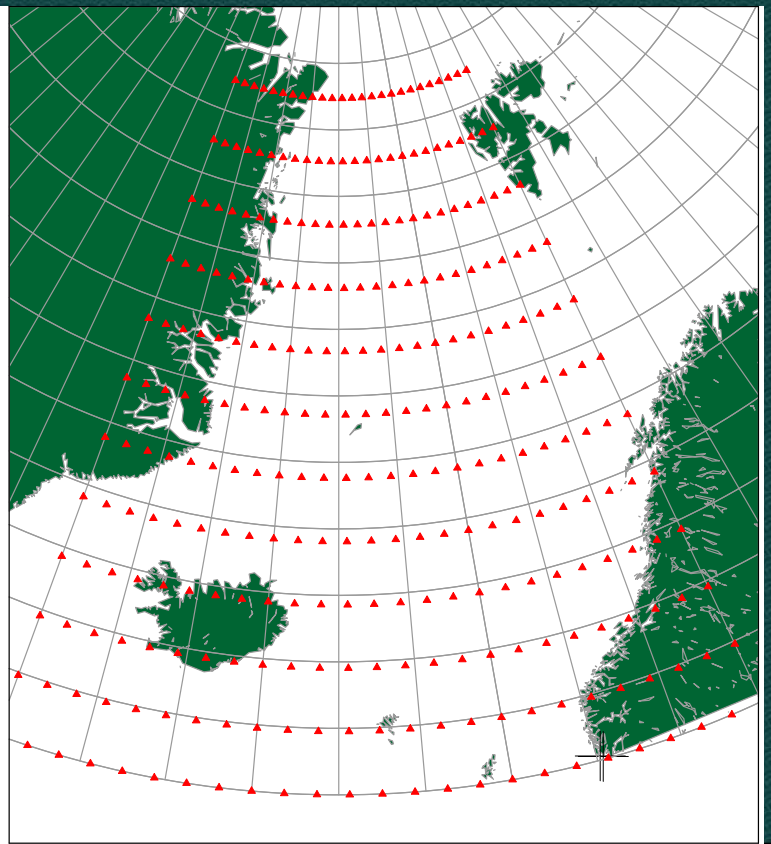
Interannual variability of the surface heat fluxes in the Nordic Seas and their links with the Arctic Oscillation

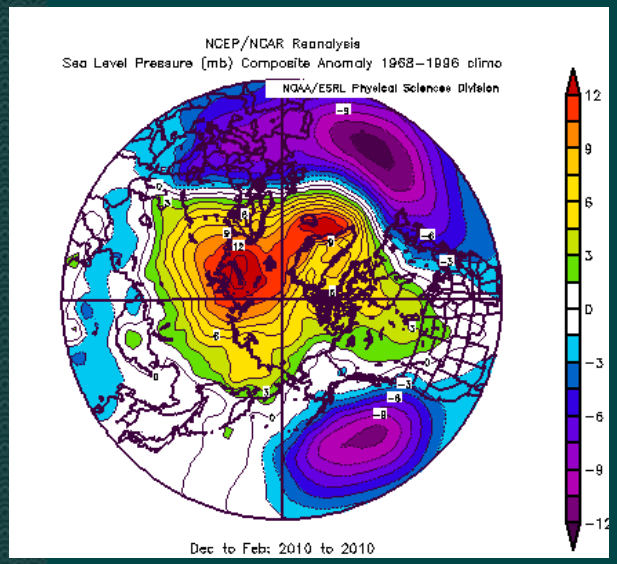


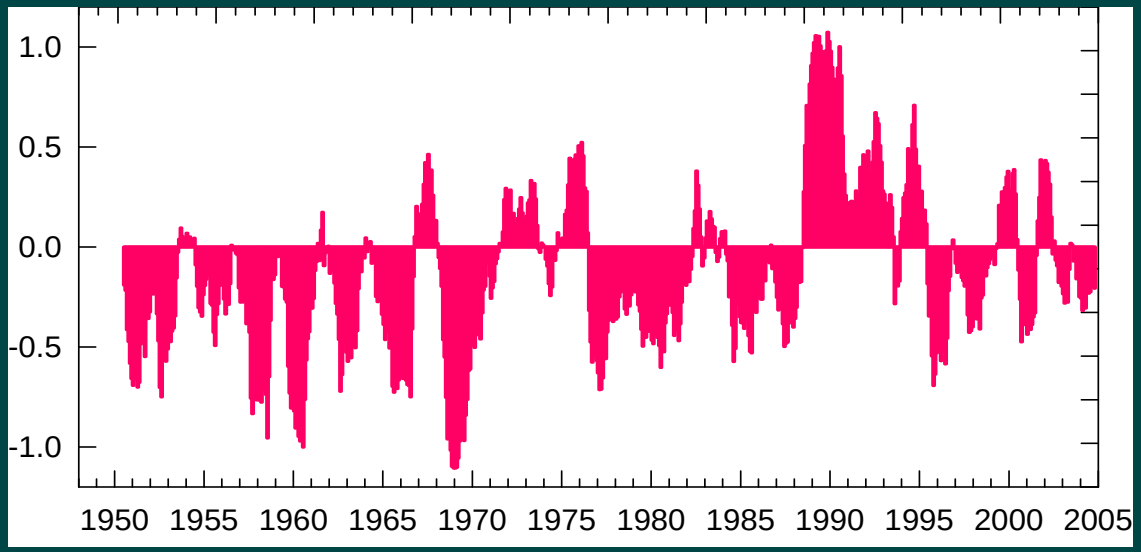
Jinping **Zhao** and Ken **Drinkwater**

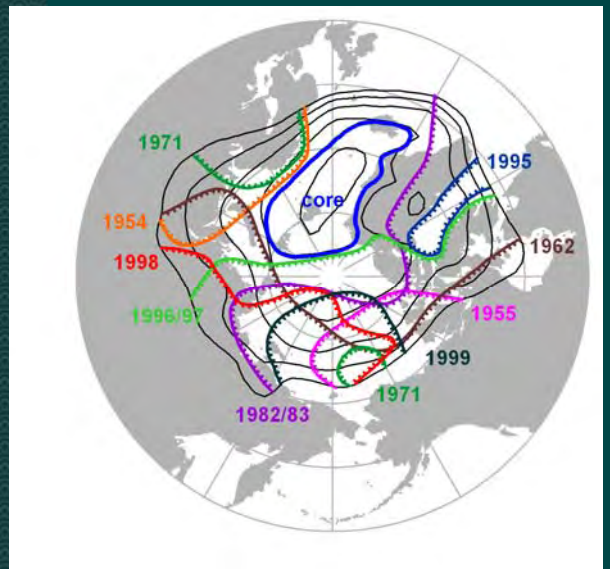
Ocean University of China

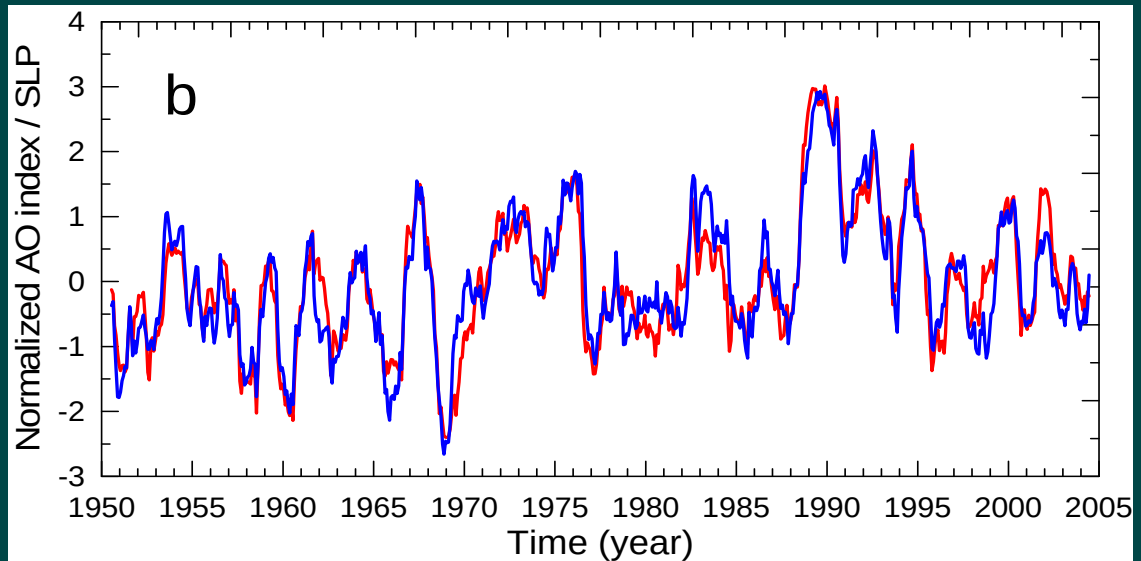
Institute of Marine Research, Norway

Arctic Oscillation Core Region (AOCR)





