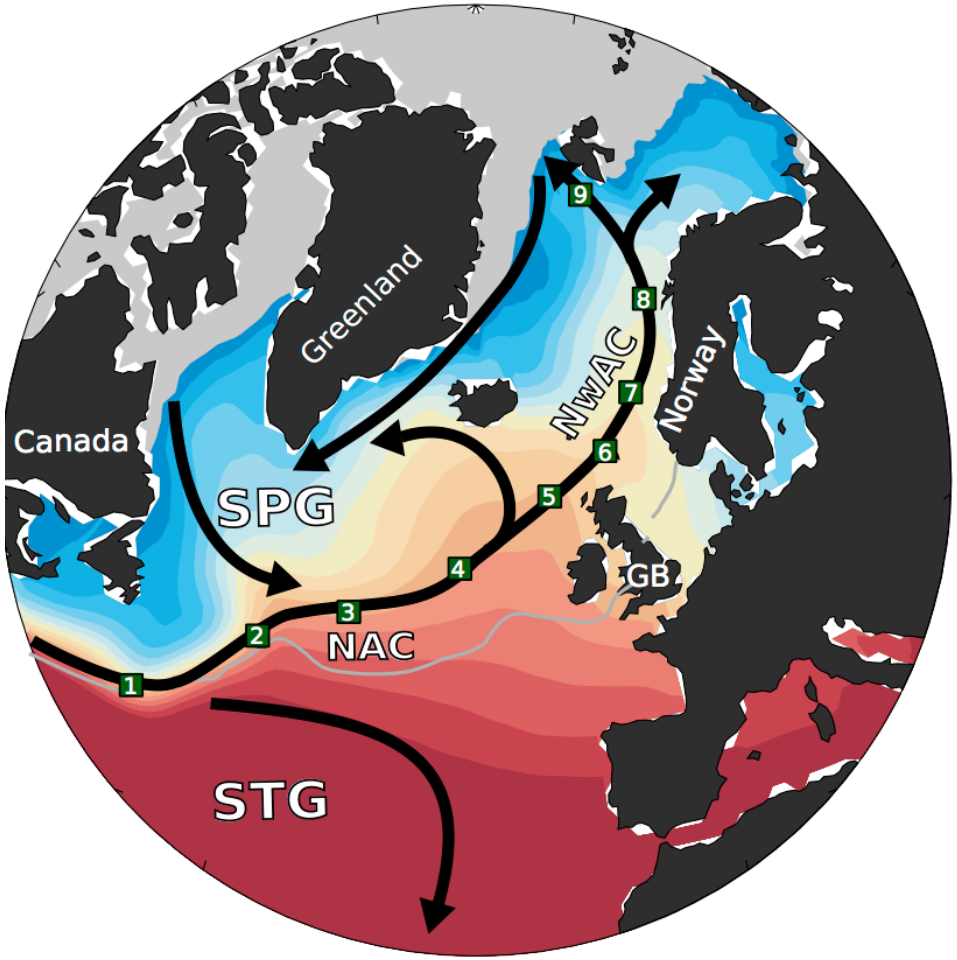
Empirical evidence for northern climate predictability provided by the ocean

Tor Eldevik, M. Årthun, I.H. Onarheim, Ø. Skagseth, H.R. Langehaug et al.

Helene, NERSC



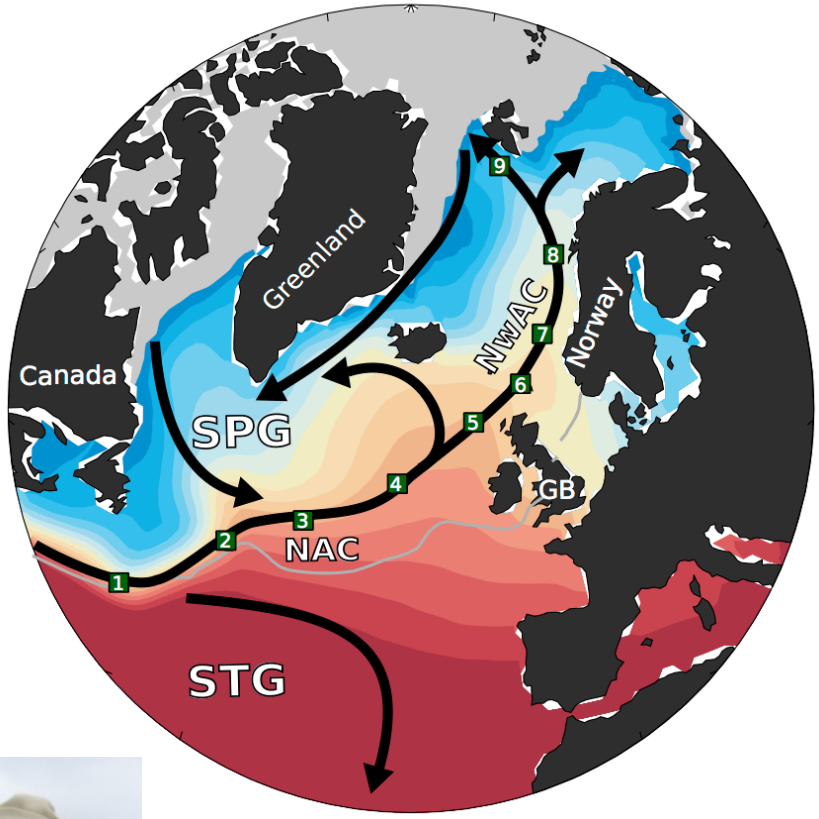
Marius, UiB

Øystein, IMR

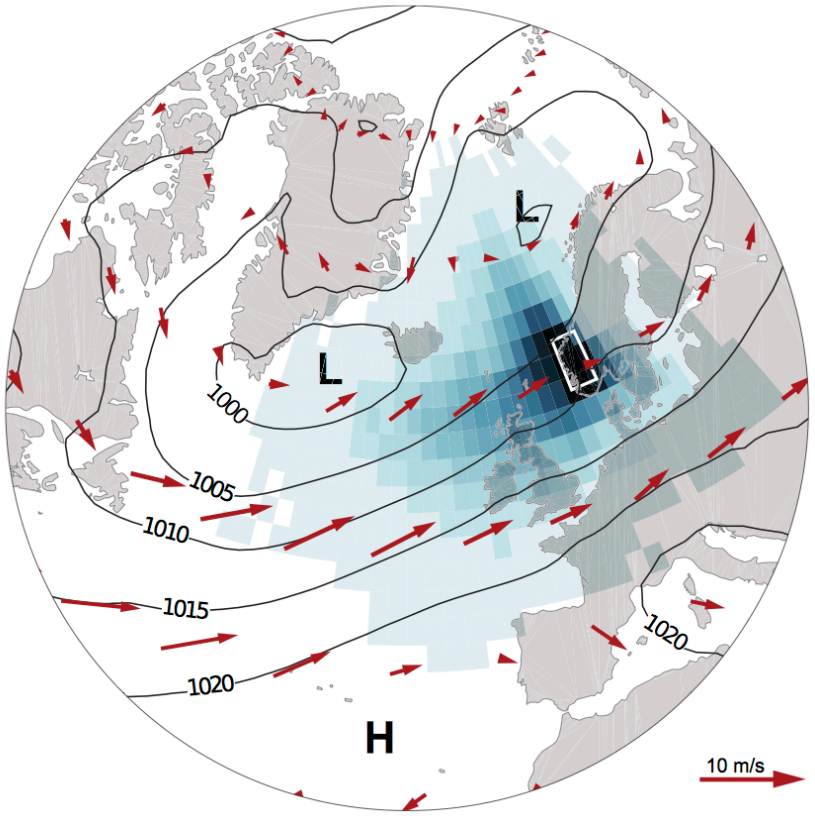
Ingrid, UiB

The “Gulf Stream” and the westerly winds

a) Ocean

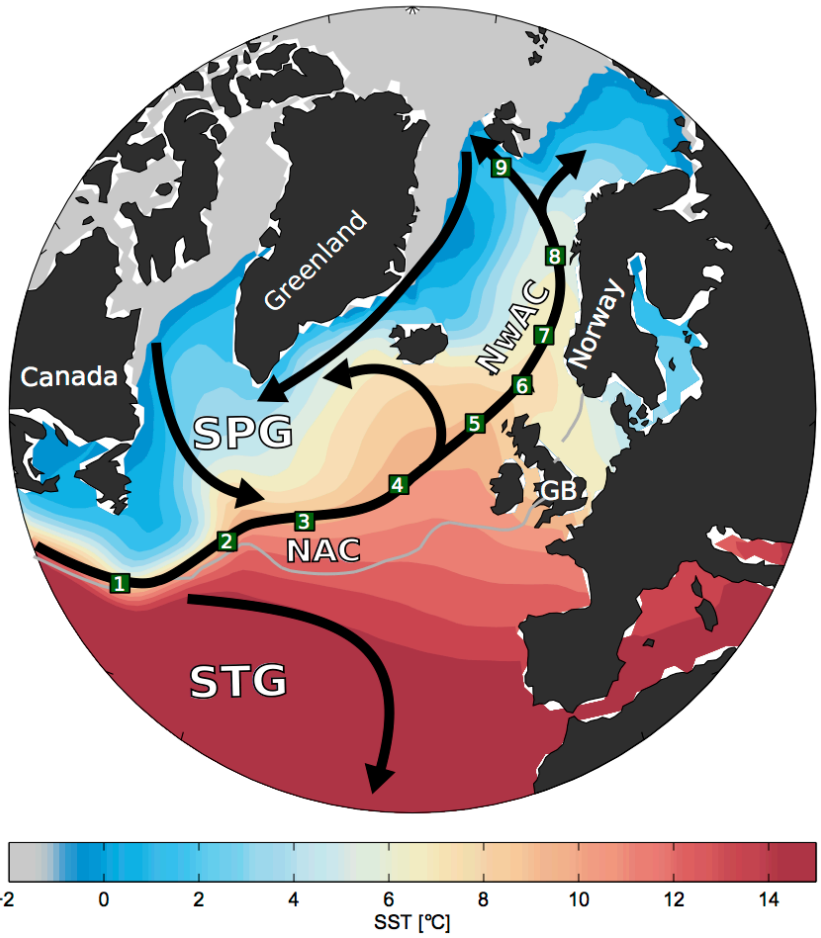


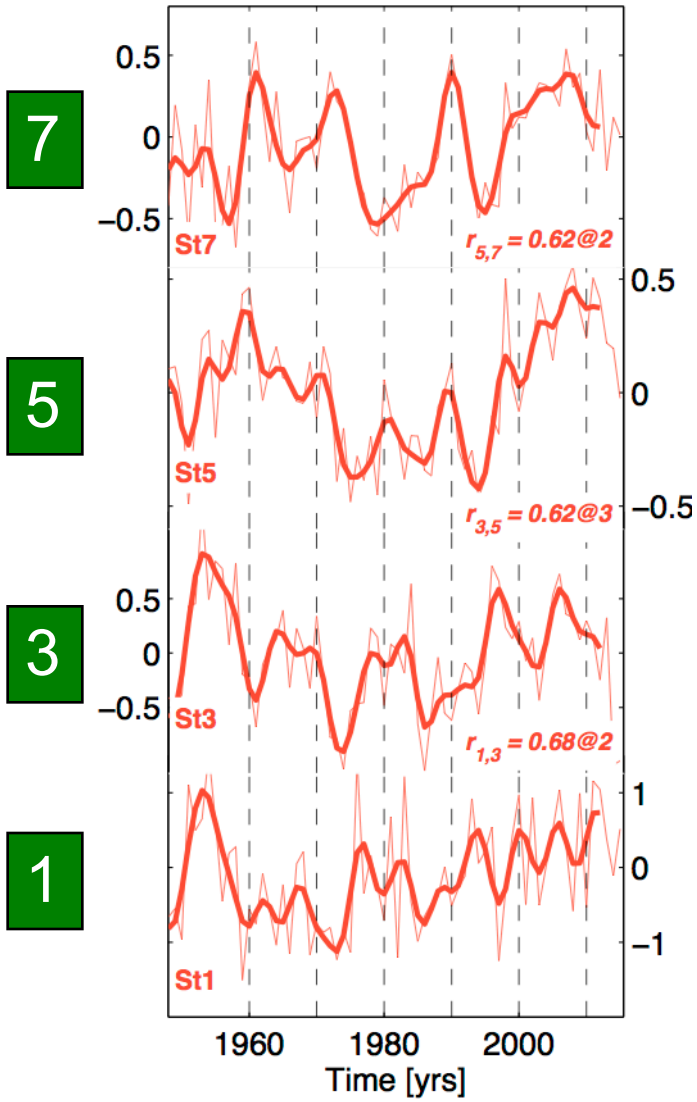
b) Atmosphere



Årthun et al. 2016: Skillful prediction of northern climate provided by the ocean. ***Nature comm.***, in revision.

Observed SST propagation (HadISST)

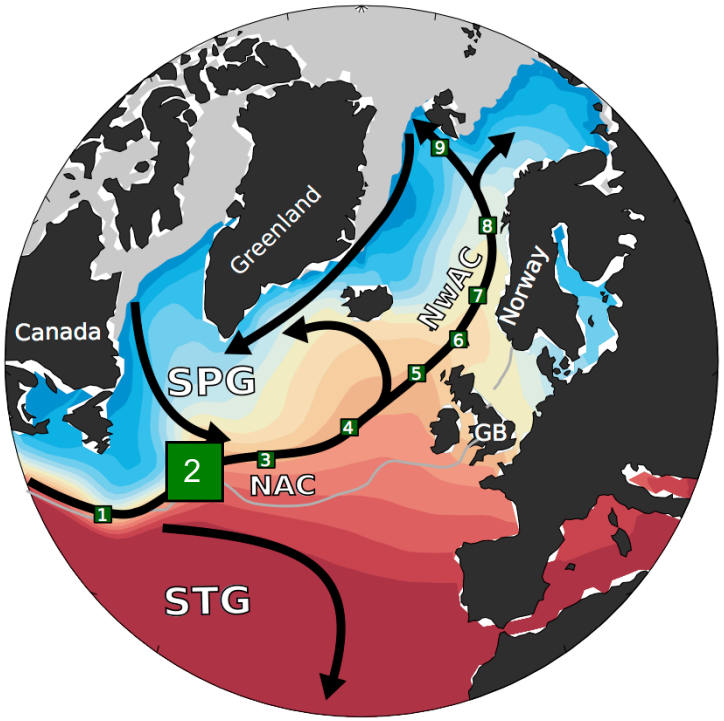




Århun et al. 2016: *Nature Comm.*, in rev.

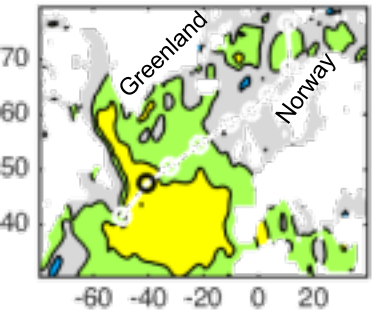
Propagating thermohaline anomalies, e.g., Sutton and Allen 1997, Holliday et al. 2008, Århun and Eldevik 2016, +++

Observed SST propagation (HadISST)

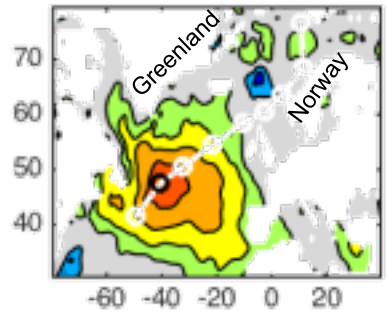


St: 2

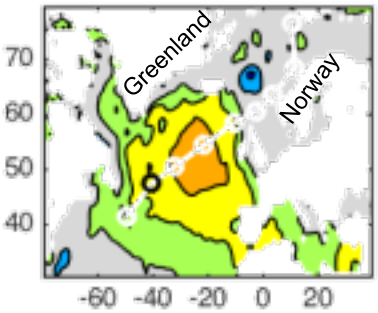
*interannual co-variance – **no** low-pass*



