Wind Stress-Induced Multiyear Predictability of Annual Sea Surface Temperature Anomalies in the Extratropical North Atlantic

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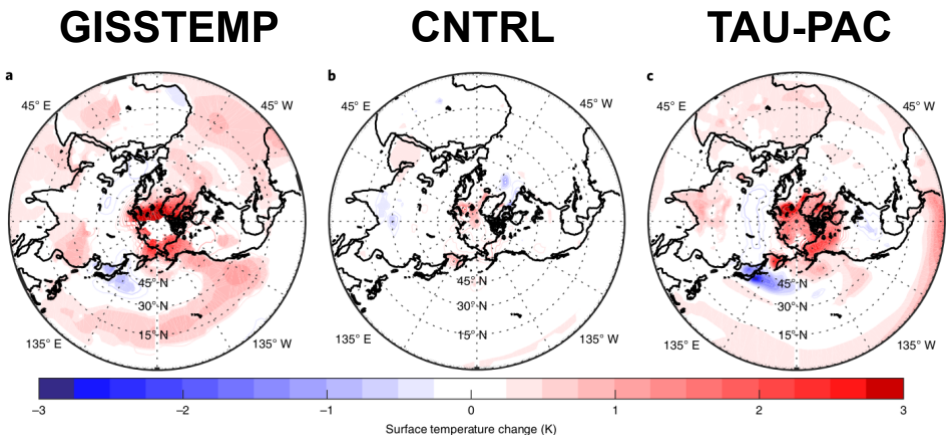
Wind stress forcing sufficient to reproduce climate variability

Through forcing the model with reanalysis wind stress anomalies:

- **Arctic early 20th century warming reproduced (*Svendsen et al. 2018*)**
- **Global warming hiatus is reproduced (*Delworth et al. 2015*)**

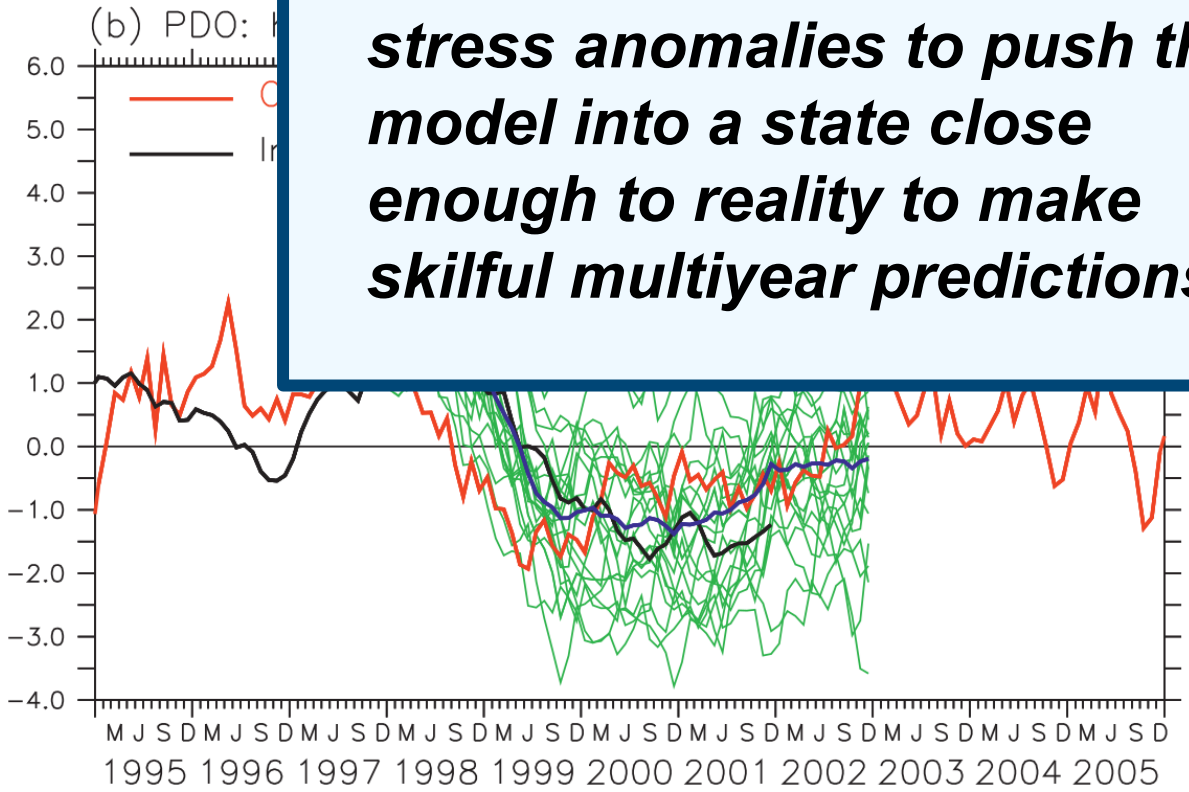
Surface temperature 1936-1945 vs. 1911-1920



