Baltic Earth/HELCOM Fact Sheet on Climate Change in the Baltic Sea

HELCOM

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Baltic Earth
Earth System Science for the Baltic Sea Region

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https://esd.copernicus.org/articles/special_issue1088.html

Special issue with 10 articles, 109 co-authors from 14 countries, knowledge from 2822 different scientific articles and institutional reports have been assessed

Baltic Earth Assessment Reports

Earth Syst. Dynam., 13, 1–136, 2022
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Earth System Dynamics
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Climate change in the Baltic Sea region: a summary

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- Knowledge gain since 2013 based upon peer-reviewed papers
- 33 parameters (atmosphere, cryosphere, land, terrestrial biosphere, ocean and sediment, marine biosphere), no anthroposphere (!!!)
- Past, present and future climate changes
- 47 scientists, 137 pp inc 35 figures, 15 tables, 800-900 references
- https://esd.copernicus.org/preprints/esd-2021-67/

Baltic Earth Assessment Reports

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Human impacts and their interactions in the Baltic Sea region

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Climate Change in the Baltic Sea

2021 Fact Sheet

baltic.earth

Earth System Science for the Baltic Sea Region

https://helcom.fi/wp-content/uploads/2021/09/Baltic-Sea-Climate-Change-Fact-Sheet-2021.pdf

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- Climate Change Fact Sheet: some background information, map showing regional future climate changes for selected parameters under RCP4.5
- 34 variables (direct and indirect)
- For each parameter: description, past and future changes, knowledge gaps, policy relevance, references (BEARs)
- More than 100 scientists, coordinated by HELCOM secretariat
- Publication 3rd September 2021 https://helcom.fi/media/publications/Baltic-Sea-Climate-Change-Fact-Sheet-2021.pdf
- German translation is now available at baltic.earth !!!!!!!!!

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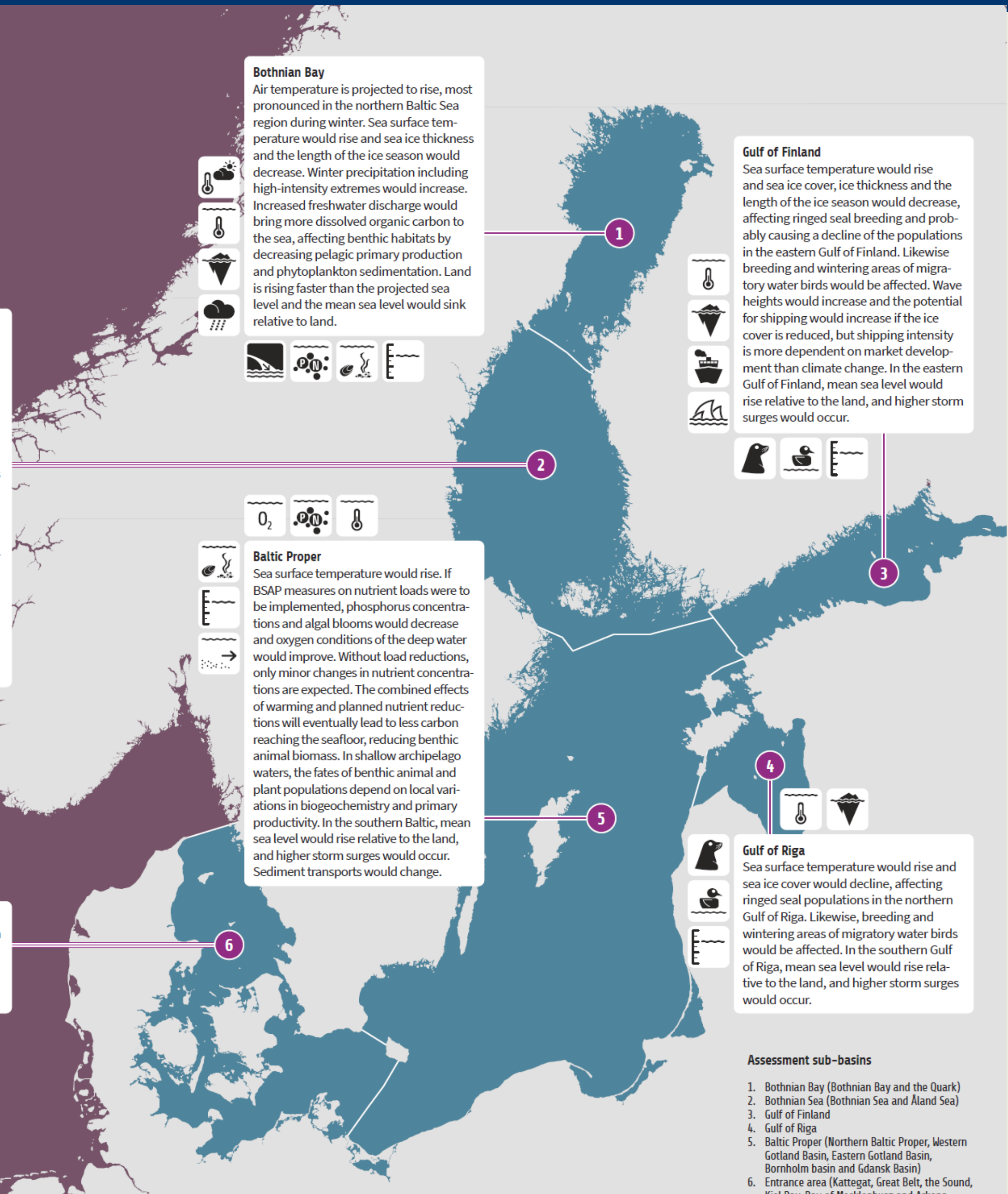
Climate future of the Baltic Sea

Projections under the RCP4.5 climate scenario

The impact map depicts projected regional changes for some of the most relevant parameters in a particular subbasin of the Baltic Sea under the RCP4.5 scenario. While there is also important information on the other parameters, there was a need to reduce the total 34 parameters to the presented parameters to make the map more legible. The presented parameters have 1) direct societal relevance/experience and/or relevance for other parameters, 2) medium to high confidence of the changes relative to the noise and model/expert judgement uncertainty under the RCP4.5 scenario, and 3) a hotspot sub-region in the Baltic with medium to high confidence of patterns of the regional changes.



Bothnian Bay
Air temperature is projected to rise, most pronounced in the northern Baltic Sea region during winter. Sea surface temperature would rise and sea ice thickness and the length of the ice season would decrease. Winter precipitation including high-intensity extremes would increase. Increased freshwater discharge would bring more dissolved organic carbon to the sea, affecting benthic habitats by decreasing pelagic primary production and phytoplankton sedimentation. Land is rising faster than the projected sea level and the mean sea level would sink relative to land.

Bothnian Sea
Sea surface temperature would rise everywhere in the Baltic and in all seasons. Most pronounced would be summer warming in the Bothnian Bay and Bothnian Sea. Winter precipitation including high-intensity extremes would increase. Increased freshwater discharge would bring more dissolved organic carbon to the sea, affecting benthic habitats by decreasing pelagic primary production and phytoplankton sedimentation. In the Bothnian Sea, Gulf of Finland and Gulf of Riga, the decline in sea ice cover would be largest. Waves would be higher and shipping might increase if the ice cover is reduced. Food accessibility for migratory water birds would improve causing a northward shift of breeding and wintering areas towards ice free coastal areas. In the Archipelago Sea, ringed seal populations might decrease.

Gulf of Finland
Sea surface temperature would rise and sea ice cover, ice thickness and the length of the ice season would decrease, affecting ringed seal breeding and probably causing a decline of the populations in the eastern Gulf of Finland. Likewise breeding and wintering areas of migratory water birds would be affected. Wave heights would increase and the potential for shipping would increase if the ice cover is reduced, but shipping intensity is more dependent on market development than climate change. In the eastern Gulf of Finland, mean sea level would rise relative to the land, and higher storm surges would occur.

O_2

Baltic Proper
Sea surface temperature would rise. If BSAP measures on nutrient loads were to be implemented, phosphorus concentrations and algal blooms would decrease and oxygen conditions of the deep water would improve. Without load reductions, only minor changes in nutrient concentrations are expected. The combined effects of warming and planned nutrient reductions will eventually lead to less carbon reaching the seafloor, reducing benthic animal biomass. In shallow archipelago waters, the fates of benthic animal and plant populations depend on local variations in biogeochemistry and primary productivity. In the southern Baltic, mean sea level would rise relative to the land, and higher storm surges would occur. Sediment transports would change.