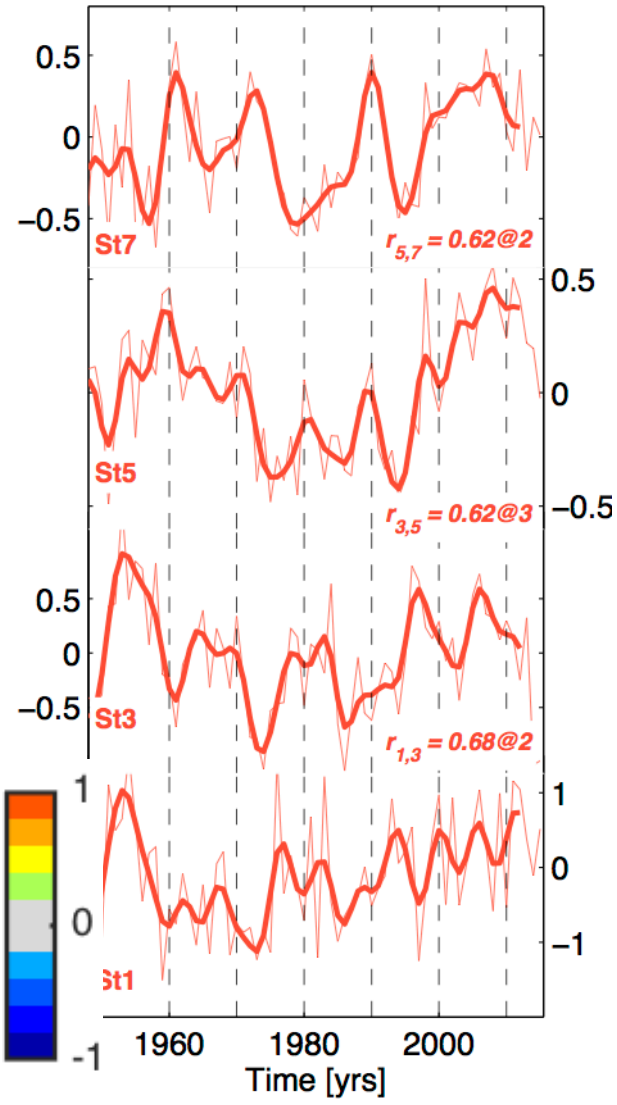
lag -1yr



no lag

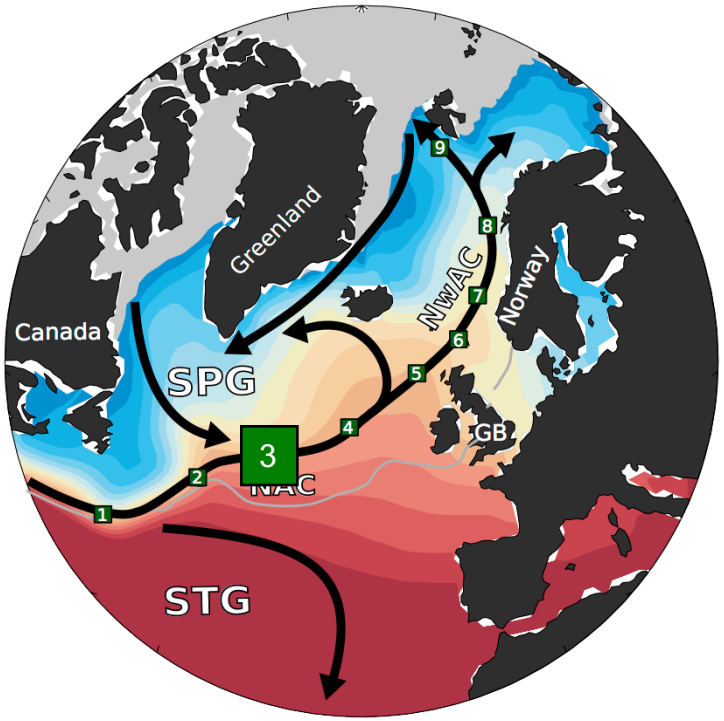


lag +1yr



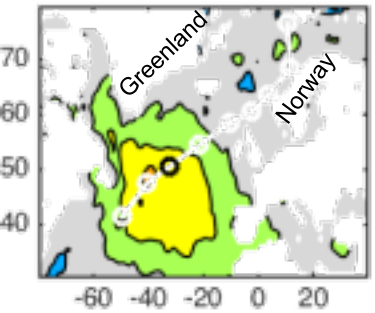
Århun et al. 2016: *Nature Comm.*, in rev.

Observed SST propagation (HadISST)

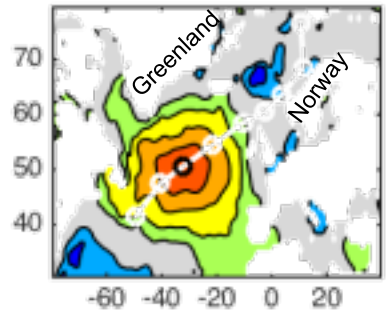


St: 3

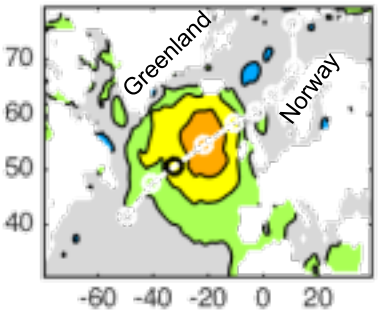
*interannual co-variance – **no** low-pass*



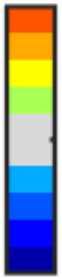
lag -1yr

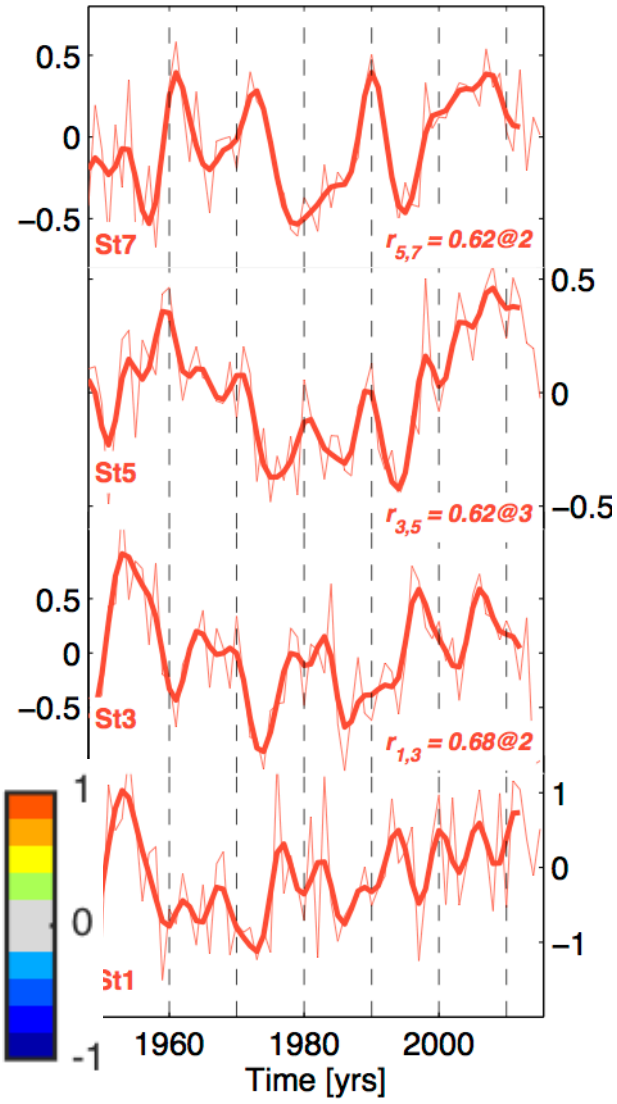


no lag



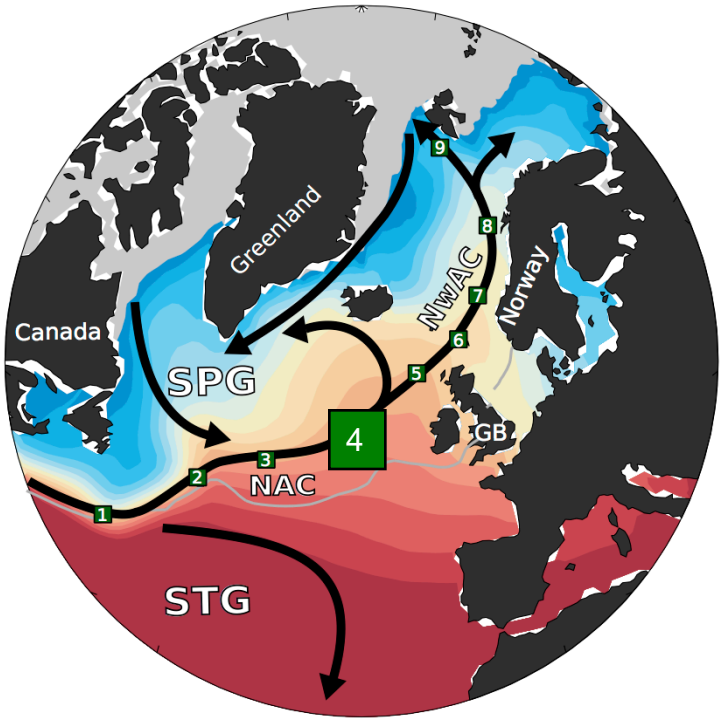
lag +1yr





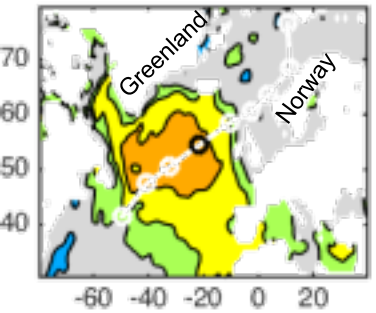
Århun et al. 2016: *Nature Comm.*, in rev.

Observed SST propagation (HadISST)

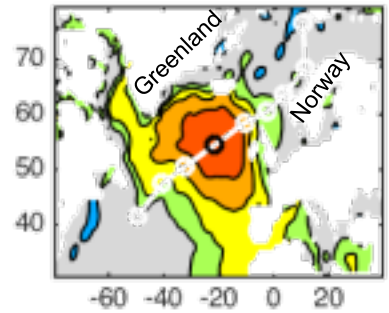


St: 4

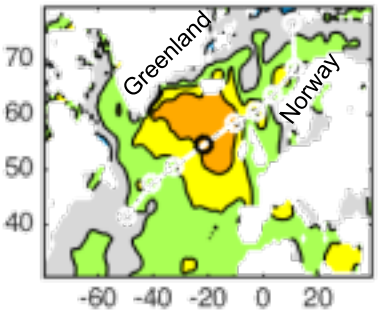
*interannual co-variance – **no** low-pass*



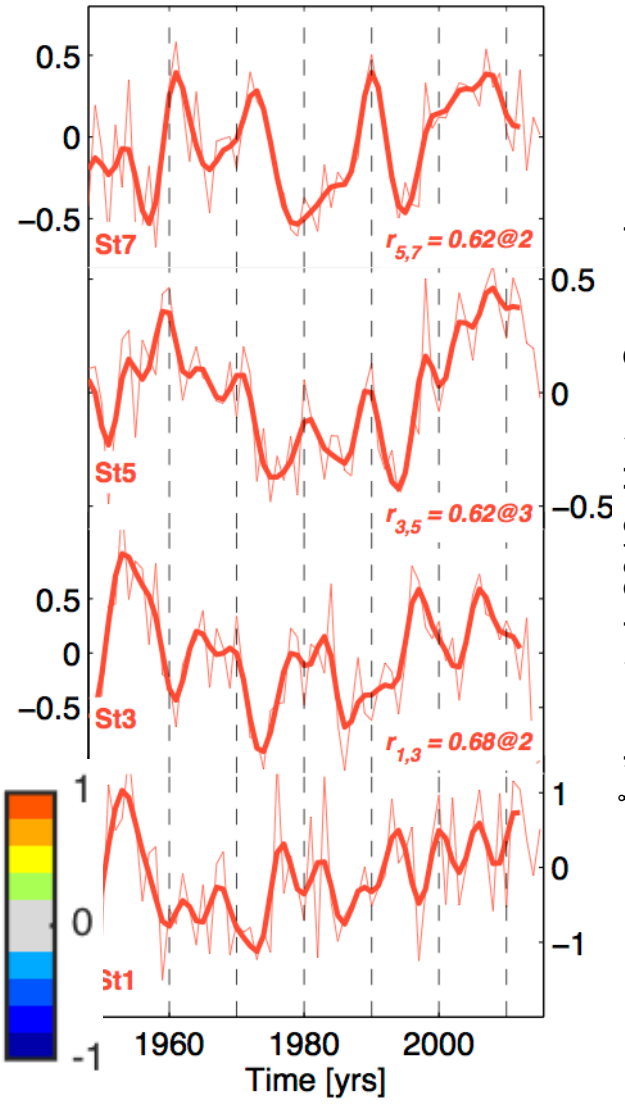
lag -1yr



no lag

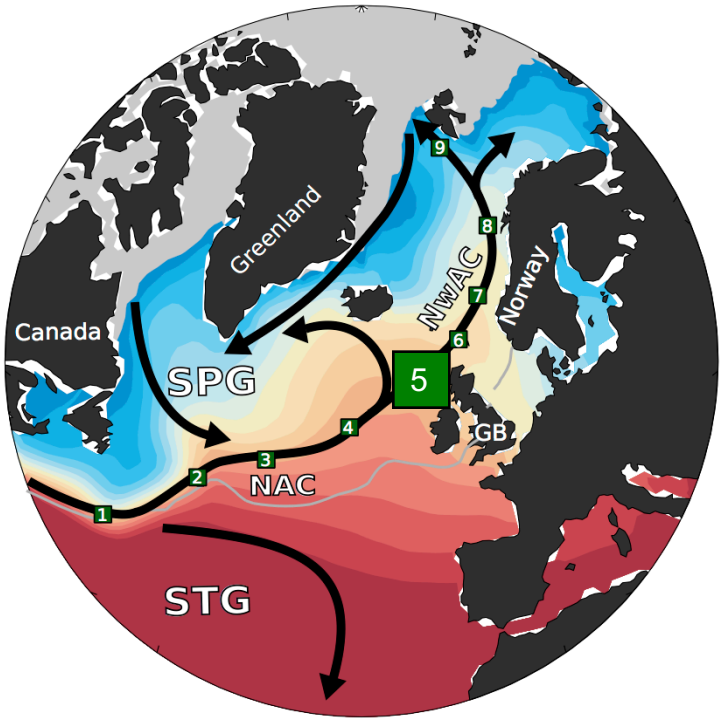


lag +1yr



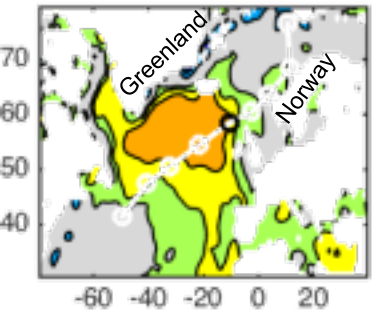
Århun et al. 2016: *Nature Comm.*, in rev.

Observed SST propagation (HadISST)

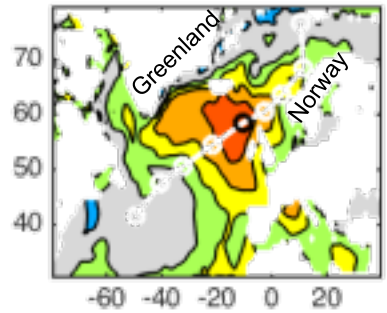


St: 5

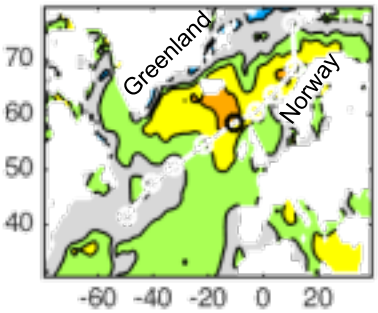
*interannual co-variance – **no** low-pass*



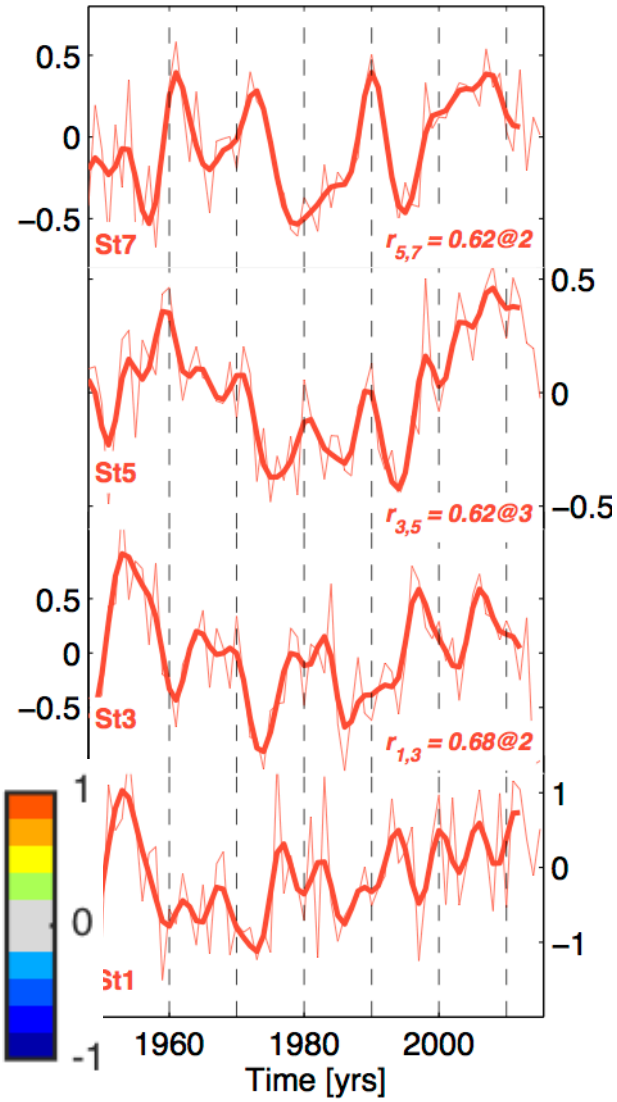
lag -1yr



no lag

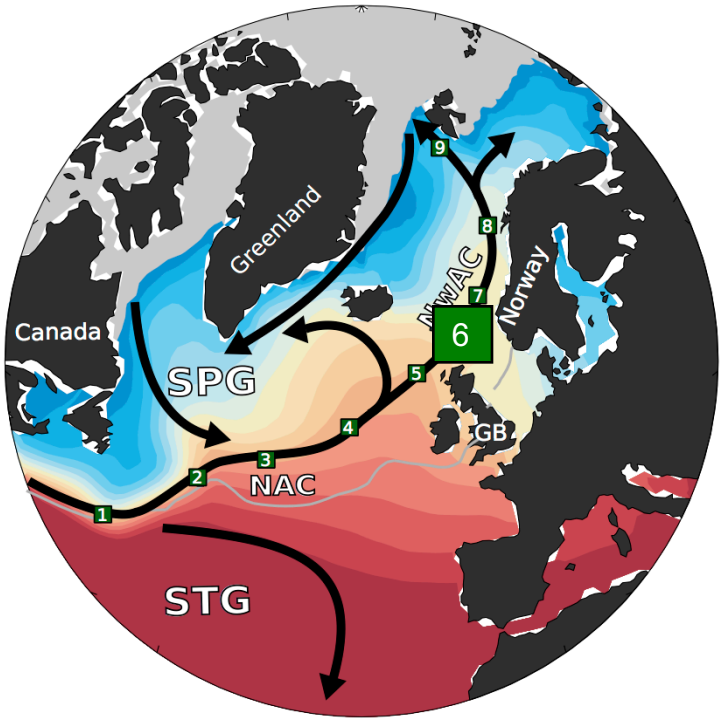


lag +1yr



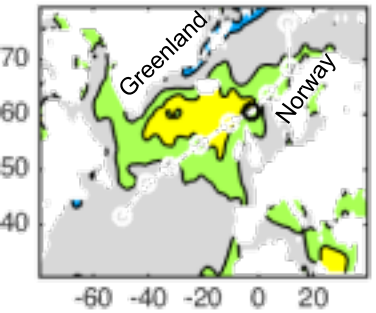
Århun et al. 2016: *Nature Comm.*, in rev.

