Assessment of the hindcast of the Labrador Sea

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Background

The subpolar North Atlantic plays a key role in global climate dynamics. Especially in the Labrador Sea, strong oceanic heat loss in the winter with a cyclonic circulation setting leads to open-ocean deep convection, by which so-called Labrador Sea Water (LSW) is generated, which contributes considerably to the generation of North Atlantic Deep Water (NADW). During the past five decades, significant hydrographic changes happened in this area (Dickson et al., 2002; Yashayaev, 2007). The subpolar North Atlantic circulation also experienced some changes, especially during the 1990s (Häkkinen and Rhine, 2004).

This study is model-based one. An eddy permitting model is used for long-term simulations. The interannual and interdecadal variability in the Labrador Sea from 1948 to 2005 are examined. The mechanism of interannual variability of the Irminger Water in the Labrador Sea is further studied.

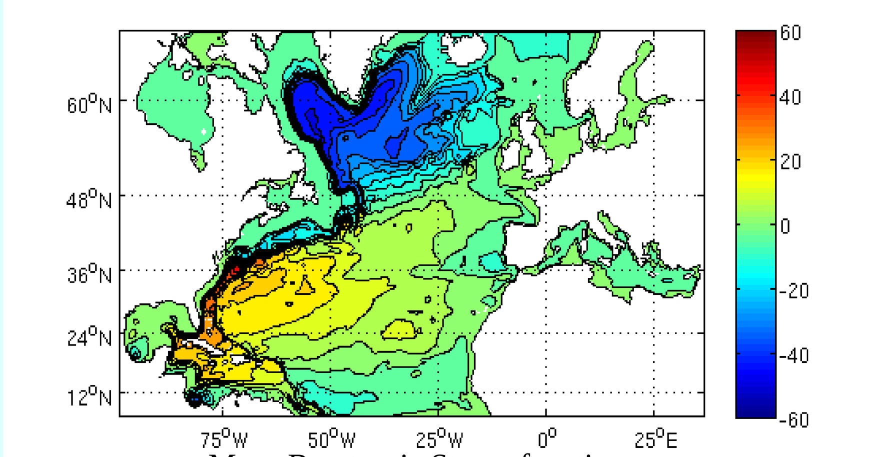
Model Setup

Ocean Model
- NEMO coupled sea-ice model (Madec, 2008);
- A spectral nudging scheme (Thompson et al. 2006)

Forcing Data
- NCEP/NCAR reanalysis data (1948-2005) for atmospheric forcing;
- SODA data for open boundaries.