Svendsen et al. 2018

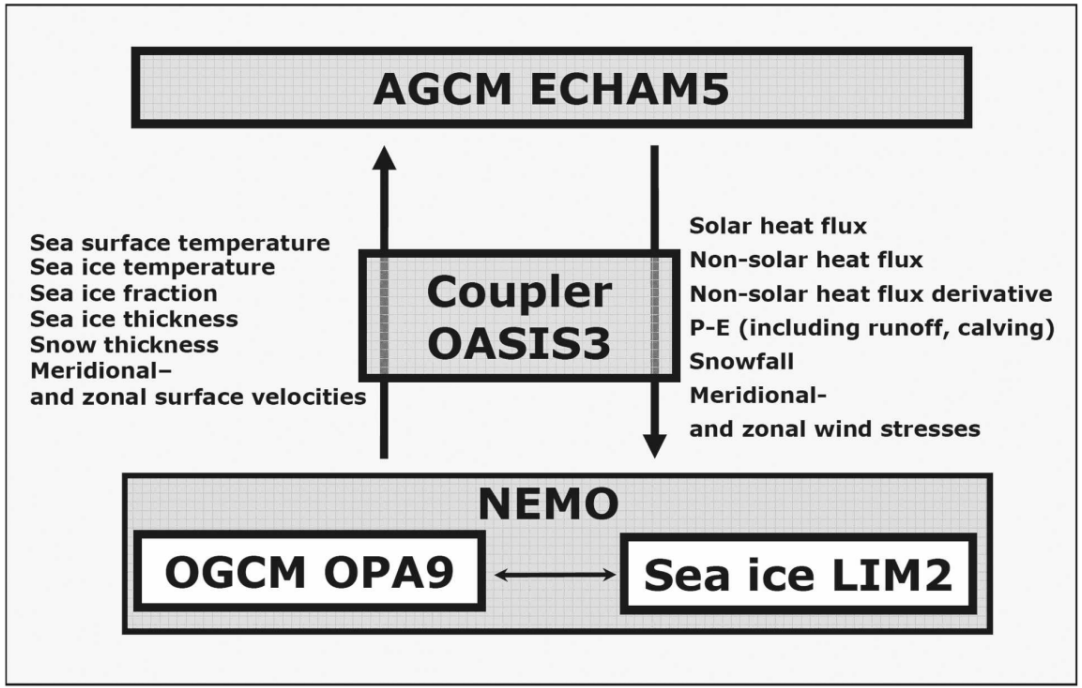
Wind str… Pacific d…

Can we use observed wind stress anomalies to push the model into a state close enough to reality to make skilful multiyear predictions?



