maximum negative trends up to 1 ml/l/decade in the area of the halocline (Bornholm and Gotland Basin). For the negative trend of surface salinity it is assumed that runoff and net precipitation play a role. However, in deeper parts the salinity trend (0.2-0.5 g/kg/decade) is reversed, although the frequency of barotropic and major saltwater inflows did not increase.

Research needs
Salinity dynamics

Better understanding of the role of P-E+R on salinity distribution and its changes on seasonal to inter-annual time scales.

Detailed assessment of the development of saline stratification and its role for increasing hypoxia.

Detailed assessment of changes in atmospheric circulation and its impact on inflows and salinity distribution in the Baltic Sea.

Salt water inflows, do we really understand the process, can we predict MBIs?

Detailed assessment of the exchange between coastal areas and open sea, and between sub-basins, the cold intermediate layer (CIL) and turbulent mixing.

Combination and harmonization of observational data bases for open access under FAIR Principles (Findable, Accessible, Interoperable, Reusable)!


Thank you!