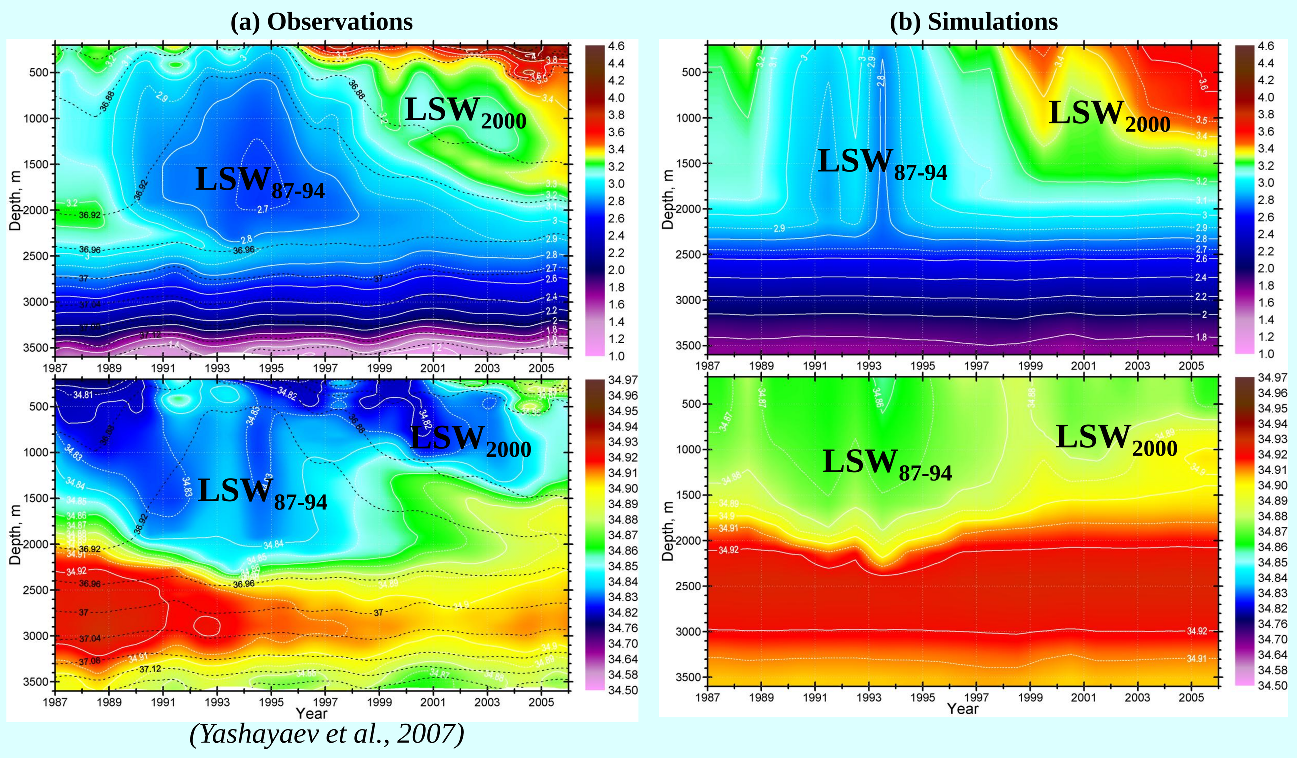
Resolution
- ¼ degree horizontal resolution and 46 vertical levels

Basin
- North Atlatic (6.7N-67N); open boundaries



Mean Barotropic Streamfunction

T & S interannual variability Over the Central Labrador Sea



(Yashayaev et al., 2007)

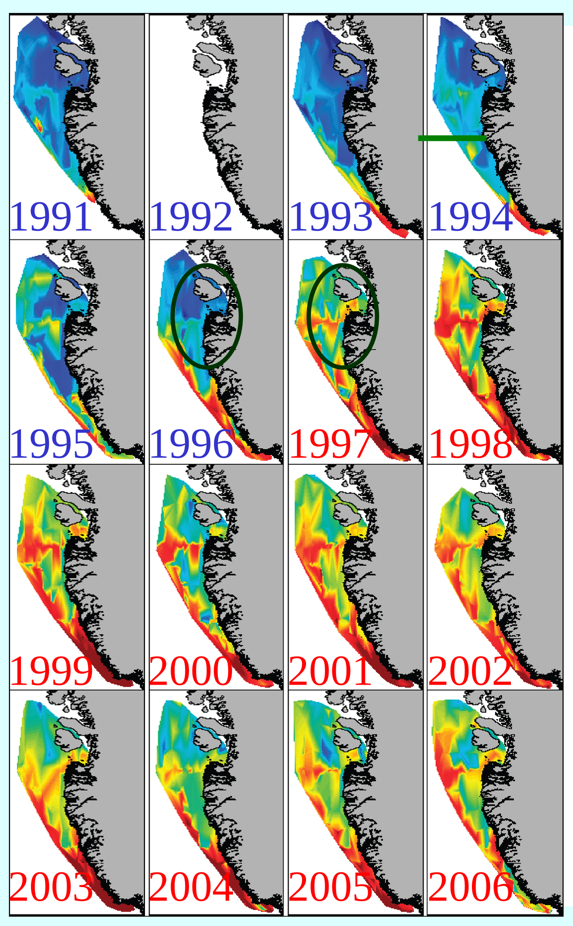
The modeled T and S during the past 50 years are in good agreement with the observations and show significant interannual and decadal variability (Figure not shown here; Yashayaev, 2007). Before 1980 the water is warmer and saltier than after 1980, which is related to the decadal variability of deep convection activity.