Observed SST propagation (HadISST)

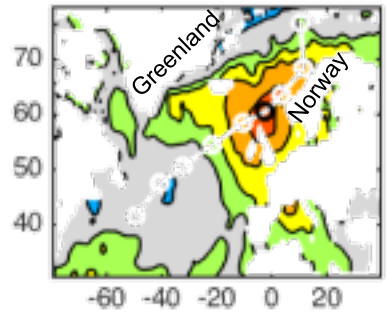


St: 6

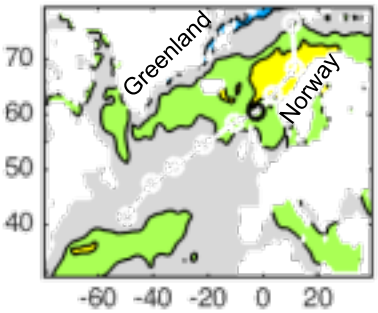
*interannual co-variance – **no** low-pass*



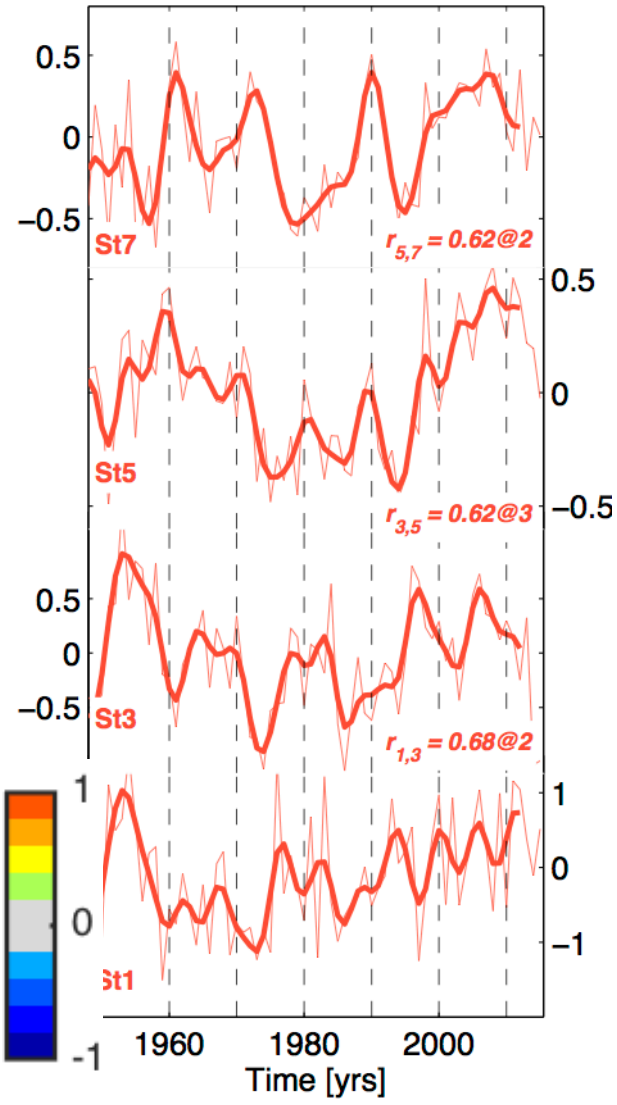
lag -1yr



no lag

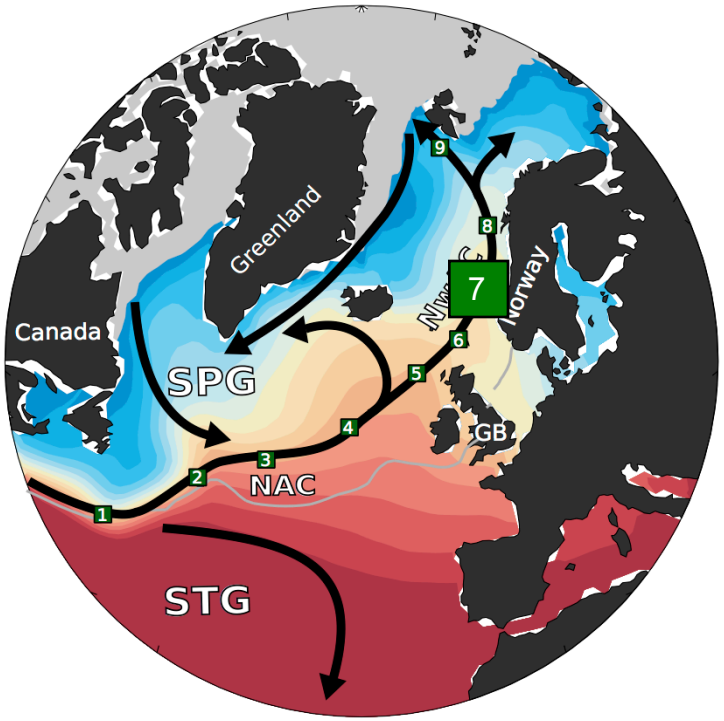


lag +1yr



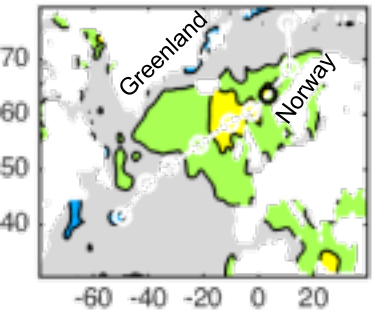
Århun et al. 2016: *Nature Comm.*, in rev.

Observed SST propagation (HadISST)

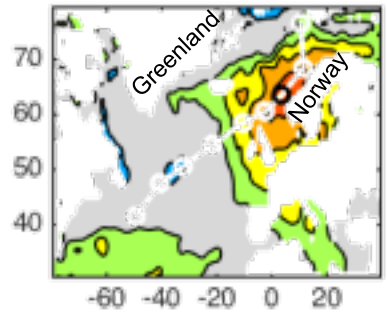


St: 7

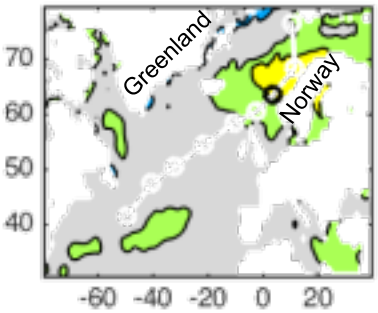
*interannual co-variance – **no** low-pass*



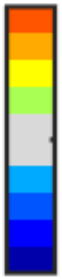
lag -1yr

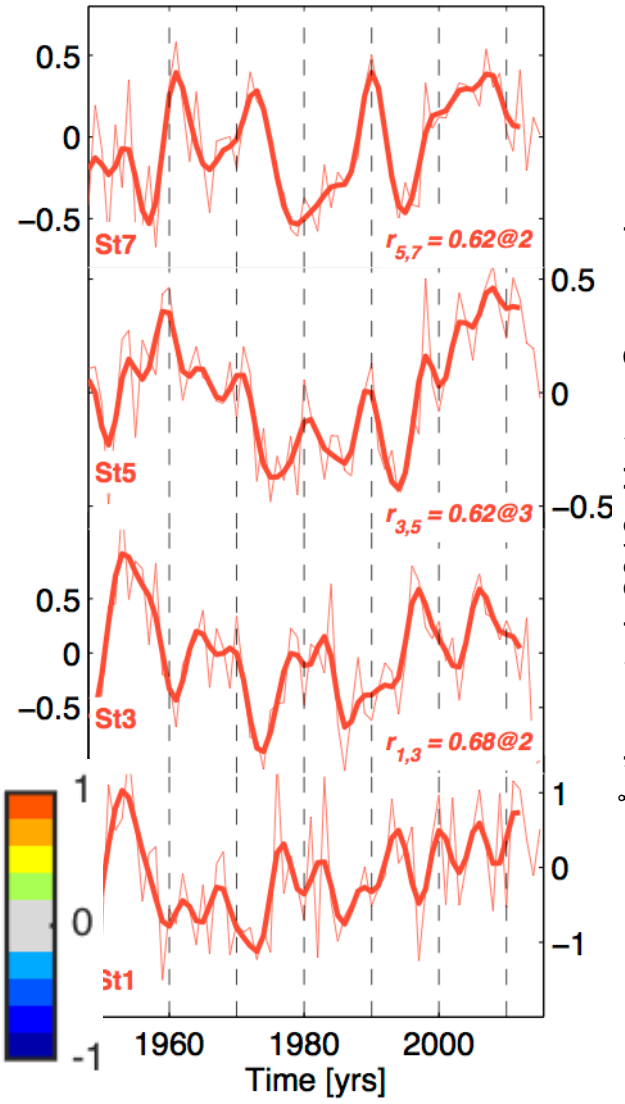


no lag



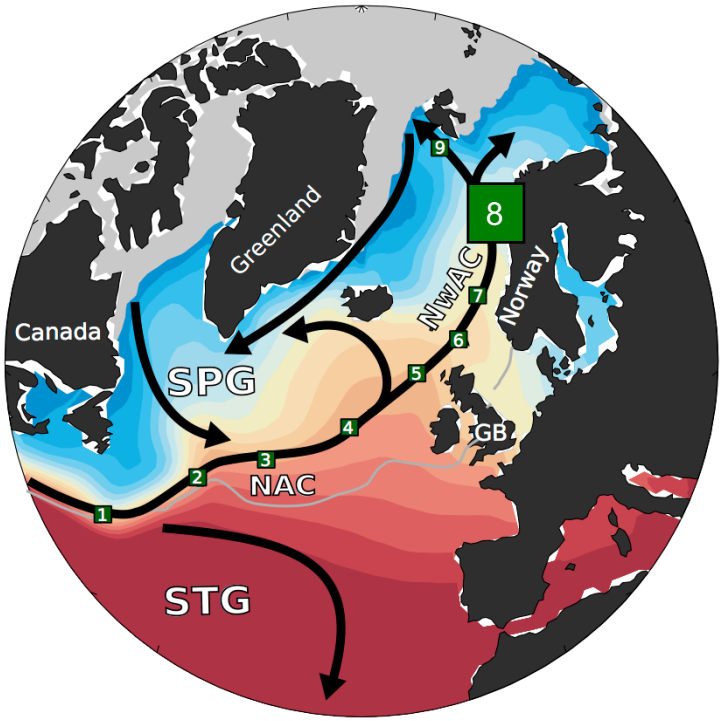
lag +1yr





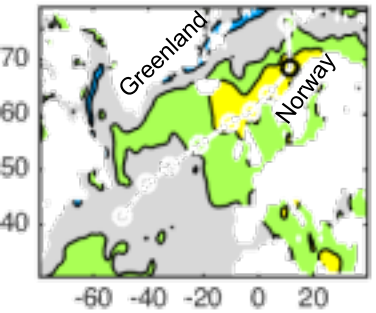
Århun et al. 2016: *Nature Comm.*, in rev.

Observed SST propagation (HadISST)

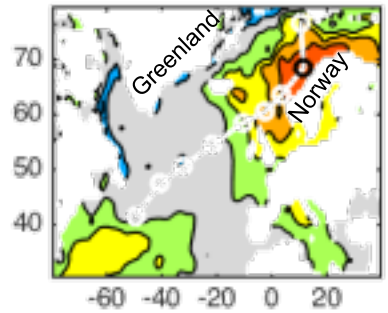


St: 8

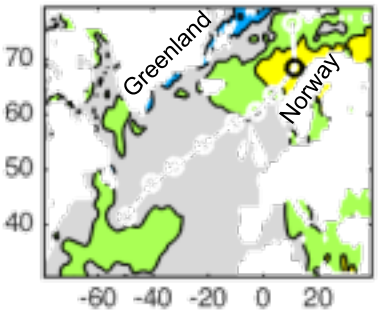
*interannual co-variance – **no** low-pass*



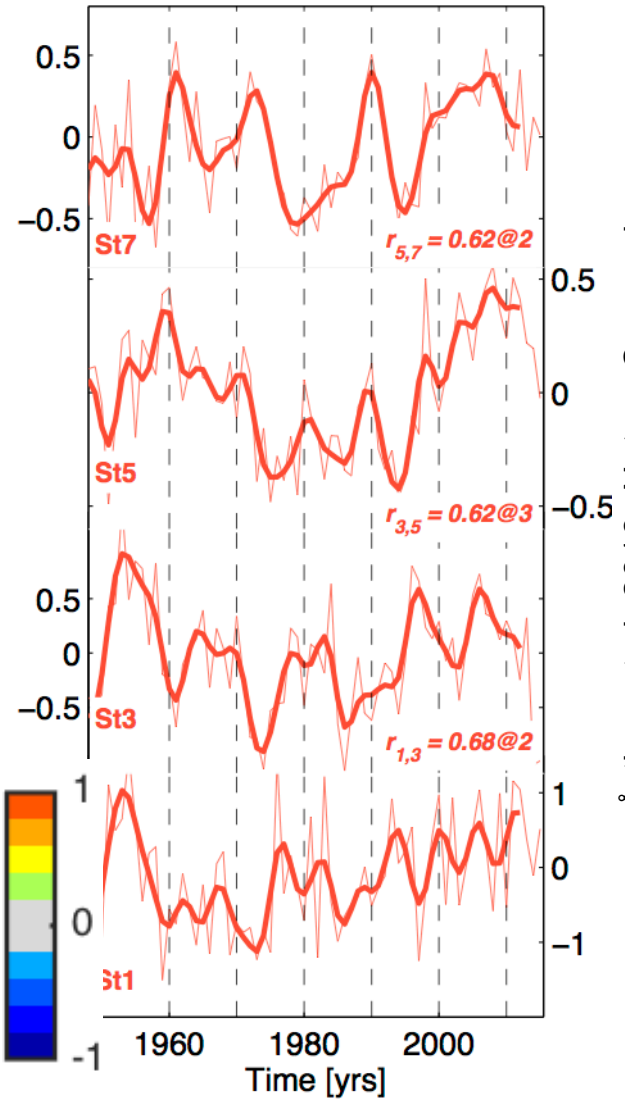
lag -1yr



no lag

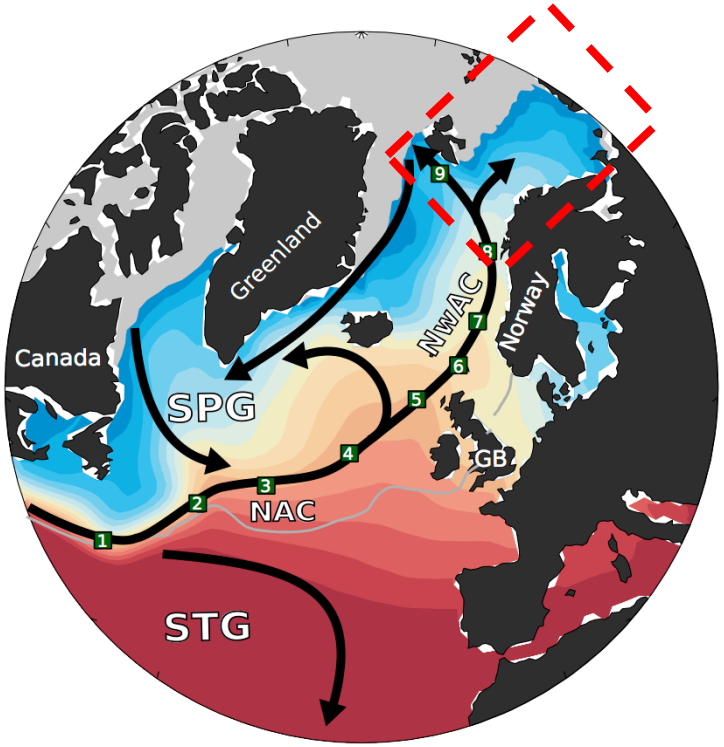


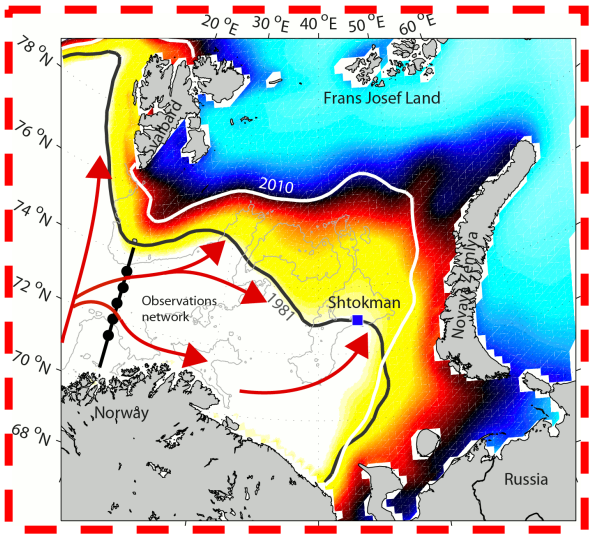
lag +1yr



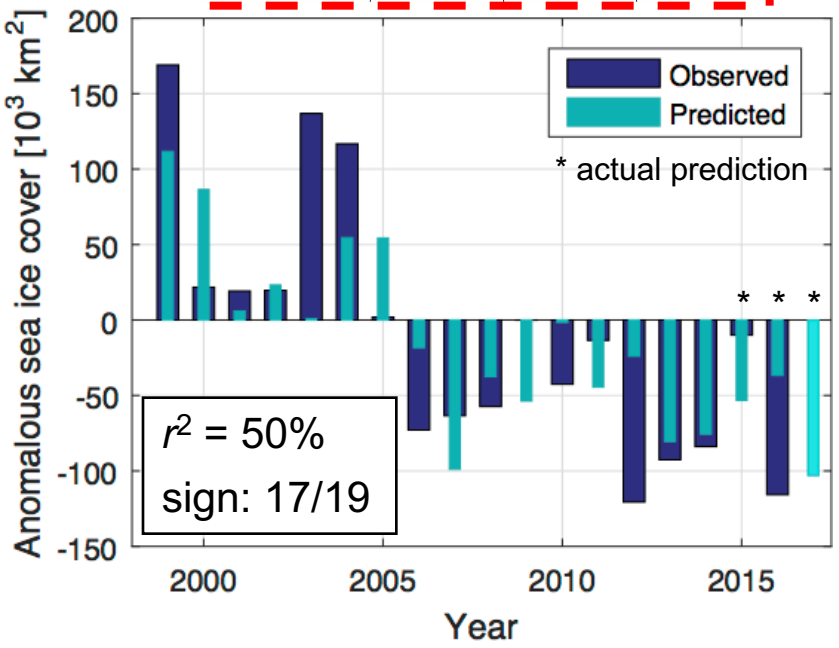
Århun et al. 2016: *Nature Comm.*, in rev.

