Climate feedbacks in the Nordic seas region and their link to the large-scale atmospheric variability

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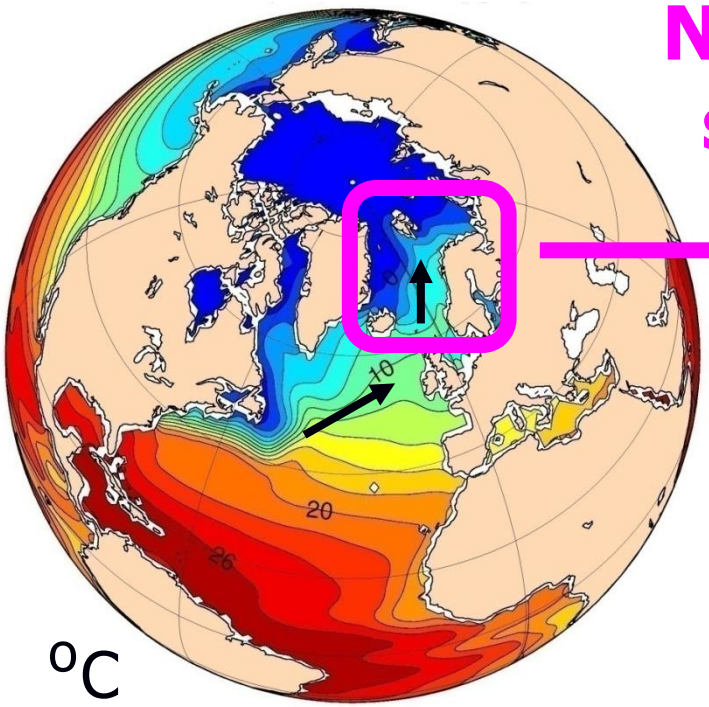
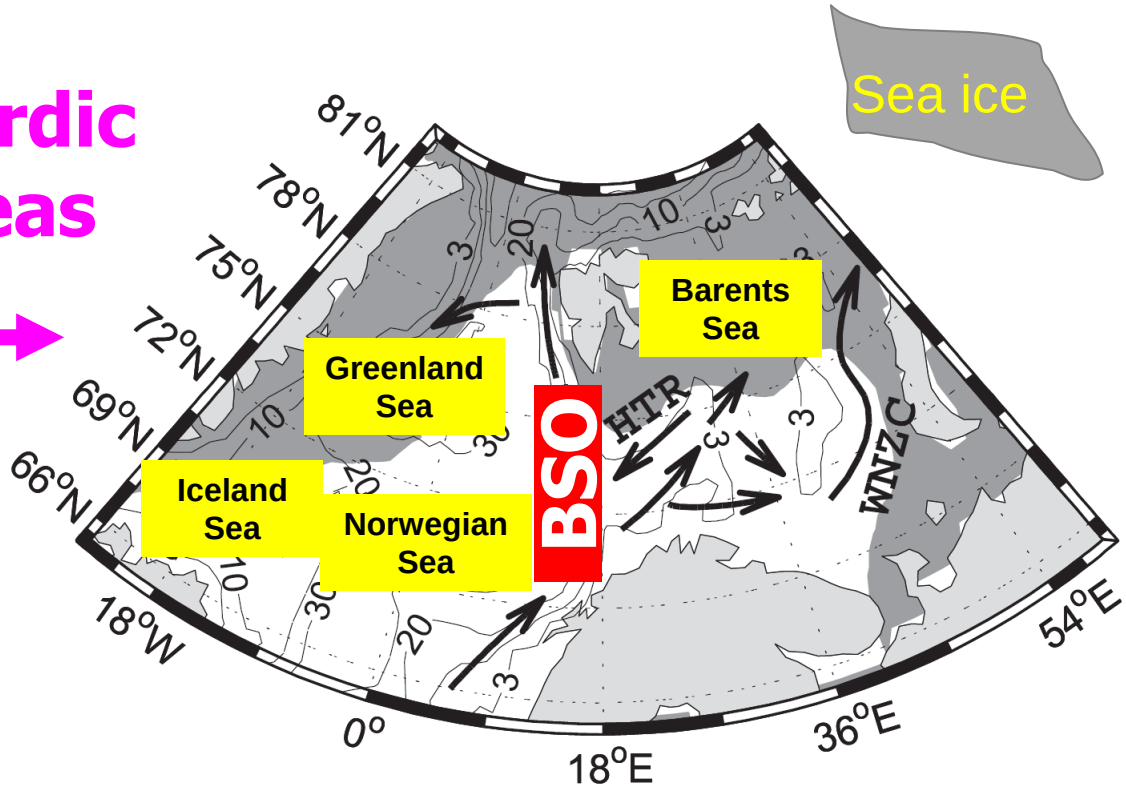
Introduction: Ocean area of interest



Temperature at 100 m (PHC)

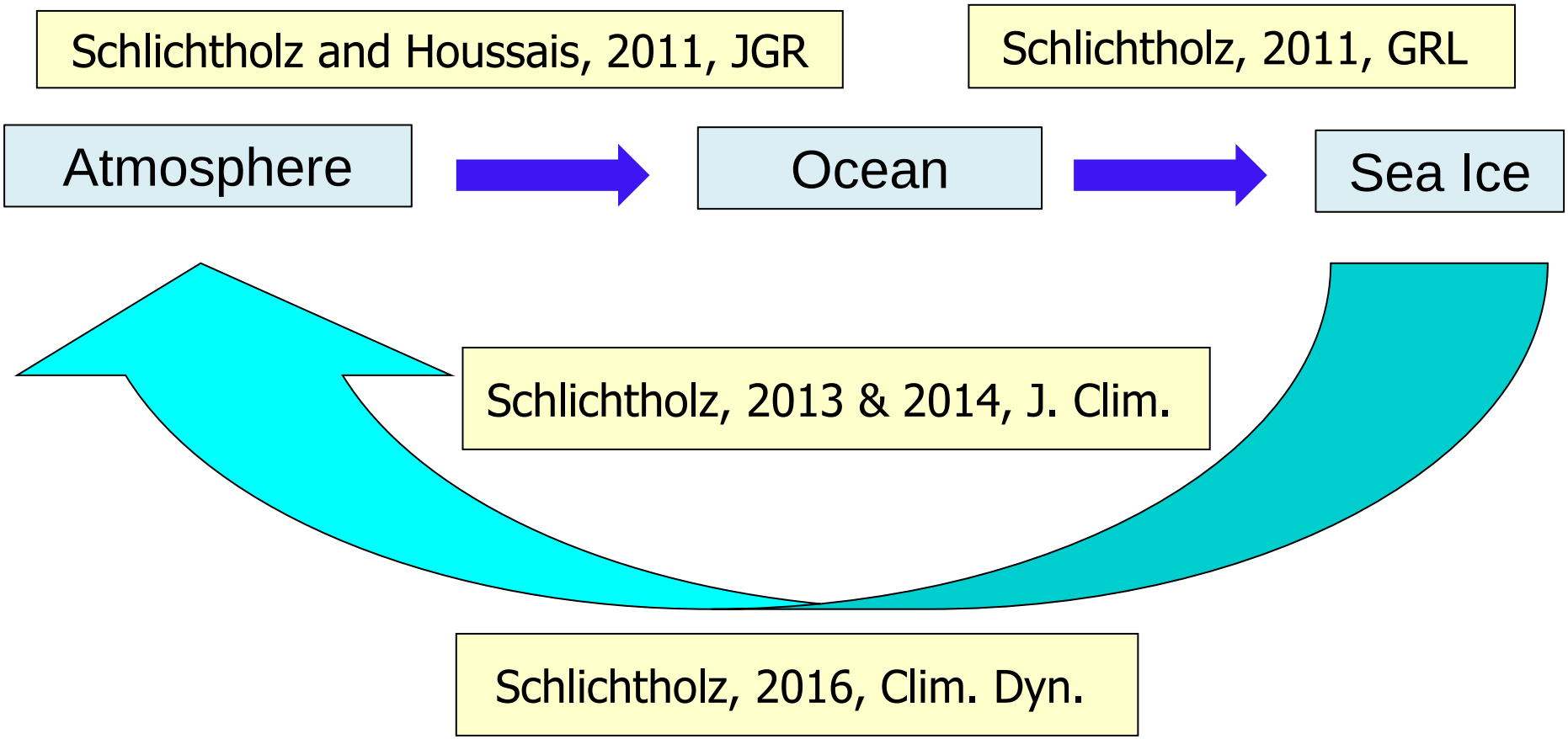
Nordic seas



BSO: Barents Sea Opening

Atlantic water flow →

Aim: Assess the role of northern high-latitude ocean temperature anomalies in local climate feedbacks and large-scale atmospheric variability and predictability



Method: Lagged regression analysis

Seasonal mean fields from 1982 to 2006
(4-month means, 1-month step)

Basic seasons

- Winter: Dec-Mar
- Spring: Mar-Jun
- Summer: Jun-Sep
- Autumn: Sep-Dec

Intermediate seasons
(-/+ 1 month shift)

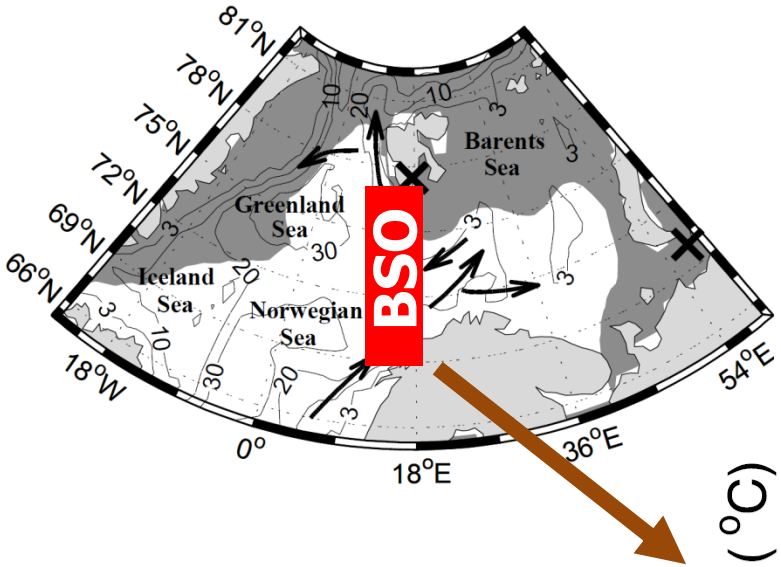
e.g.