Gulf of Riga
Sea surface temperature would rise and sea ice cover would decline, affecting ringed seal populations in the northern Gulf of Riga. Likewise, breeding and wintering areas of migratory water birds would be affected. In the southern Gulf of Riga, mean sea level would rise relative to the land, and higher storm surges would occur.

CO_2
pH↓

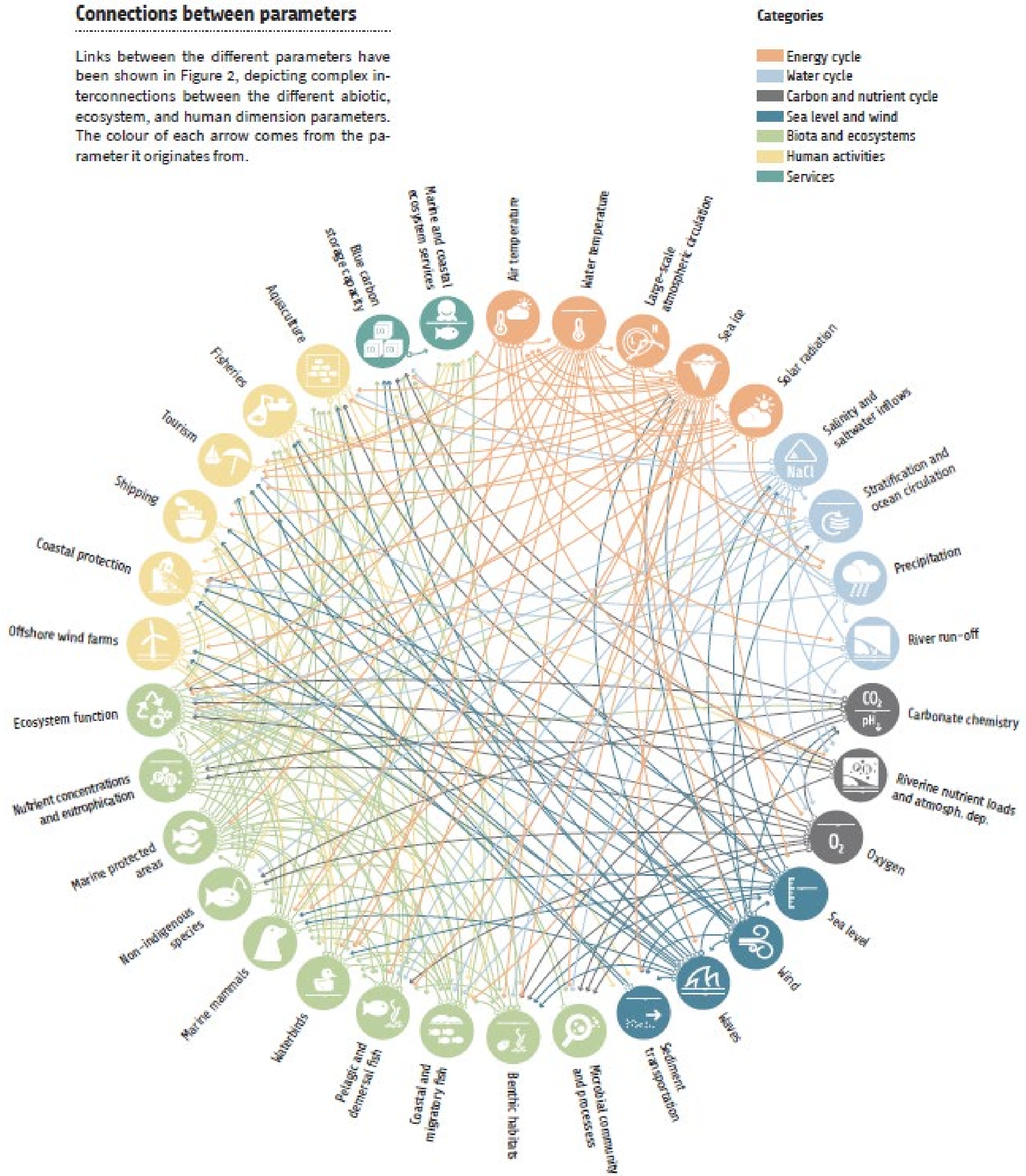
Baltic Sea entrance area
Sea surface temperature would rise. Mean sea level is projected to rise relative to the land, and higher storm surges would occur. Higher atmospheric pCO_2 would cause increased acidification.

Assessment sub-basins

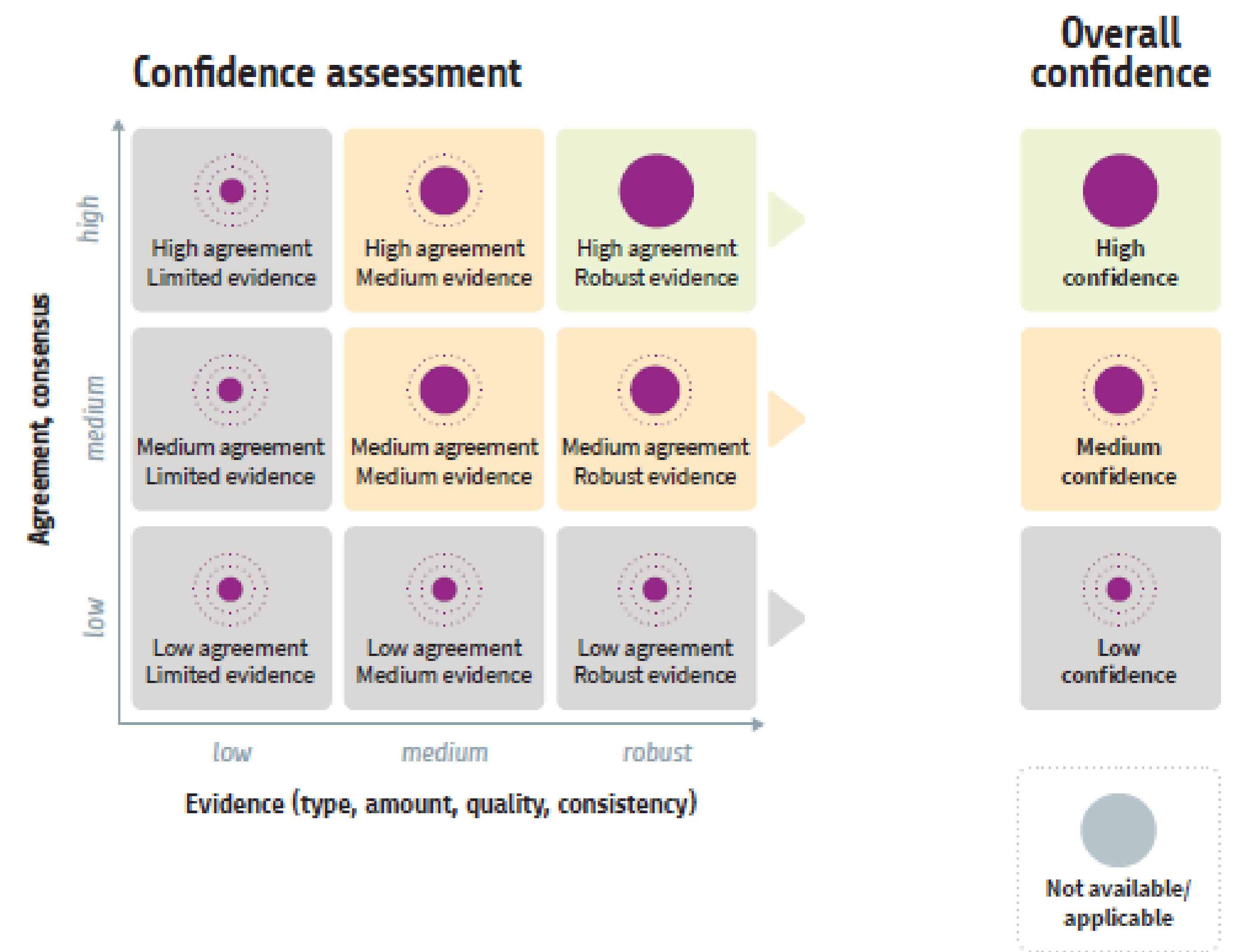
1. Bothnian Bay (Bothnian Bay and the Quark)
2. Bothnian Sea (Bothnian Sea and Åland Sea)
3. Gulf of Finland
4. Gulf of Riga
5. Baltic Proper (Northern Baltic Proper, Western Gotland Basin, Eastern Gotland Basin, Bornholm basin and Gdansk Basin)
6. Entrance area (Kattegat, Great Belt, the Sound,

Connections between parameters

Links between the different parameters have been shown in Figure 2, depicting complex interconnections between the different abiotic, ecosystem, and human dimension parameters. The colour of each arrow comes from the parameter it originates from.