Ding et al. 2013

KCM - Kiel Climate Model *(Park et al. 2009)*



Atmospheric component:
ECHAM5 *(Roeckner et al. 2003)*
- T42 (~2.8°) horizontally
- 19 vertical levels

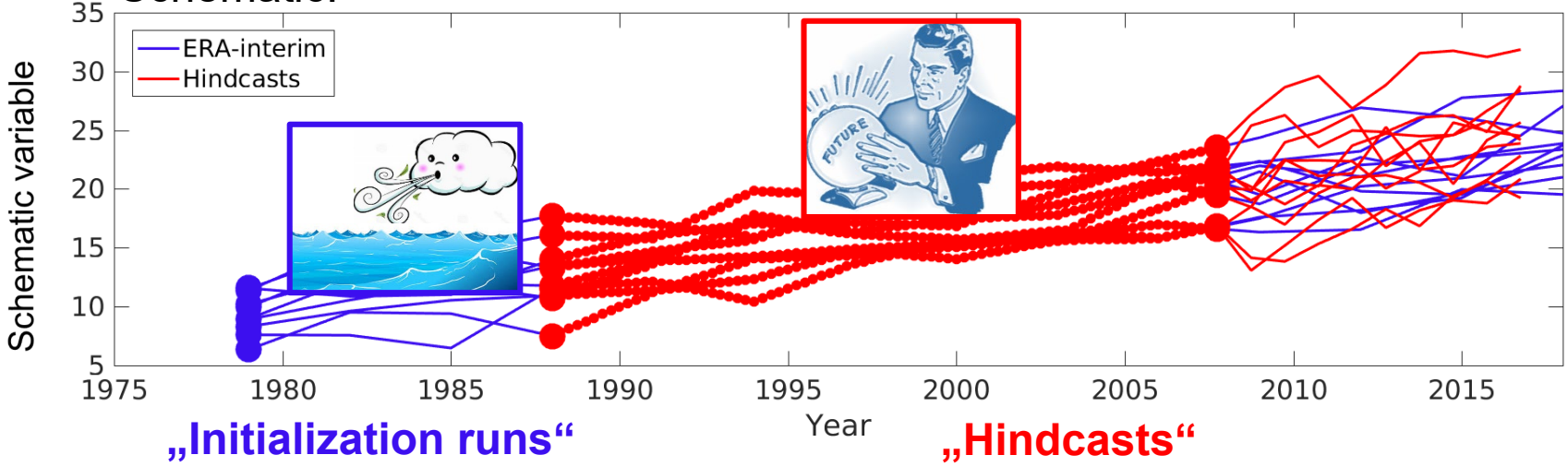
Ocean-sea ice component:
NEMO *(Madec 2008)*
- ~2° horizontally
- 31 vertical levels

Experiment Set-up

$$\tau_{FULL} = \tau_{model\ daily\ climatology} + \tau_{ERA\ daily\ anomalies}$$

← zonal & meridional; affecting only momentum flux

Schematic:



„Initialization runs“

Runs with prescribed wind stress anomalies (from ERA-interim)