Observed **Barents Sea ice** predictability





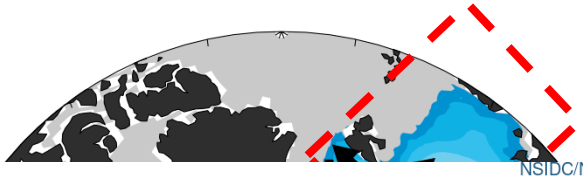
Onarheim et al. 2015: Skillful prediction of Barents Sea ice cover. ***GRL***

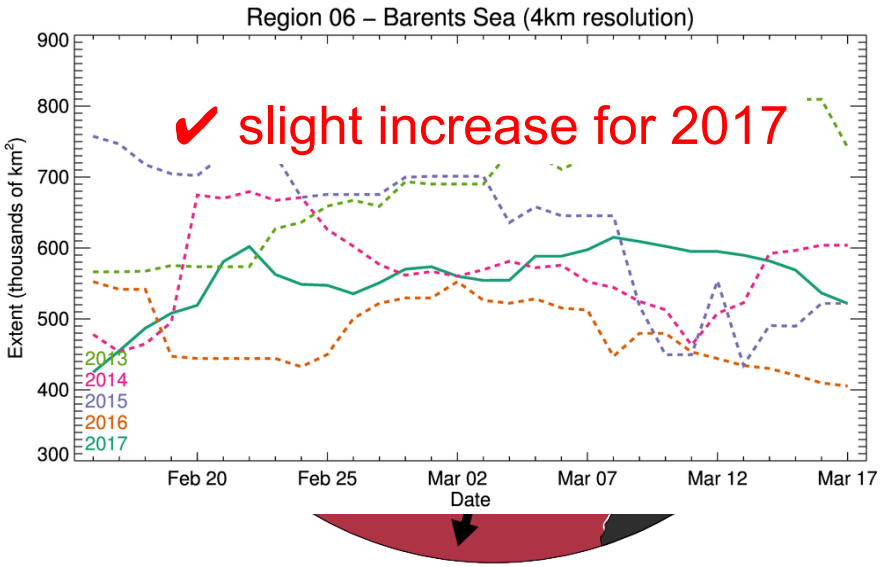


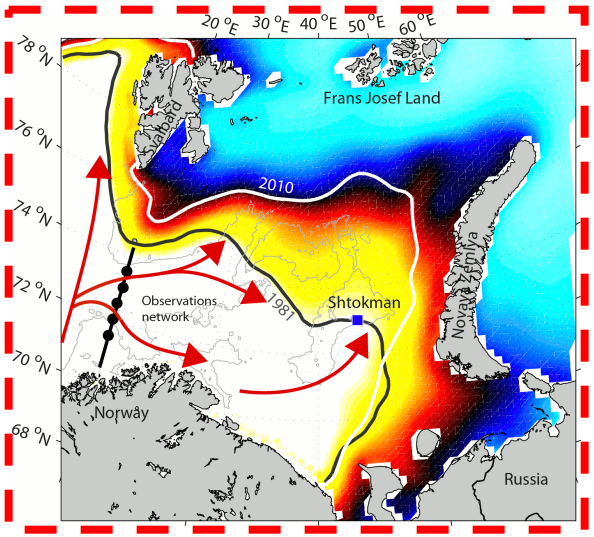
Onarheim et al. 2015: *GRL* – ***updated***; Årthun et al. 2012: *JClim*

Obs-based 1-yr prediction

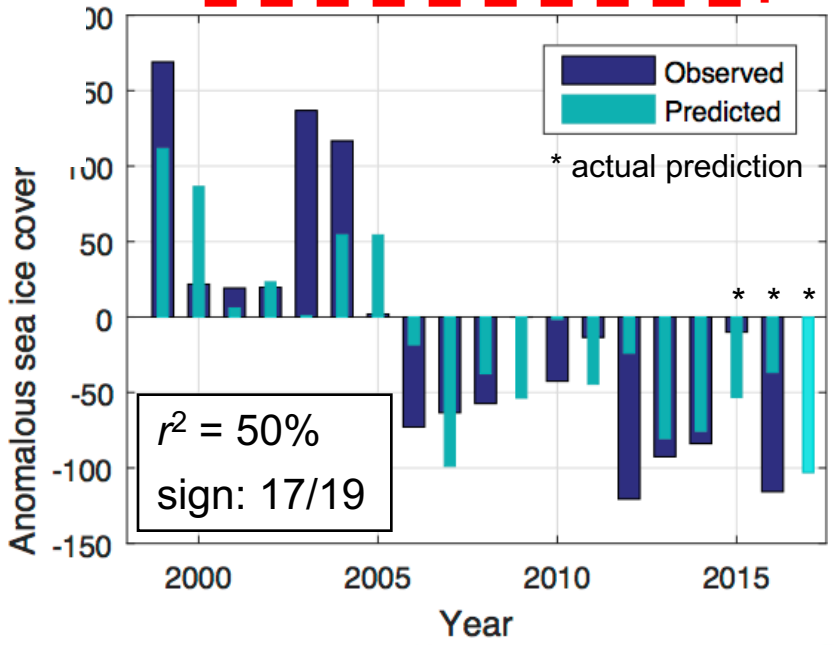
Observed **Barents Sea ice** predictability







Onarheim et al. 2015: Skillful prediction of Barents Sea ice cover. ***GRL***



Onarheim et al. 2015: *GRL* – ***updated*** ; Årthun et al. 2012: *JClim*

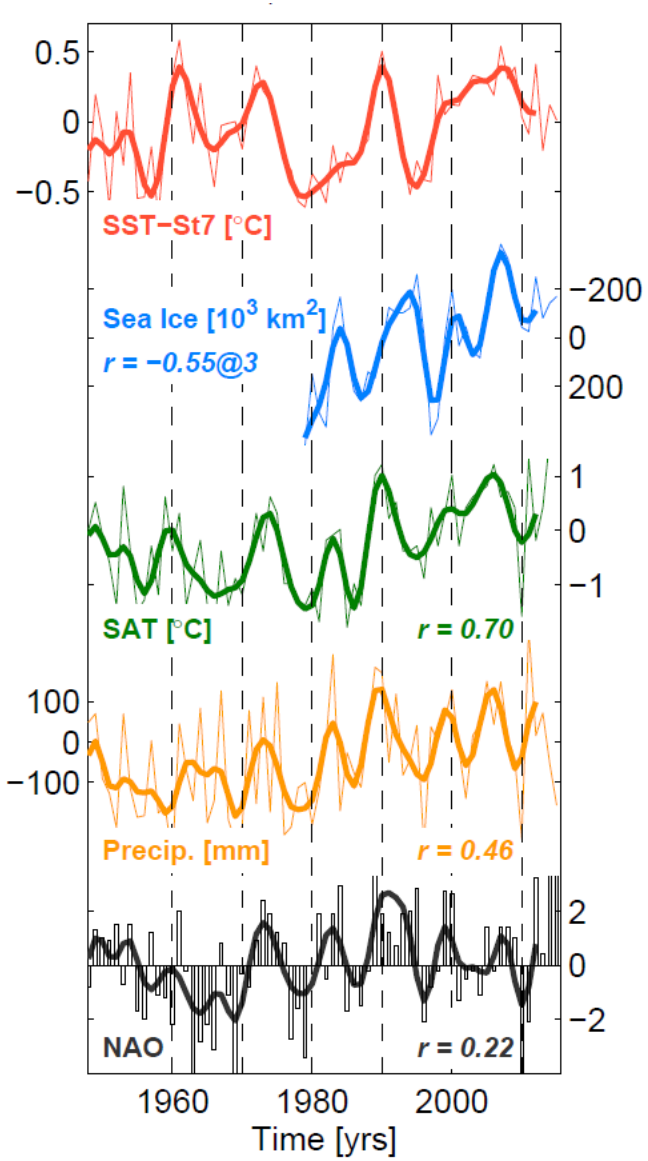
Influence on Arctic-Atlantic climate

- Annual **SAT** and **precipitation** from met.no
- Arctic winter **sea ice** from HadISST. We consider Atlantic domain (90W-90E).

- Norwegian **SAT**, **precipitation**, and Arctic **sea ice** co-vary with Norwegian Sea **SST**.

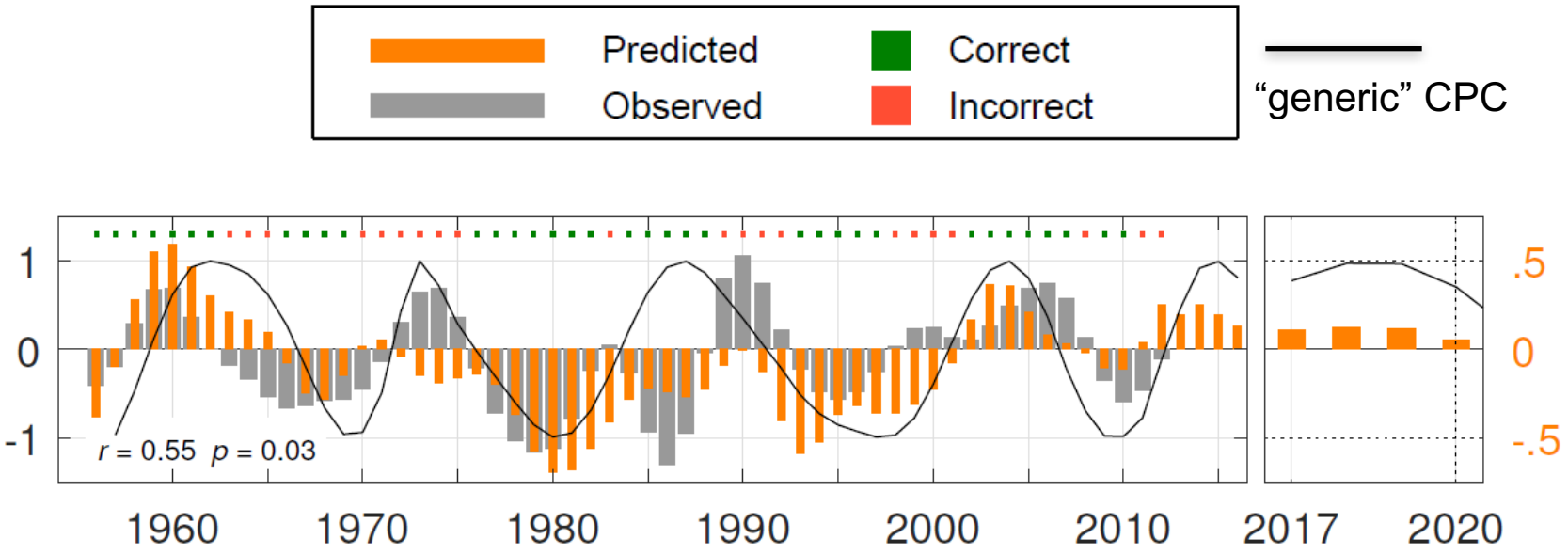
- Climate impacts associated with regional SST anomalies are complementary to those of the **NAO**.

Årthun et al. 2016:
Skillful prediction of northern climate provided by the ocean. ***Nature comm.***, in revision.



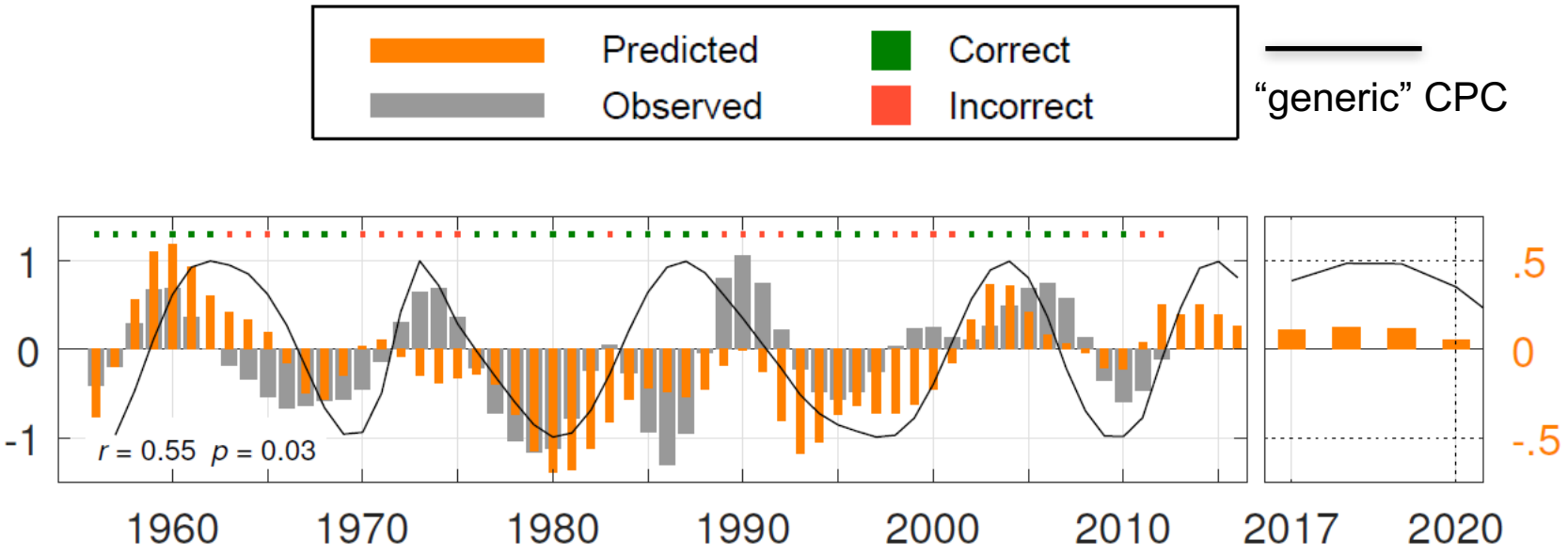
Årthun et al., in rev.

Surface air temperature - Norway



- Sign of prediction correct 67% of the time
- More skilful than random chance and climatology predictions
- Temperatures above long-term average toward 2020

Surface air temperature - Norway



- Sign of prediction correct 67% of the time
- More skilful than random chance and climatology predictions
- Temperatures above long-term average toward 2020
- Extends also to sea ice – slight increase (cf. also Yeager et al 2015)

Physical environment, e.g., climate model

?

