

IOW contribution to WP3

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Task 3.1 Develop and implement the dynamical downscaling tools

Task 3.2 Production of the downscaled decadal predictions

Task 3.3 Evaluation and validation of the downscaled decadal predictions

Deliverables:

D3.1 Report on modelling methods and experimental protocols for dynamical downscaling of decadal predictions

in regional seas (Task 3.1). [M12, SMHI]

D3.2 Report on delivery of the downscaling model simulations (Task 3.2). [M36, CMCC]

D3.3 Report on valuation of downscaled decadal predictions for regional seas (Task 3.3). [M48, IOW]

D3.4 Report on recommendations for the production of regional climate predictions in the format of a white paper

for the scientific community (Task 3.3). [M48, IOW]

Previous work at IOW

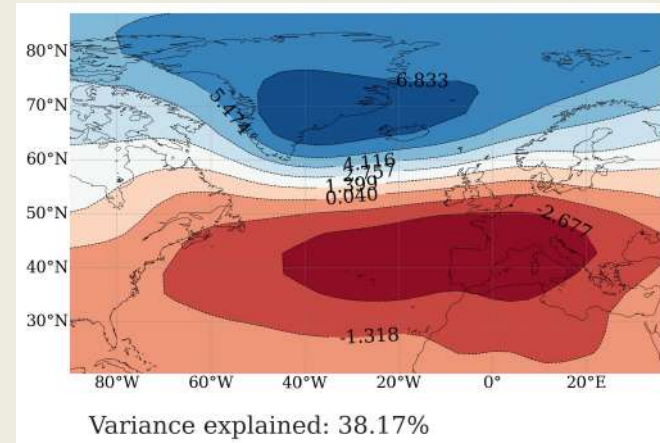
Memory:

- 1) Any part of the World Ocean such as the North Atlantic
- 2) Regional: Baltic Sea (or MedSea, Black Sea)

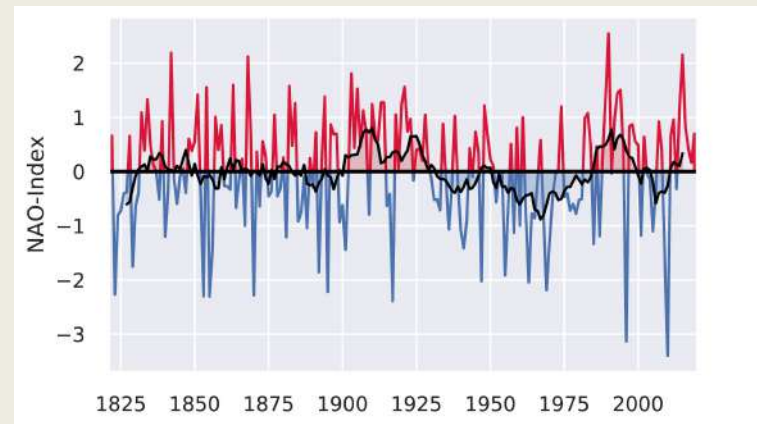
Teleconnections

Modes of climate variability: North Atlantic Oscillation (NAO)

- Most dominant mode of climate variability in the Northern Hemisphere during winter
- Positive NAO:
 - strong westerlies
 - mild temperatures
 - more precipitation
- Negative NAO
 - warm summers
 - cold winter
 - less precipitation

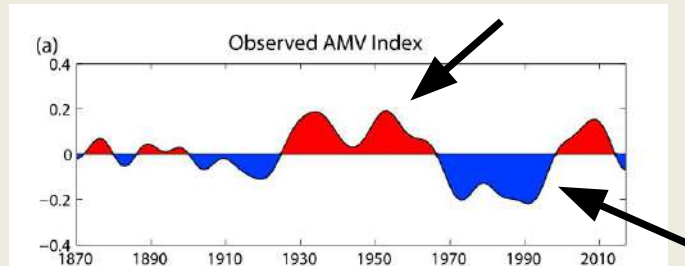


Florian Börgel; NAO (EOF1) for the period 950 – 1800 in ECHO-G, Data: Hünicke et al., 2010