„Hindcasts“

Initialized hindcasts (predictions) – no prescribed wind stress

Boundary condition: Historical CO_2 forcing

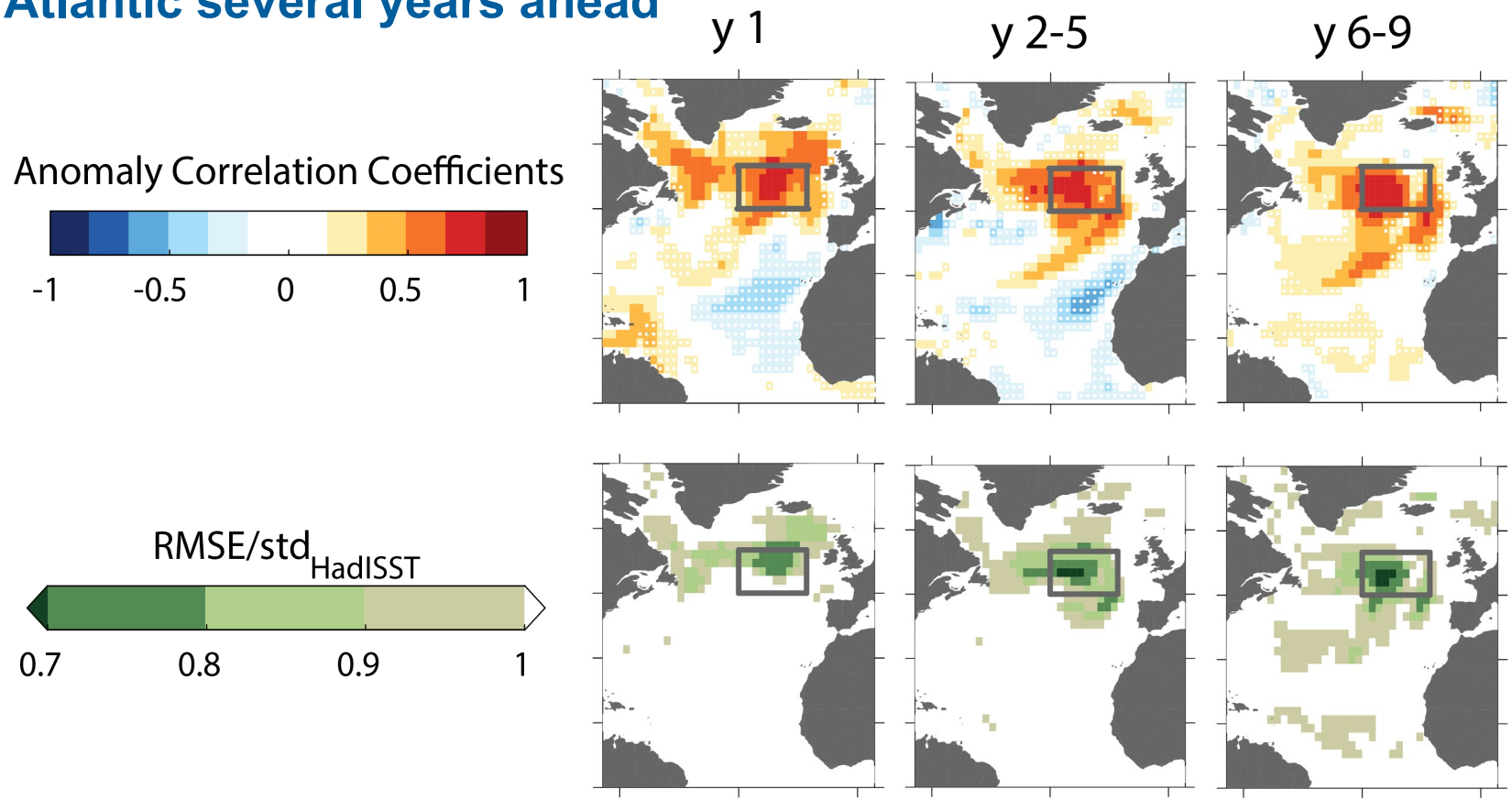
To evaluate

Initialized Hindcast Results

„Climate state realistic enough to make skilful predictions?“

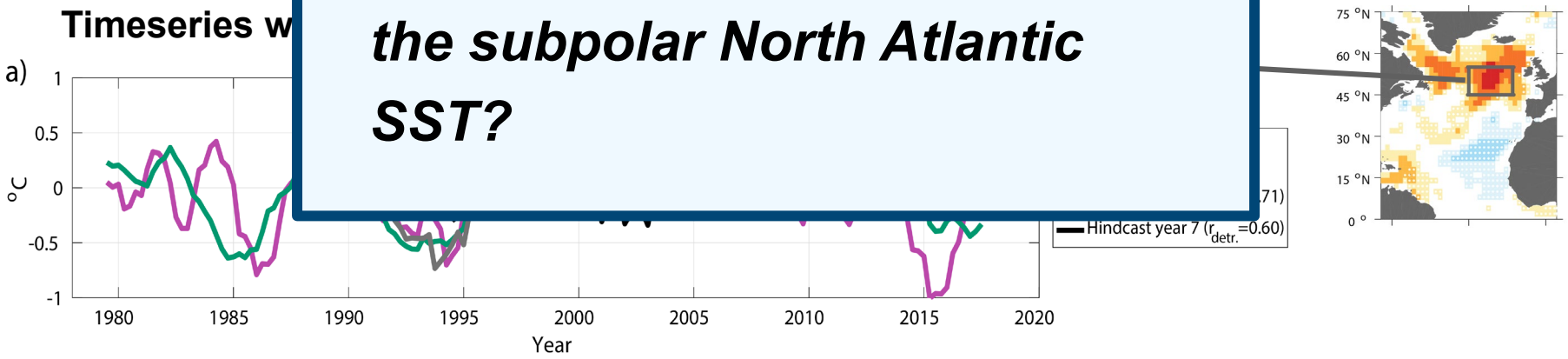
- Detrendin
- Time window: 12-months running mean / prediction months 1-12, 3-15, ...
- Compare against persistence (observational auto-correlation)