- early winter (Nov-Feb)
- late winter (Jan-Apr)

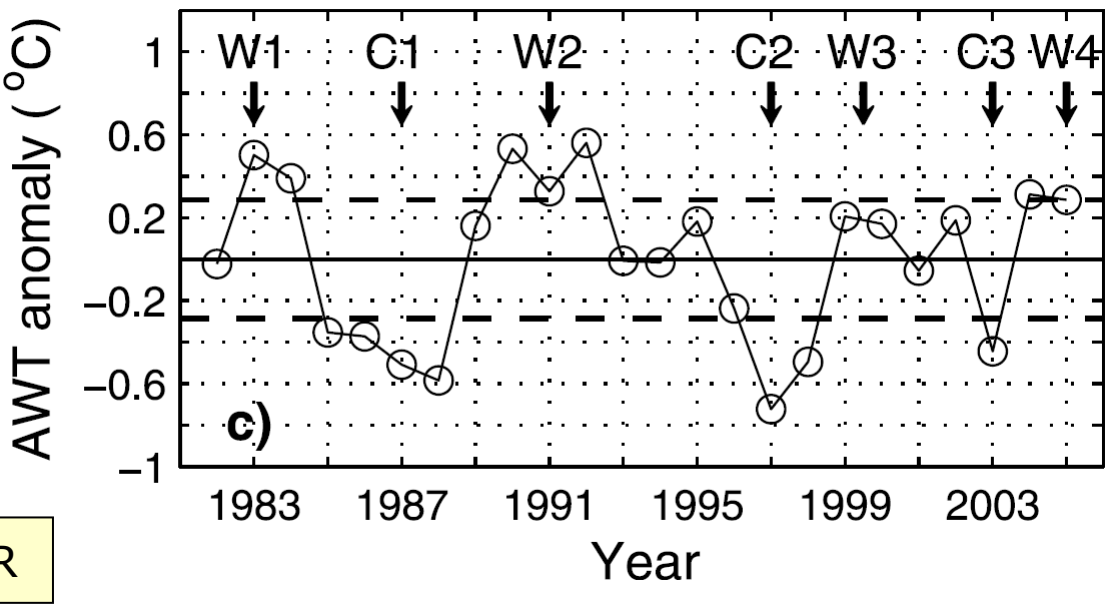
Data:

- NCEP/NCAR atmospheric reanalysis (Kalnay et al., 1996)
- Surface oceanic fields (Reynolds et al., 2007):
  sea surface temperature (SST)
  sea ice concentration (SIC)
- Subsurface hydrographic data from ICES (2006) and WOD05 (Boyer et al., 2006)

Summer Atlantic water temperature (AWT) at 100-300 m in the Barents Sea Opening



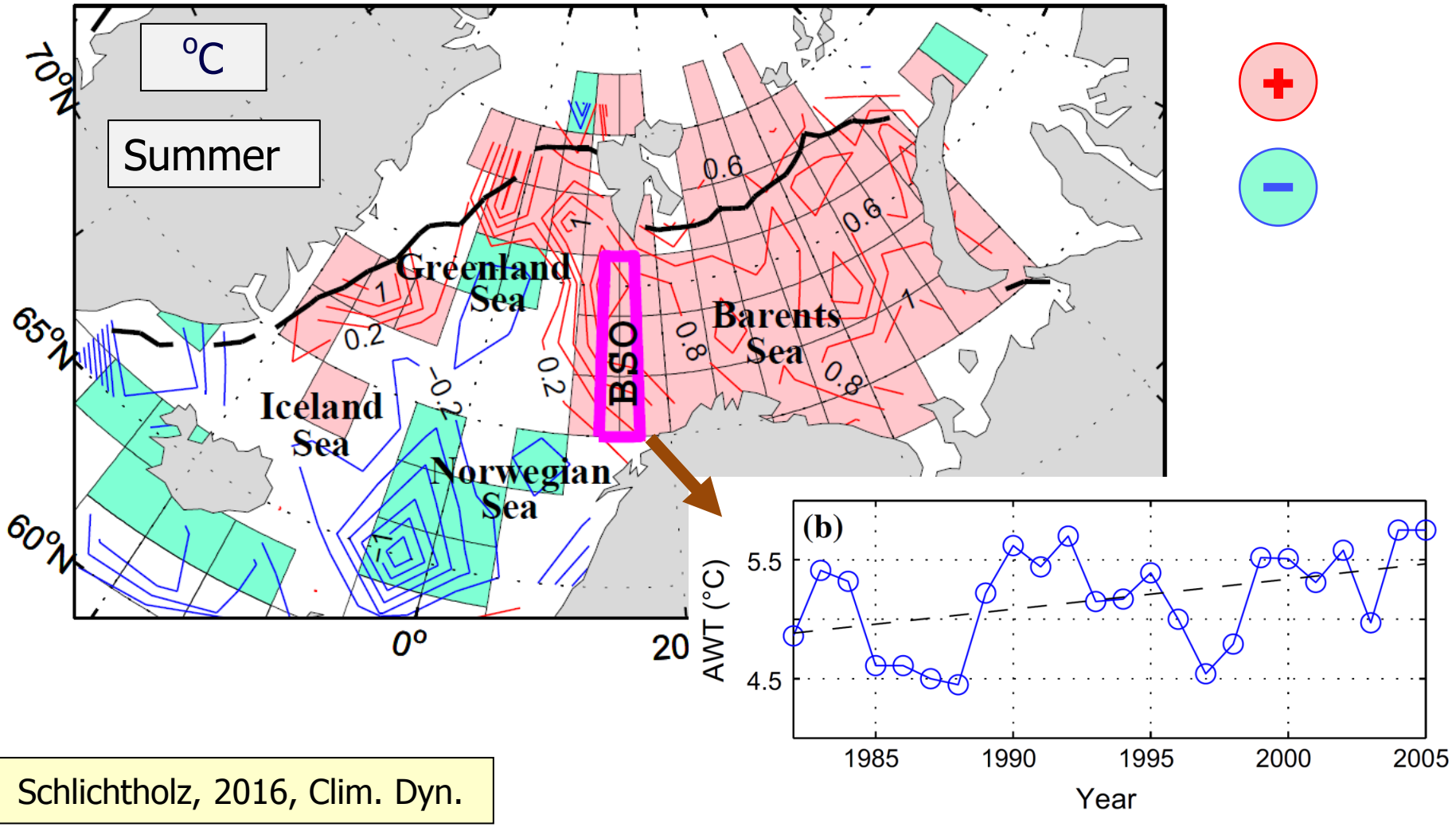
detrended anomalies



Schlichtholz and Houssais, 2011, JGR

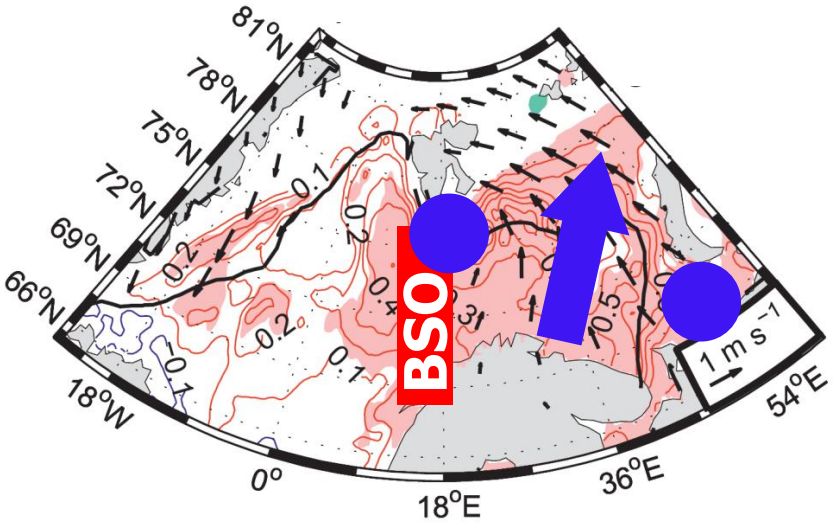
Composite difference of subsurface (50-150 m) ocean temperature

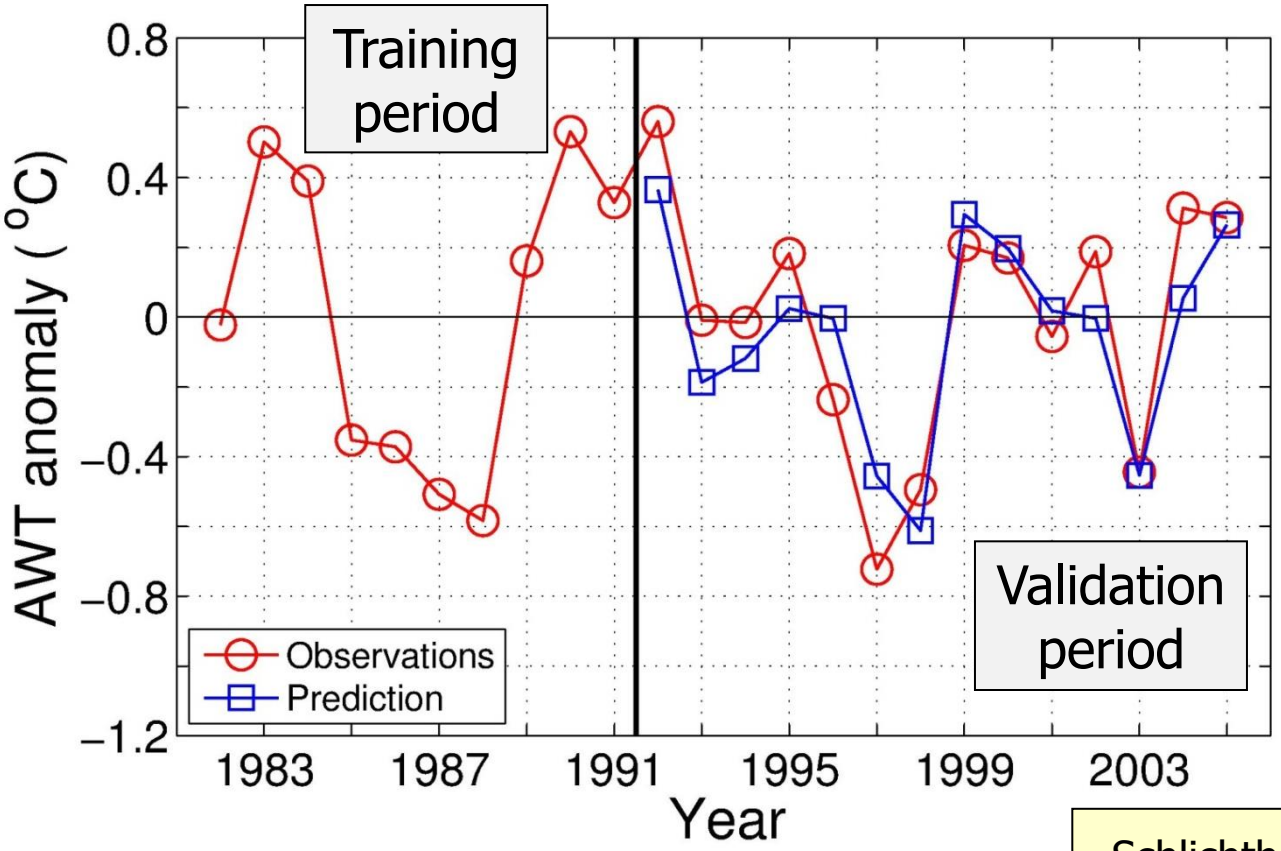
(AWT-BSO warm years – AWT-BSO cold years)



Schlichtholz, 2016, Clim. Dyn.