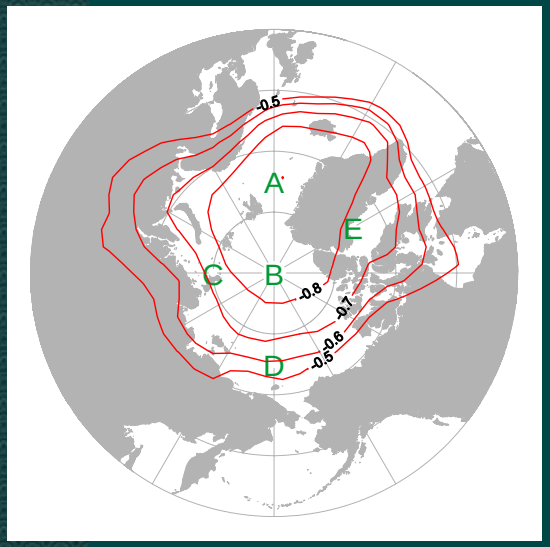


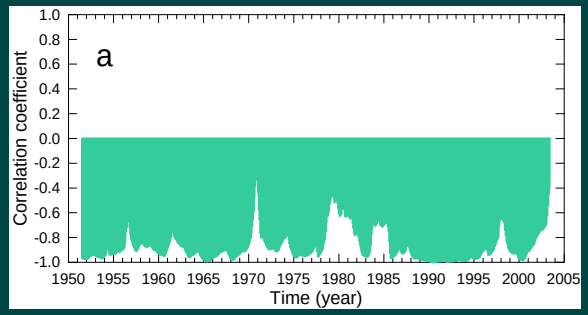


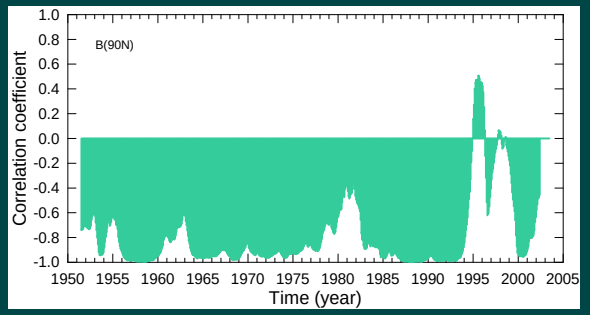
Running correlation coefficient (RCC) between AO index and the grid SLP

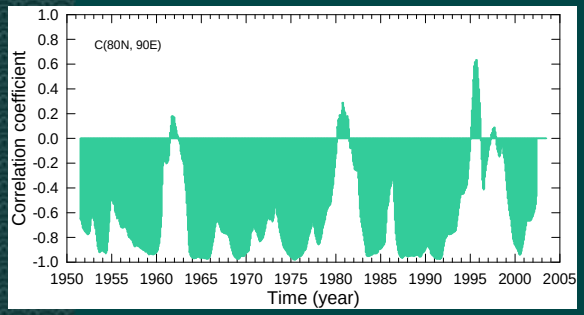
Window length n=24
two-year data is used

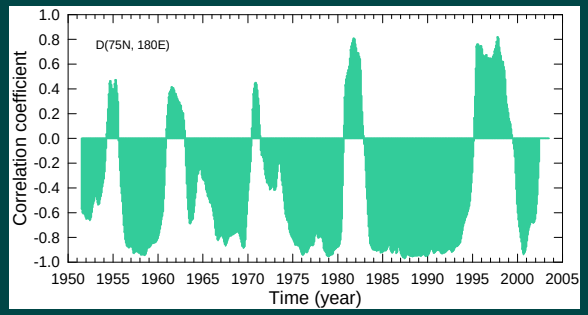
$$R_i = \frac{\sum_{k=i-n}^{i+n} (X_k - \bar{X})(Y_k - \bar{Y})}{\sqrt{\sum_{k=i-n}^{i+n} (X_k - \bar{X})^2} \sqrt{\sum_{k=i-n}^{i+n} (Y_k - \bar{Y})}}$$