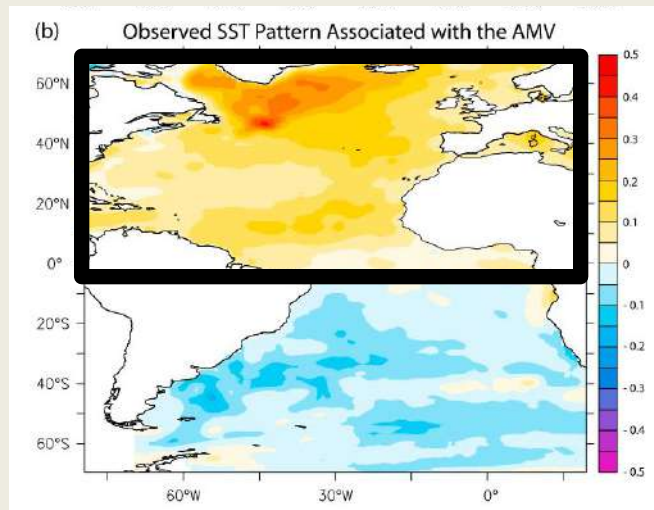


NAO index for boreal winter (Jones et al., 1997). Index baseline period 1951 - 1980.

Observed Key Elements of Atlantic Multidecadal Variability (AMV)

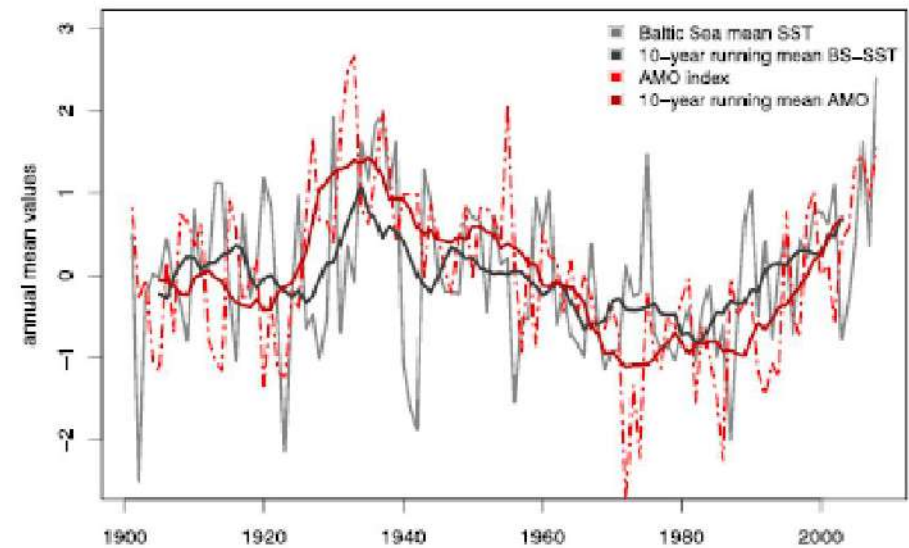
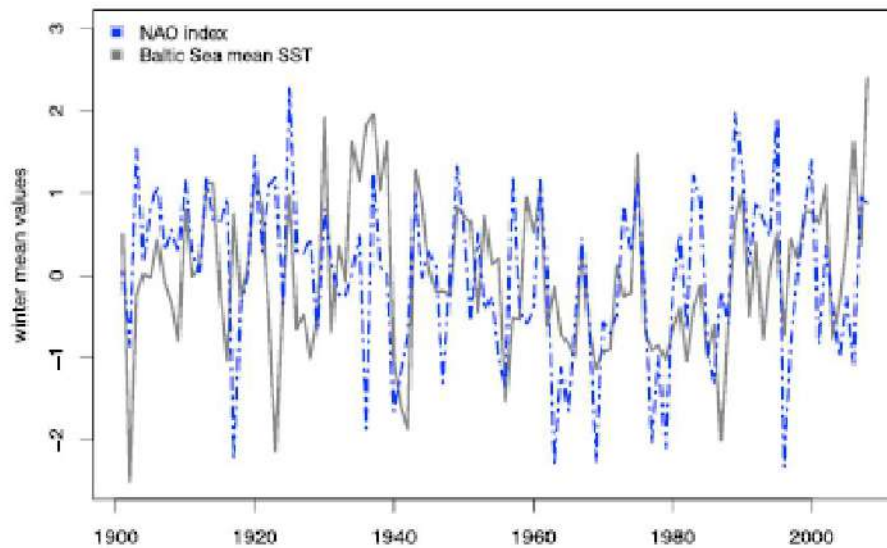


Defined as the 10-year low-pass-filtered area-weighted average of residual SST anomalies over the North Atlantic



The SST pattern associated with AMV is often derived by regressing detrended SST anomalies on the AMV index

(e.g., Knight et al., 2005; Ruiz-Barradas et al., 2013; Sutton & Hodson, 2005)



Detrended and normalized time series of the Baltic Sea annual mean SST and two climate indices. (left) Winter (December–February) mean NAO. (right) Annual and 10-year running mean AMO and SST. SST = sea surface temperature; NAO = North Atlantic Oscillation; AMO = Atlantic Multidecadal Oscillation.