Prediction of the summer AWT anomalies from the previous late winter „on ice wind" index

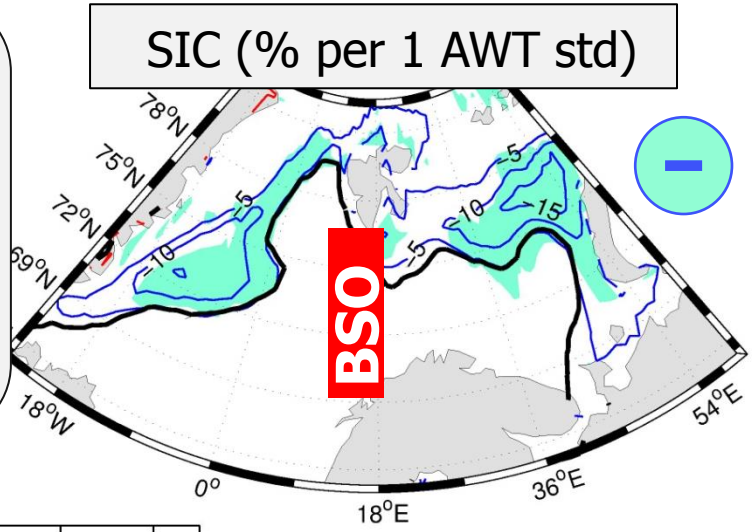


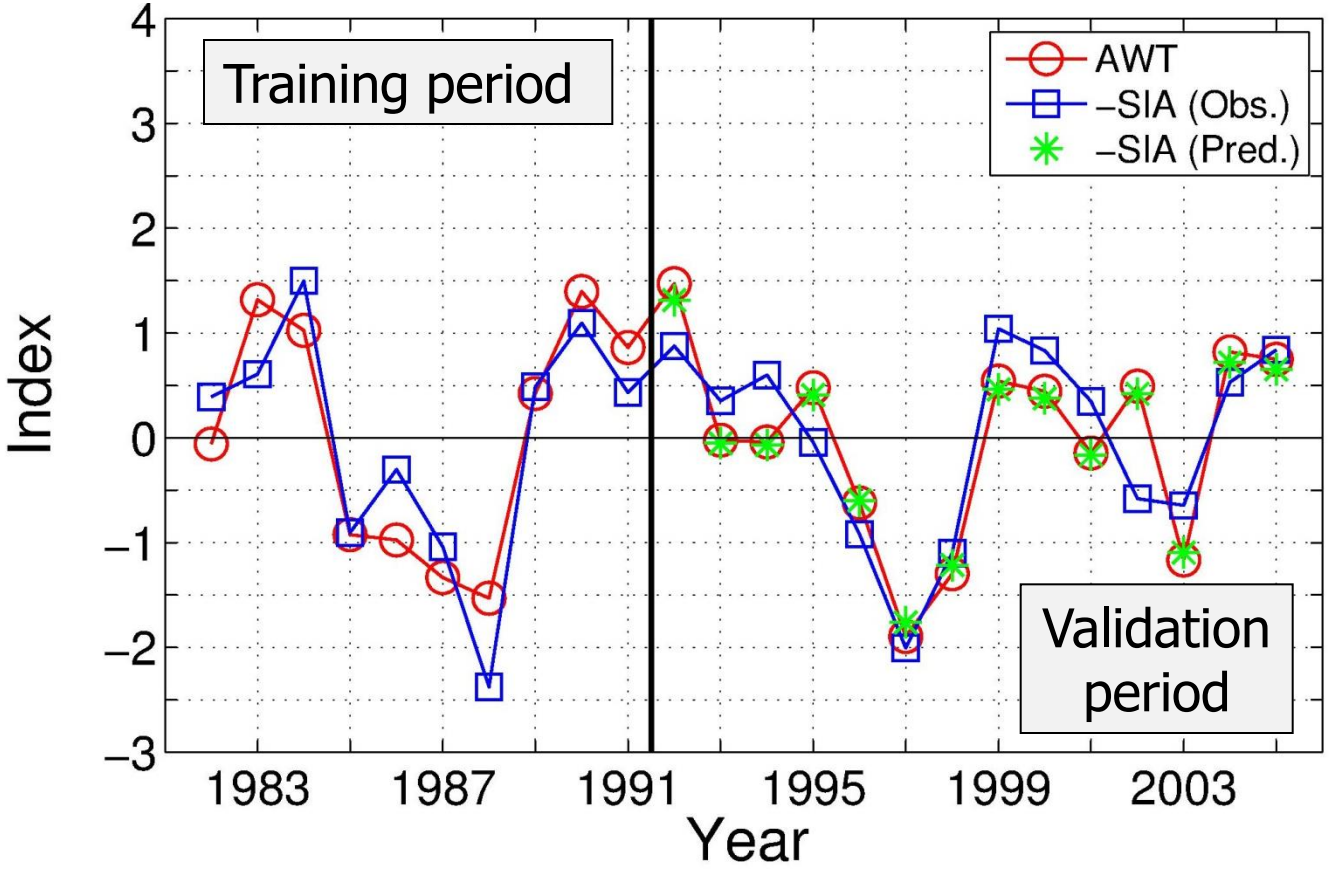


Skill: 79% of explained variance

Schlichtholz and Houssais, 2011, JGR

Prediction of early winter anomalies of the sea ice area (SIA) in the Nordic seas from the previous summer AWT index

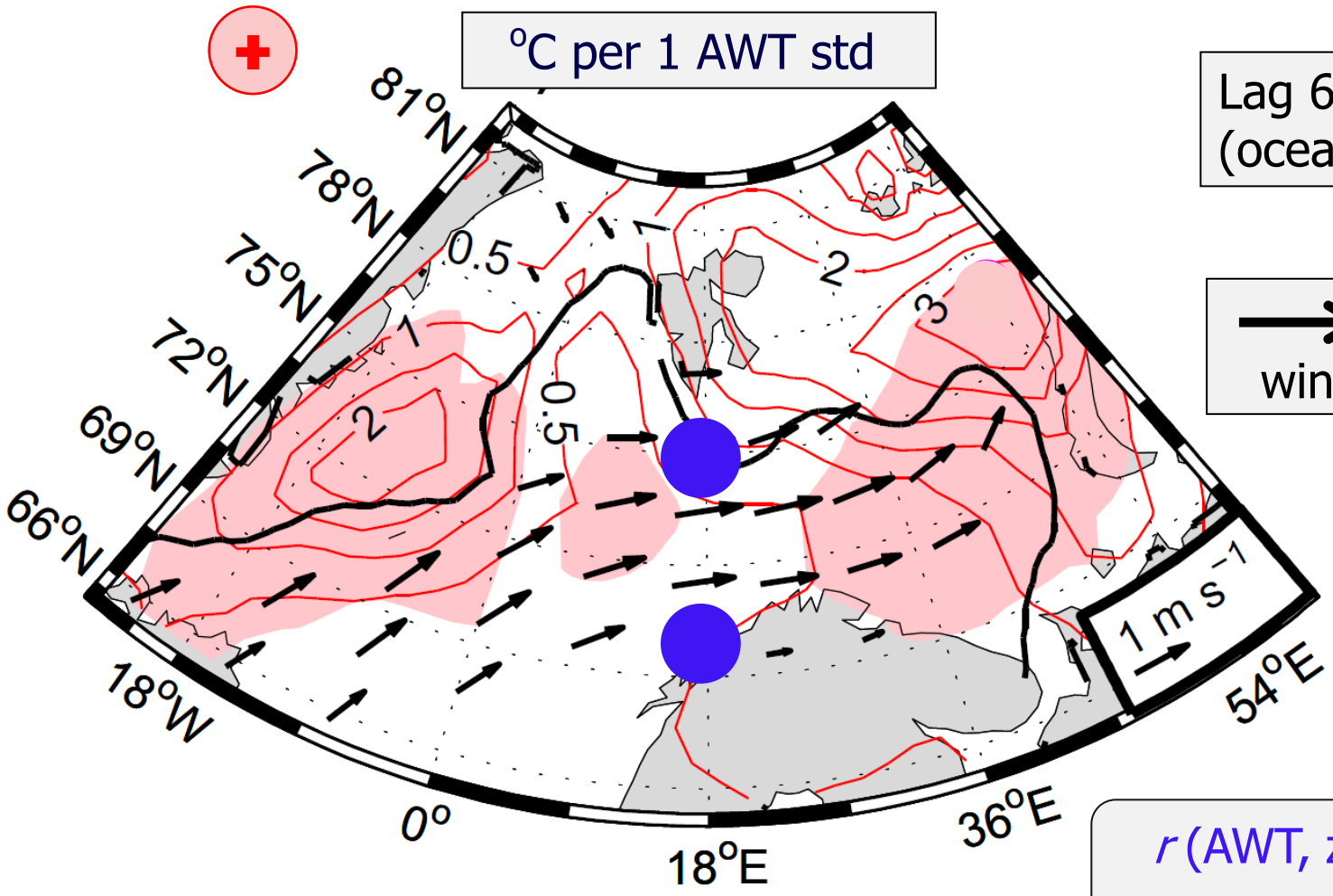




Skill: 71% of explained variance

Schlichtholz, 2011, GRL

AWT-associated winter anomalies of surface air temperature (SAT) and surface wind