In particular, during the past two decades there are two class of LSWs formed: LSW_{87-94} and LSW_{2000}. LSW_{87-94} is cooler, fresher and deeper than LSW_{2000}. The model simulated the two class of LSWs well.

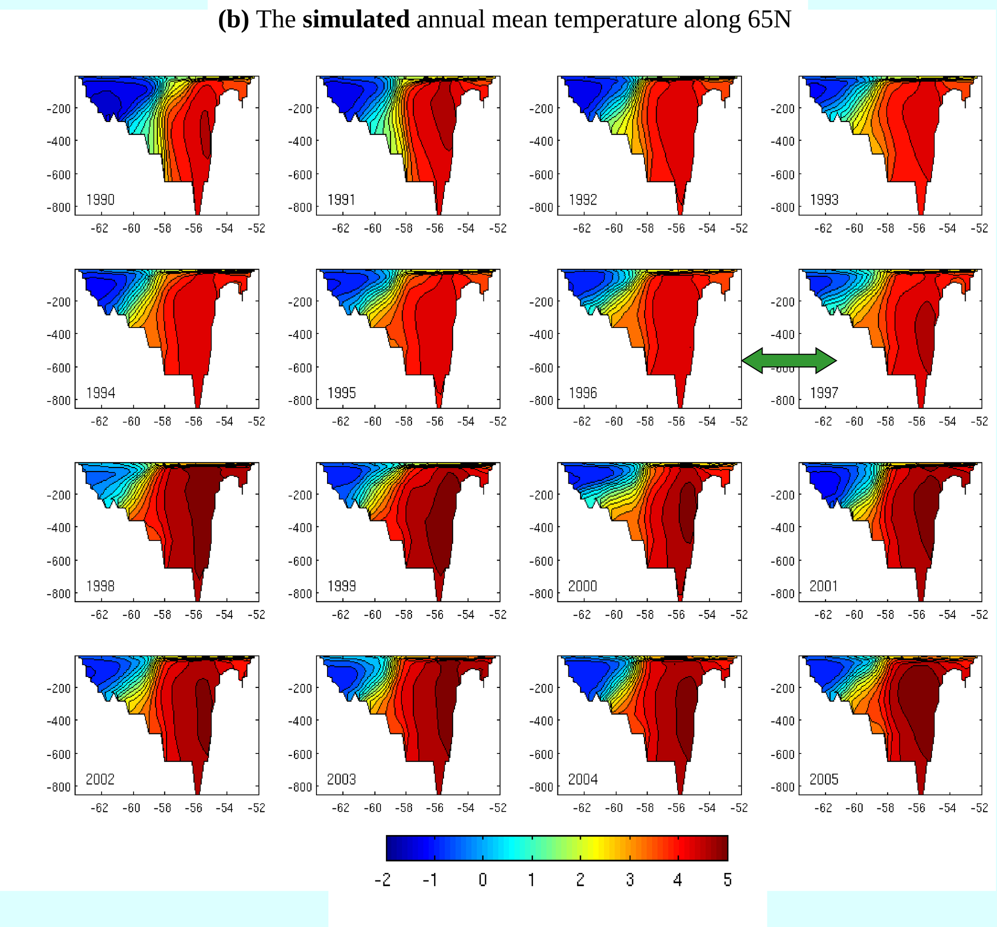
Discrepancy: (1) "saltilization" bias; (2) mis-representation of the freshening trend at the deep layer.