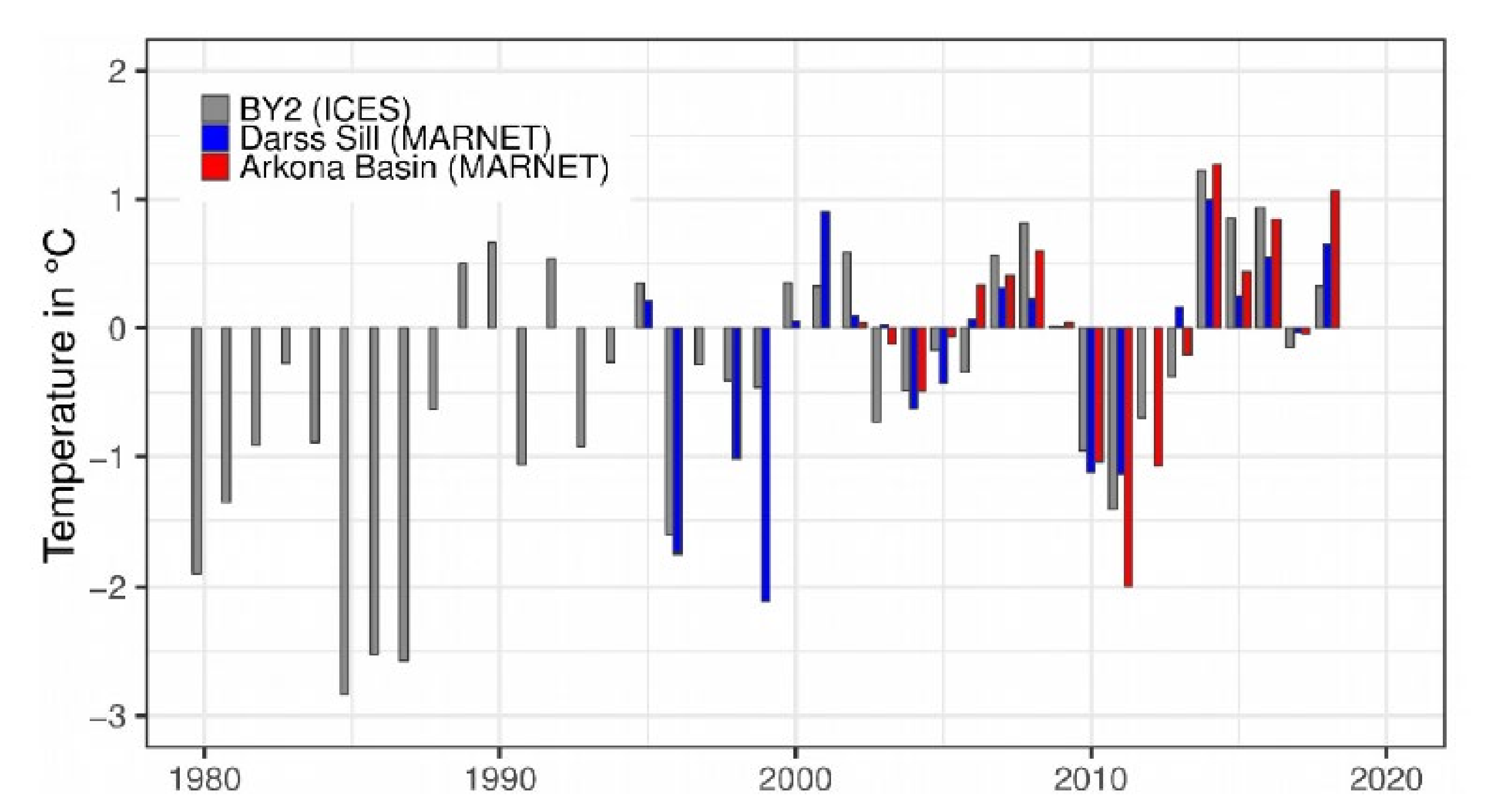


3 confidence levels



Present climate change

Annual mean sea surface temperature anomalies relative to 2002-2018



(Source: Meier et al., 2022)