r (AWT, zonal wind) = 0.8

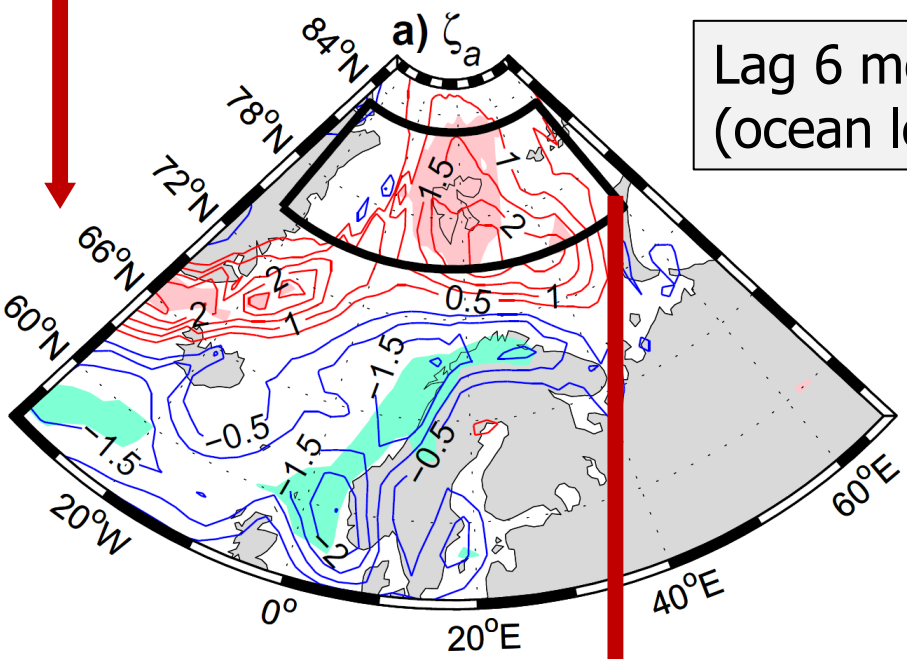
Schlichtholz, 2013, J. Clim.

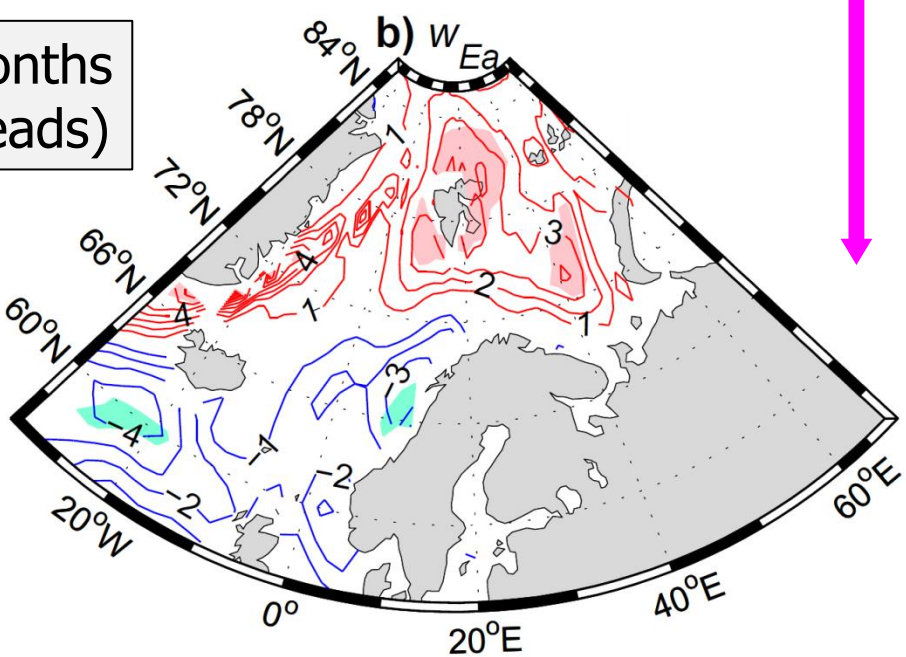
AWT-associated winter anomalies of surface wind vorticity and atmospheric Ekman pumping

10^{-6} s^{-1} per 1 AWT std

10^{-4} m s^{-1} per 1 AWT std

Lag 6 months (ocean leads)

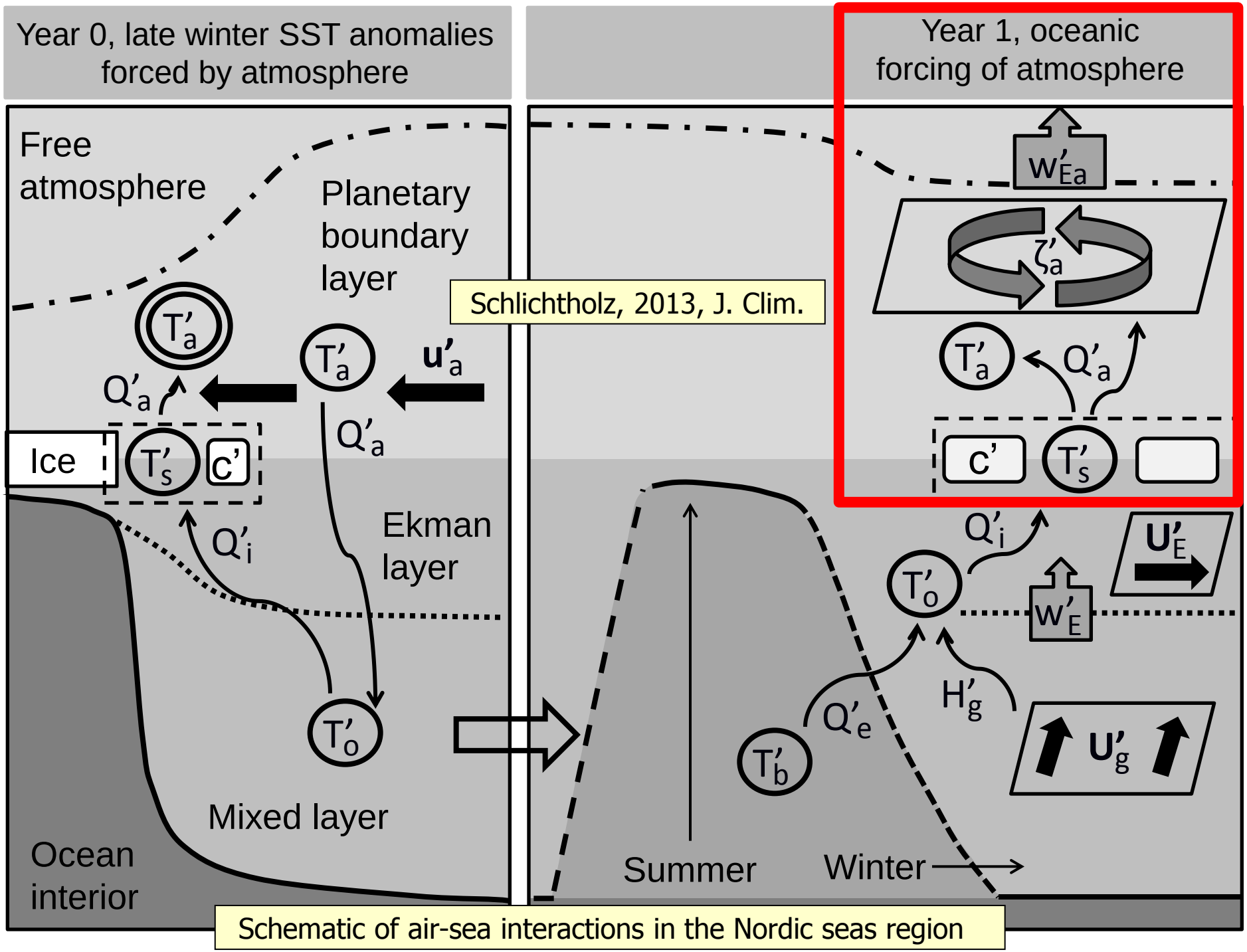




positive upward

r (AWT, wind vorticity) = 0.77

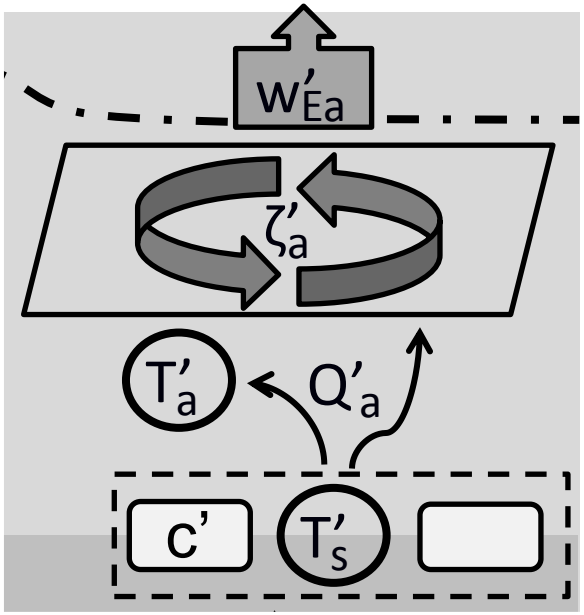
Schlichtholz, 2013, J. Clim.



Schematic of air-sea interactions in the Nordic seas region

Local and remote atmospheric response to oceanic forcing in the Nordic seas area

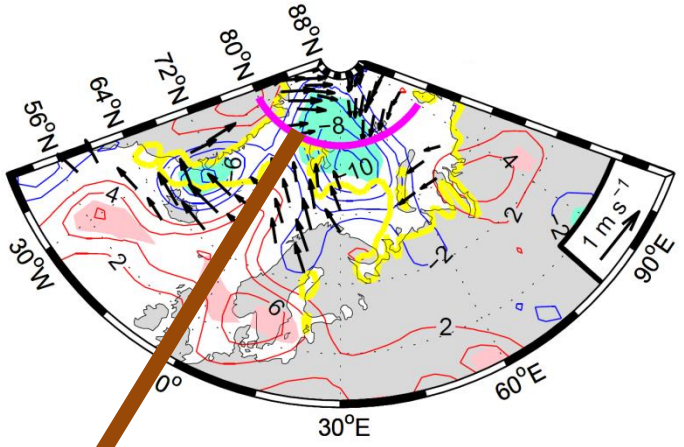
How deep ?