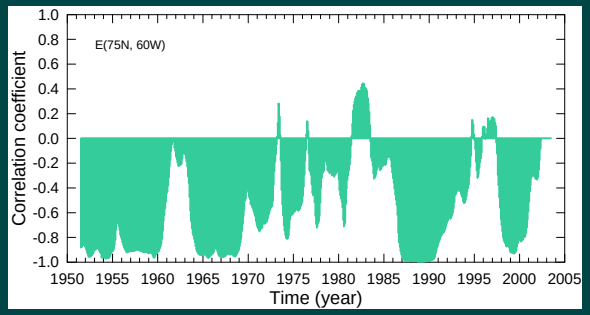




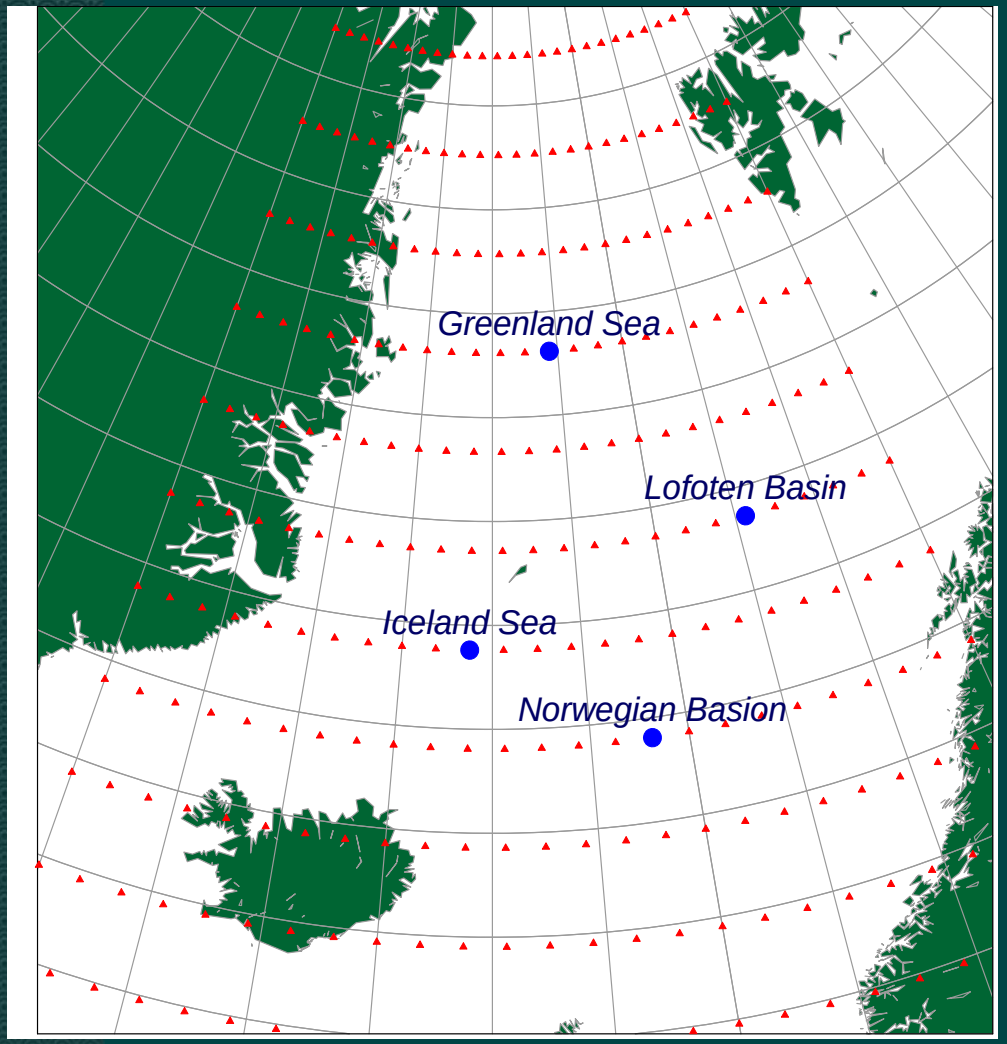


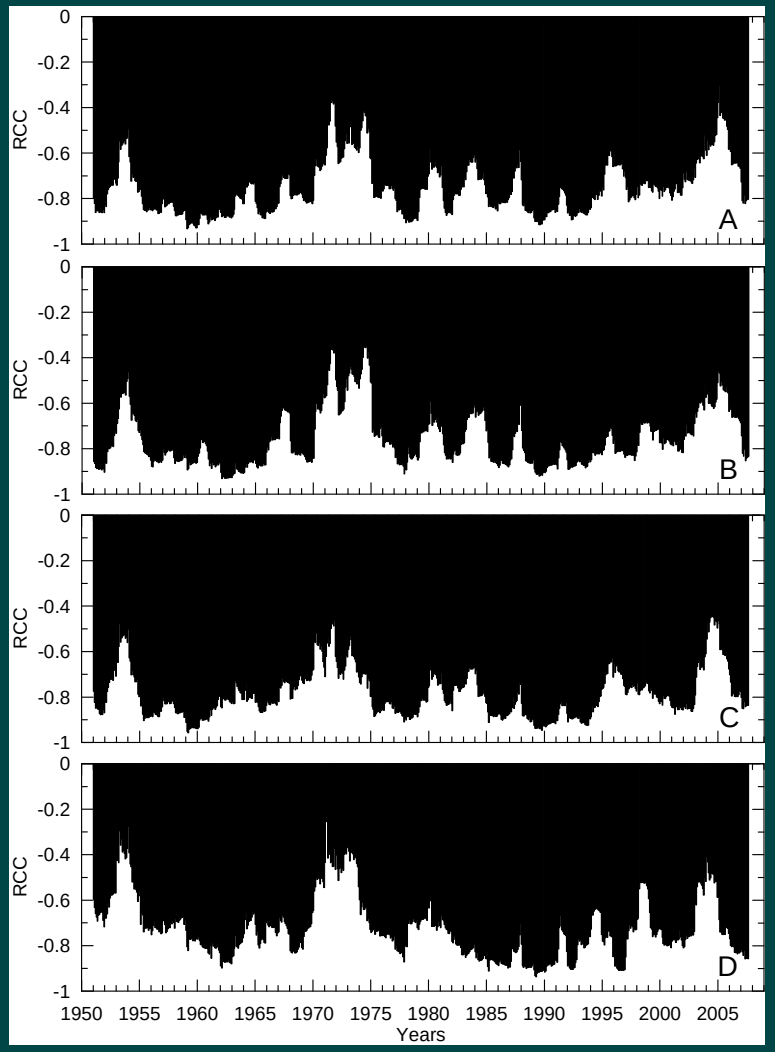




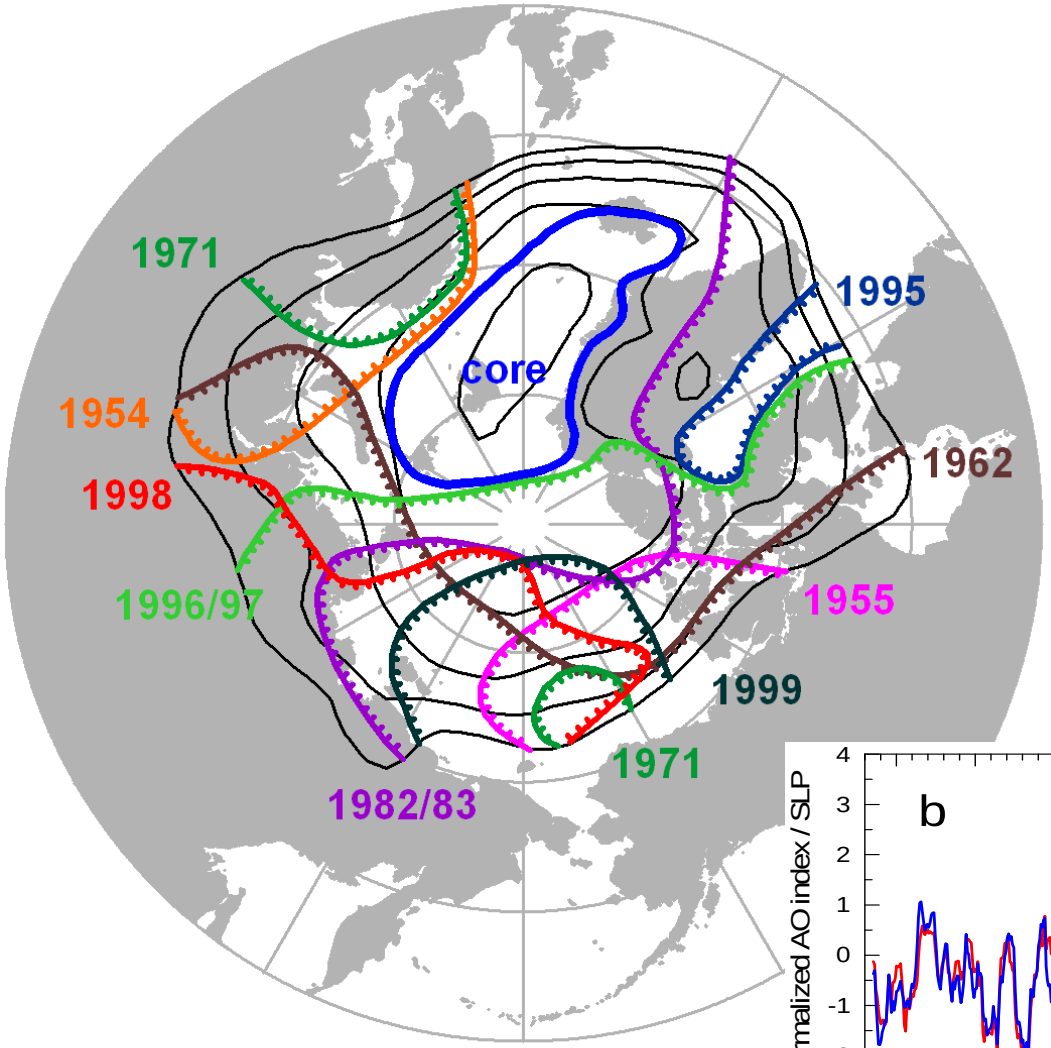


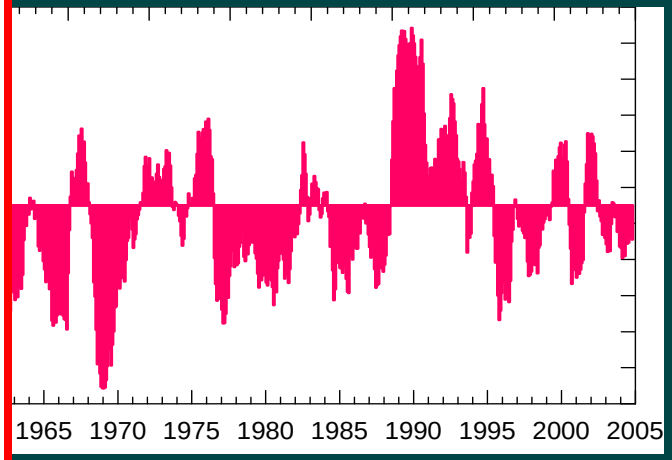
Highly correlated between AO index and SLPs

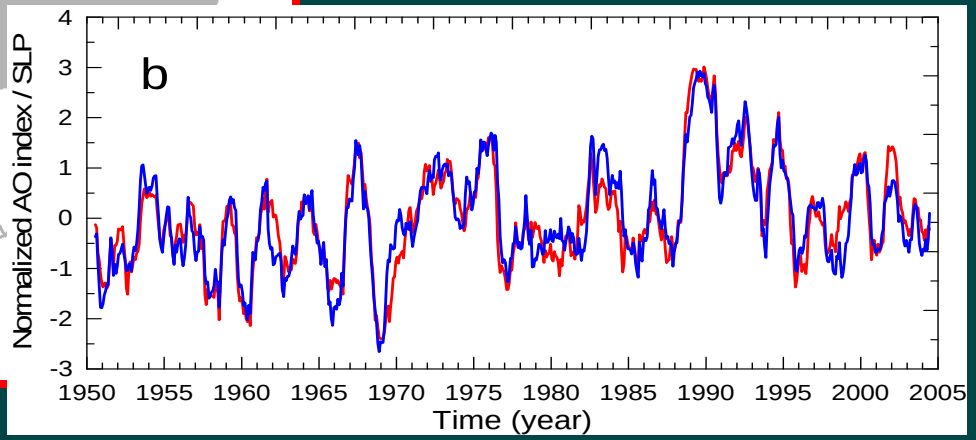




(AOCR)







Zhao, J., Y. Cao, and J. Shi (2006): Core region of Arctic Oscillation and the main atmospheric events impact on the Arctic. Geophys. Res. Lett., 33: L22708, oi:10.1029/2006GL027590.

Purpose of this study

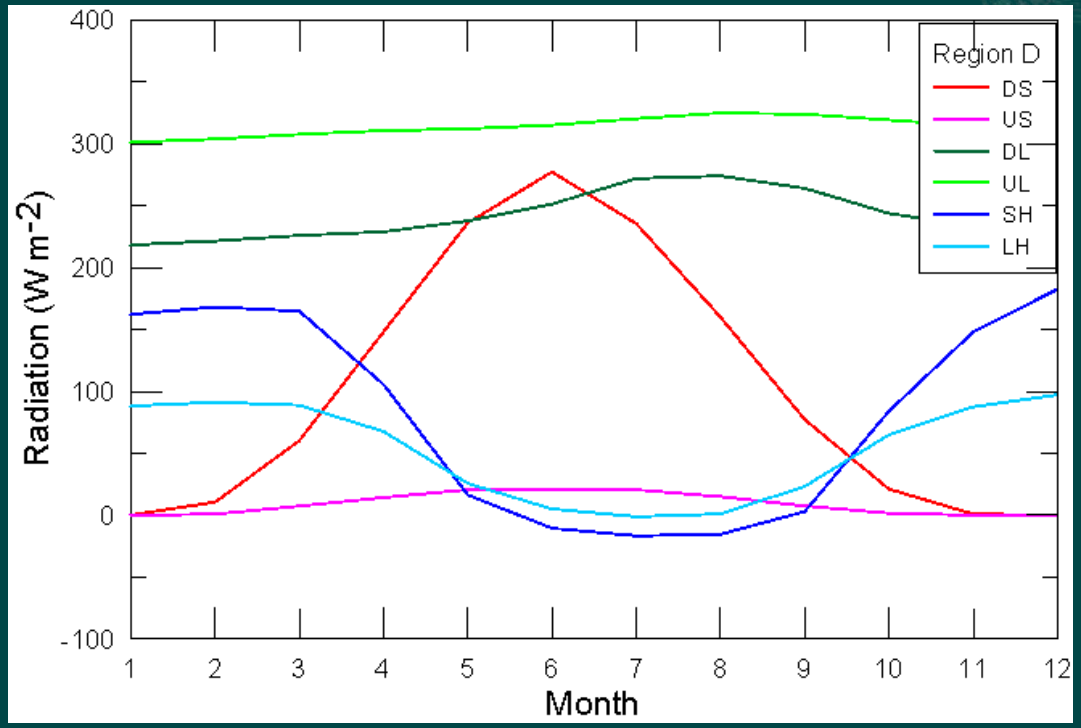
Answer the question:

- AO impacts ocean
- or, ocean drives the AO

- Start work by finding out the correlation between AO and heat fluxes
- Heat fluxes data: NCEP-DOE Reanalysis-2 (1979-2009), an improved version of the NCEP Reanalysis-1
- AO index data: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao_index.html

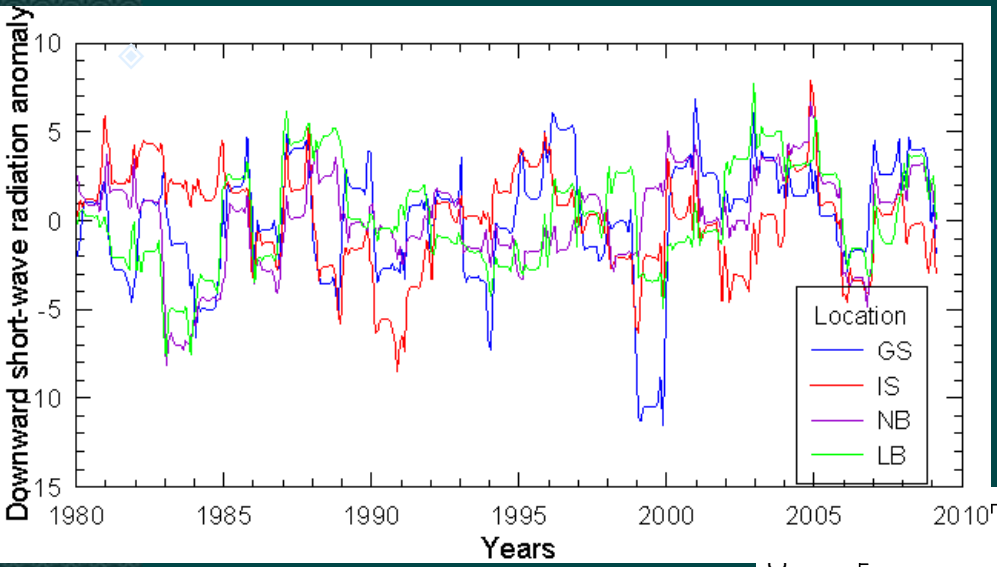
Monthly heat flux

The dominant heat fluxes are
- DS (summer)
- ~~US~~ (summer)
- ~~DL~~
- UL
- SH (winter)
- LH (winter)