Ecosystem – specifics or aggregated

the Nansen LEGACY

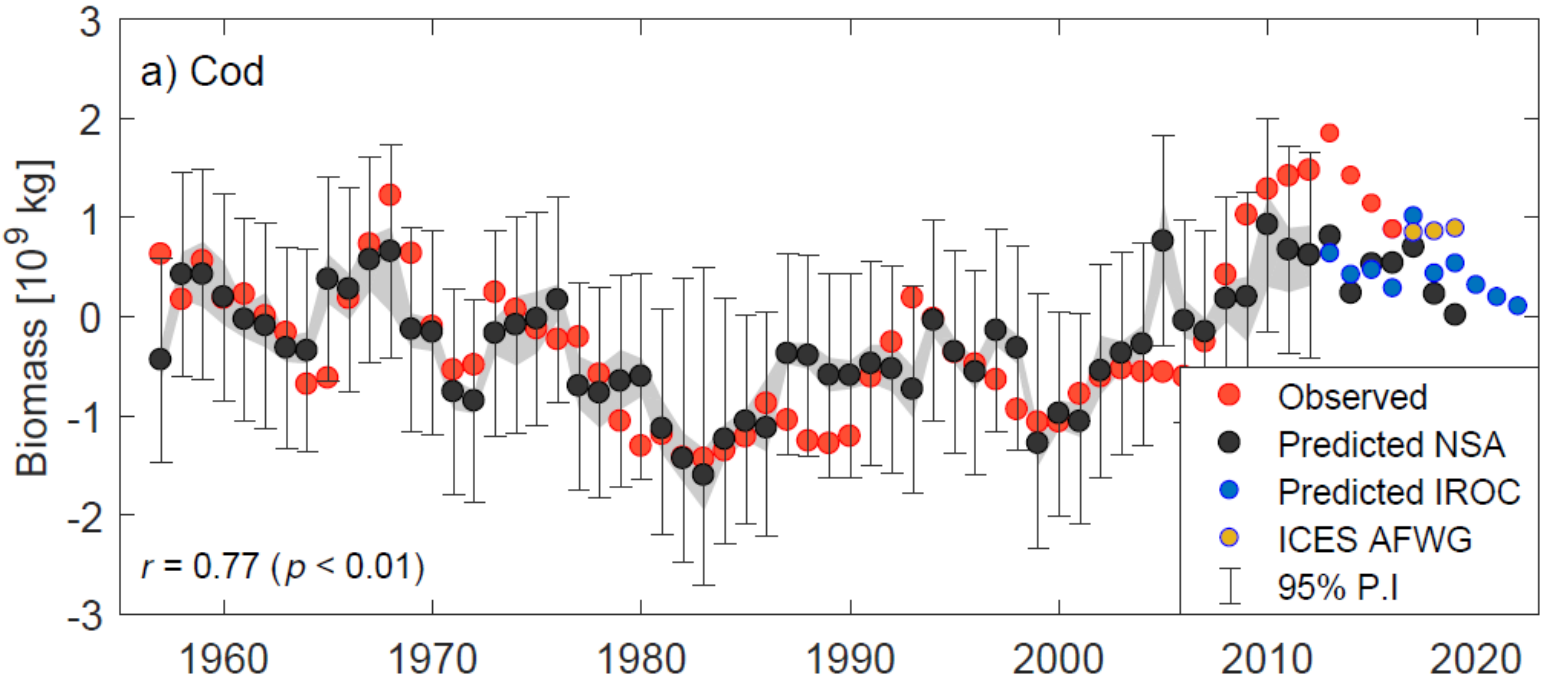
Physical environment, e.g., climate model

Habitat

Ecosystem – specifics or aggregated

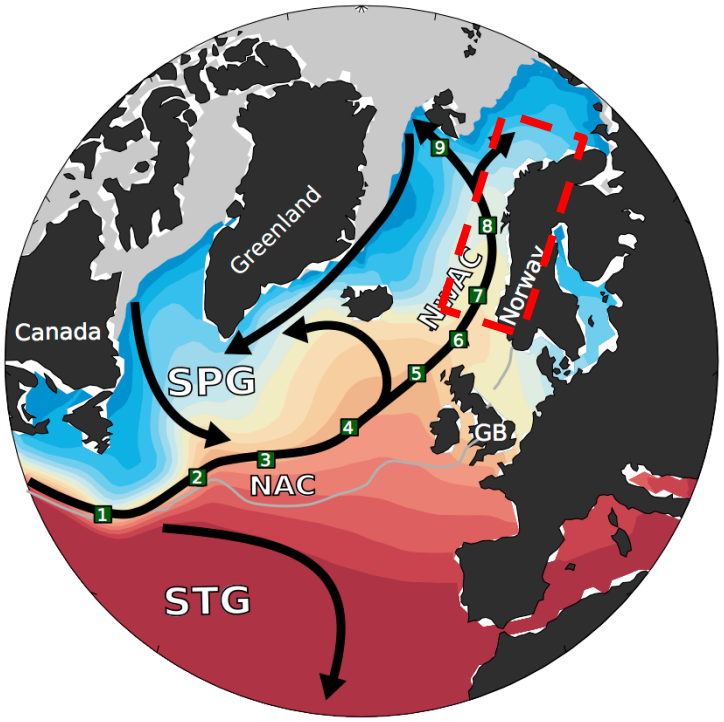
the Nansen LEGACY

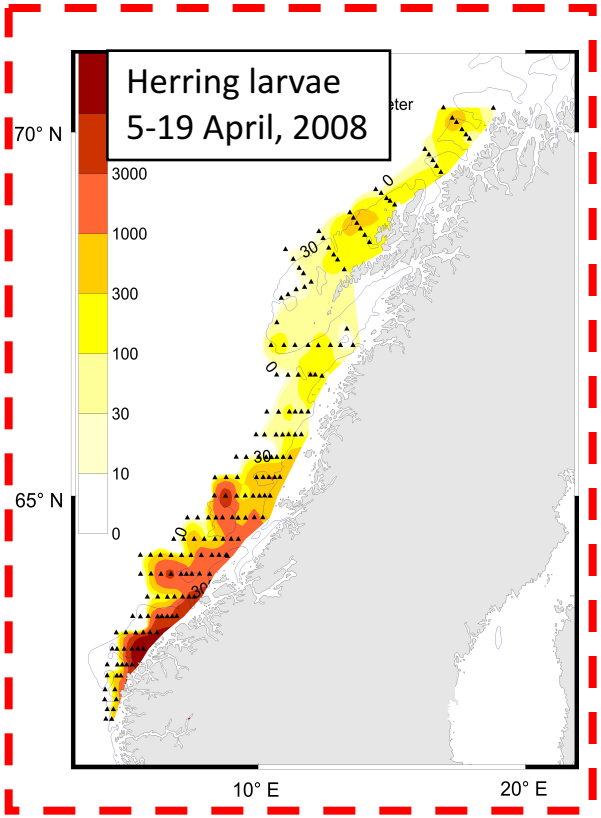
Prediction of cod stock biomass based on upstream hydrography
7-year prediction horizon



Årthun et al., in prep

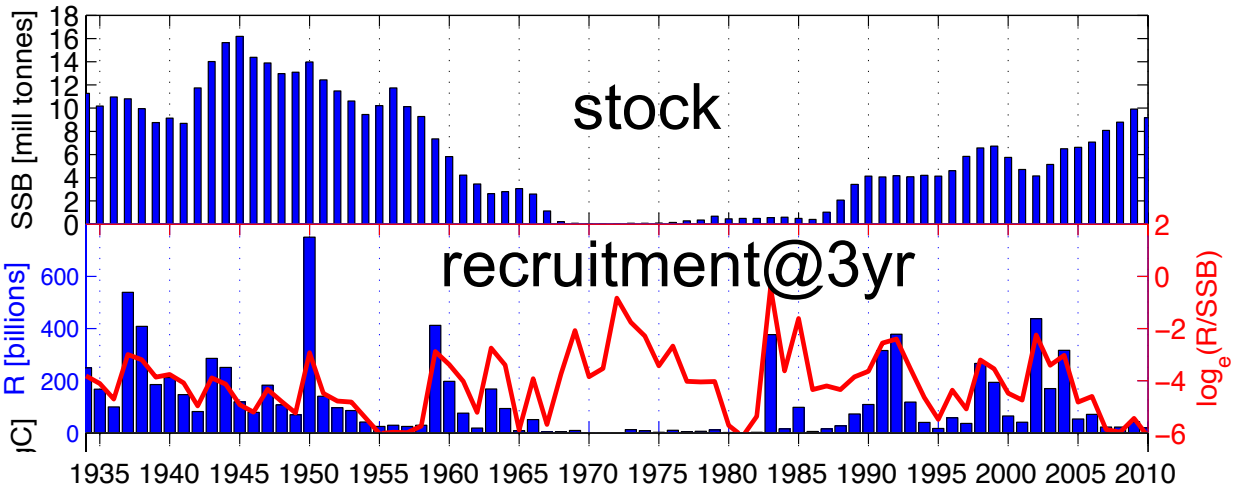
Norwegian Spring Spawning Herring

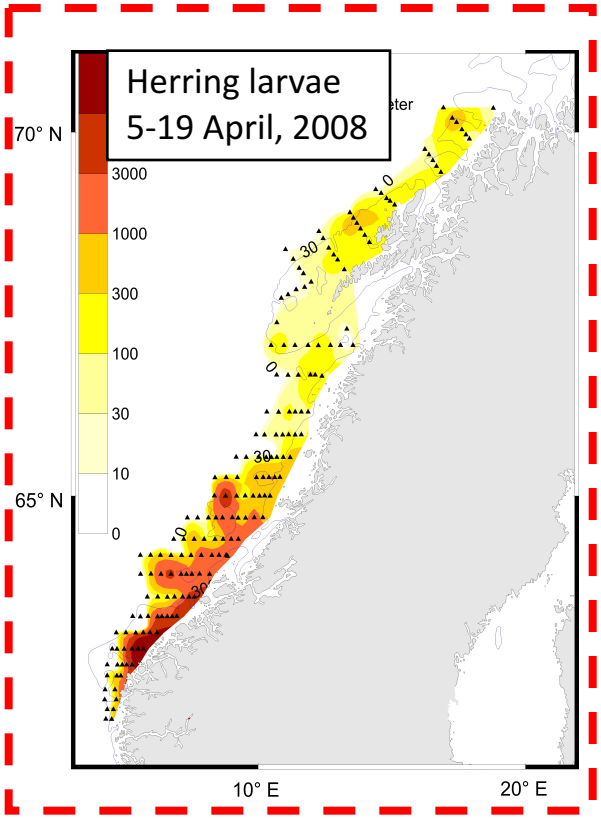




Skagseth et al. 2015: Characteristics of the NCC during Years with High Recruitment of Norwegian Spring Spawning Herring ***PLOS1***

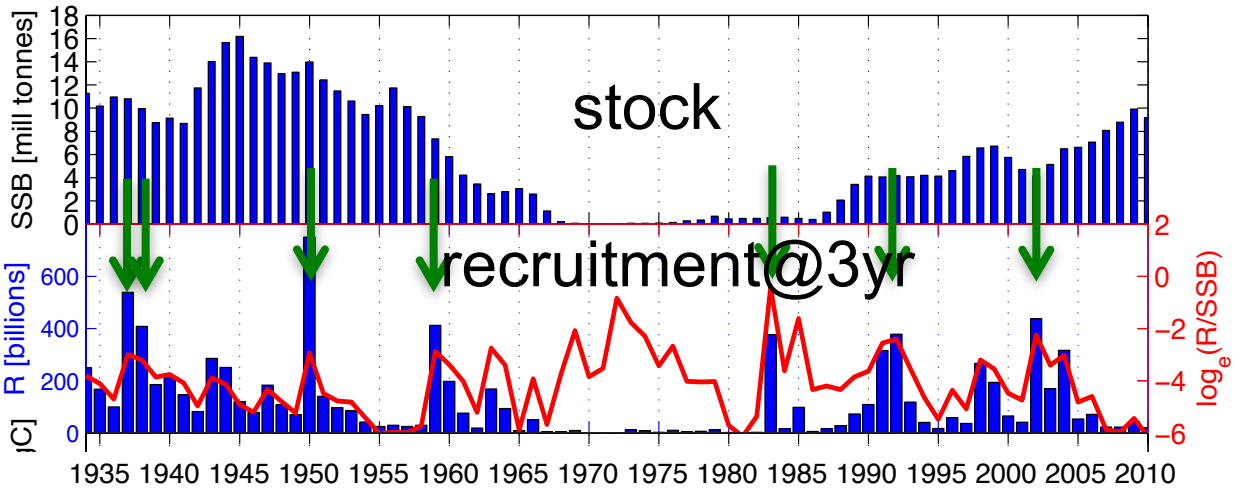
Norwegian Spring Spawning Herring

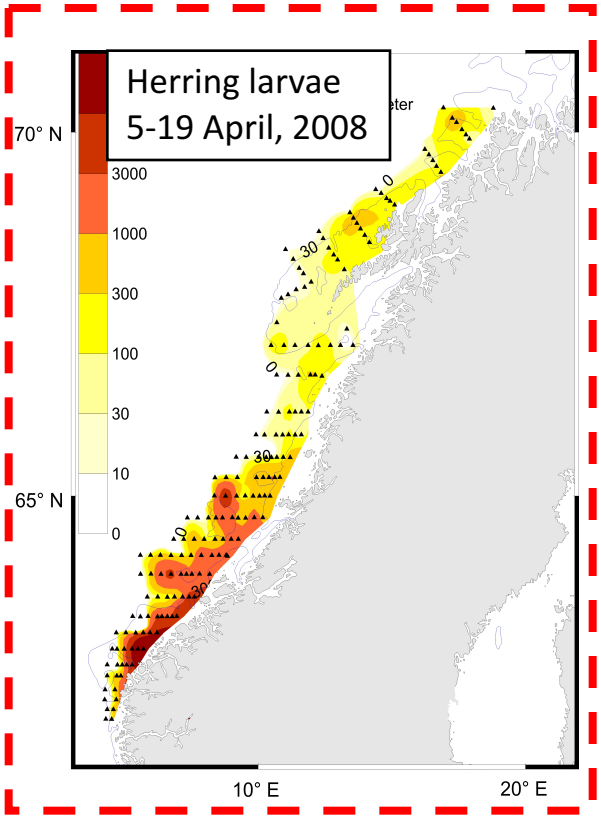




Skagseth et al. 2015: Characteristics of the NCC during Years with High Recruitment of Norwegian Spring Spawning Herring ***PLOS1***

Norwegian Spring Spawning Herring





+ SW summer winds; increased strat.
+ intensified coastal current

Skagseth et al. 2015: Characteristics of the NCC during Years with High Recruitment of Norwegian Spring Spawning Herring ***PLOS1***

Favourable climatic conditions
+ recruitment potential
➔ 3yr prediction horizon

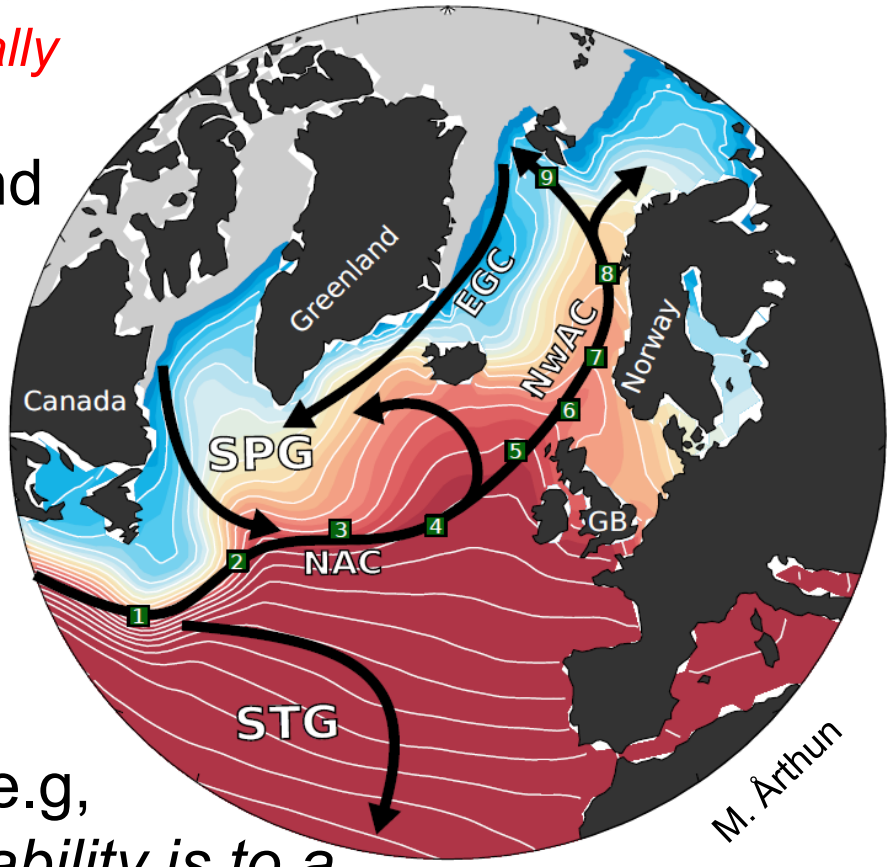
The (ASOF) issues at hand:

what is the source of thermohaline anomalies?

– *geographically & mechanistically*

how are anomalies maintained and propagated?