(Source: Kniebusch et al., 2019a)

Are the “teleconnections” between the North Atlantic and the Baltic Sea internal variability or externally forced?

Barghorn et al. 2025 (Env. Res. Lett.)

Our strategy: Use a SMILE (Single Model Initial-condition Large Ensemble) to separate forced and internal variability

$$totalAMV = fAMV + iAMV$$

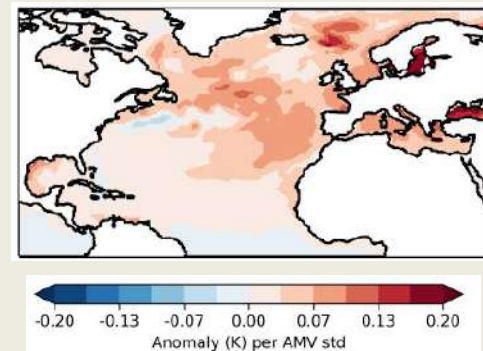
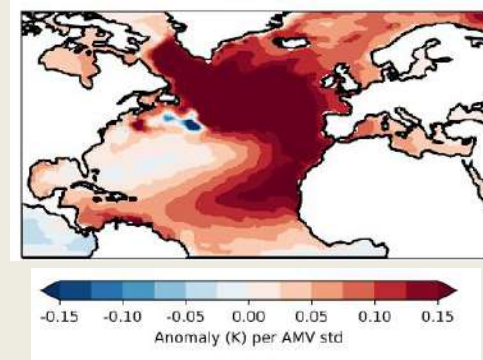
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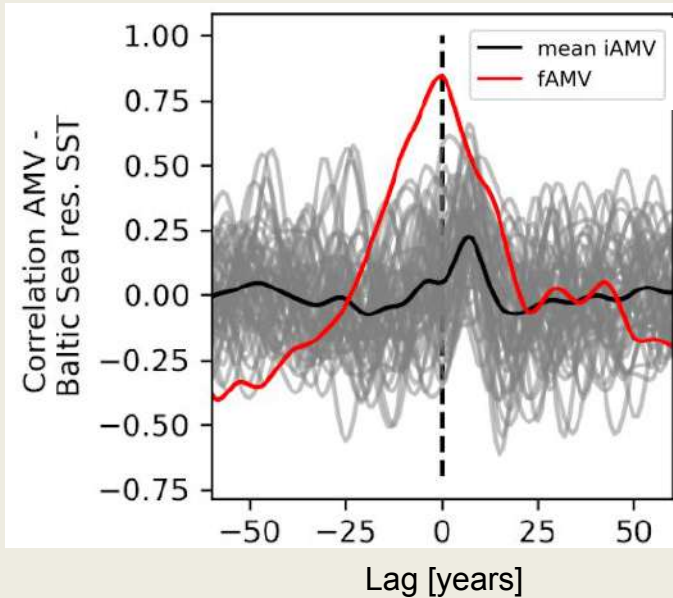
1880-2020



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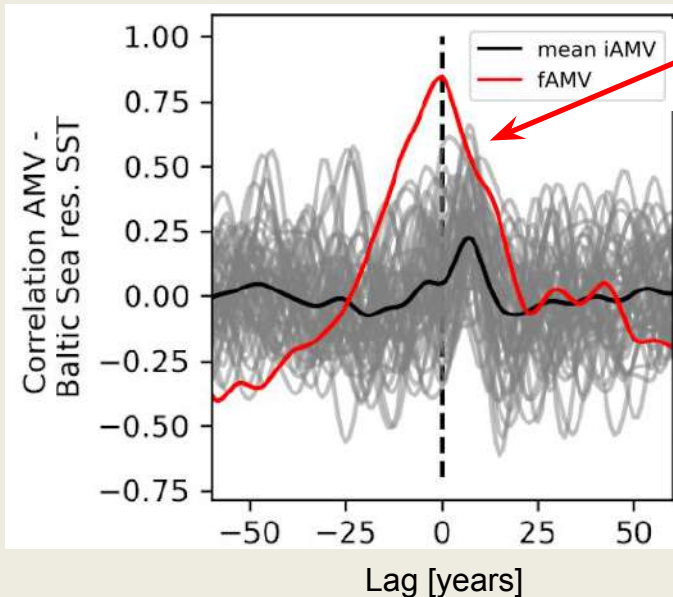
Cross-correlations with Baltic SSTs