Annual maximum sea ice extent

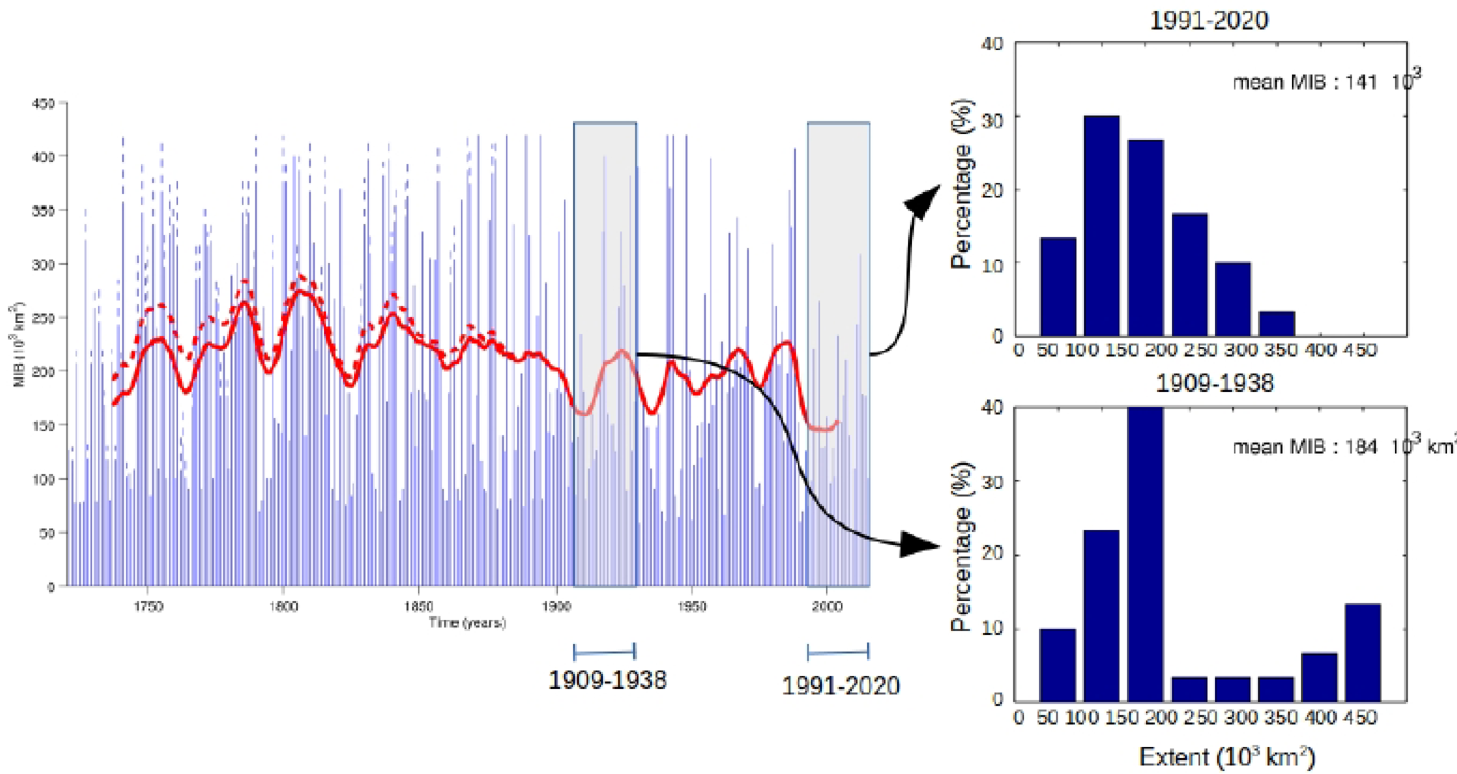
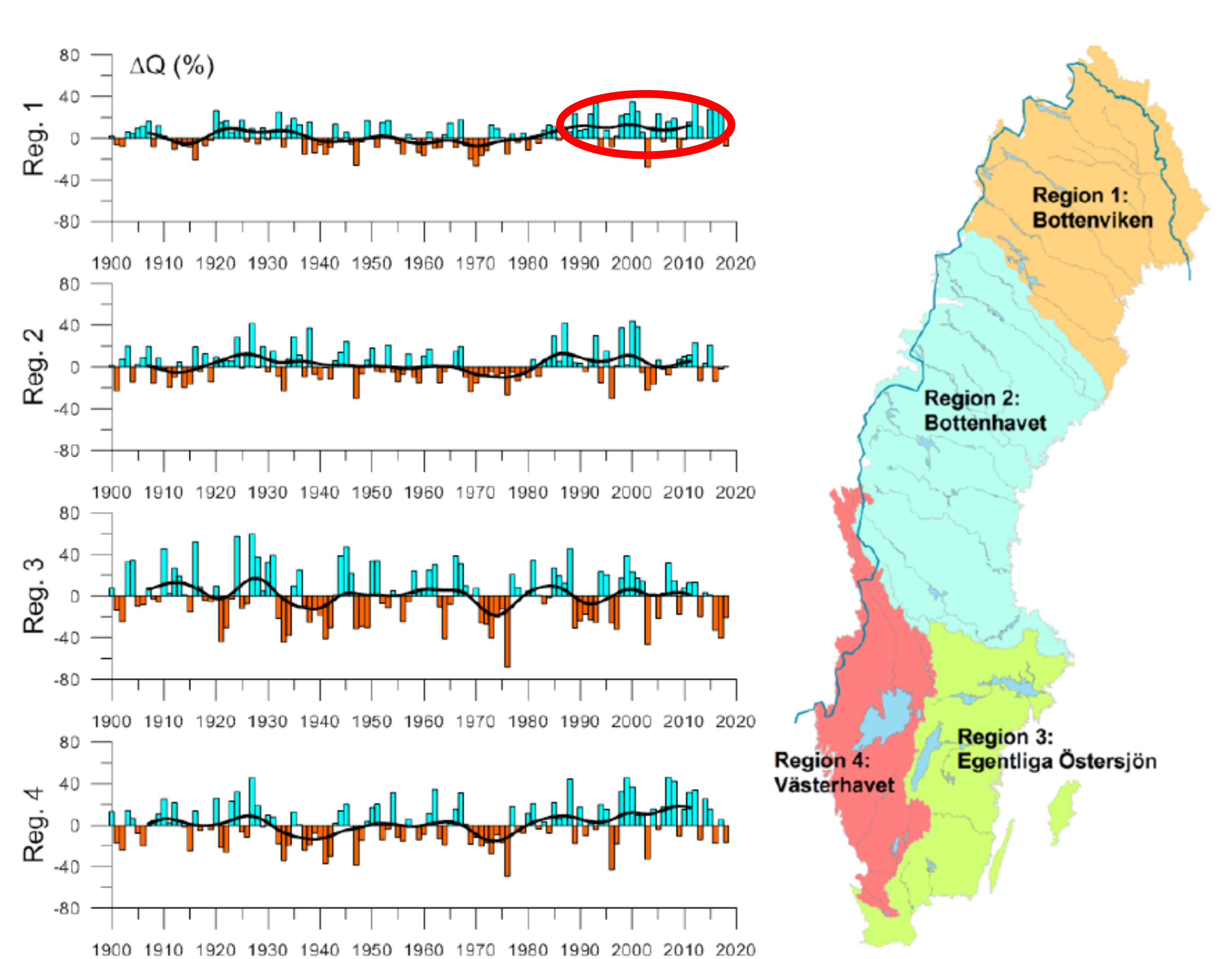


Figure 14. The graph on the left shows the annual maximum sea ice extent of the Baltic Sea (MIB) in kilometres squared (km^2) during 1720–2020. Blue bars show the annual mean, and red lines show the 15-year running means. The dashed bars represent the error range of the early observations (Vihma and Haapala, 2009). The error range of the 30-year moving average is indicated by two red curves, which converge into one when high-quality data became available. The graphs on the right show the 30-year distribution functions of MIB during 1909–1938 and 1991–2020. Data sources: https://www.eea.europa.eu/data-and-maps/daviz/maximum-extent-of-ice-cover-3#tab-chart_1 (last access: 17 February 2022); Finnish Meteorological Institute (https://en.ilmatieteenlaitos.fi/ice-season-in-the-baltic-sea, last access: 17 February 2022).

(Source: Meier et al., 2022)

River discharge from four Swedish catchment basins

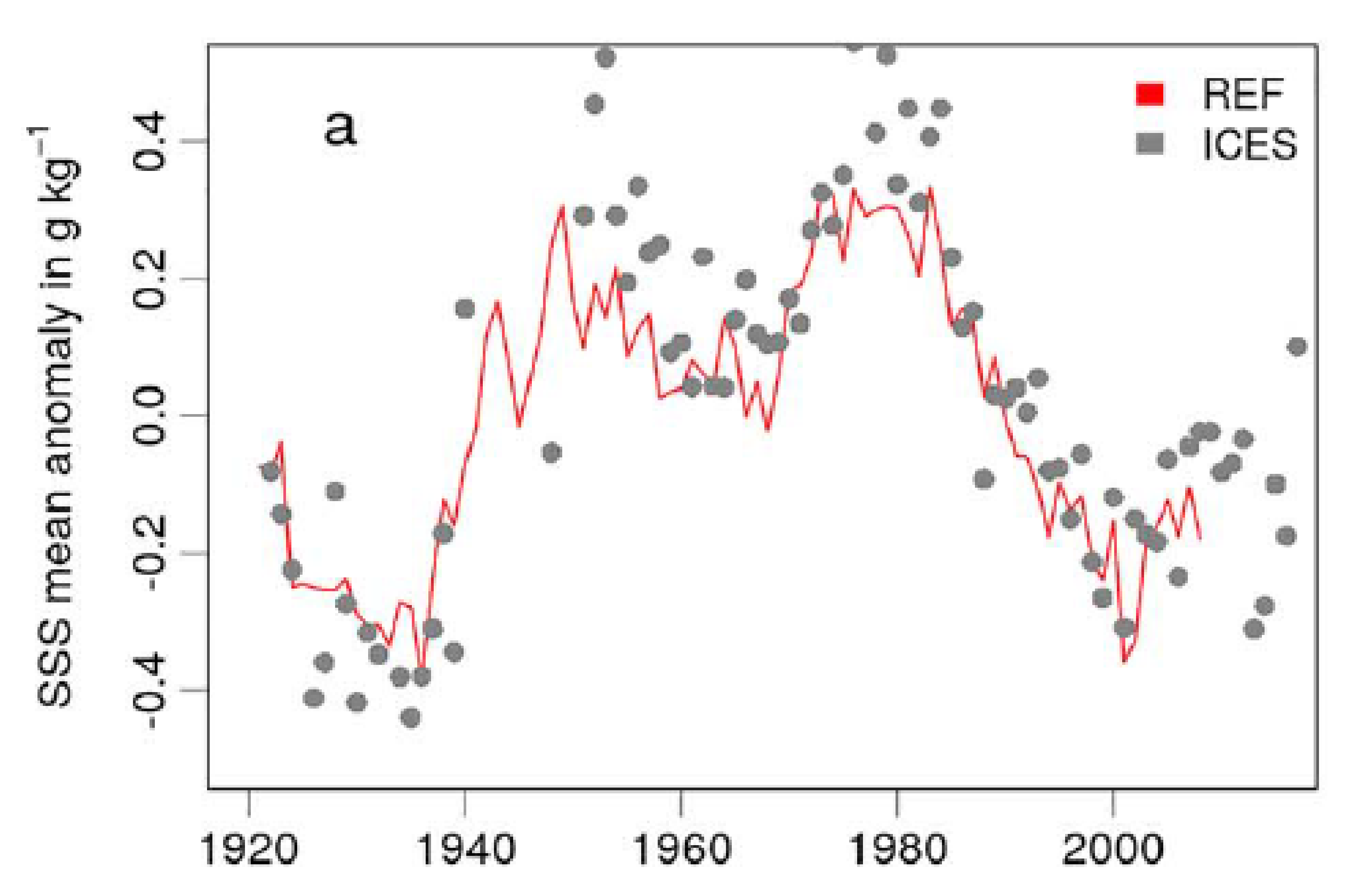


Figur 4. Summerad avrinning för fyra regioner, årsvärden 1900-2018, som avvikelse mot medelvärdet för 1961-1990.