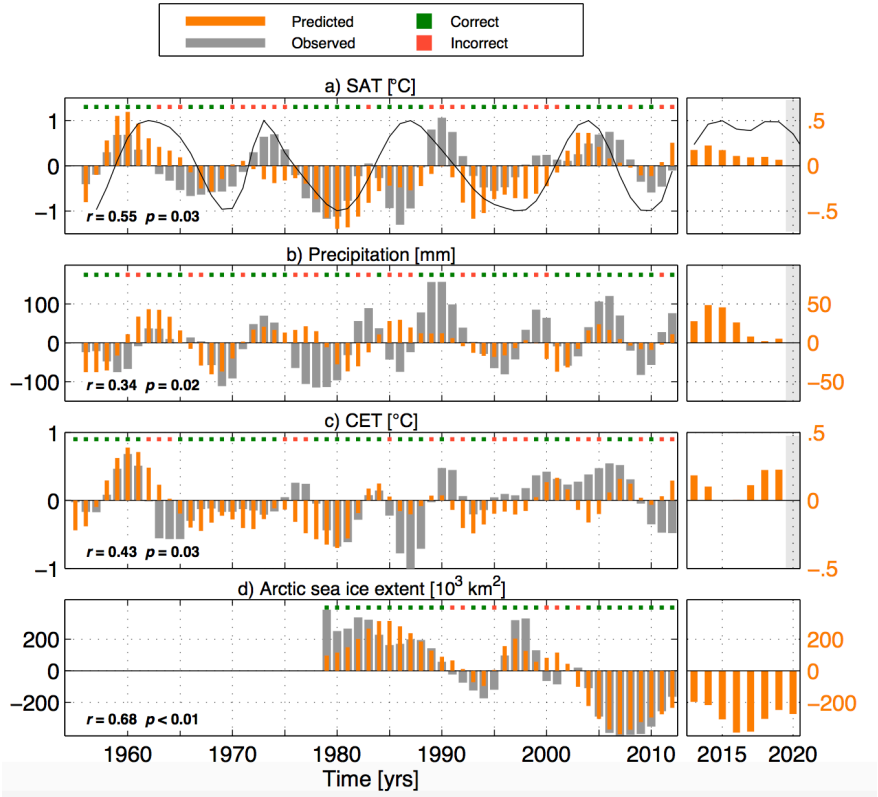
establish “ground truth”, i.e., the empirical evidence for predic-tability in climate & ecosystems



Challenge: substantiate *the pre-dictable mechanisms* implied by, e.g, the statement *Global climate variability is to a large extent triggered by changes in the North Atlantic sea surface state* (EU NACLIM project)

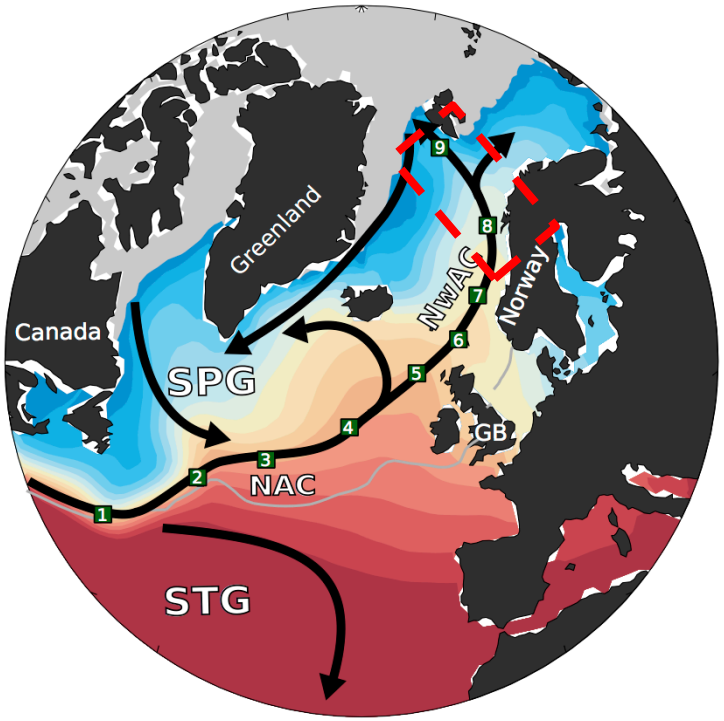
content

- *what I talk about when I talk about climate prediction*
- ocean heat
- sea ice
- land (+ sea ice)
- fish

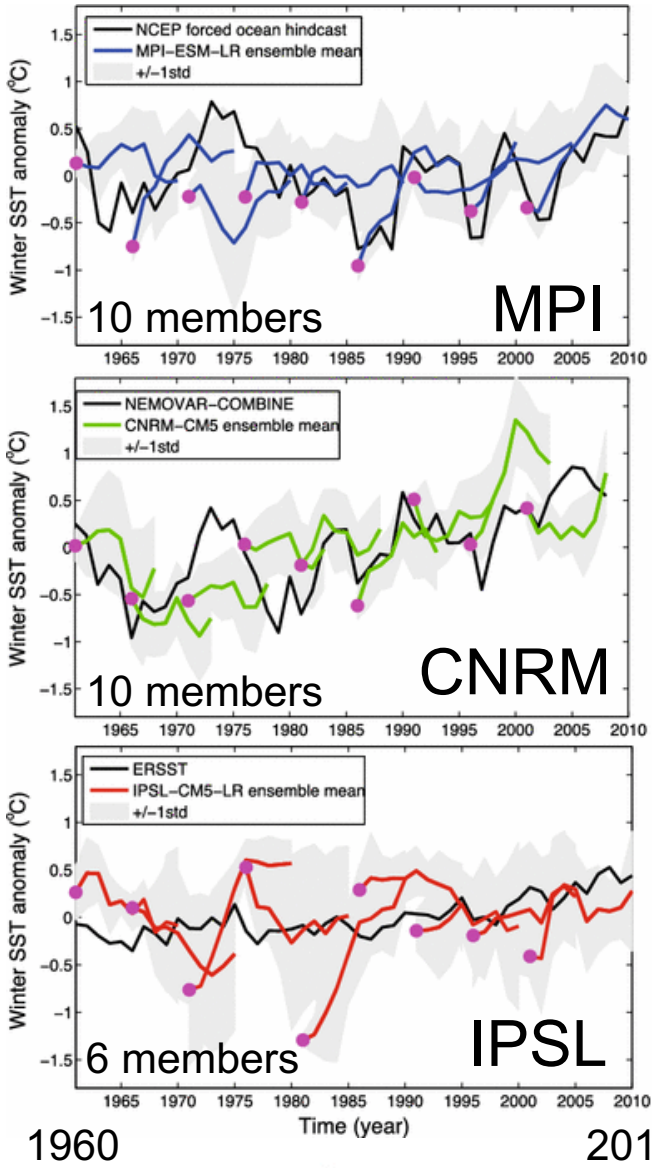


Årthun et al. 2016: *Nature Comm.*, in rev.

Modelled SST propagation and predictability



Langehaug et al. 2016: On model differences and skill in predicting SST in the Nordic and Barents Seas. ***Clim. Dyn.***

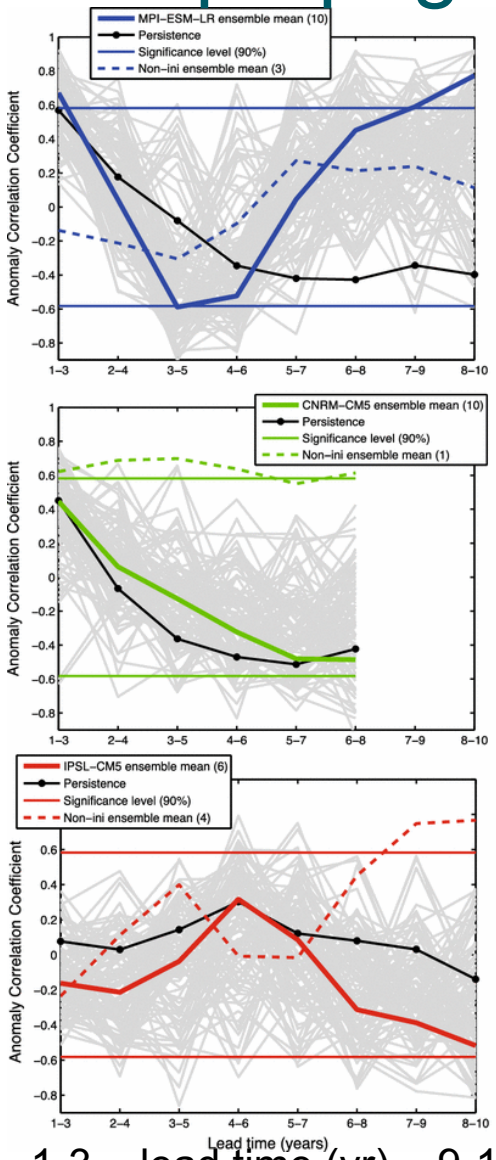


Langehaug et al. 2016: *Clim. Dyn.*

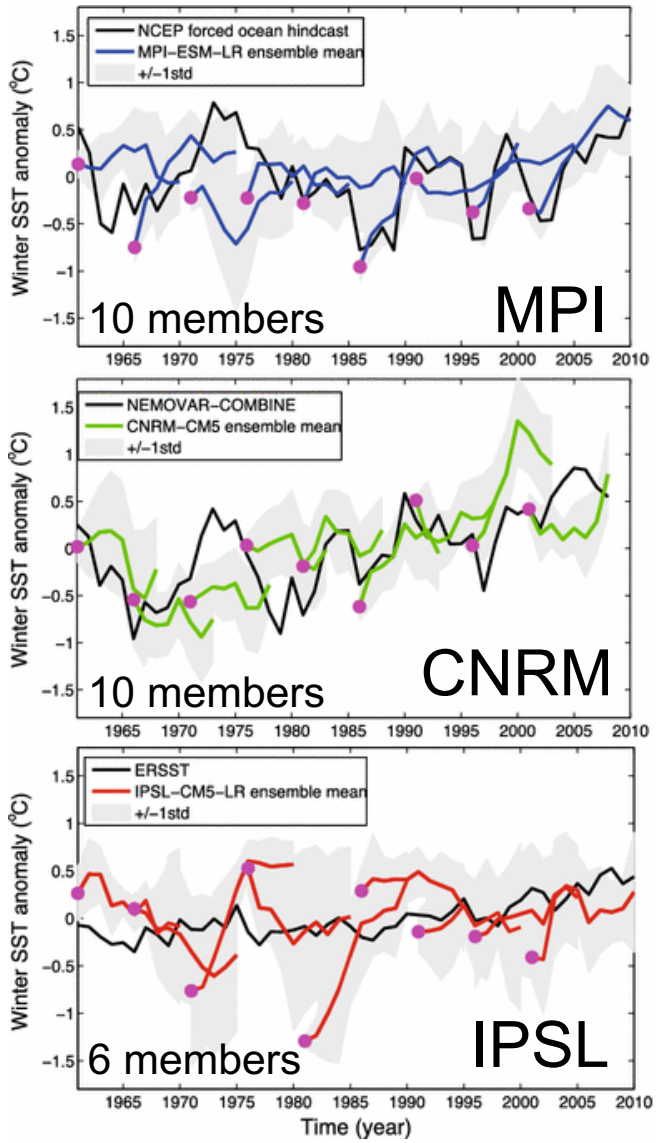
Modelled SST propagation and predictability

Hindcast corr skill
— ensemble mean
--- non-init (hist)
–o–persistence

Skill differ due to
+ initialization
+ resolution
+ sea ice climatology
+ link to NAtl/AMOC
+ …