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Cross-correlations with Baltic SSTs



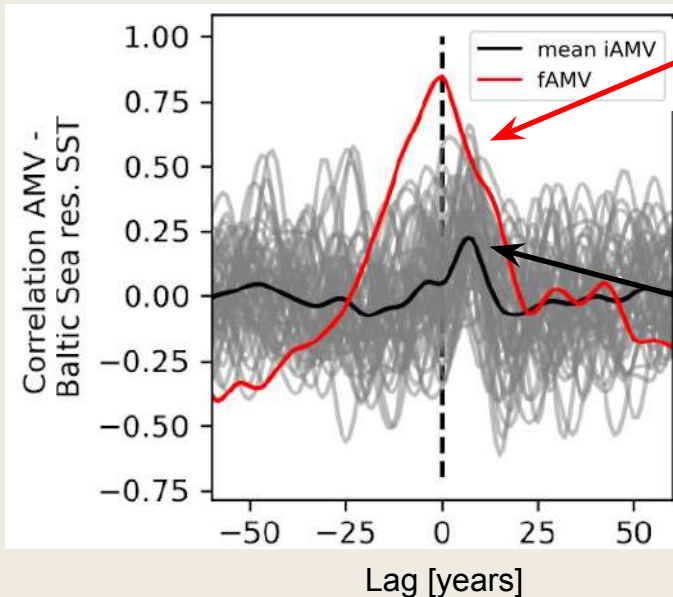
Very high correlation of forced components at lag-0

□ Baltic and North Atlantic SSTs respond similarly to external forcing

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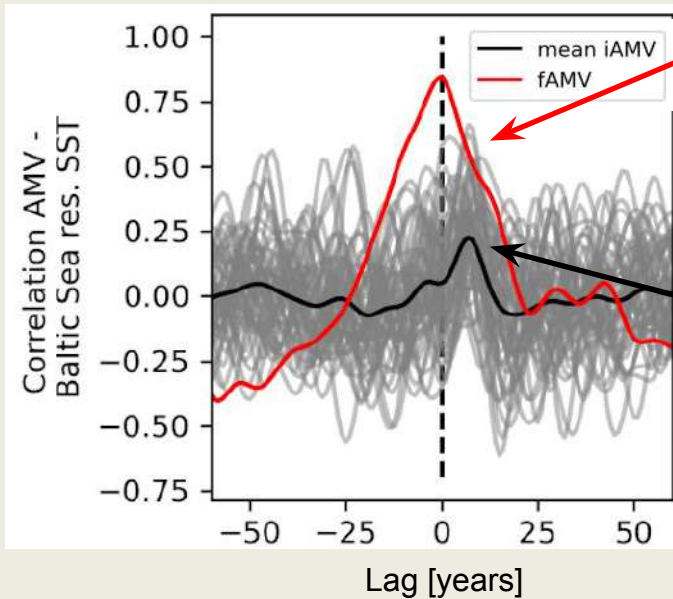
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Highest correlation of internal components when Baltic Sea leads by 7 years

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Cross-correlations with Baltic SSTs