1997 Subsurface Sudden Warm of the Irminger water temperature

(a) The **observed** 150-600m Temperature



(b) The **simulated** annual mean temperature along 65N



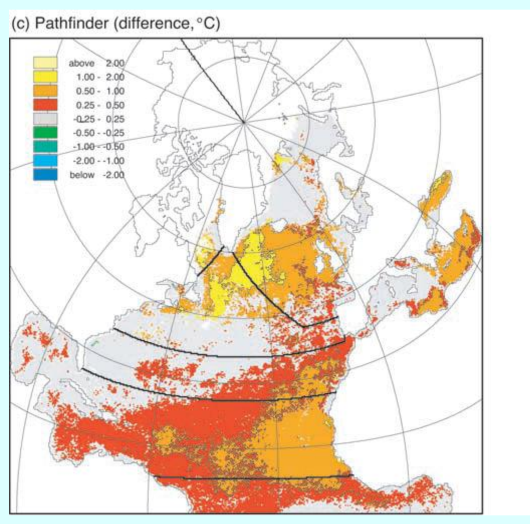
Observational studies indicate that the IWT experienced a sudden warm along the west coast of Greenland in 1997, which is thought as a cause for a sudden switch of Jakobshavn Isbrae from slow thickening to rapid thinning in 1997 (Holland et al. 2008).

The sudden warming also appears in our simulations.

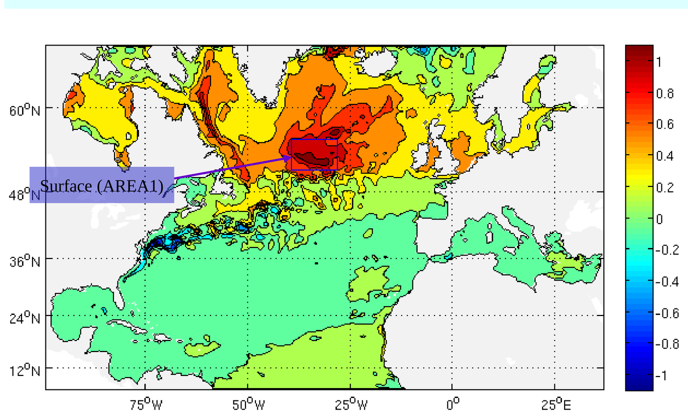
Recent Warming of the North Atlantic

(SST difference between 1995-2003 and 1985-1994)

(a) Observations



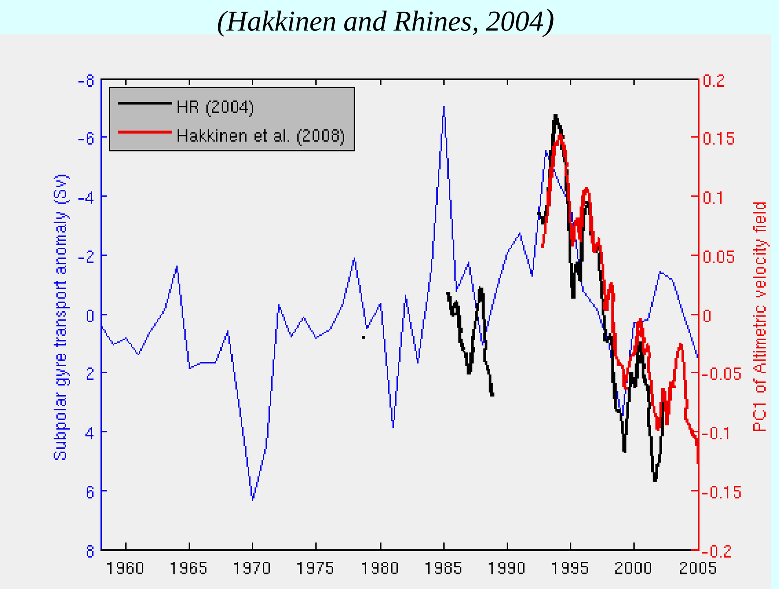
(b) Simulations



(Marsh et al., 2008)