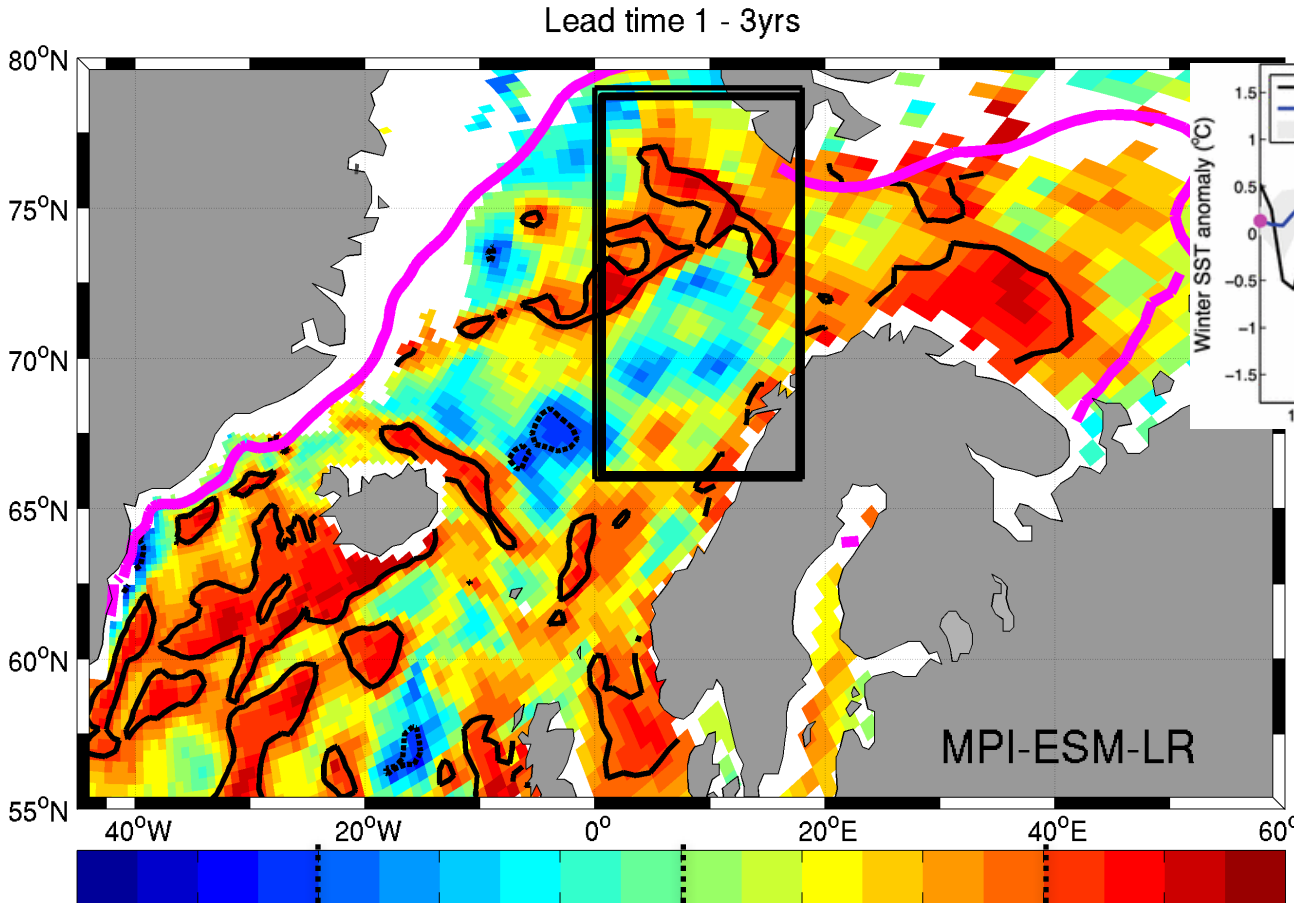


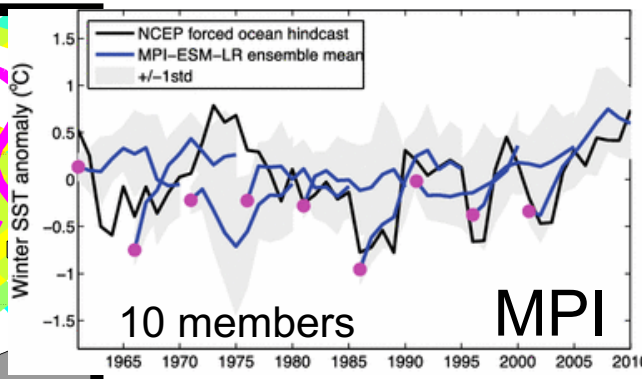
1-3 lead time (yr) 9-10

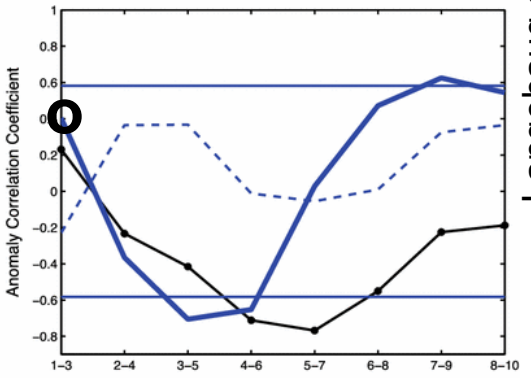


Langehaug et al. 2016: *Clim. Dyn.*

Modelled SST propagation and predictability





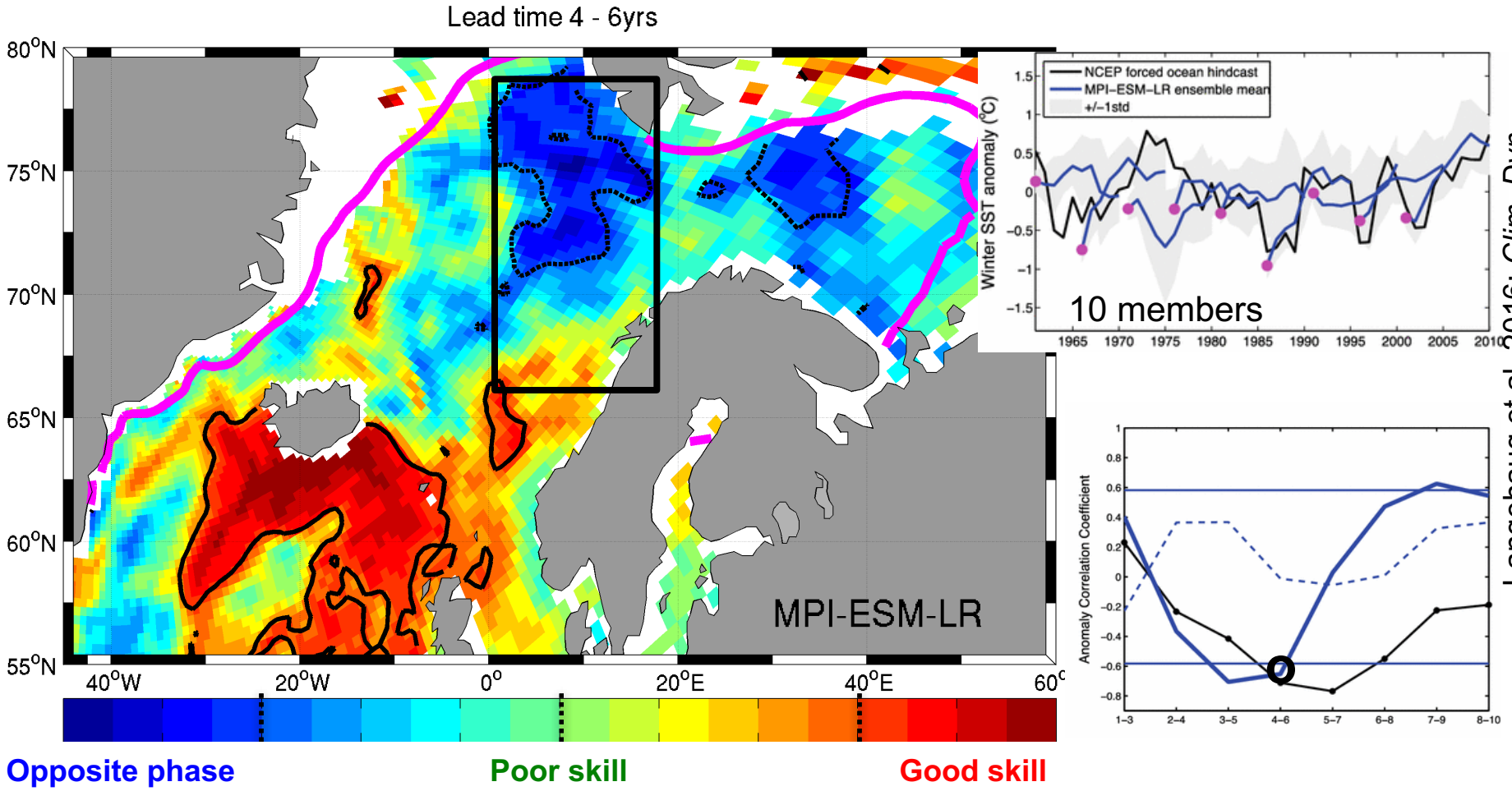


Langehaug et al. 2016: *Clim. Dyn.*

Opposite phase **Poor skill** **Good skill**

lagged corr with HadISST

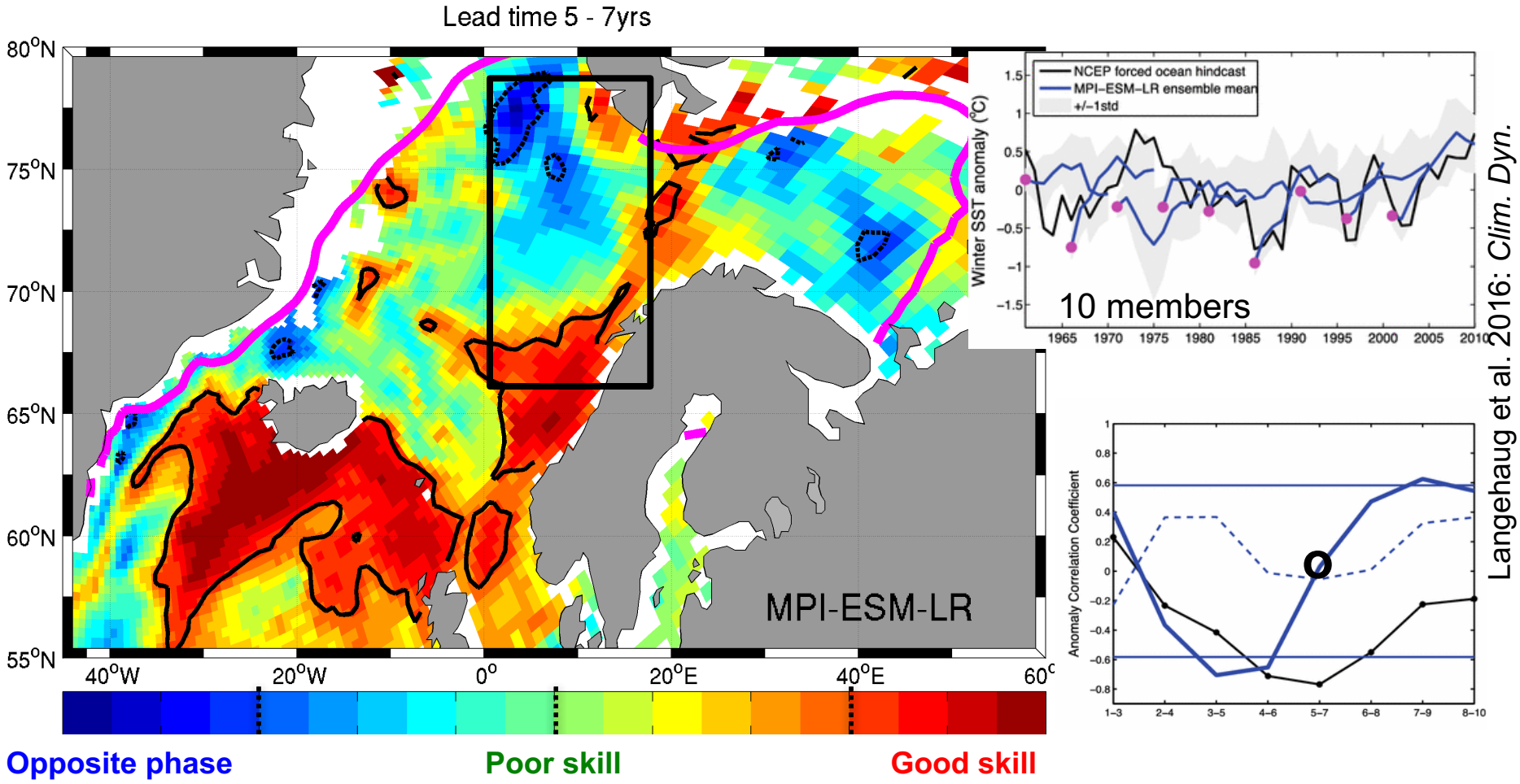
Modelled SST propagation and predictability



Langehaug et al. 2016: *Clim. Dyn.*

lagged corr with HadISST

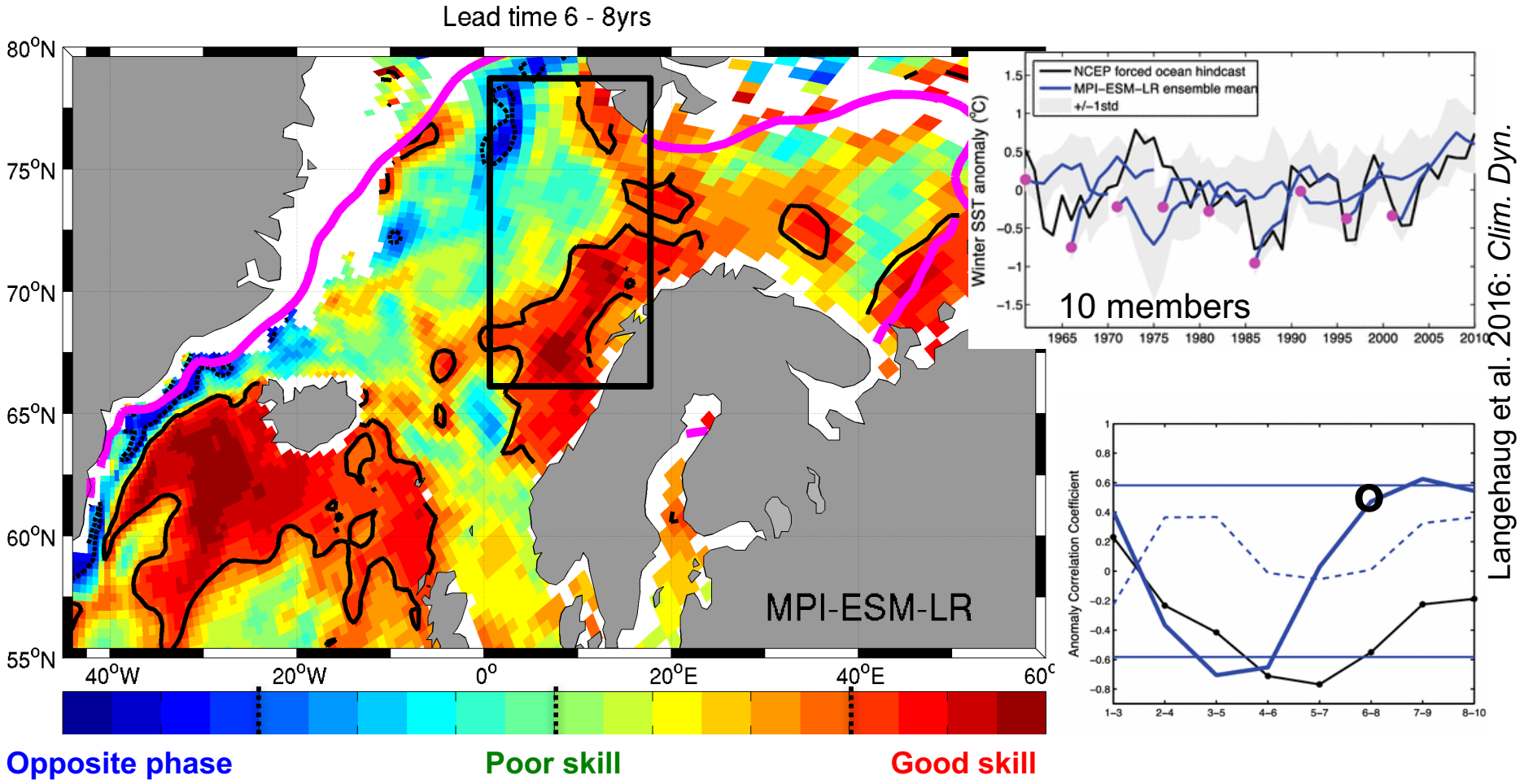
Modelled SST propagation and predictability



Langehaug et al. 2016: *Clim. Dyn.*

lagged corr with HadISST

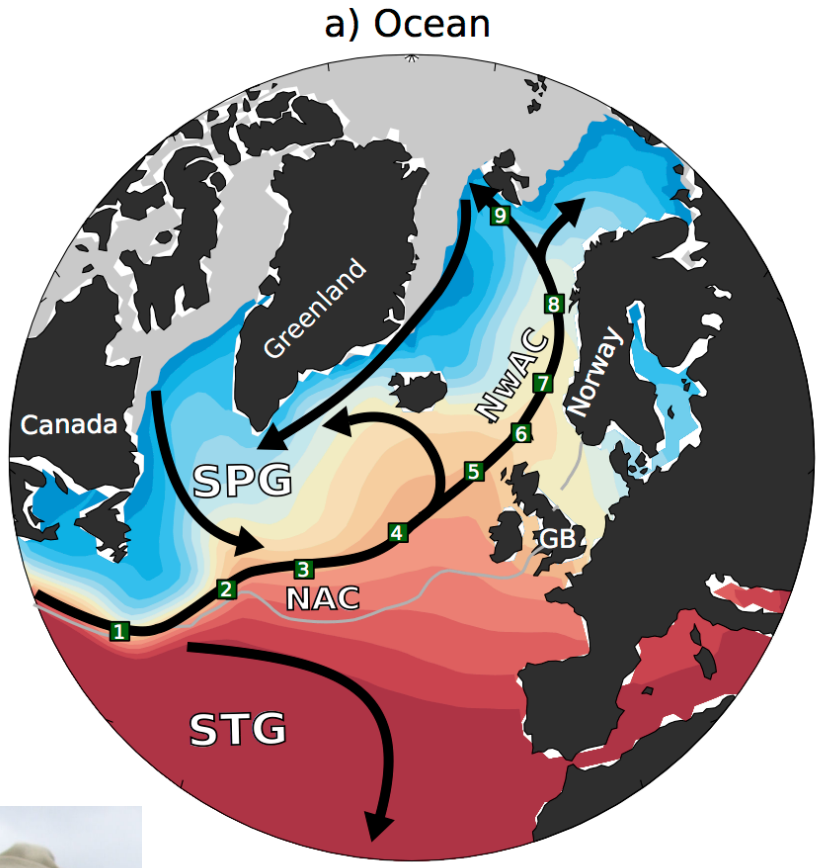
Modelled SST propagation and predictability

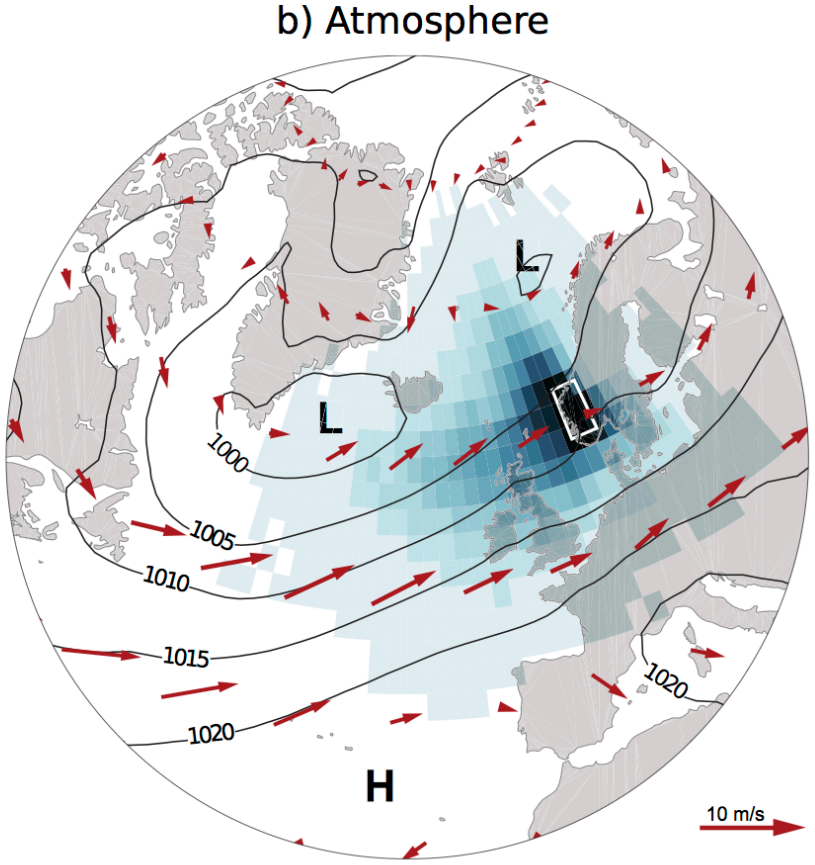


Langehaug et al. 2016: *Clim. Dyn.*

lagged corr with HadISST

How to get predictability beyond the ocean?

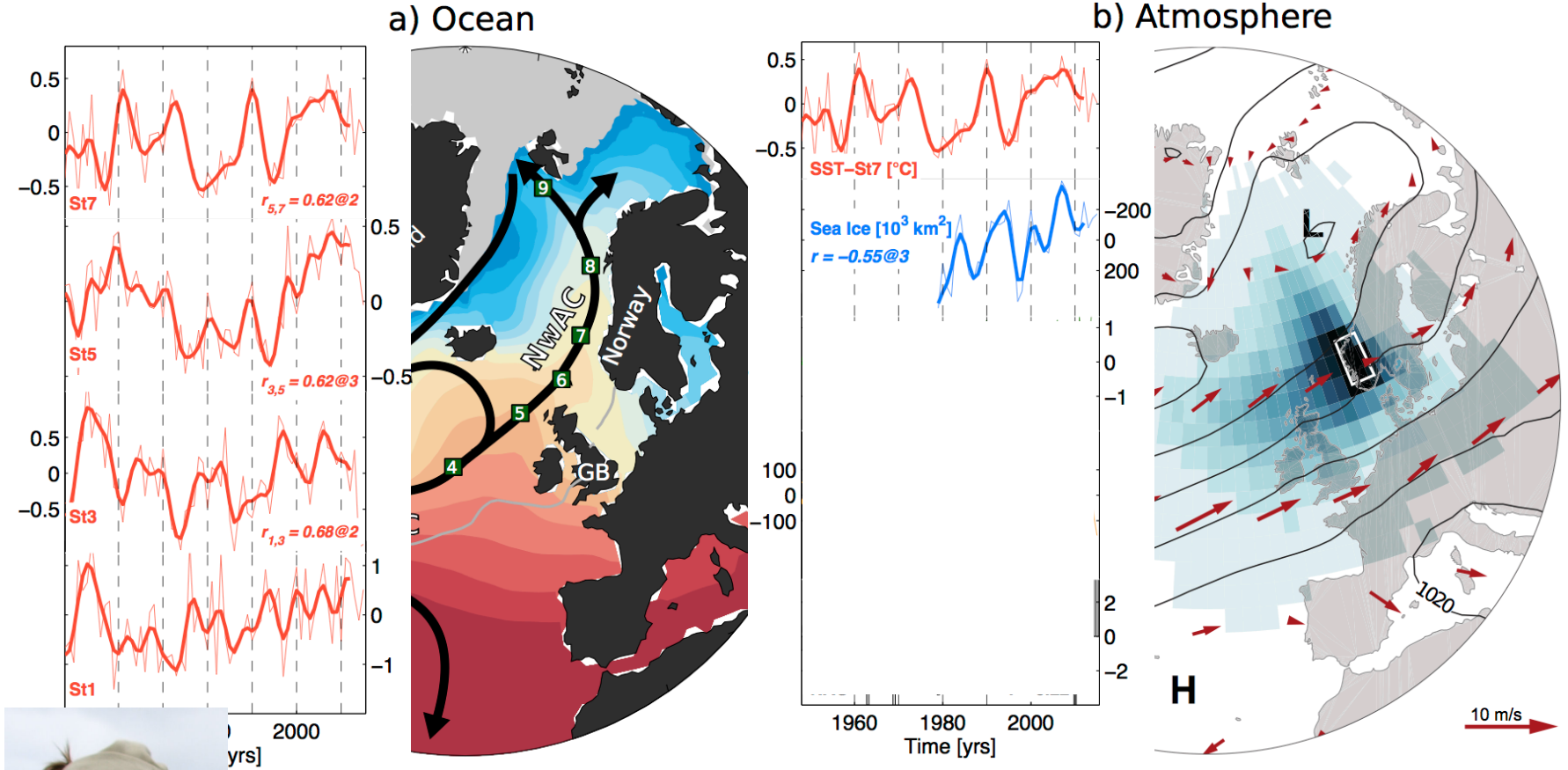




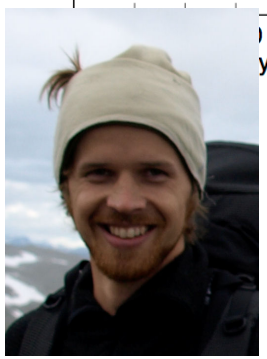
Årthun et al. 2016: *Nature Comm.*, in rev.