How far ?

Schlichtholz, 2014, J. Clim.

AWT-associated winter anomalies of wind divergence at 80 deg. N



10^{-7} s^{-1} per 1 AWT std

Lag 6 months (ocean leads)

Pressure (hPa)

200
400
600
800
1000

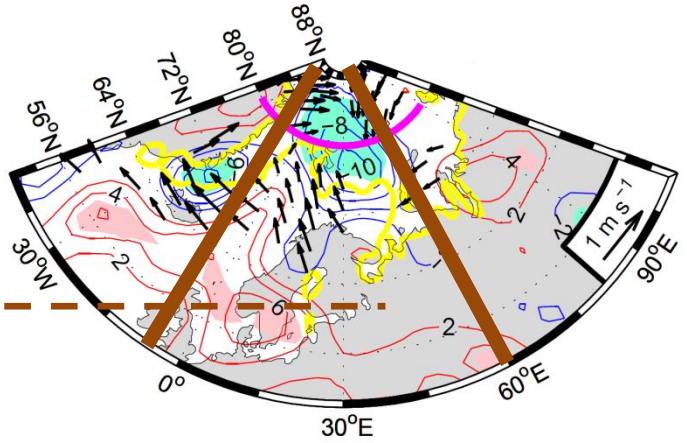
−30 −10 10 30 50 70 90

Longitude (°E)

mean temperature, °C

Schlichtholz, 2014, J. Clim.

AWT-associated winter anomalies of zonally-averaged vertical velocity



10^{-3} Pa s^{-1} per 1 AWT std ω' (positive downward)

Lag 6 months (ocean leads)

Pressure (hPa)

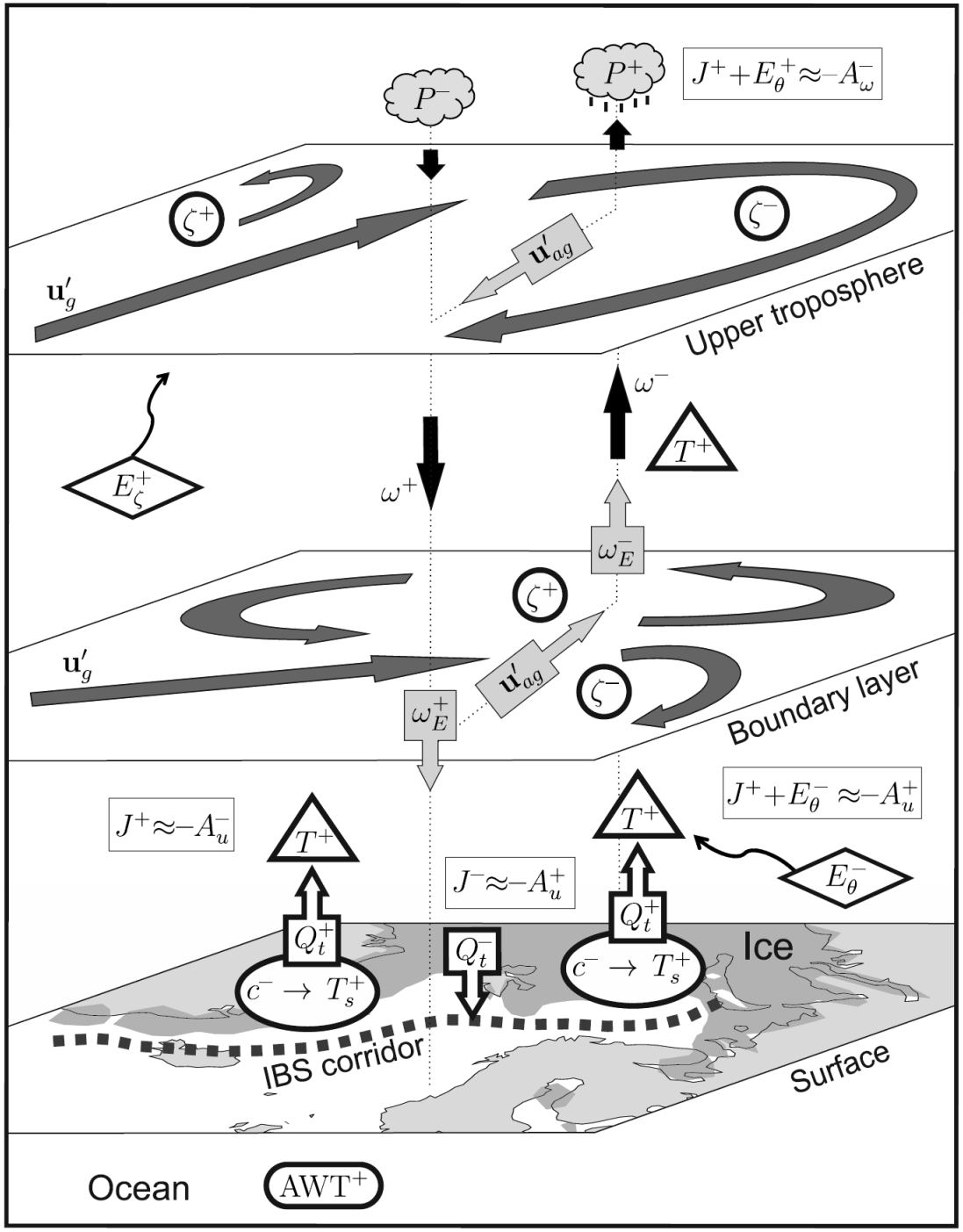
200
400
600
800
1000

50 55 60 65 70 75 80 85 90

Latitude (°N)

thick contours: mean ω

Schlichtholz, 2014, J. Clim.

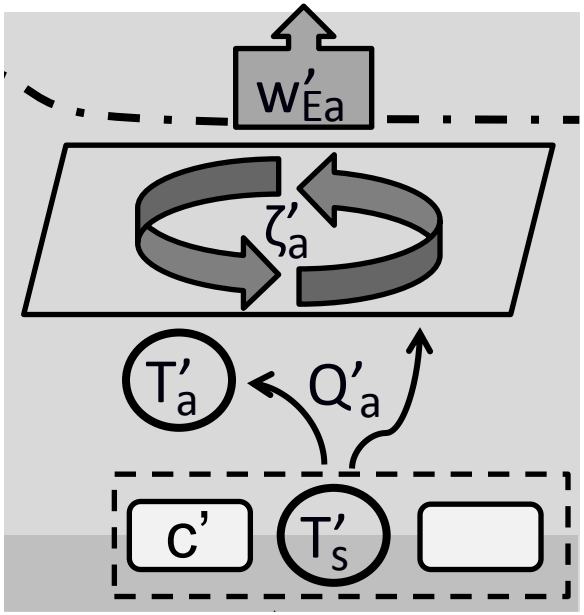


Schematic of the local atmospheric response to oceanic heat anomalies in the Nordic seas region

Schlichtholz, 2014, J. Clim.

Local and remote atmospheric response to oceanic forcing in the Nordic seas area

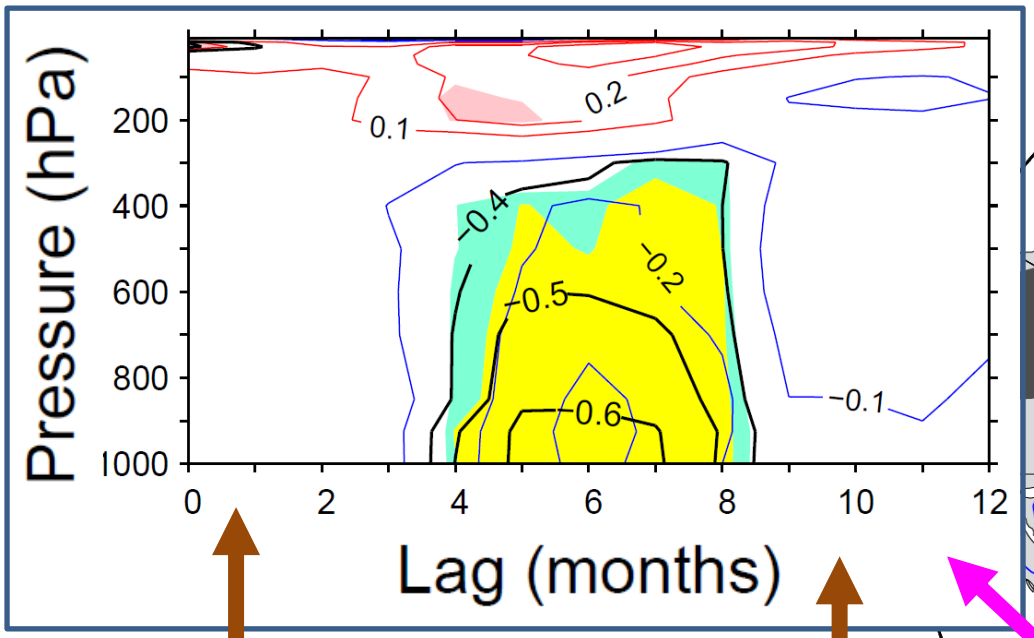
How deep ?