Decline of Subpolar North Atlantic Circulation During the 1990s

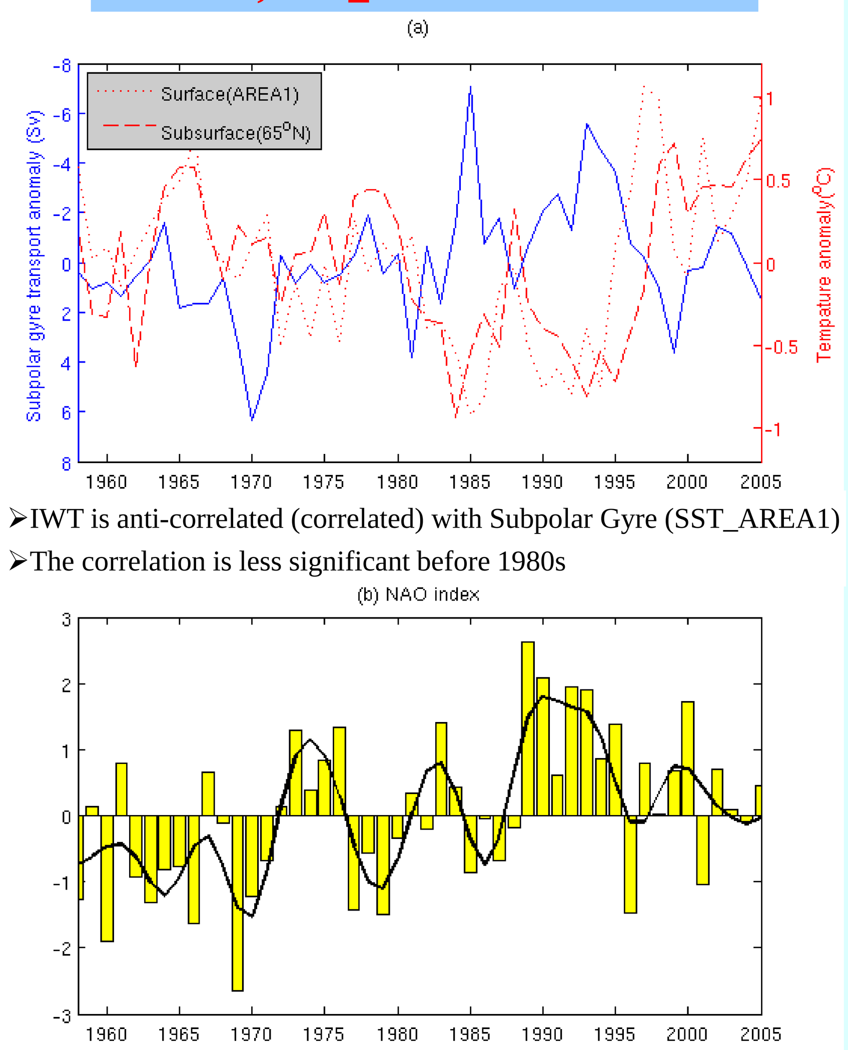
(Hakkinen and Rhines, 2004)



The decline of North Atlantic subpolar gyre during the 1990s derived from altimeter data (Häkkinen and Rhine, 2004), is part of decadal variability.

On the mechanism of interannual variability of the Irminger Water in the Labrador Sea

IWT, SST_AREA1 and SPGI

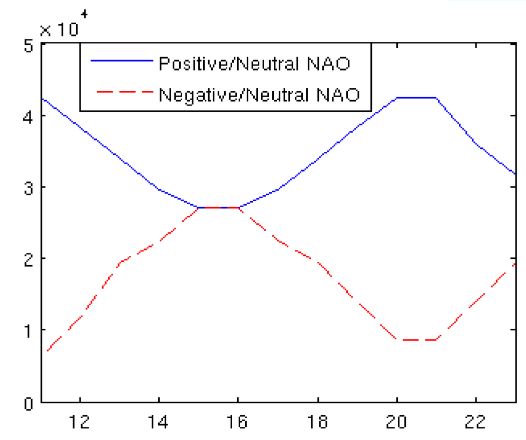


- ➢IWT is anti-correlated (correlated) with Subpolar Gyre (SST_AREA1)
- ➢The correlation is less significant before 1980s