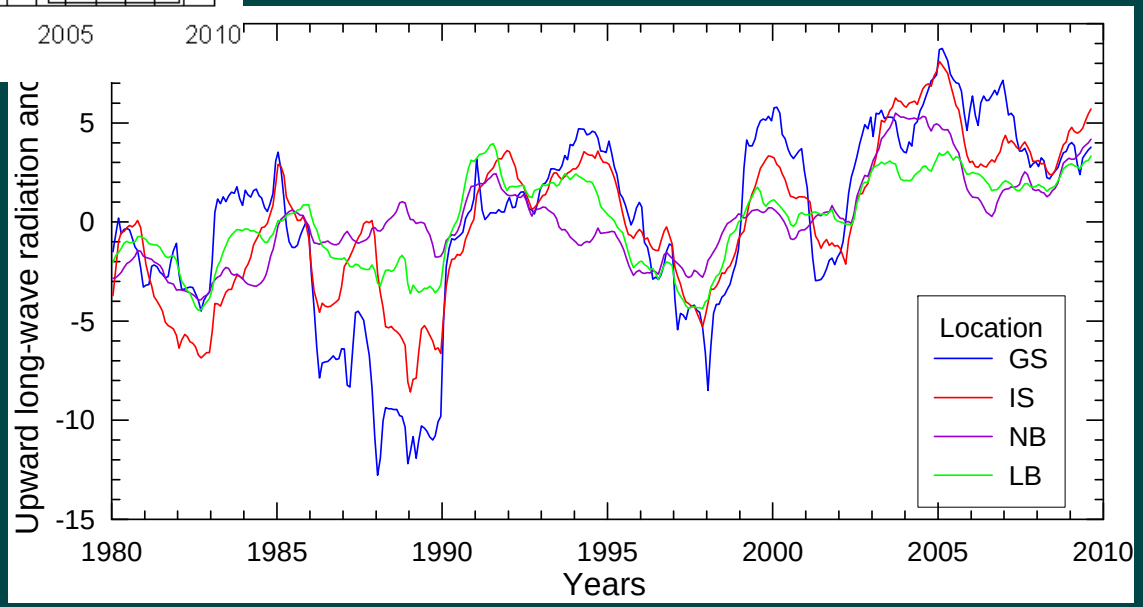
DS – downward short-wave radiation flux
US – upward short-wave radiation flux
DL – downward long-wave radiation flux
UL – upward long-wave radiation flux
SH – sensible heat flux
LH – latent heat flux

Temporal variation of radiations in the four representative regions

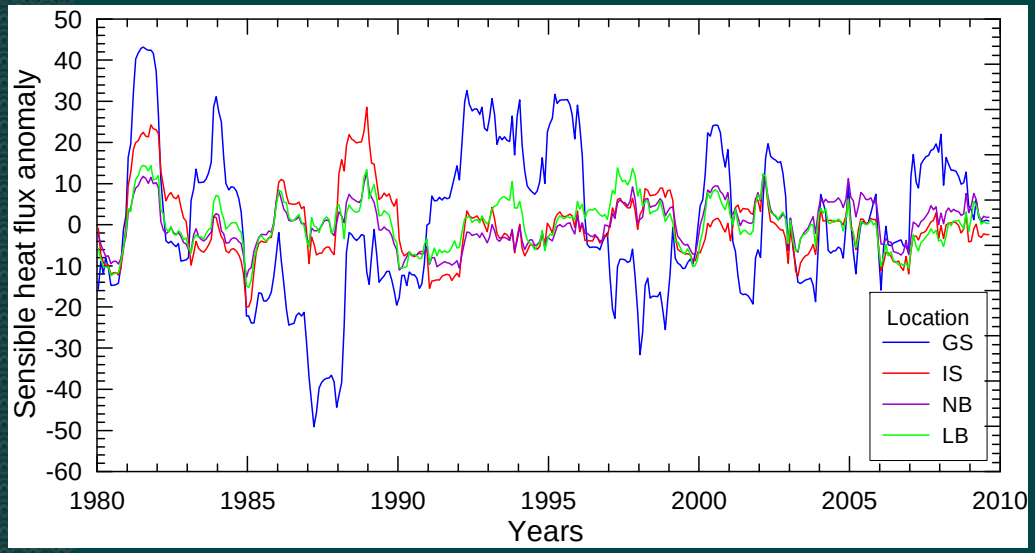


downward short-wave flux

Upward long-wave flux

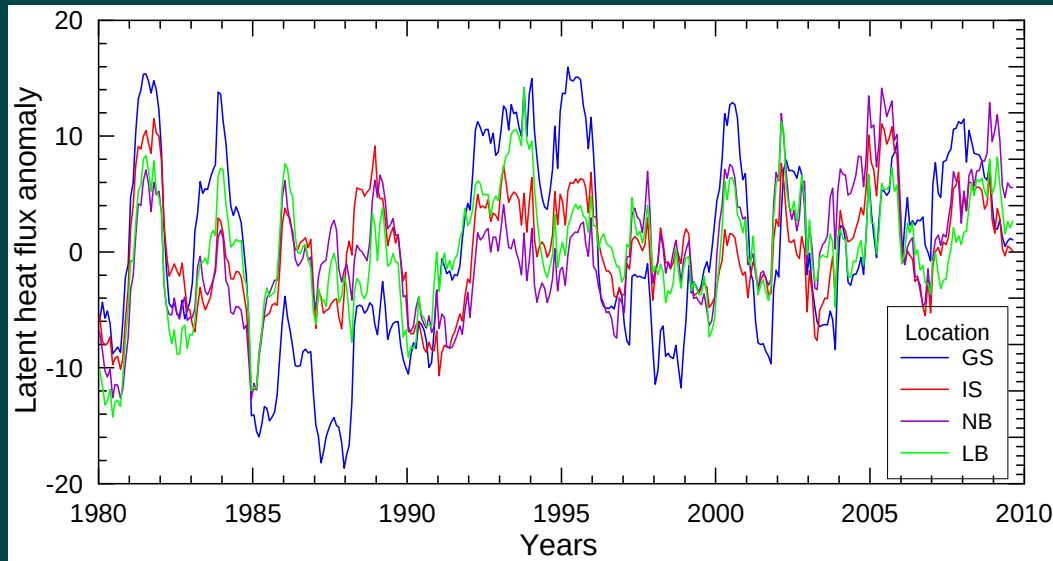


Temporal variation of radiations in the four representative regions



Sensible heat flux

- Latent heat flux



Correlations with Arctic Oscillation (AO)

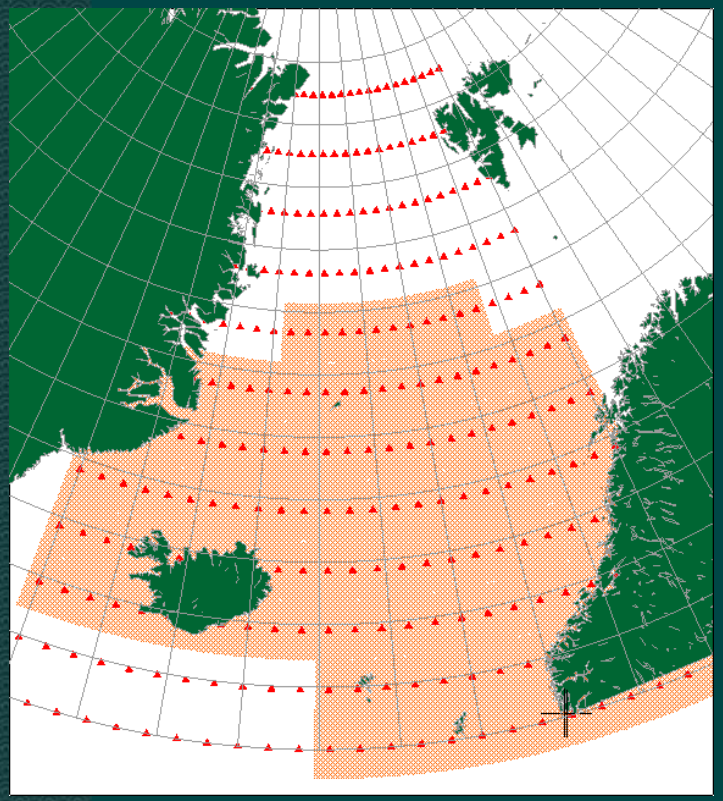
- Correlation coefficient (CC)
  - CC between AOI and DS =-0.22
  - CC between AOI and UL =-0.02
  - CC between AOI and SH =-0.12
  - CC between AOI and LH = 0.30