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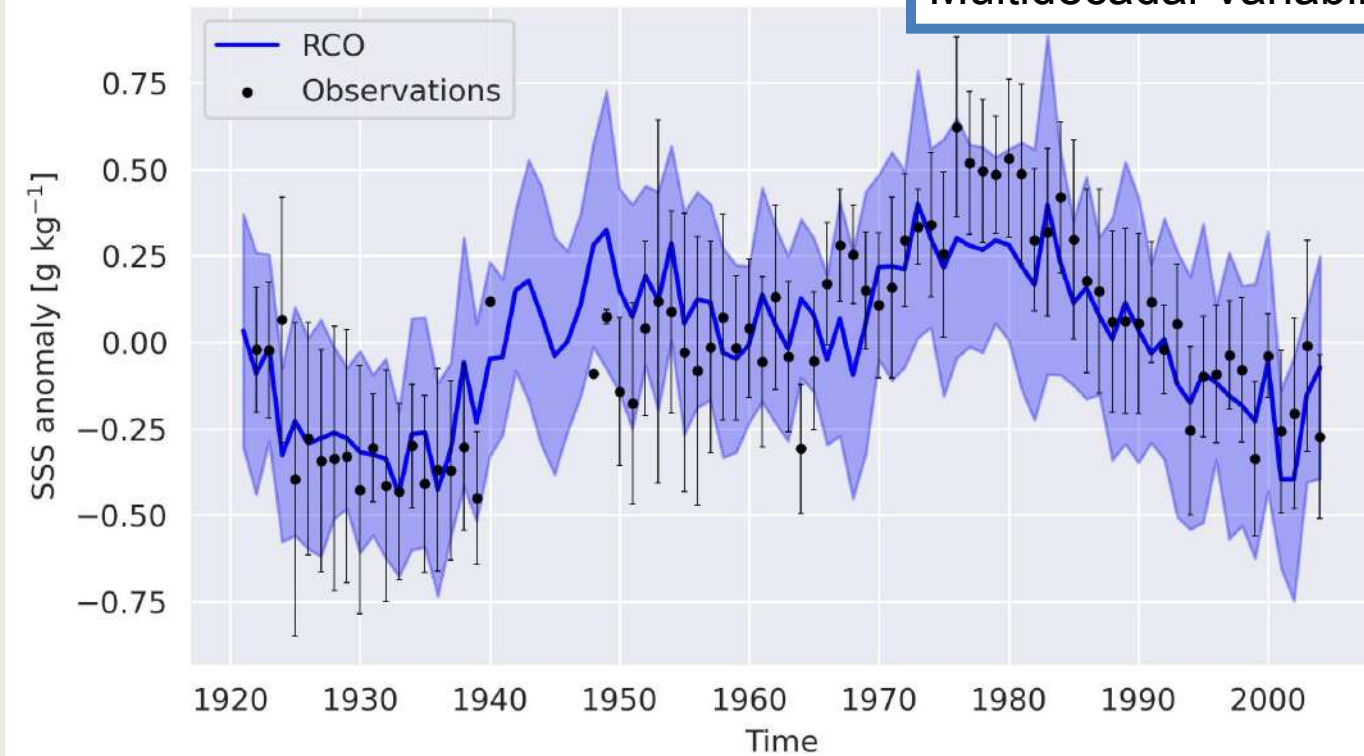
Due to NAO+ situation