Sensitive Experiments

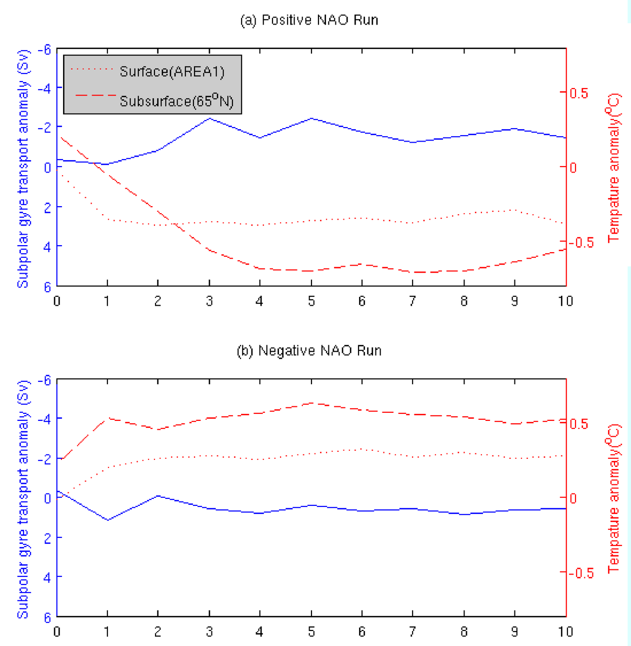
Constant Forcing Experiments (10 years):
- -Positive NAO Run
- -Negative NAO Run

Oscillation Forcing Experiments (13 years):
- -Positive/Neutral NAO Run
- -Negative/Neutral NAO Run



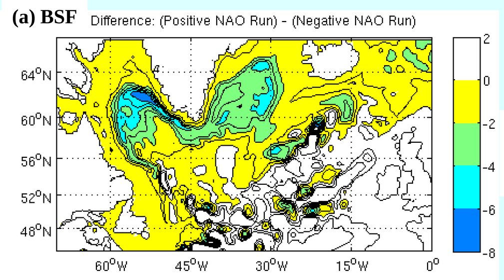
Integrated *Taux* from 64.5W to 45.25W along 60N

Constant Forcing Experiments

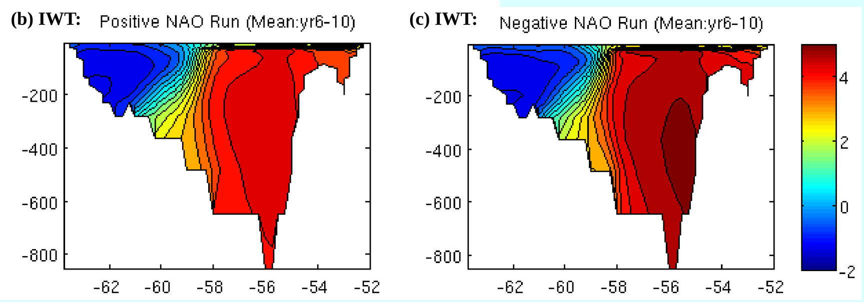


IWT, SST_AREA1 and SPGI:

With the positive NAO forcing, subpolar gyre is stronger and IWT (SST_AREA1) is colder, which is reverse with the negative NAO forcing.