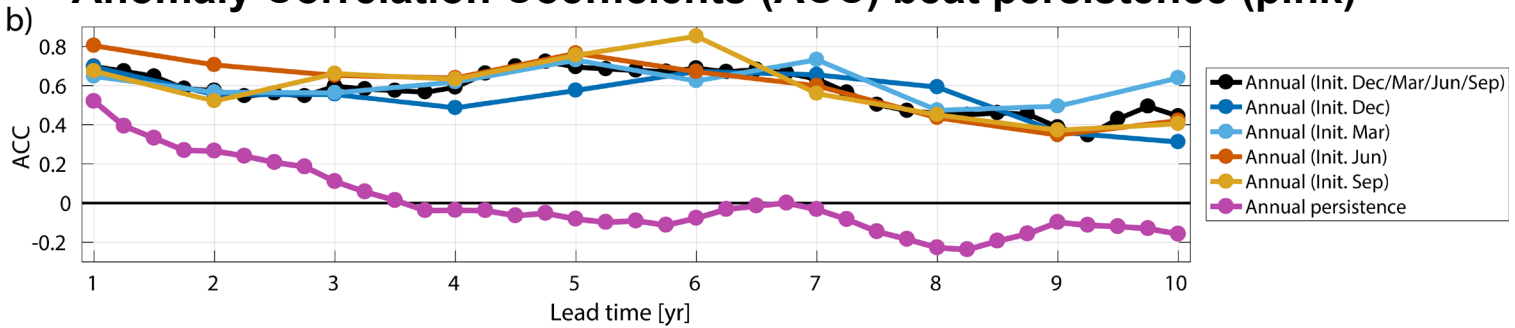
Significant skill of the hindcast ensemble-mean to predict annual SST anomalies in the extratropical North Atlantic several years ahead



Significant skill of the hindcast ensemble-mean to predict annua
Atlantic seve

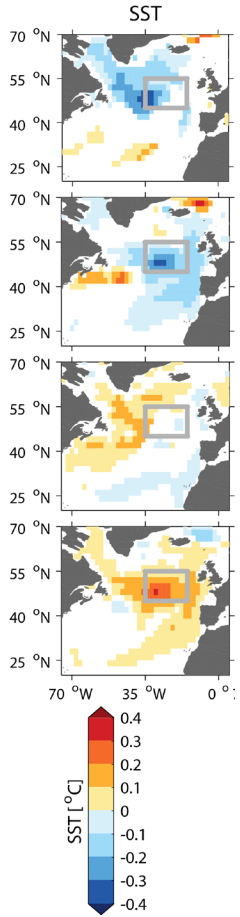
Sources for predictive skill in the subpolar North Atlantic SST?