Årthun et al. 2016: Skillful prediction of northern climate provided by the ocean. ***Nature comm.***, in revision.

How to get predictability beyond the ocean?



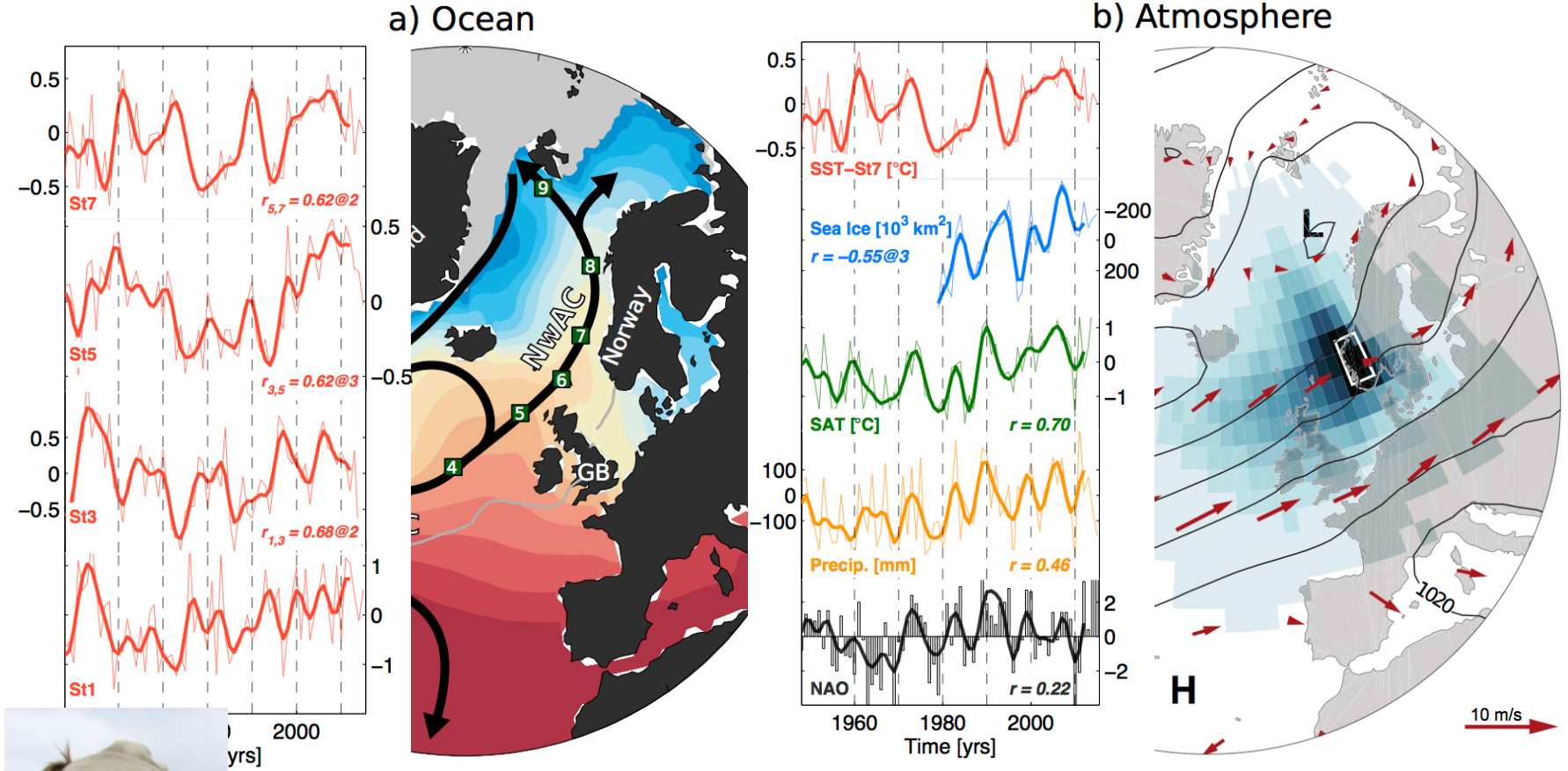
Årthun et al. 2016: *Nature Comm.*, in rev.



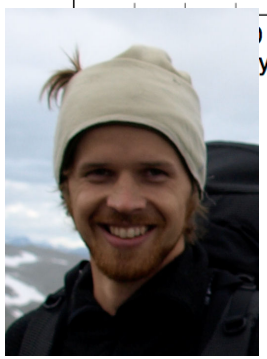
Norwegian Sea heat (SST) is reflected in

+ Arctic winter sea ice cover (30% @3yr) – see also Yeager et al. (2016, GRL)

How to get predictability beyond the ocean?



Århun et al. 2016: *Nature Comm.*, in rev.



Norwegian Sea heat (SST) is reflected in

+ Arctic winter sea ice cover (30% @3yr) – see also Yeager et al. (2016, GRL)
+ Norwegian SAT (49%) and precipitation (21%) over land
+ practically *independent* from NAO (5%)

How to get predictability beyond the ocean?

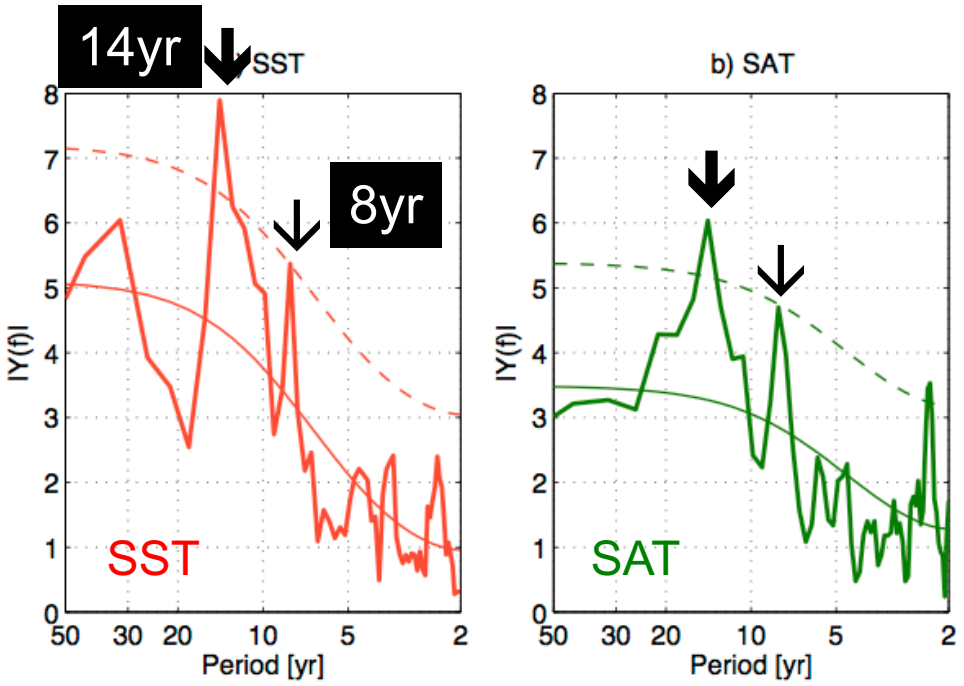
- **ocean-land co-variability**
  – NAO, **no lag, no predictability**

- **variable "Gulf Stream" reflected over land**
  – mean wind, **5–10yr predictive potential**

- **coupled atmosphere-ocean mode**
  – ocean adds variance; how and how predictable?
  – what ultimately sets the ocean time scale(s)?

Årthun et al. 2016: *Nature Comm.*, in revision
Helland-Hansen and Nansen 1909: *The Norwegian Sea*
Langehaug et al. 2016: *Clim. Dyn.*
Onarheim et al. 2015: *GRL*

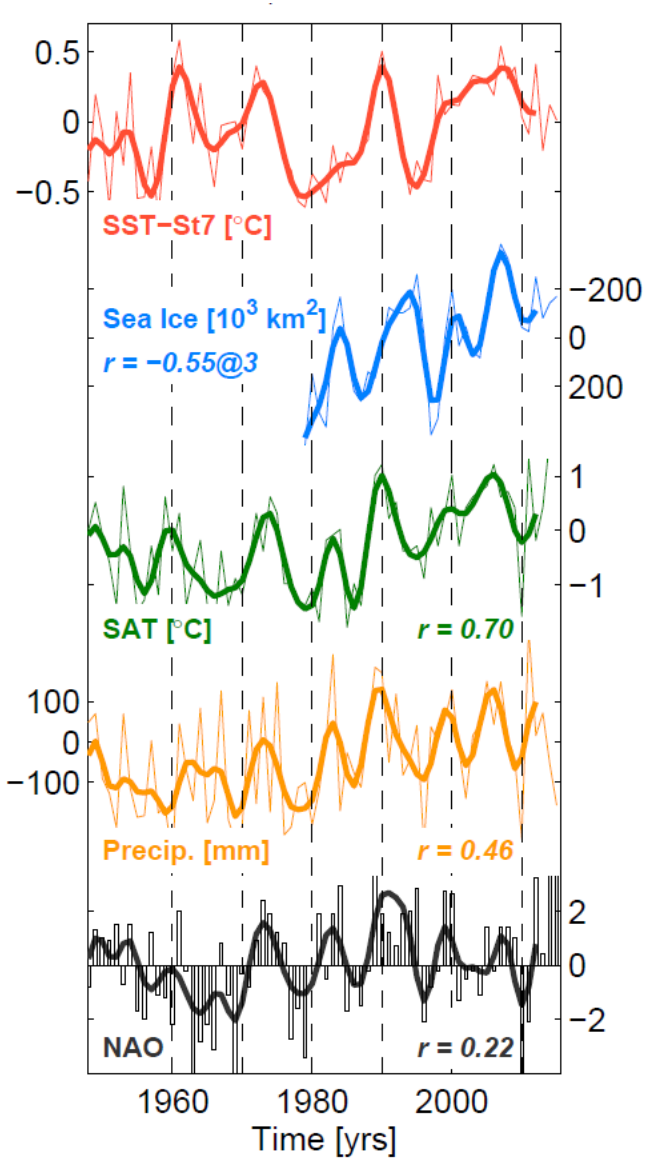
Influence on Arctic-Atlantic climate



14-yr timescale ➔ ocean advection

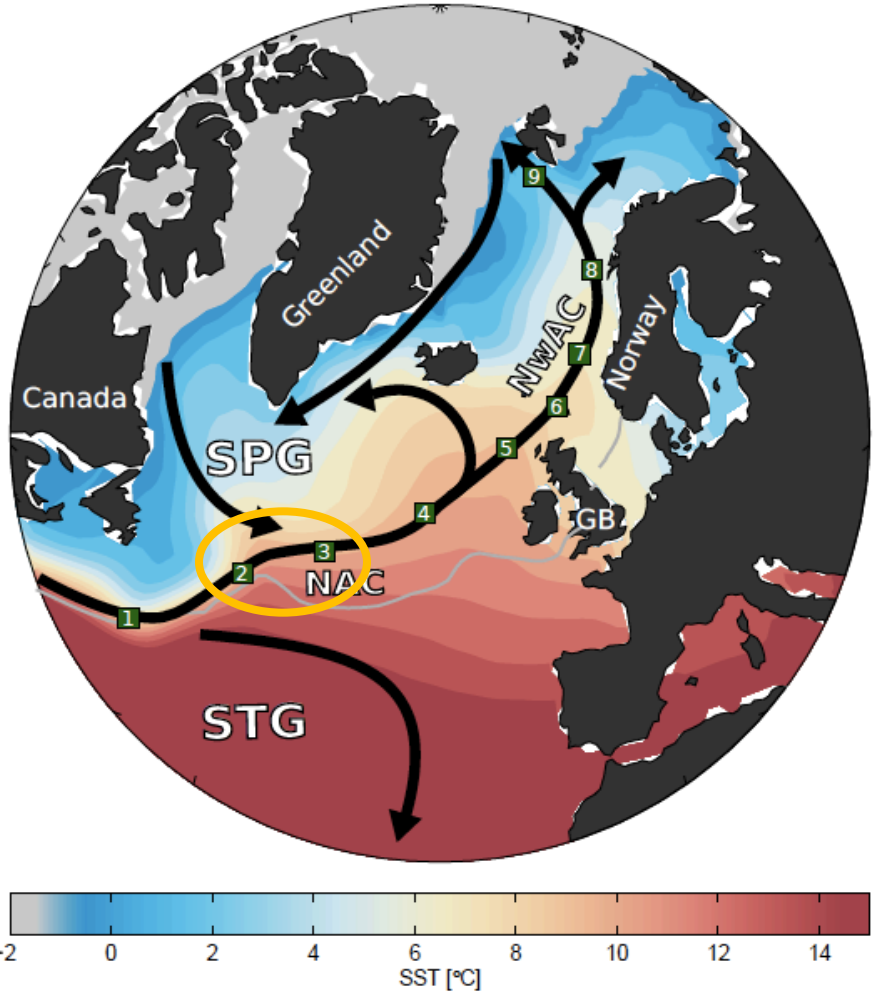
8-yr timescale ➔ NAO

E.g., Moron et al. 1998; Häkkinen 2000; Marshall et al. 2001; Reintges et al. 2016.

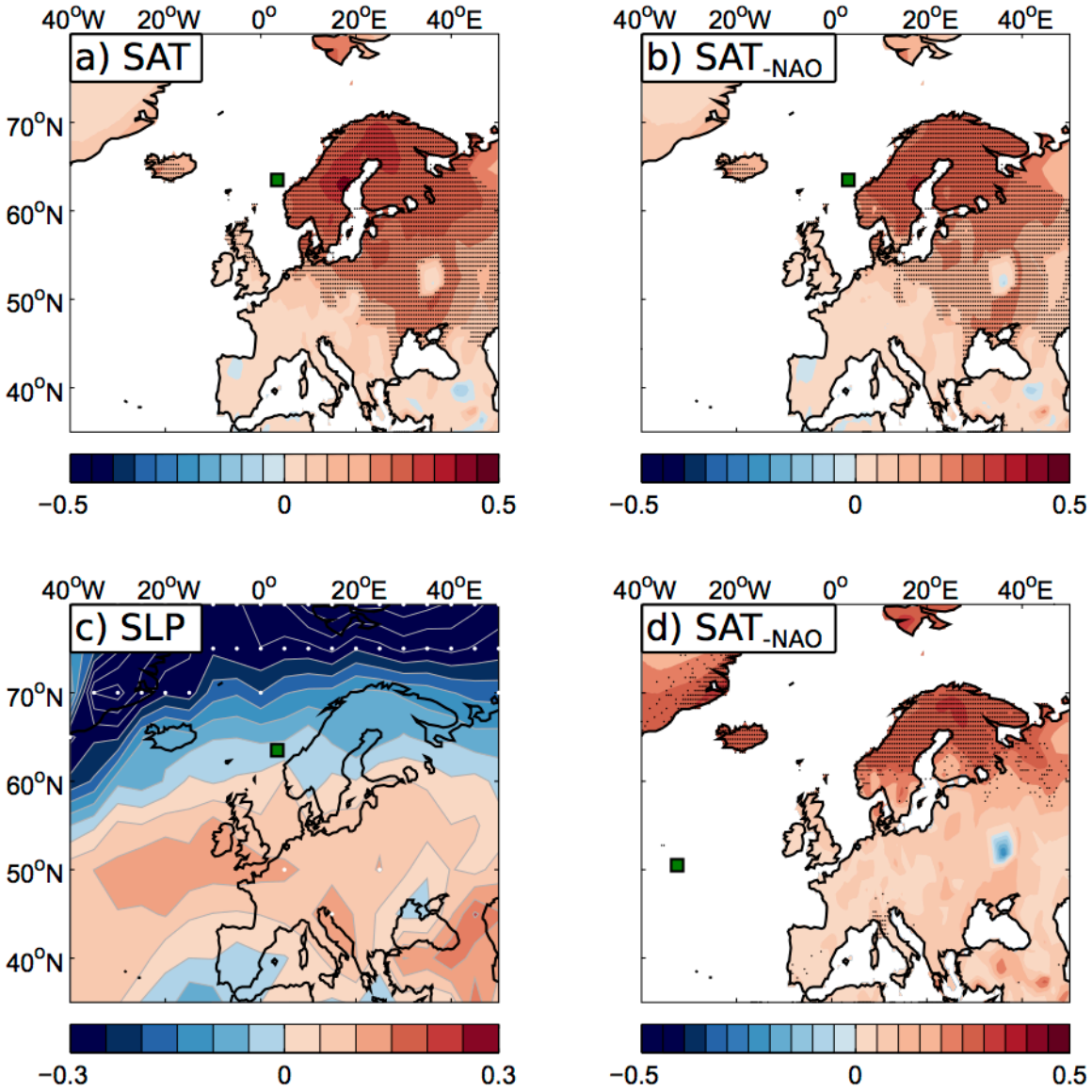


Årthun et al., in rev.

Is northern climate predictable?



- Predictions of annual Norwegian **SAT** and winter Arctic **sea ice** extent based on subpolar North Atlantic SST (#2,3)
- 5-yr low-pass filter -> pentadal tendencies
- Linear regression models based on time series between 1948 and 2012
- Forecast horizon: **7** & **10** years



Årthun et al. 2016: *Nature Comm.*, in rev.