If we calculate the correlation coefficient directly, the result is quite poor

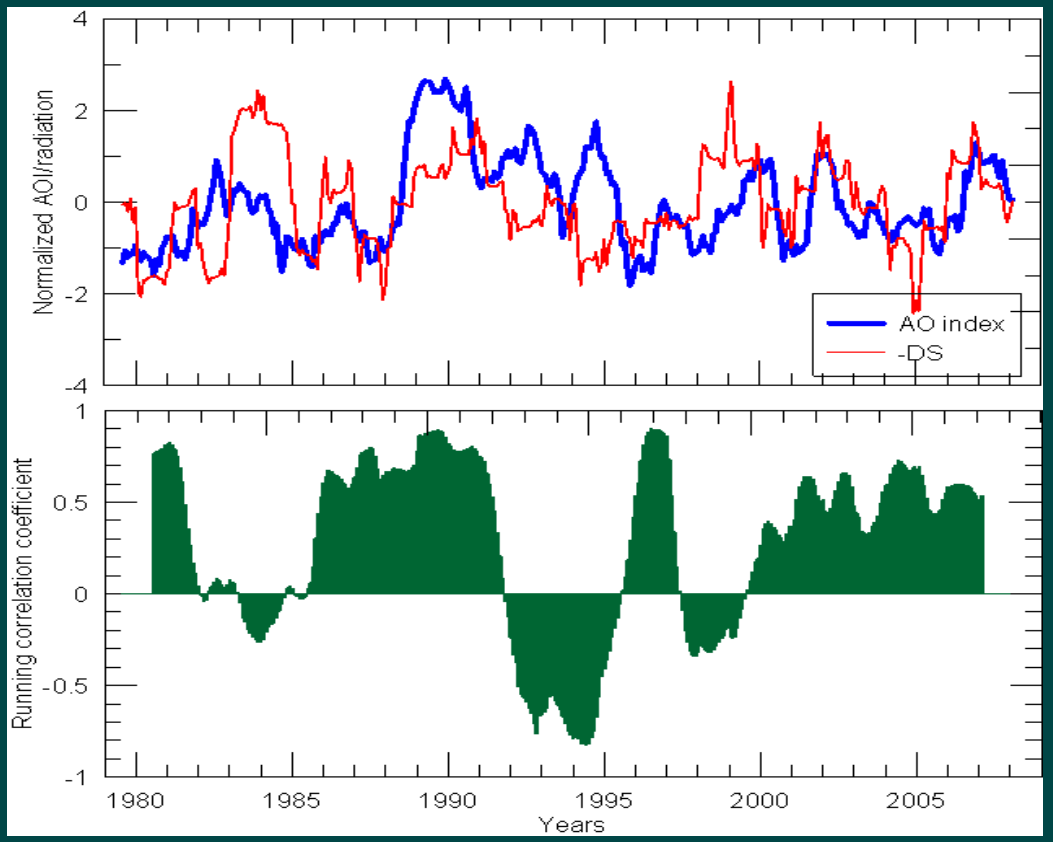
However, if we consider the regional difference of the radiation the higher correlation between AO index and the radiations will emerge

(1) Downward short-wave radiation and radiation and correlation with AO index

Absorbed heat ~ S_0−DS



Correlation coefficient = -0.31



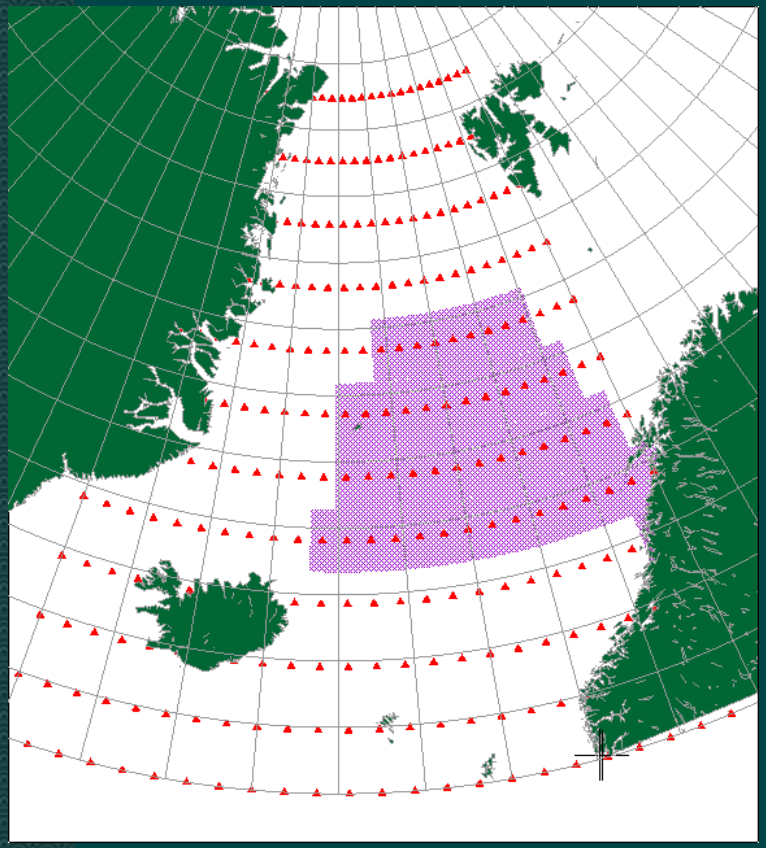
(2) upward long-wave radiation and correlation with AO index

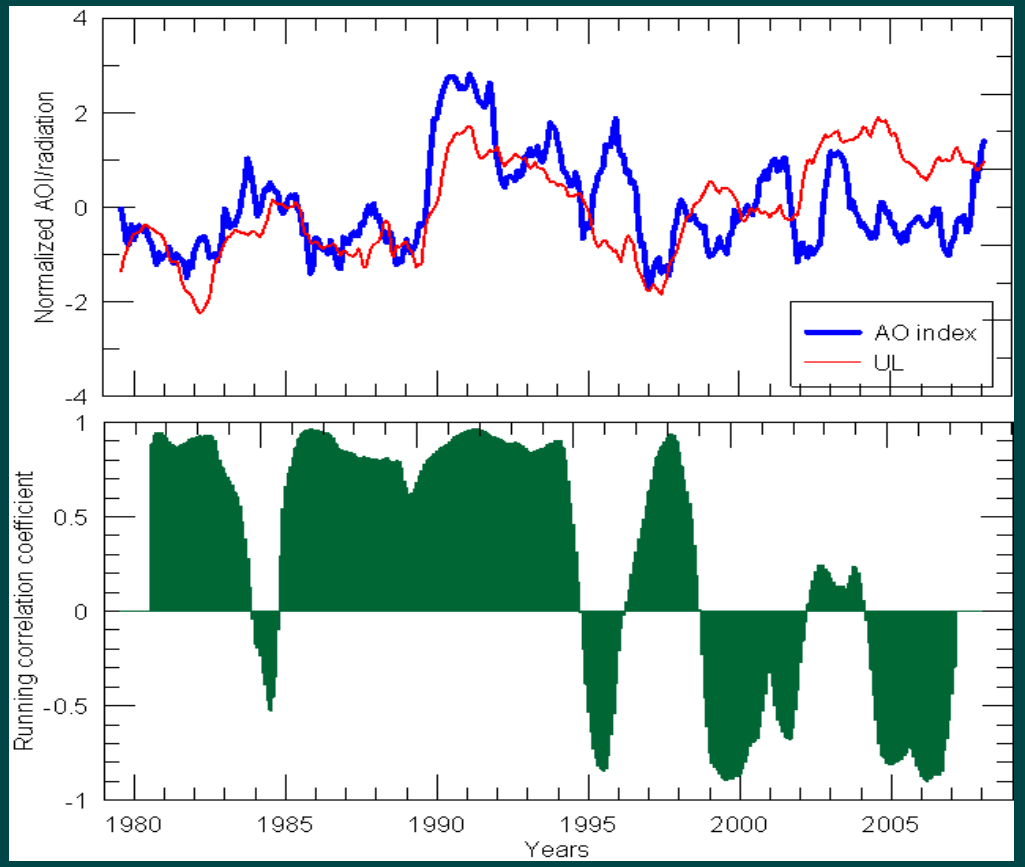
AO is 14 months leading

Correlation coefficient = 0.47

1979-1994 cc=0.86

1995-2009 cc=0.03





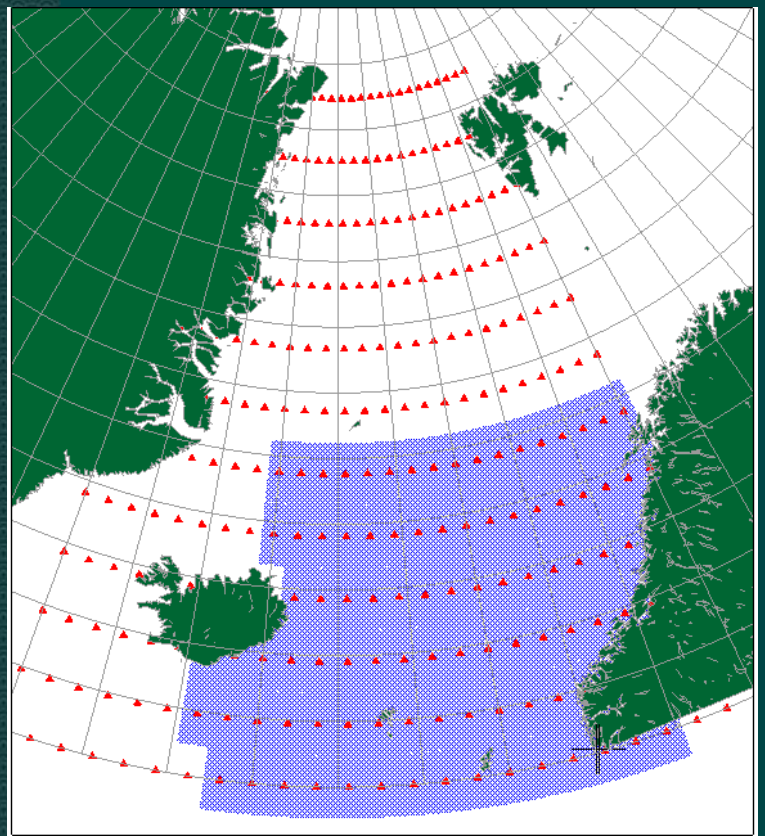
(3) Sensible heat and correlation with AO index