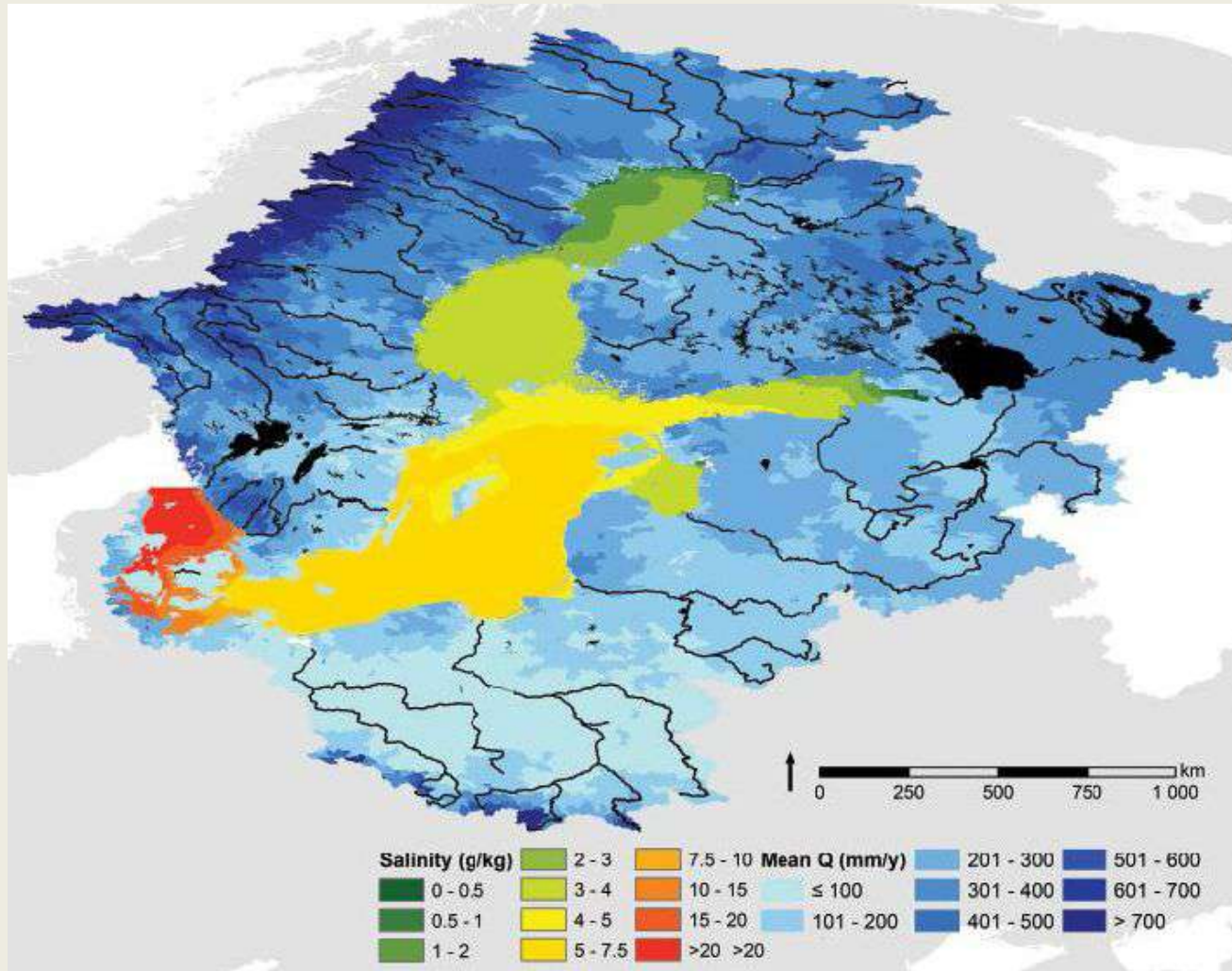
Teleconnections between the North Atlantic and the Baltic Sea region

Sea surface salinity

Low-frequency variability is probably caused by the Atlantic Multidecadal Variability

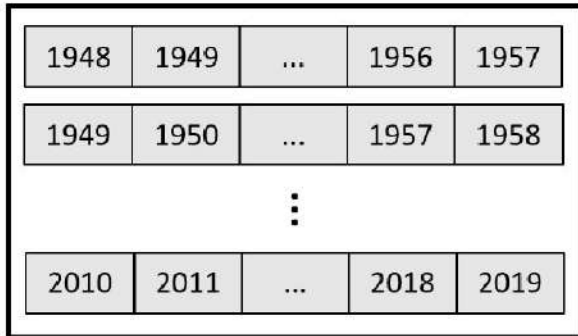


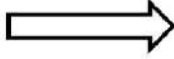
Meier et al., 2023 (npj climate and atmospheric science)



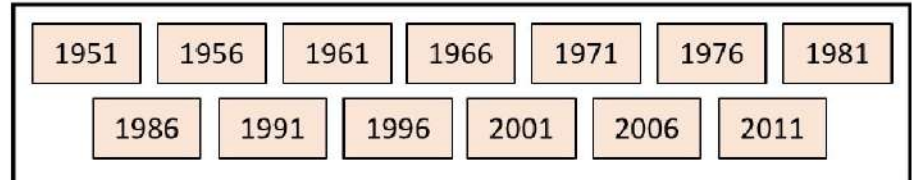
- Reference run 1948-2019
- Full ensemble of 819 members (10-yr simulations)

63 forcing time series (10y)



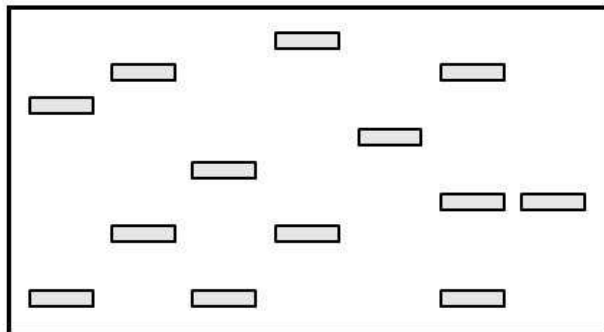
applied to


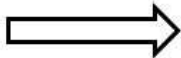
13 initial fields (reference run 01.01.YYYY)