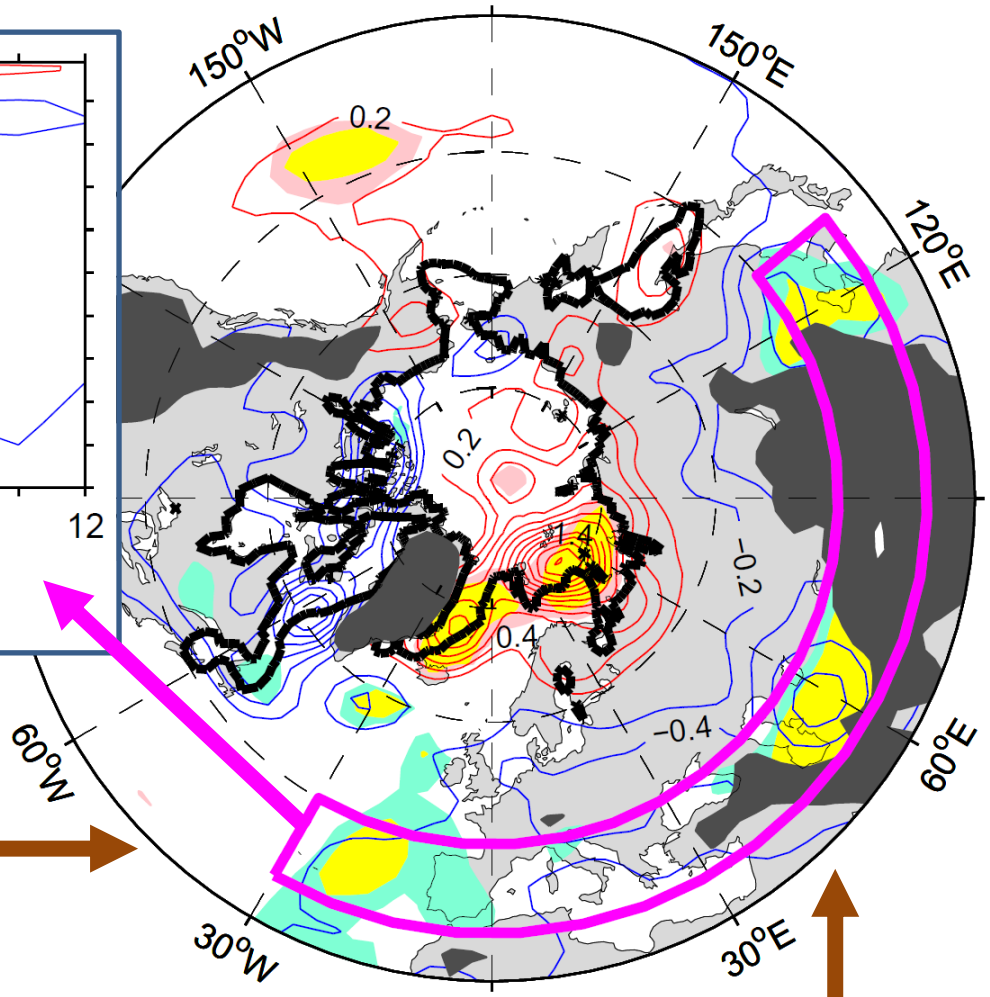
How far ?

Schlichtholz, 2016, Clim. Dyn.

AWT-associated anomalies of air temperature



correlation *r*



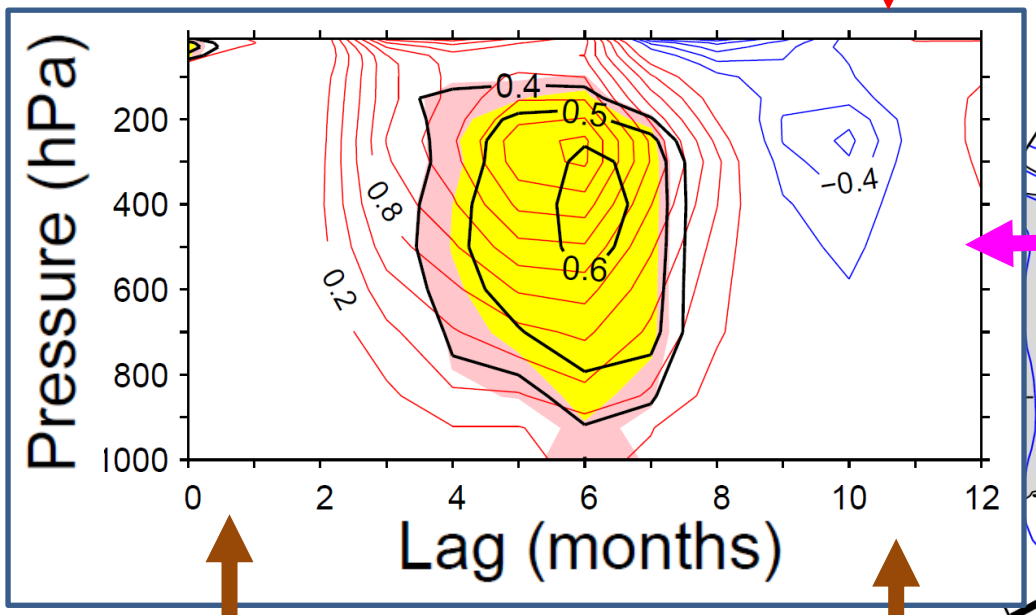
95% CL

°C per 1 AWT std

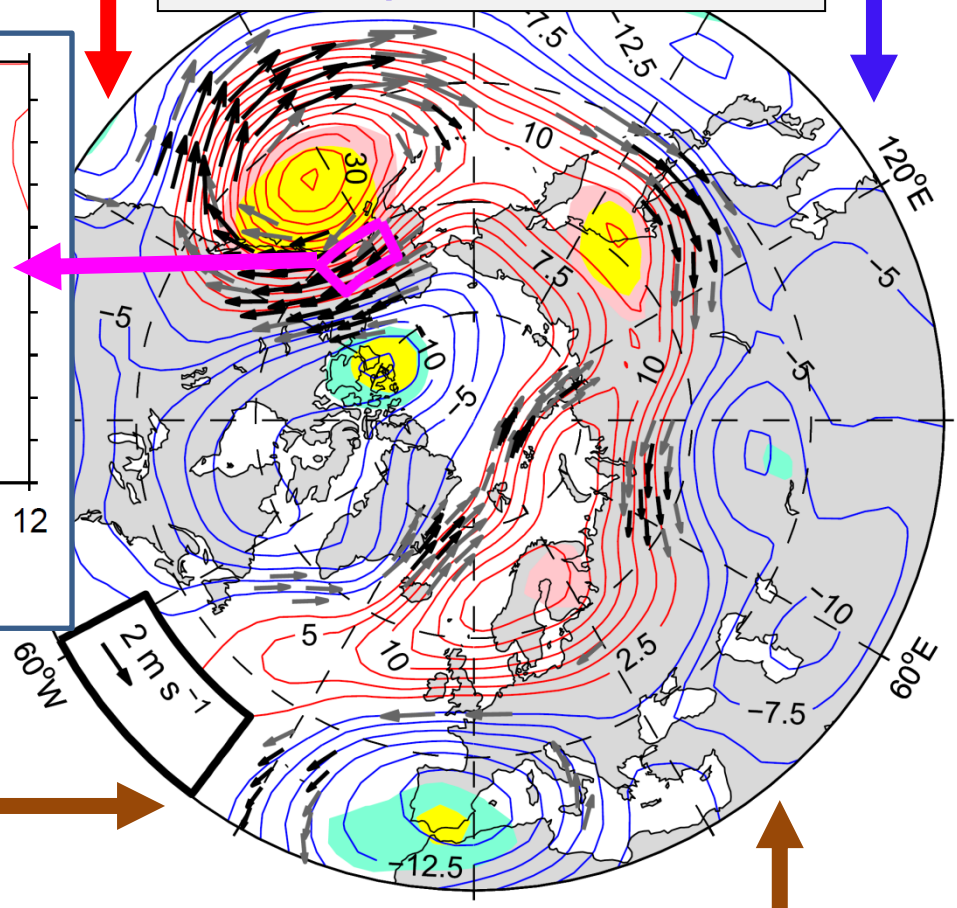
1000 hPa, winter
ocean leads by 6 months

AWT-associated anomalies of geopotential height (contours) and wind velocity (arrows)