(Source: Lindström, 2019)

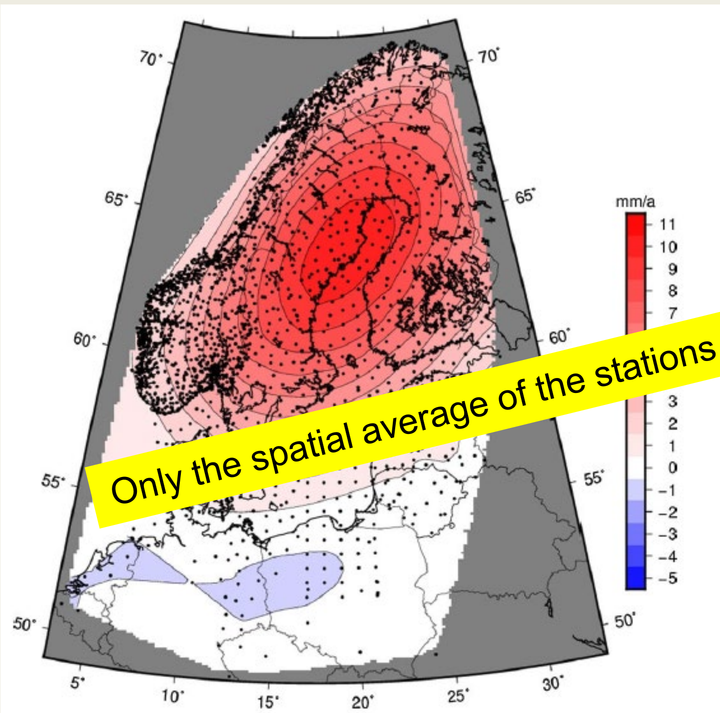
NaCl

Sea surface salinity



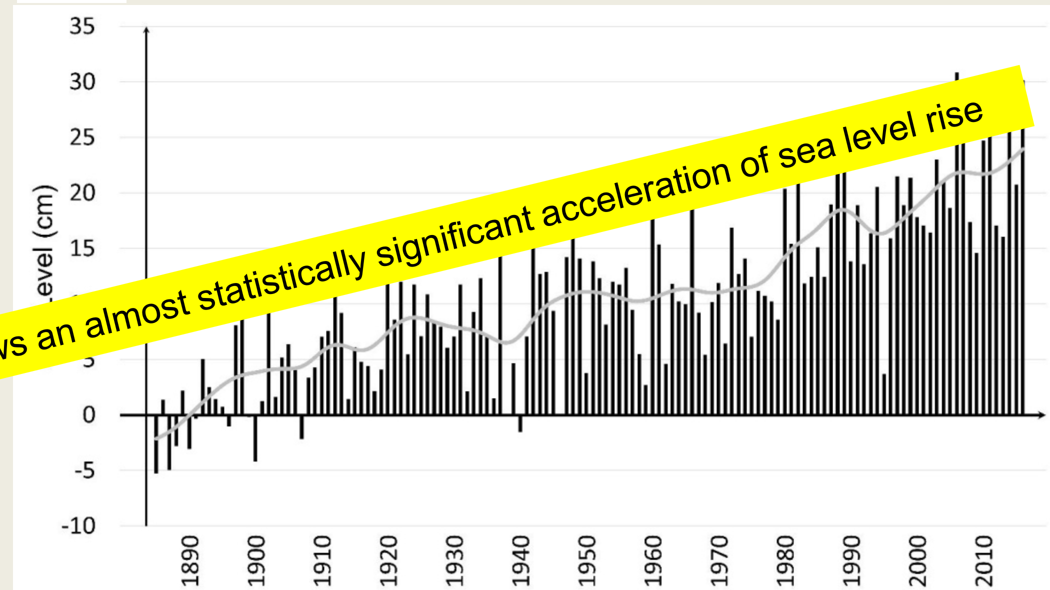
(Source : Madline Kniebusch et al., 2019)

Land uplift (mm/yr)



Vestøl et al. (2019)

Sea level rise



Only the spatial average of the stations shows an almost statistically significant acceleration of sea level rise

Annual mean sea level changes in centimeters for 14 Swedish mareographs since 1886. The data are corrected for land uplift. The grey line shows a smoothed curve. (Source: Swedish Meteorological and Hydrological Institute)