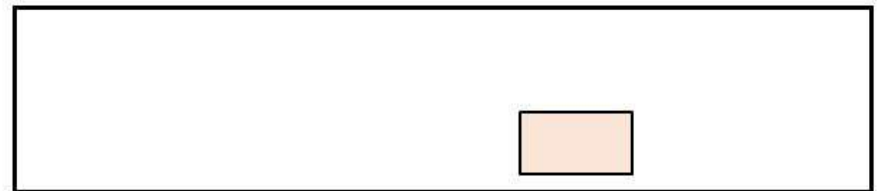
- Subsampling of the forcings:

Specific forcing time series



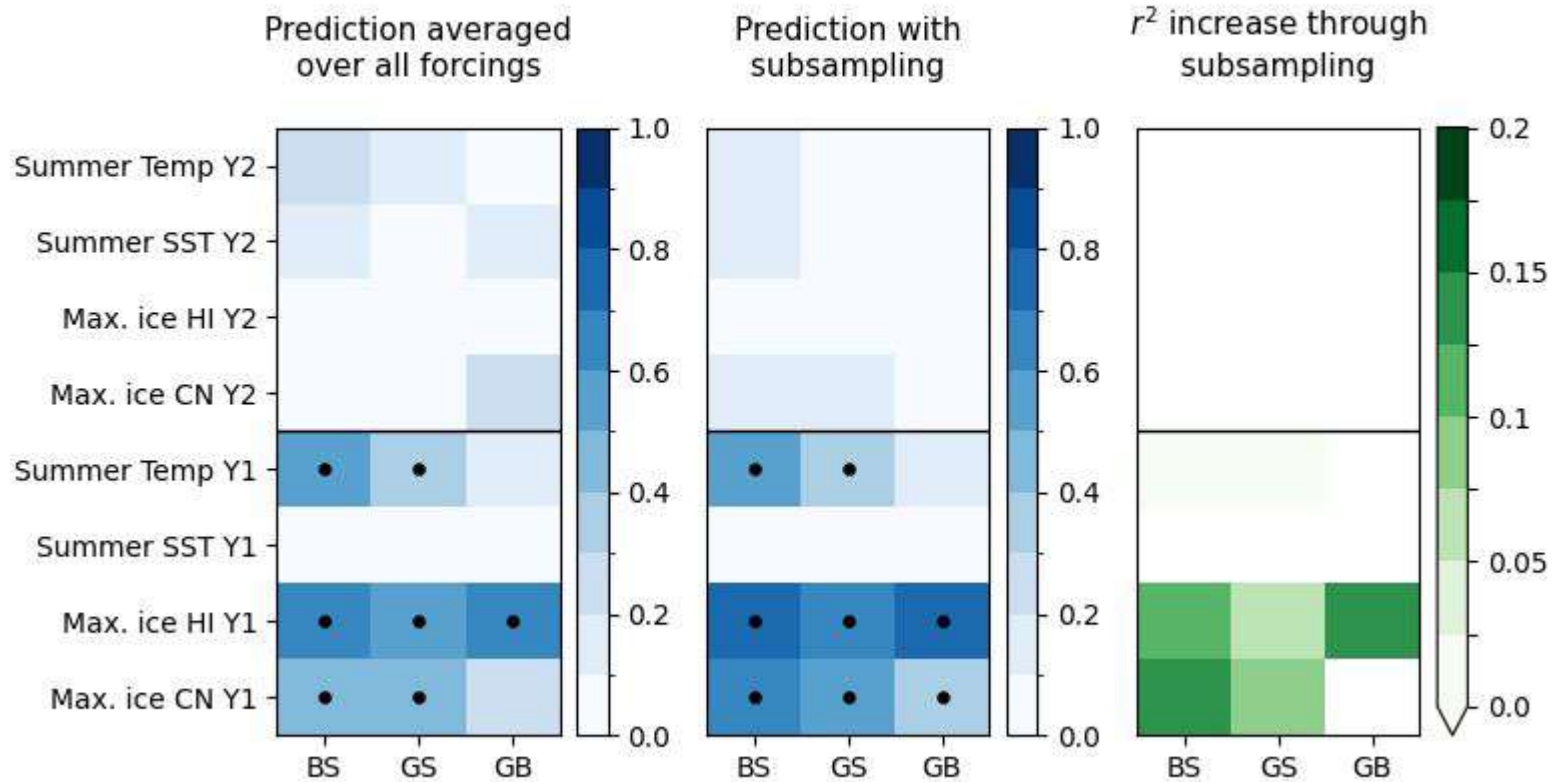
applied to


1 initial field



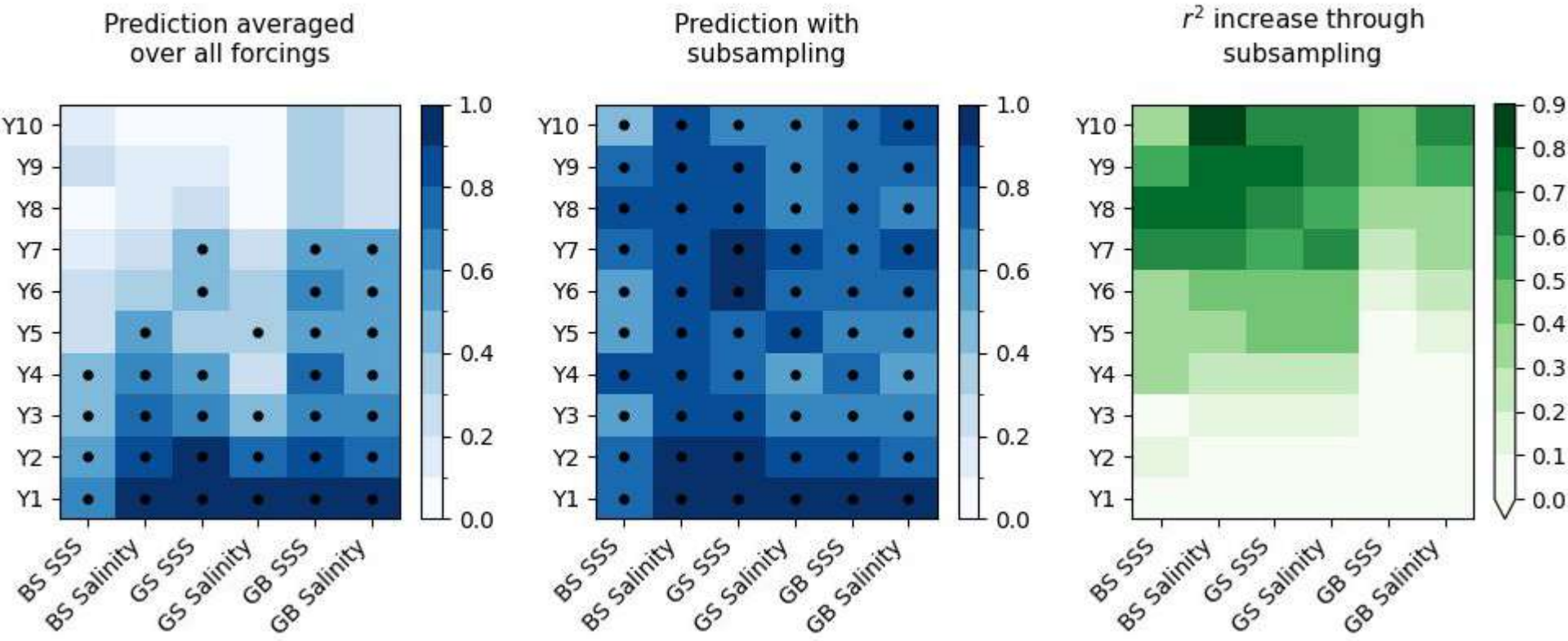
(Master thesis Marti Wolff)

Squared correlations (r^2) between prediction and reference run.
 Subsampling based on initial Baltic Sea temperature.



BS - Baltic Sea, GS - Gotland Sea, GB - Gulf of Bothnia

Squared correlations (r^2) between annual values of prediction and reference run.
 Subsampling based on past 10y GB salinity and future 10y AMV index.



BS - Baltic Sea, GS - Gotland Sea, GB - Gulf of Bothnia

Planned work in RIVIERADE

- 1) Analysis of climate variability across Europe (Northern Europe) to better understand low-frequency variability in temperature and precipitation (e.g. 30-year variability of precipitation over the Baltic Sea region)
- 2) Selection of ensemble members with AMOC, NAO states, etc. in existing SMILE simulations
- 3) determination of predictability for Northern Europe and the Baltic Sea through downscaling using “identical twin” experiments
- 4) Downscaling of CMCC DCPP data, predictions and comparison with observations