zonal wind: m s^{-1} per 1 AWT std



gpm per 1 AWT std



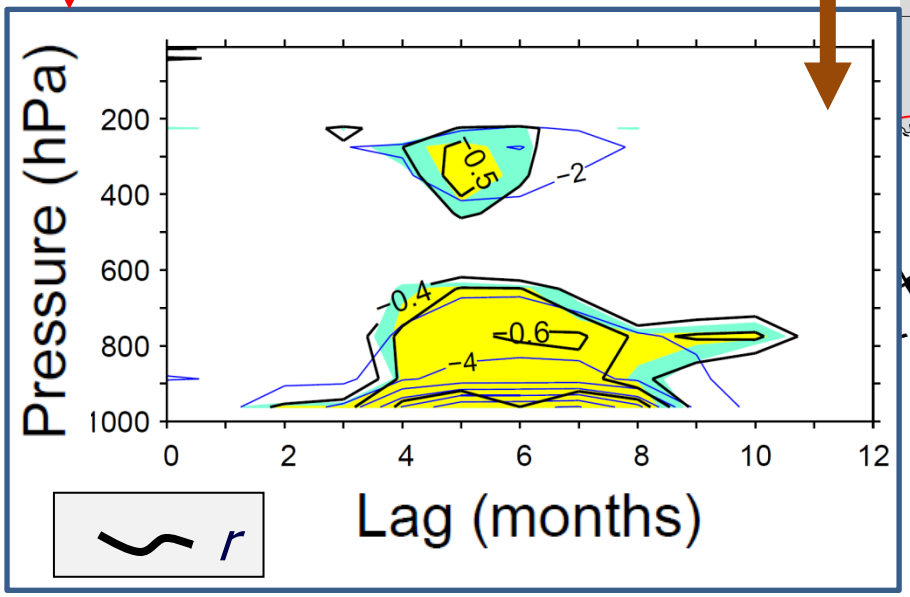
correlation *r*

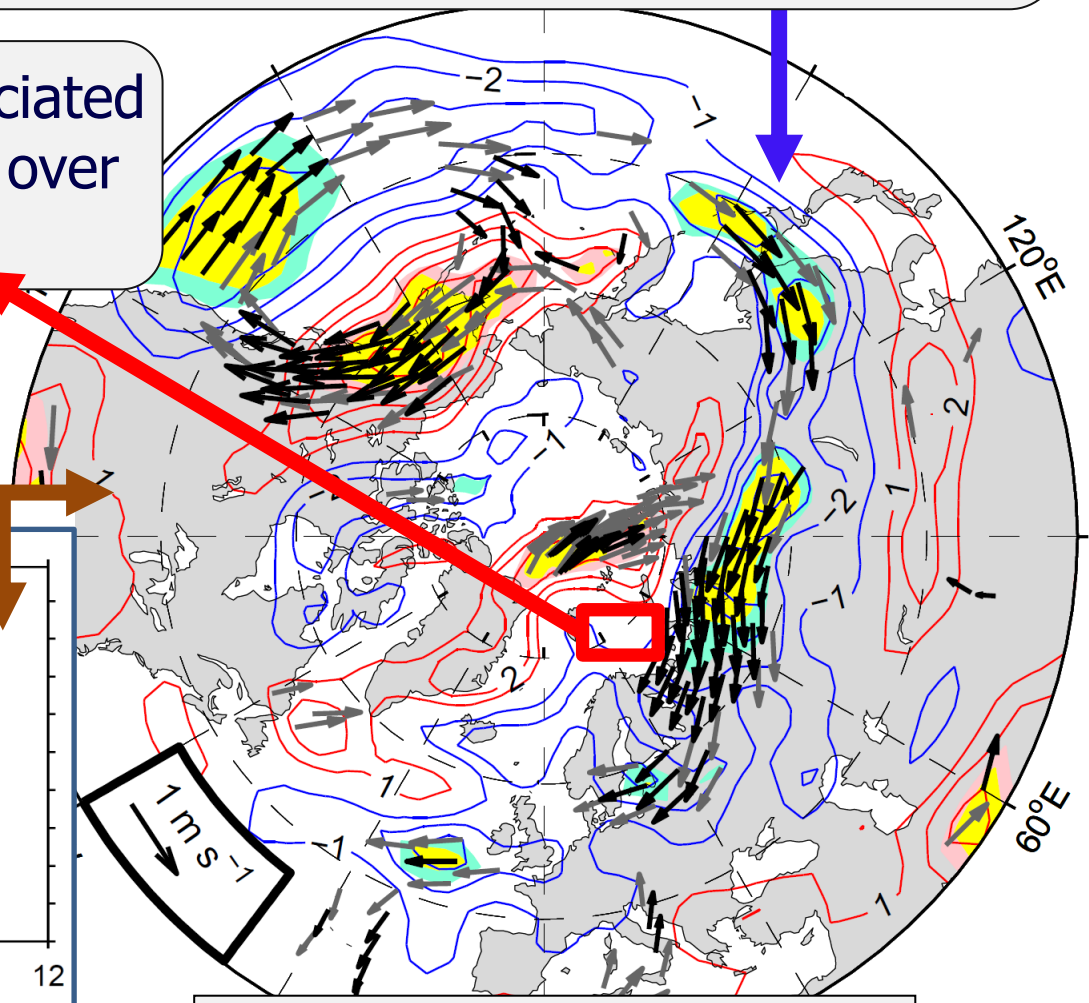
95% CL

300 hPa, winter
ocean leads by 6 months

AWT-associated winter anomalies of Eady parameter at 700 hPa (contours) and wind shear between 500 and 850 hPa (arrows)

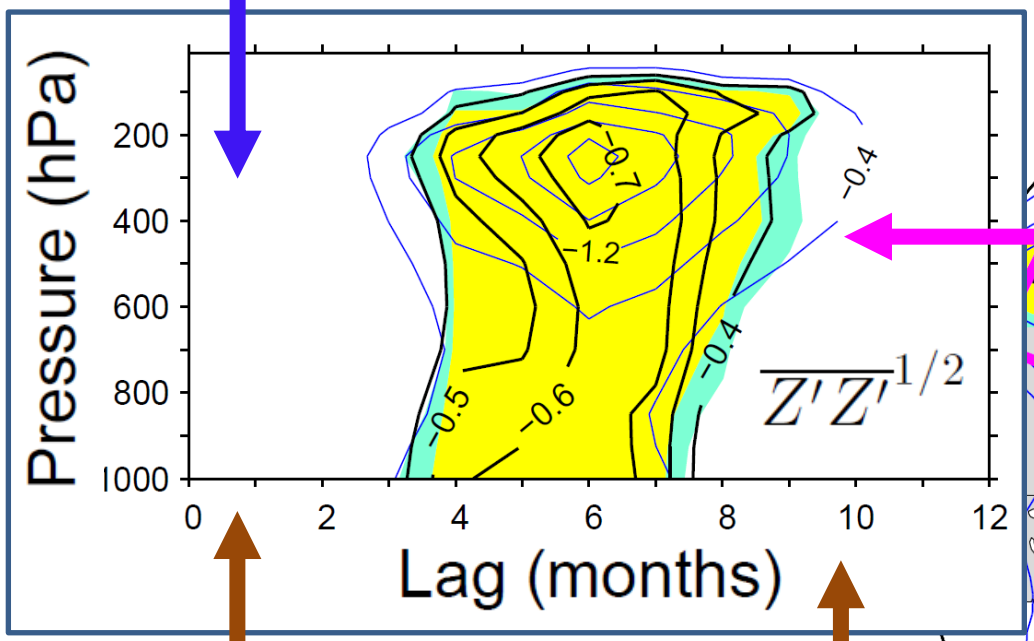
and evolution of the AWT-associated buoyancy frequency (10^{-4} s^{-1}) over the Barents Sea



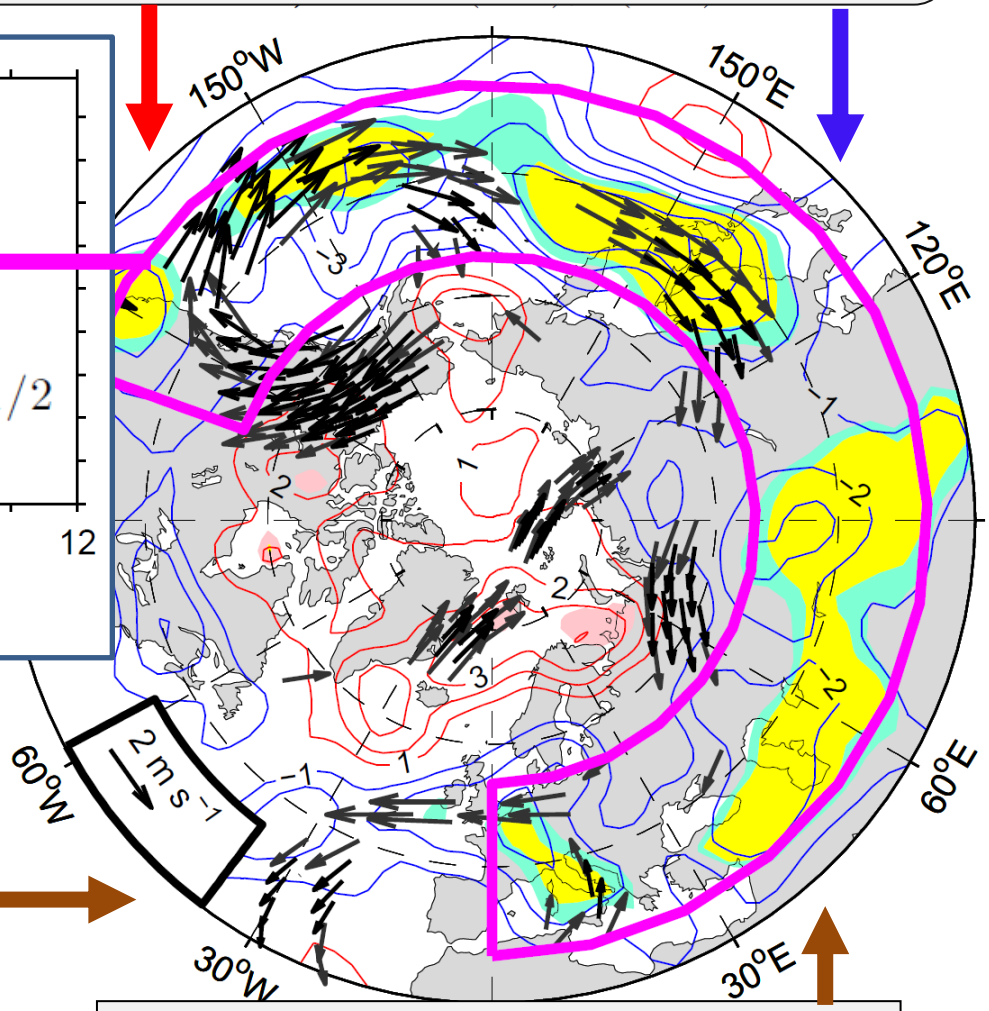


10^{-2} day^{-1} per 1 AWT std

AWT-associated anomalies of storm track activity (contours) and wind velocity (arrows)