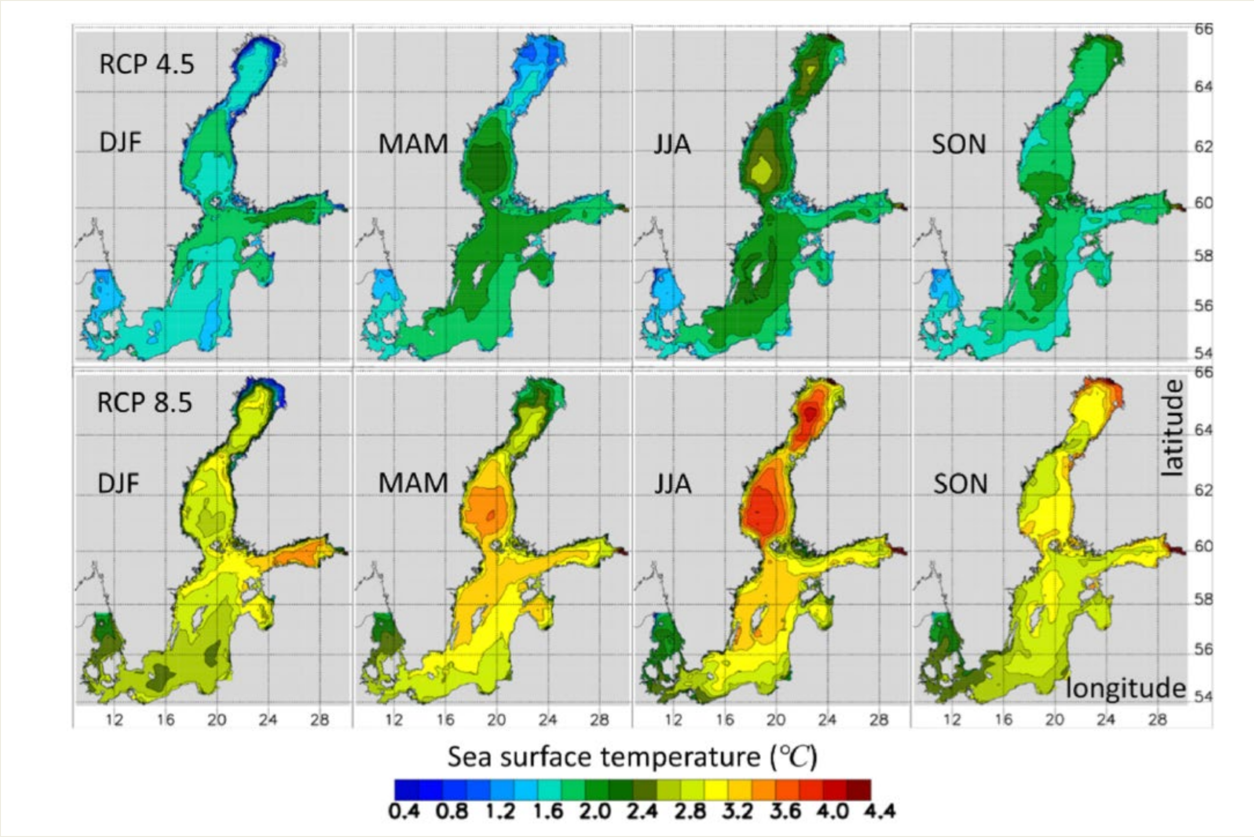
Future climate change

Seasonal mean sea surface temperature change between 1976-2005 and 2069-2098

Winter Spring Summer Autumn

„Medium“ emission scenario

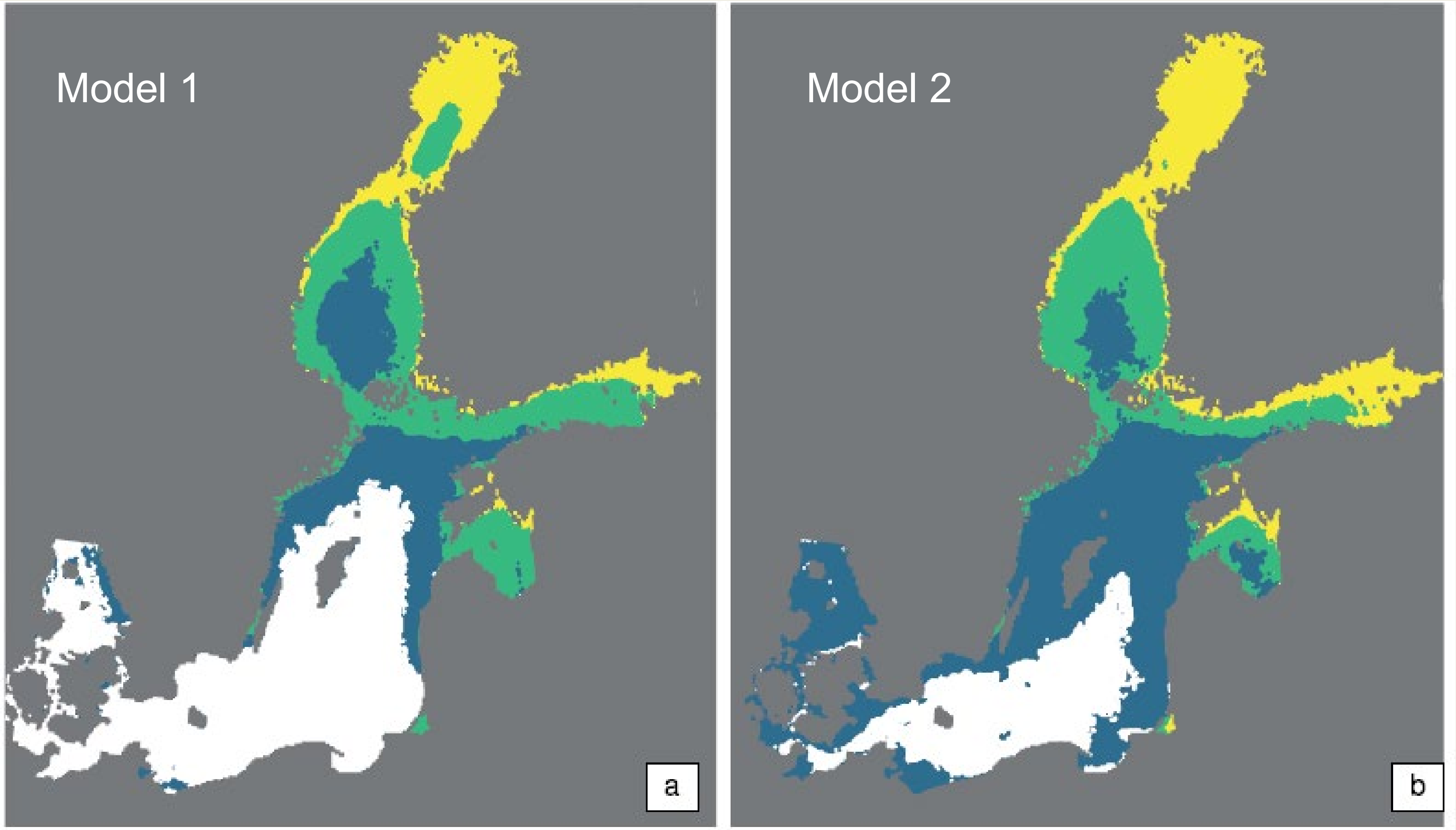
„High-end“ emission scenaro



(Source: Meier et al., 2021)

Annual maximum sea ice extent

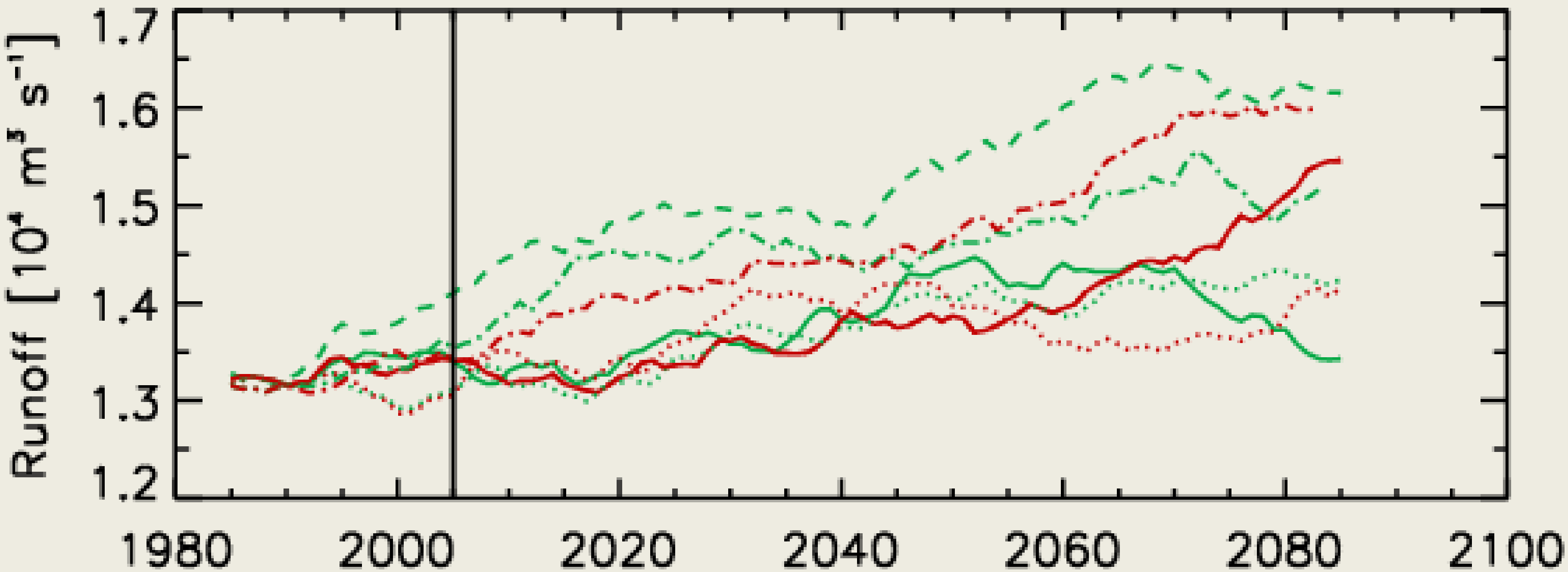
Historical period 1970-1999 and „Medium“ RCP 4.5, „High-end“ RCP 8.5 2070-2099



(Source: Höglund et al., 2017)