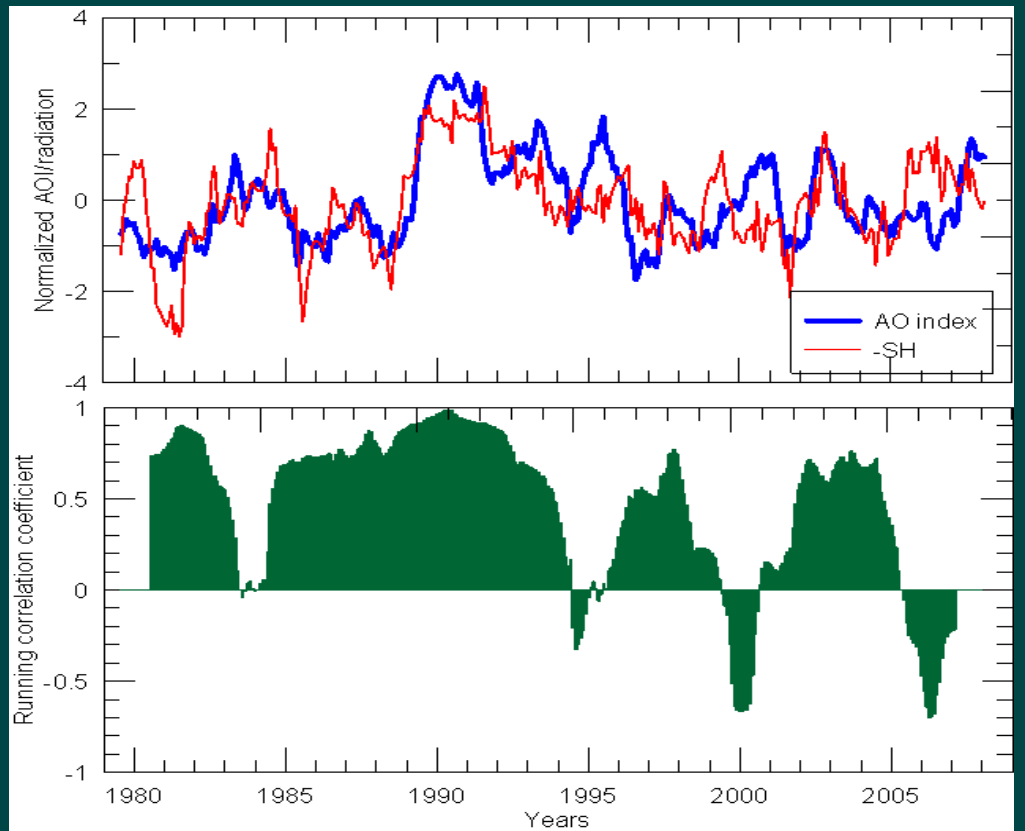
AO is 9 months leading

Correlation coefficient = -0.63

1979-1994 cc=-0.78

1995-2009 cc=-0.26





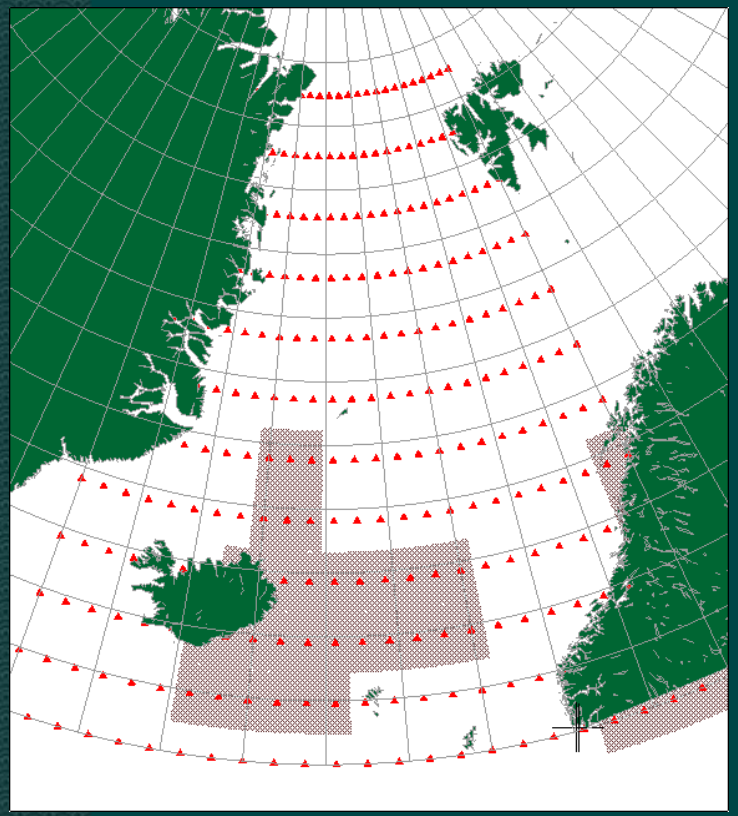
(4) Latent heat and correlation with AO index