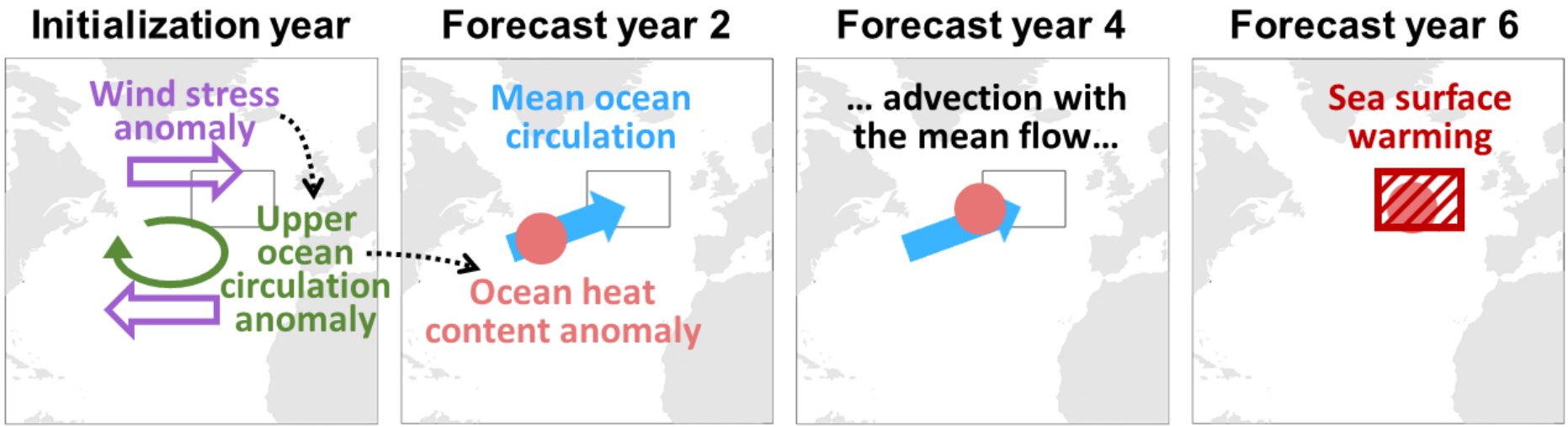


Wind-driven ocean dynamics enable predictability

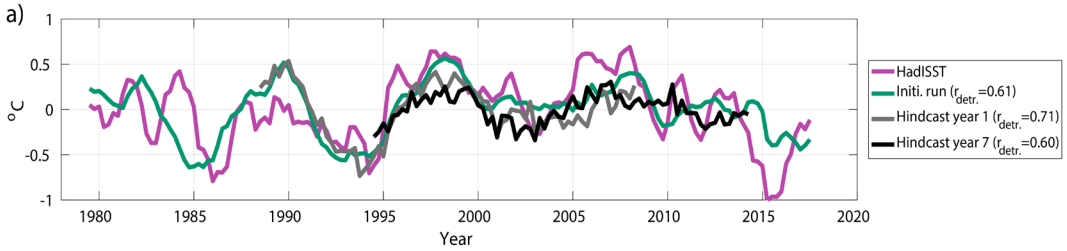
- **Wind-driven response of PSI (barotropic streamfunction) causes subsurface heat (HC<700m) build-up**
- **Heat further maintained by circulation and moving eastward over several years**
- **HF (heat flux, defined downward) is only damping SST anomalies**



Schematic mechanism



Summary



Wind stress initialization yields skilful multiyear hindcasts of annual extratropical North Atlantic sea surface temperature anomalies.

The skill is essentially insensitive to the initialization calendar month.

The skill is linked to an upper ocean heat content anomaly that leads anomalous sea surface temperatures by several year.

Reintges, A., Latif, M., Bordbar, M. H., and Park, W., 2020
Wind Stress-Induced Multiyear Predictability of Annual Extratropical North Atlantic Sea Surface Temperature Anomalies
Geophysical Research Letters

Motivation for ongoing work

Possible causes for 'missing' AMOC contribution in this specific study:

- **initialisation based on wind-stress only**
- **rather short (multiyear) timescale**

- **coarse resolution**
- **cold surface biases**

} → **hampered air-sea interaction?** model dependent!

How do CMIP6 models differ in their North Atlantic predictability?

- **What role does the NAO-AMOC interaction play?**
- **What role do mean state biases play?**