River discharge from the Baltic Sea catchment area

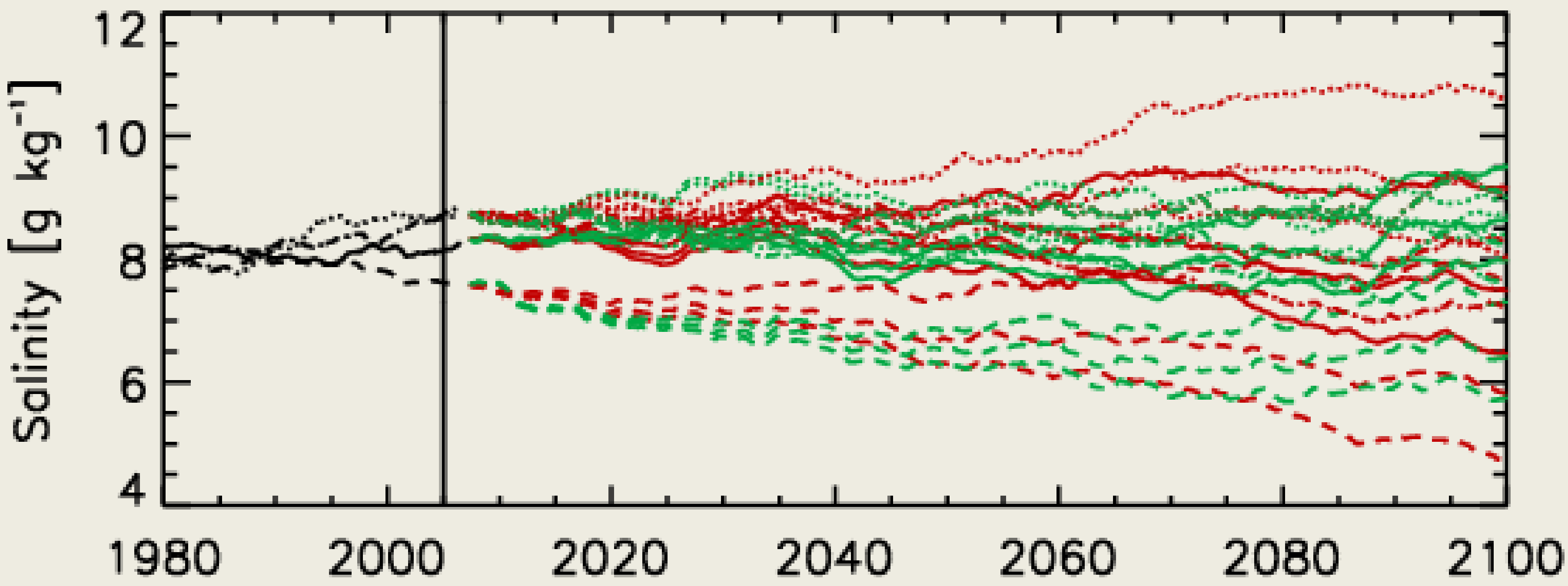
„Medium“ RCP 4.5, „High-end“ RCP 8.5, four global models (line types)



(Source: Meier et al., 2021)

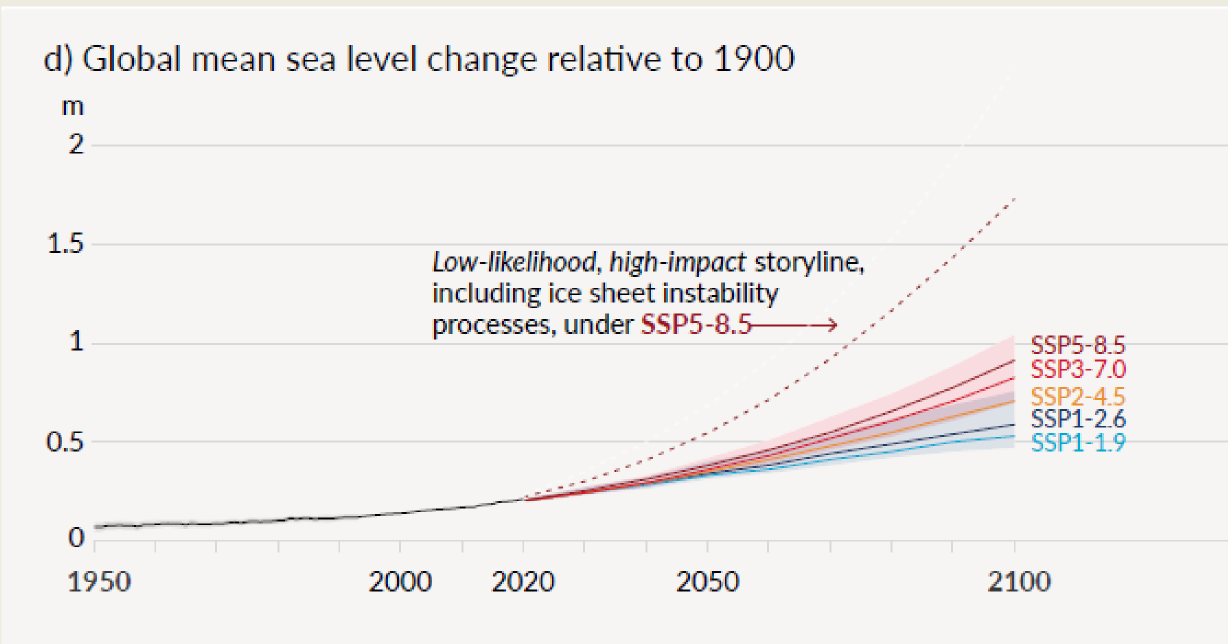
NaCl

Volume averaged salinity

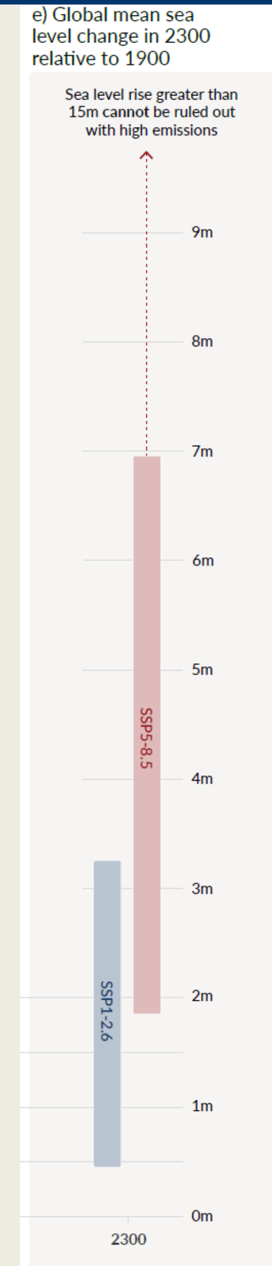


(Source : Meier et al., 2021)

Mean sea level in the Baltic Sea is projected to rise slightly less (87%) than mean global sea level (Meier et al., 2022)

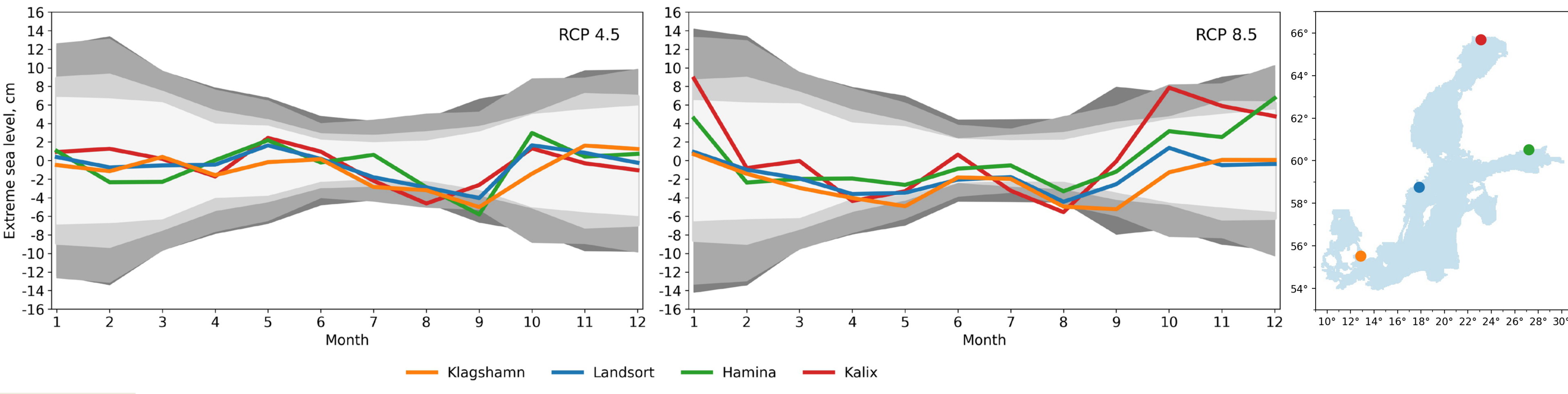


(Source: IPCC, 2021)