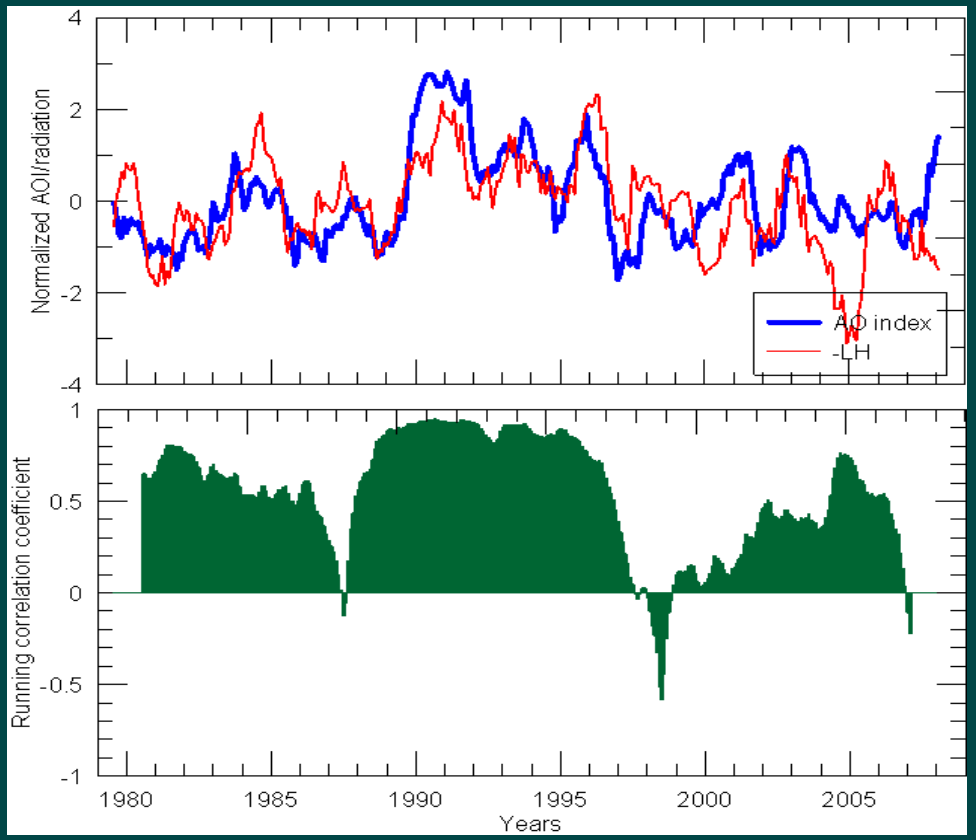
AO is 14 months leading

Correlation coefficient = -0.56

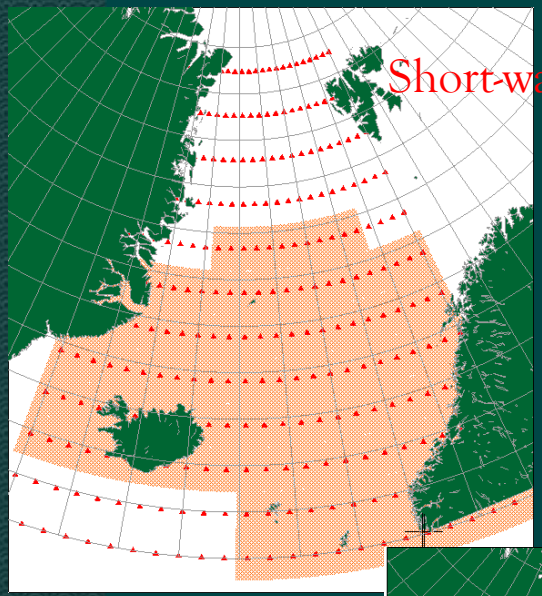
1979-1994 cc=-0.75

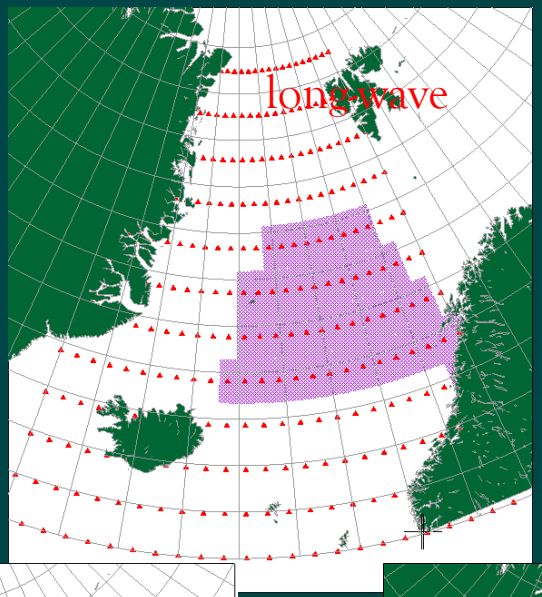
1995-2009 cc=-0.32

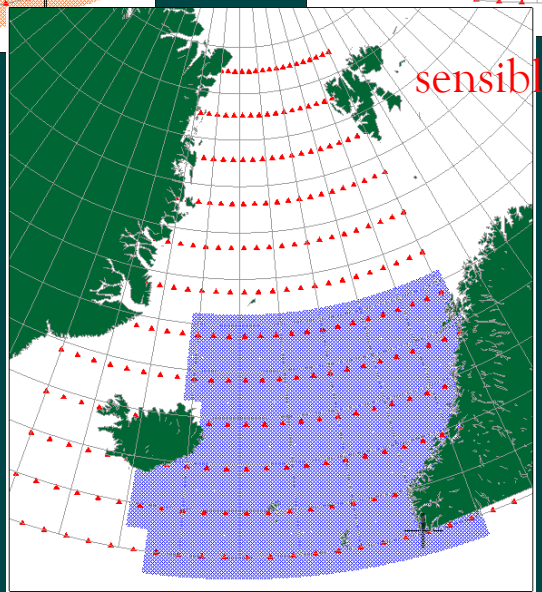


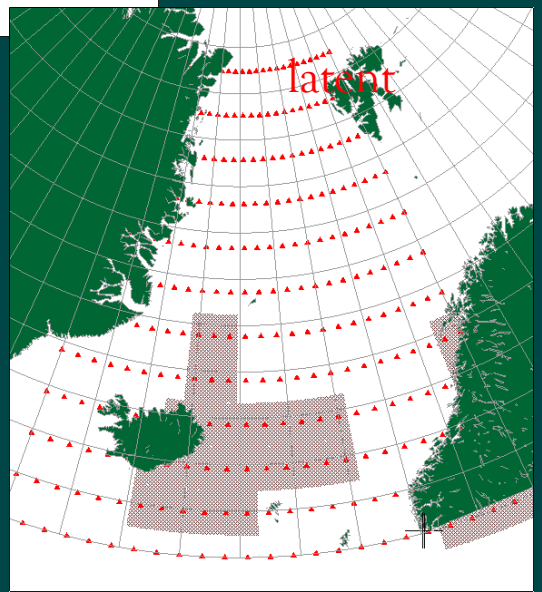


Regional response









The explanation of the result

- Why the UL is positively correlated with AO, whereas the SH and LH are negatively correlated with AO index?

(1) Sensible and latent heats influence only a thin layer, where the long-wave radiation propagated much higher.

(2) Sensible and latent heats reduce the long-wave radiation, and negative influence to AO. Or, the