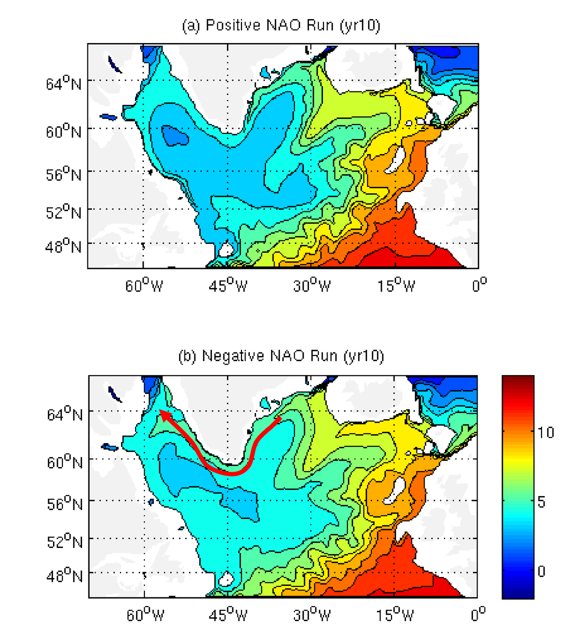


The Distribution of BSF and IWT

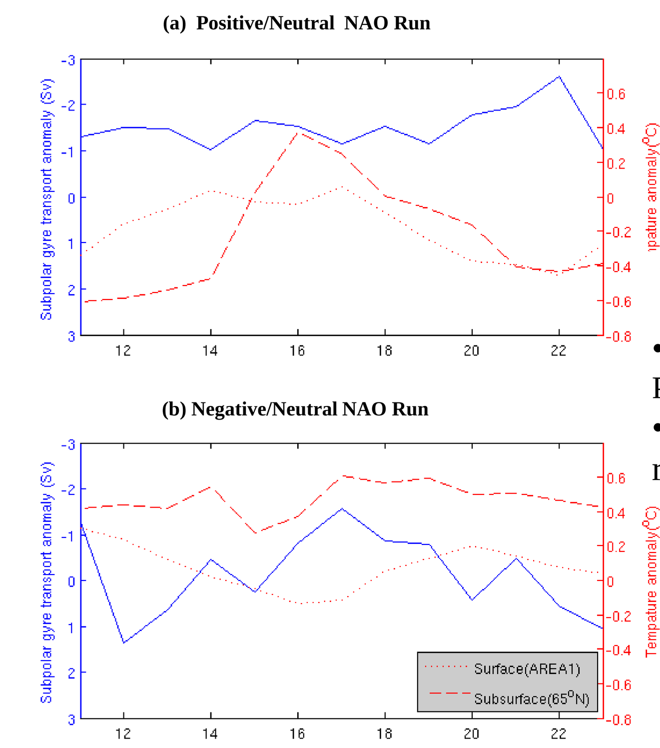


When the subpolar gyre is weeker in the negative NAO run, more warm subtropical water can go to the boundary current and the IWT will increase.

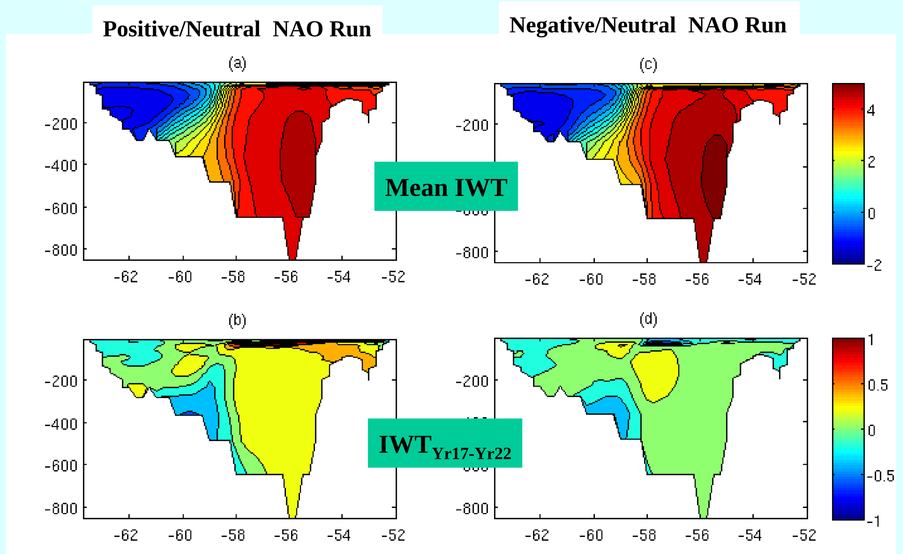
Temperature at 483m depth



Oscillation Forcing Experiments



IWT, SST_AREA1 and SPGI:
- Their correlation is more significant in Positive/Neutral NAO run
- There are about 2 years delay as to the response of SPG to NAO.



Under a background of Positive NAO forcing, the variability of IWT is more correlated with the changes of Subpolar gyre.

Summary

- The interannual variability over the Subpolar NA is represented by OGCMs;
- IWT is anti-correlated (correlated) with Subpolar Gyre (SST_AREA1), but less significant before 1980s;
- The relationship between SST_AREA1, IWT and SPGI is strongly affected by the phase of NAO: the anti-symmetric response of SPG to NAO (Lohmann et al., 2009).

Reference

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