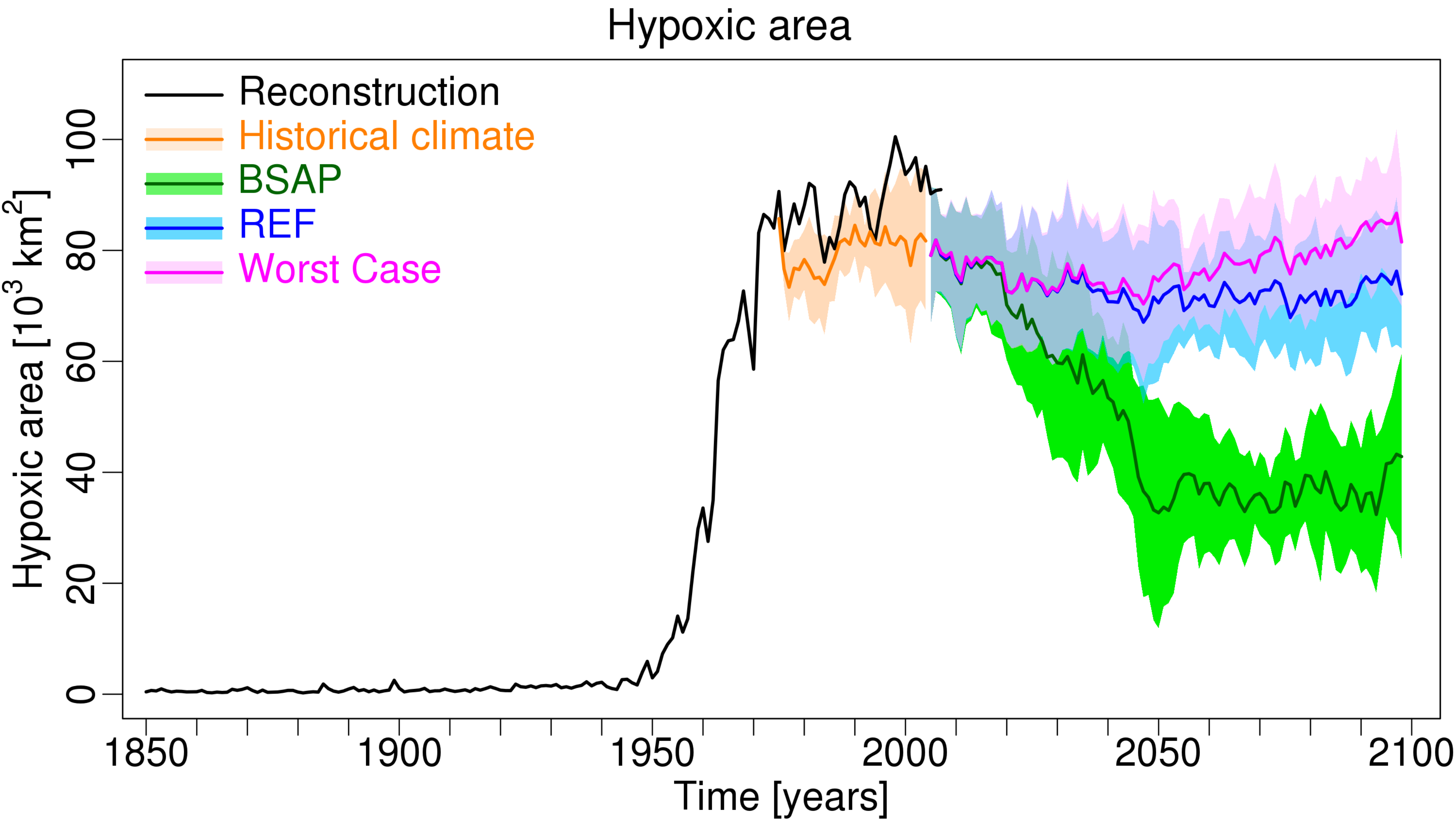
Sea level extremes

No robust trends in extreme values of sea level relative to mean sea level (Meier et al., 2022)



(Source: Kseniia Safonova, IOW)

Dead sea bottom without higher forms of life (Photo: J. Lokrantz/Azote)

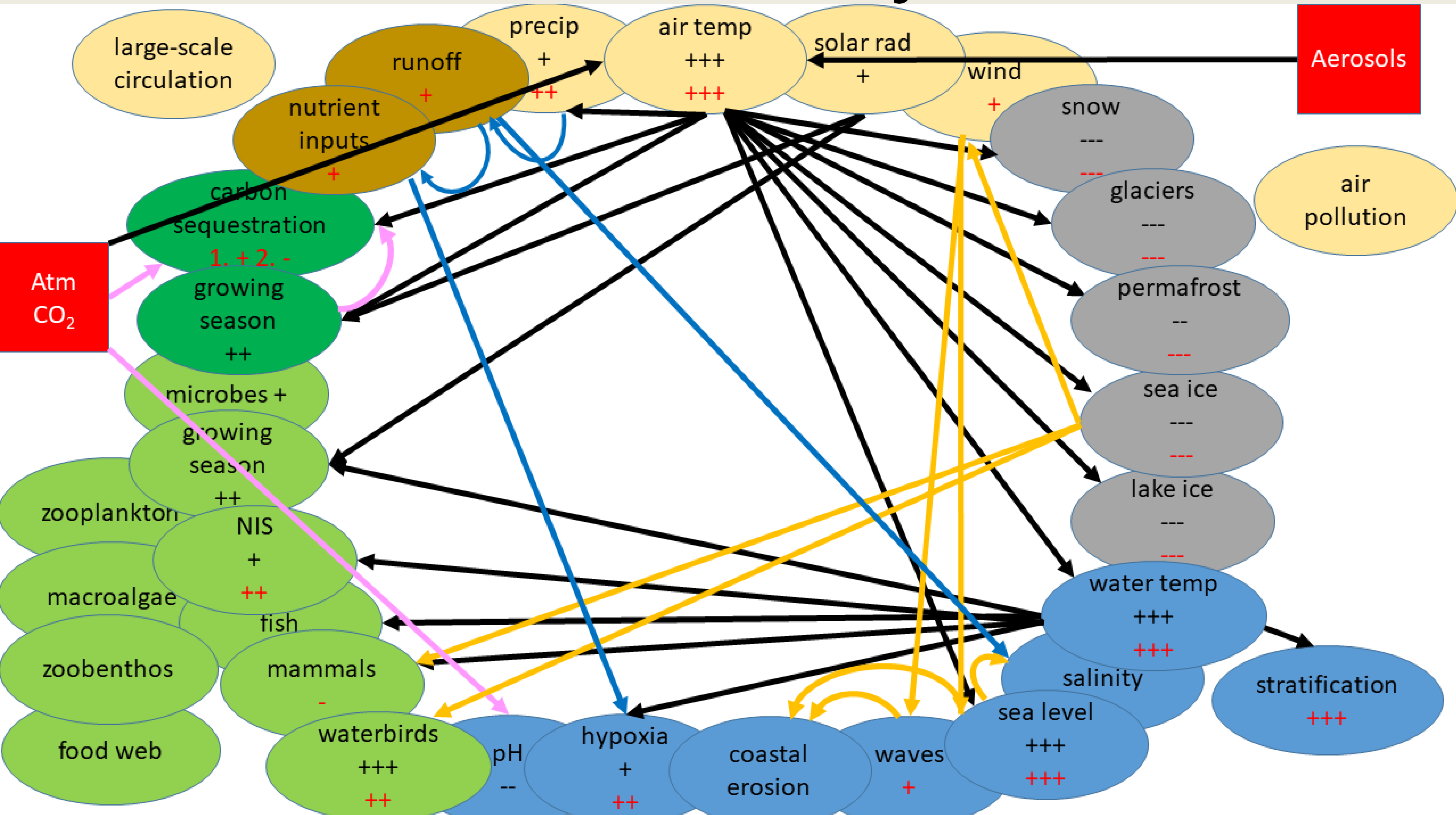


(Source: modified after Meier et al., 2019)

Indirect parameters (affected also by other drivers)

- Increase in shipping to ice-free sea areas
- Northward shift of breeding and wintering areas of waterbirds
- Decrease in ringed seal population, one of the four marine mammal species in the Baltic Sea

Summary



(Meier et al., 2022)

Selected results

(1) Scenarios for the Baltic Sea project a **sea surface temperature** increase of 1.1°C (RCP2.6) to 3.2°C (RCP8.5) by the end of this century, compared to 1976-2005.

(2) In the future, it is very likely that the **maximum sea ice extent** will further decrease.

(3) Due to the large uncertainty in projected freshwater supply from the catchment area, wind and global sea level rise, **salinity** projections show a widespread trend, and no robust changes were identified.

(4) Global **sea level** will rise and consequently the Baltic sea level as well, counteracted by land uplift in the northern areas.

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Thank you for your attention!