correlation *r*

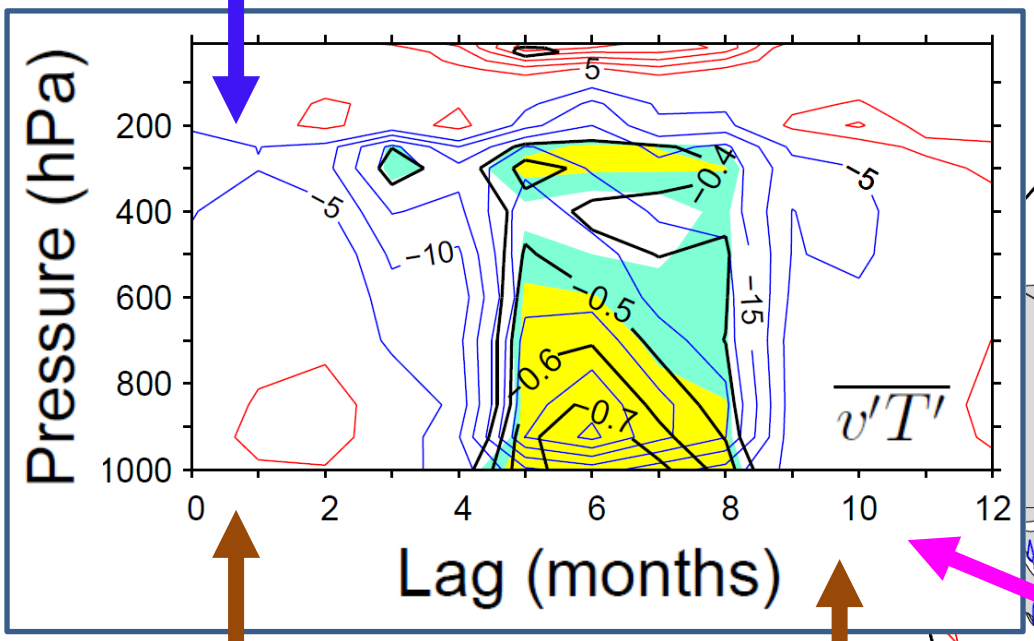


95% CL

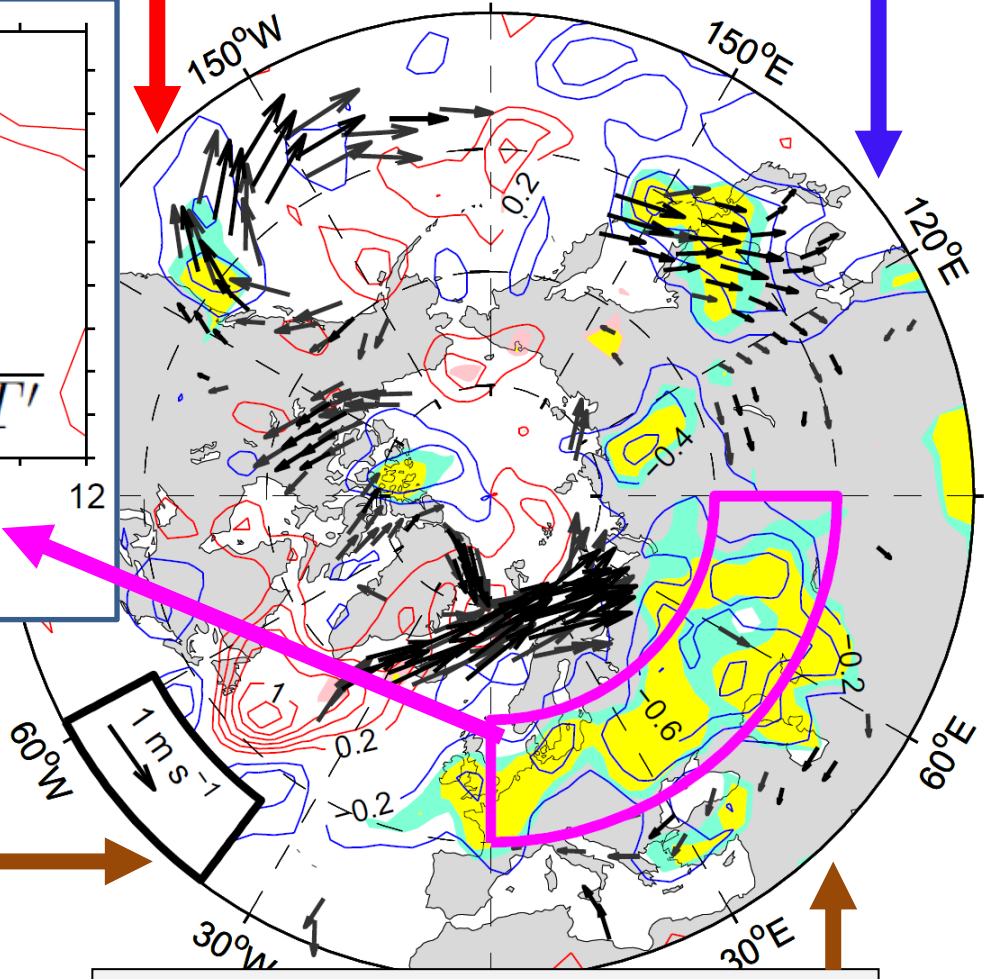
gpm per 1 AWT std

300 hPa, winter
ocean leads by 6 months

AWT-associated anomalies of poleward eddy heat flux (contours) and wind velocity (arrows)



correlation *r*

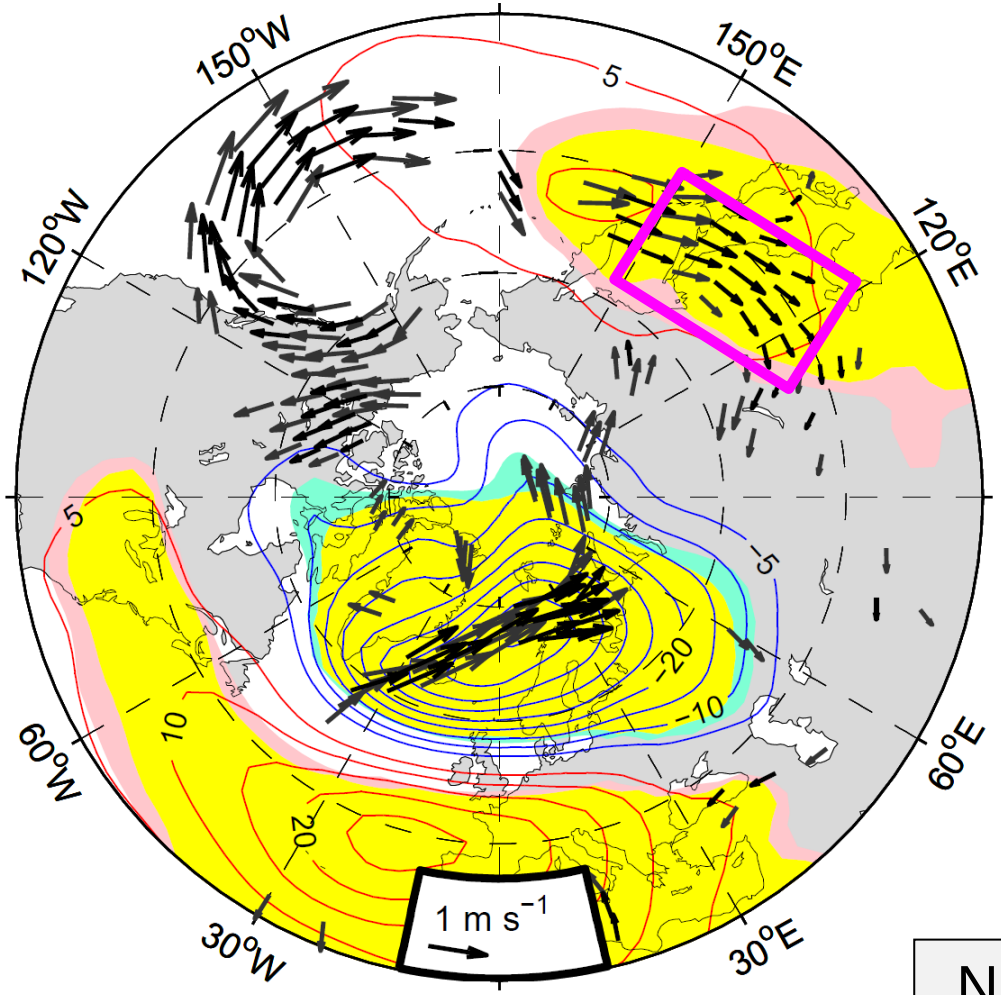


95% CL

°C m s^{-1} per 1 AWT std

925 hPa, winter
ocean leads by 6 months

AWT-associated winter anomalies of wind velocity (m s^{-1}, arrows) and NAO-associated winter anomalies of geopotential height (gpm, contours) at 850 hPa



AWT leads by 6 months

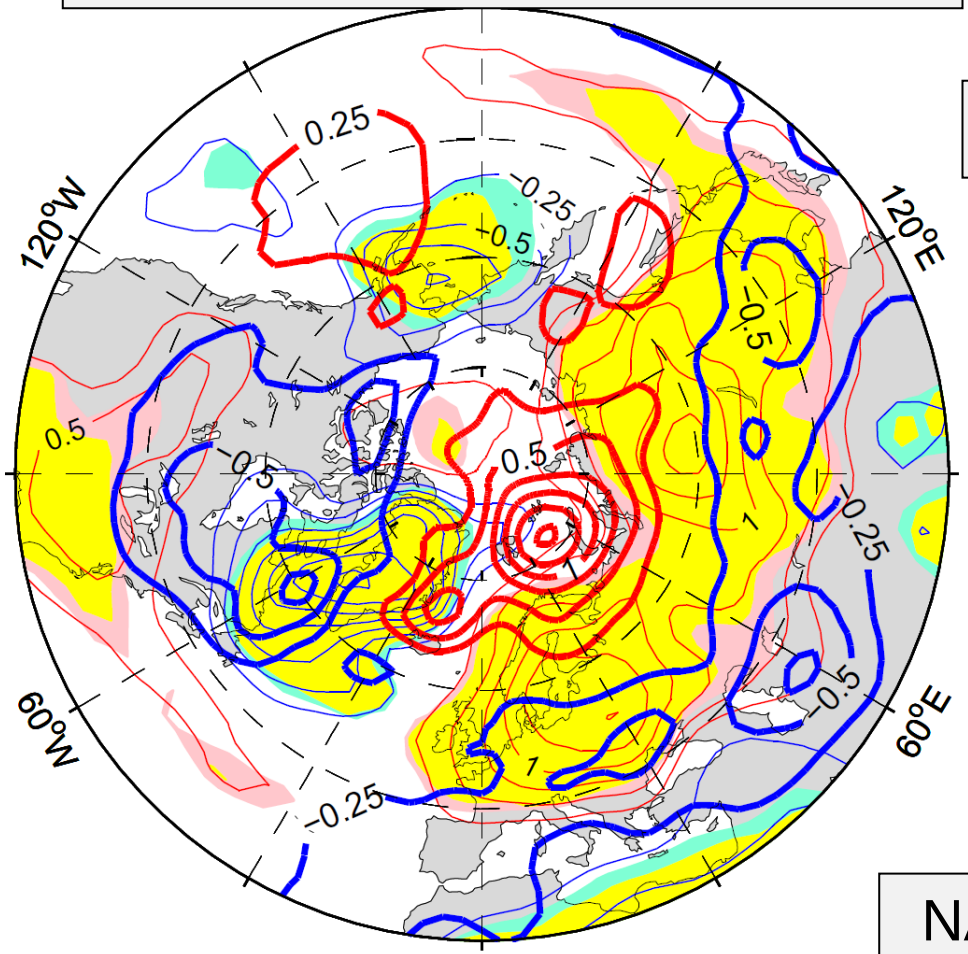
NAO (lag = 0):

+ − 95% CL

NAO = North Atlantic Oscillation

AWT-associated and NAO-associated winter anomalies of low-level (1000-850 hPa average) tropospheric air temperature

°C per unit AWT and NAO indices



AWT (leads by 6 months):

NAO (lag = 0):

+ − 95% CL

NAO = North Atlantic Oscillation

Conclusion: summer AWT – precursor of atmospheric anomalies in several remote regions during the following winter

- Surface air temperature in mid-latitude Eurasia ($r^2 = 0.40$)
- Surface winds in the Far East ($r^2 = 0.52$)
- Upper-level winds over Alaska ($r^2 = 0.37$)
- Upper-level synoptic activity over mid-latitude Eurasia/North Pacific ($r^2 = 0.59$)
- Low-level synoptic poleward eddy heat flux over central Eurasia ($r^2 = 0.62$)

r^2(AWT, NAO) = 0.00

Schlichtholz, 2016, Clim. Dyn.