Reason for leading of AO index

AO increases

SLP decreases

Wind enhances

current enhances

Long-wave
Sensible increases
Latent

more heat advected

14 months

Why 14 months

it should depend on the distance the warm water transported

$$T = \frac{dis\tan ce}{velosity} \approx \frac{6000km}{0.2m/s}$$

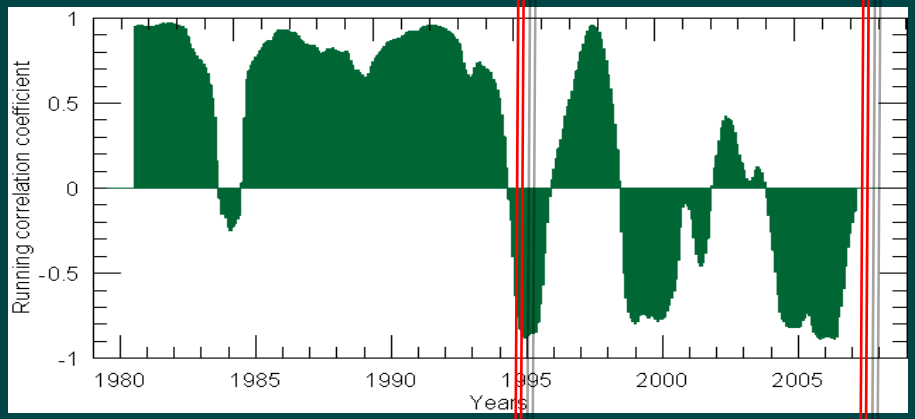
What happens after 1995

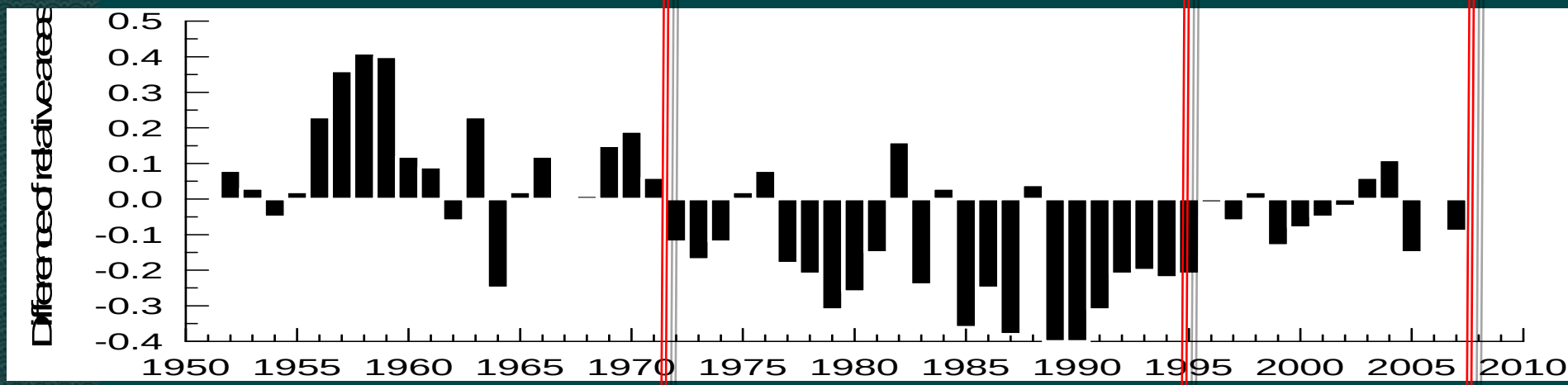
Before global warming

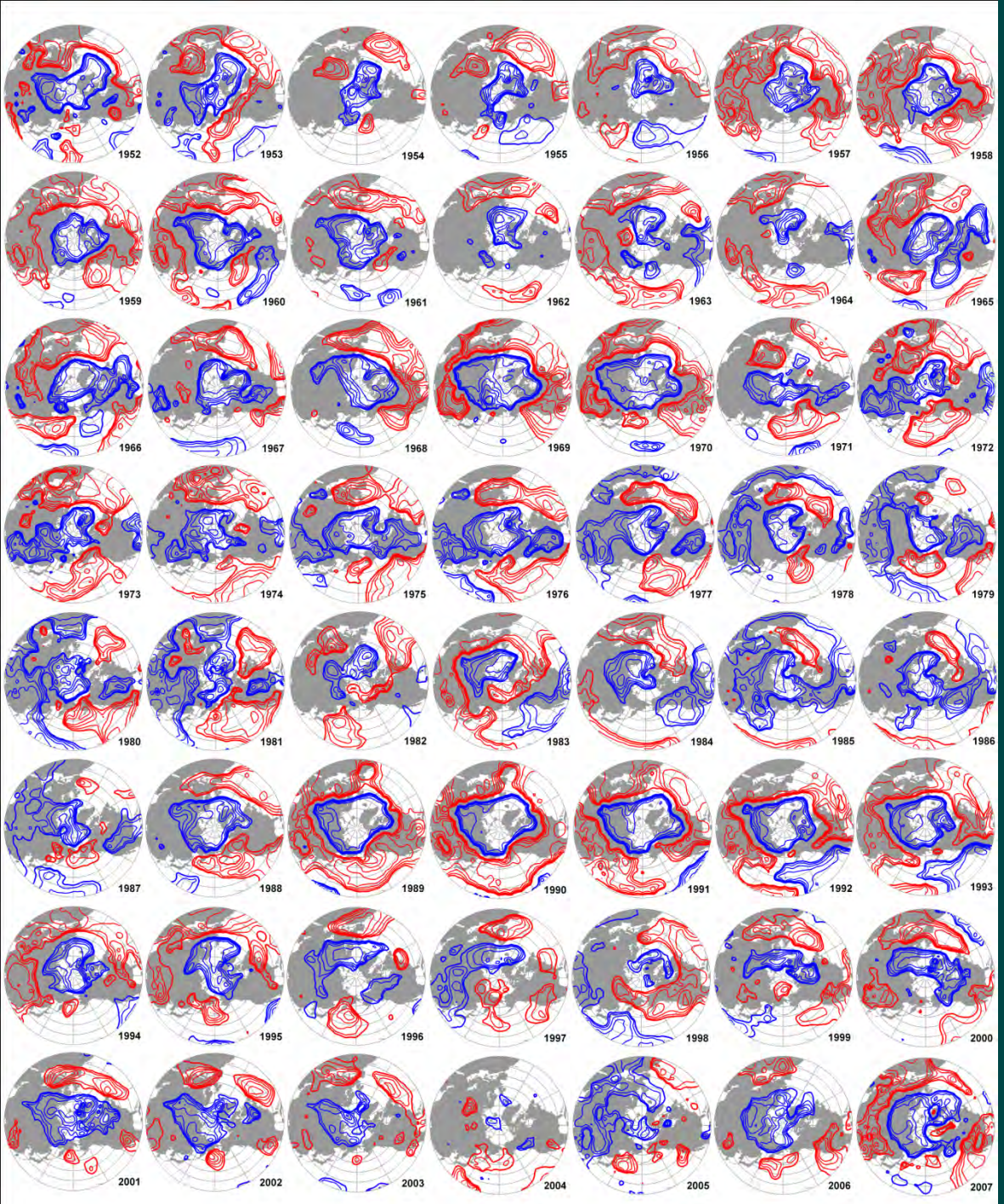
global warming
Arctic not warming

Arctic warming

- Related with the spatial variation of AO

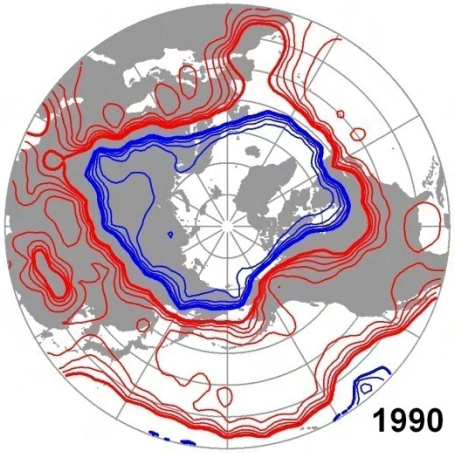


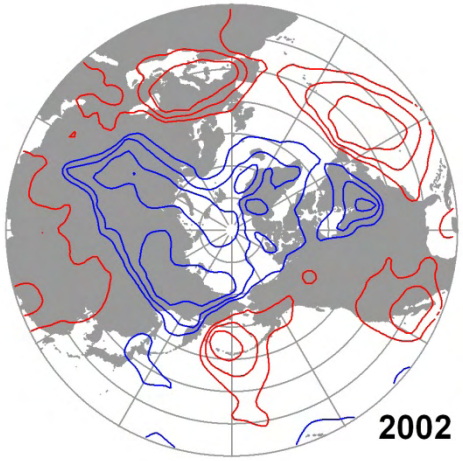


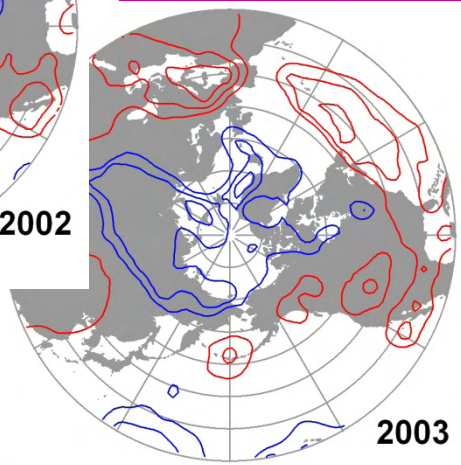


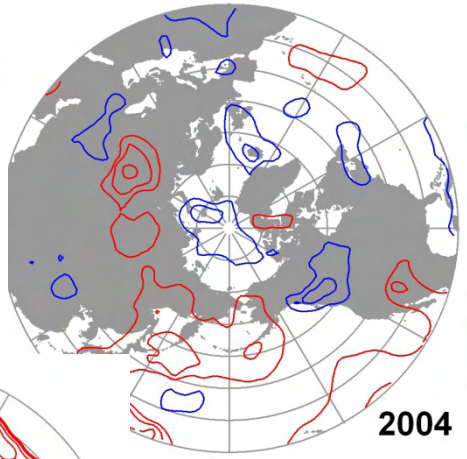
Running Correlation Coefficient patterns in past 56 years

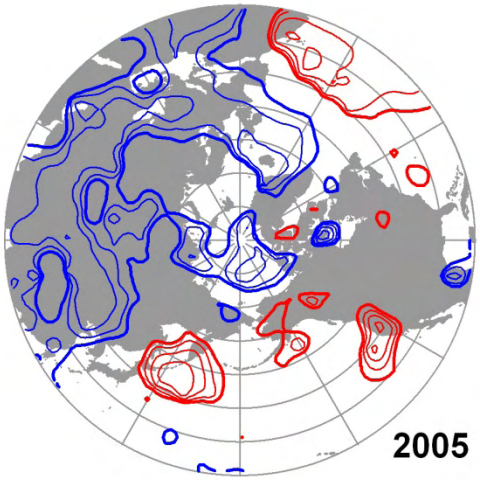
During the Arctic warming, the AO spatial distribution looks weak and unclear.

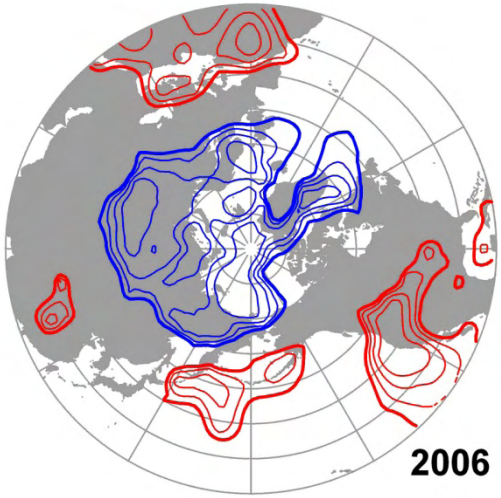


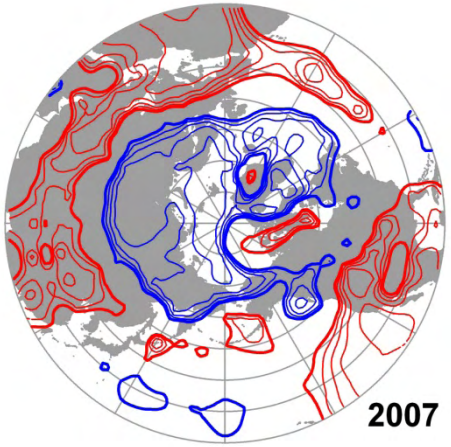












Zhao Jinping, Yong Cao and Jiuxin Shi, 2010, Spatial variation of the Arctic Oscillation and its long-term change, TELLUS, DOI: 10.1111/j.1600-0870. 2010.00472, 62A, 661-672.

Summary

(1) AO index is correlated with short-wave radiation.

- AO index correlated well by one year leading with
  - long-wave radiation flux
  - sensible heat flux
  - latent heat flux

All the high correlation are region dependent

(2) Solar radiation is the main driven mechanism to produce AO.

And the long-wave radiation is another driven factors.

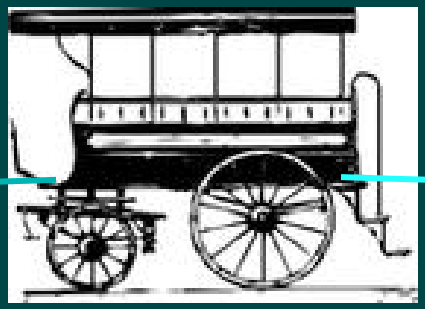
In fact, the short-wave radiation is determined by Atmospheric factors.

Summary

Heat from Ocean

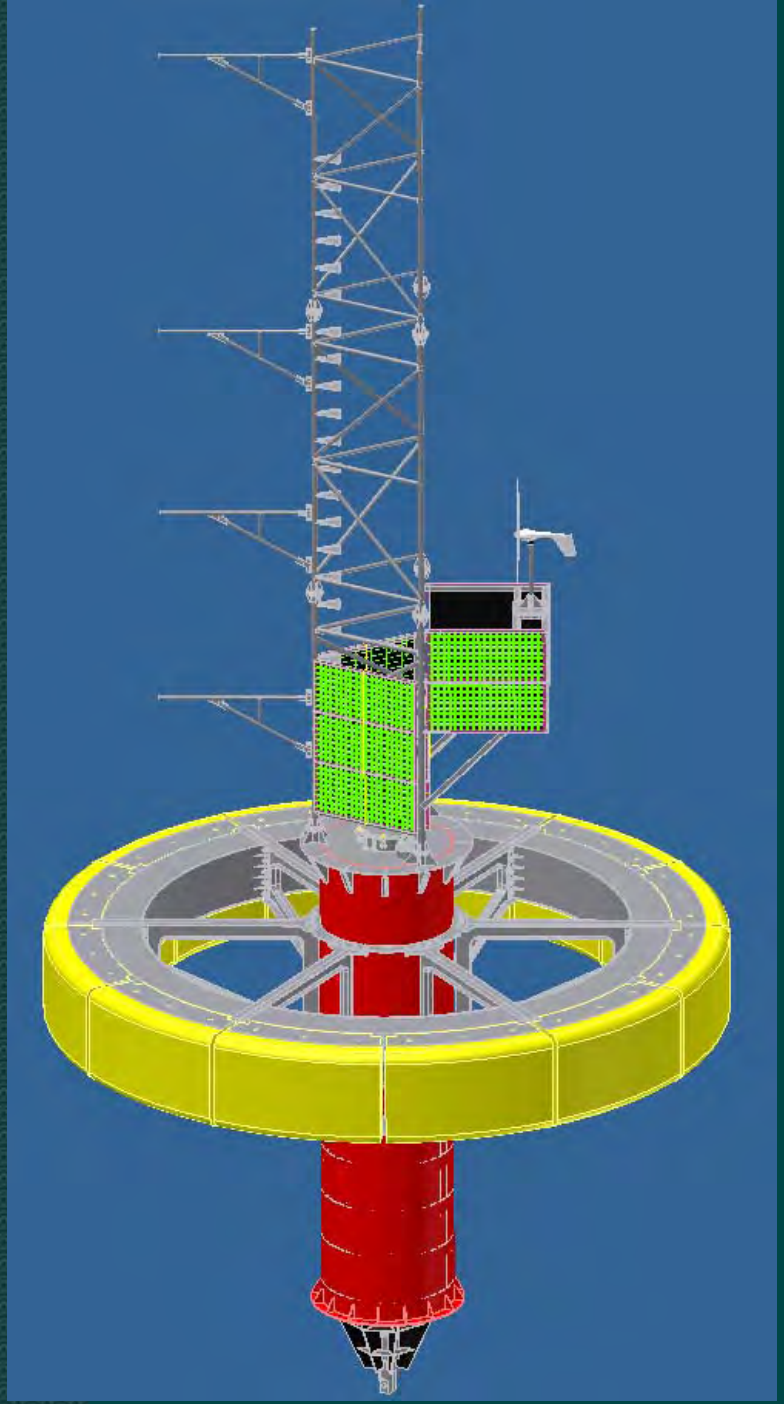
Arctic Oscillation

SW radiation

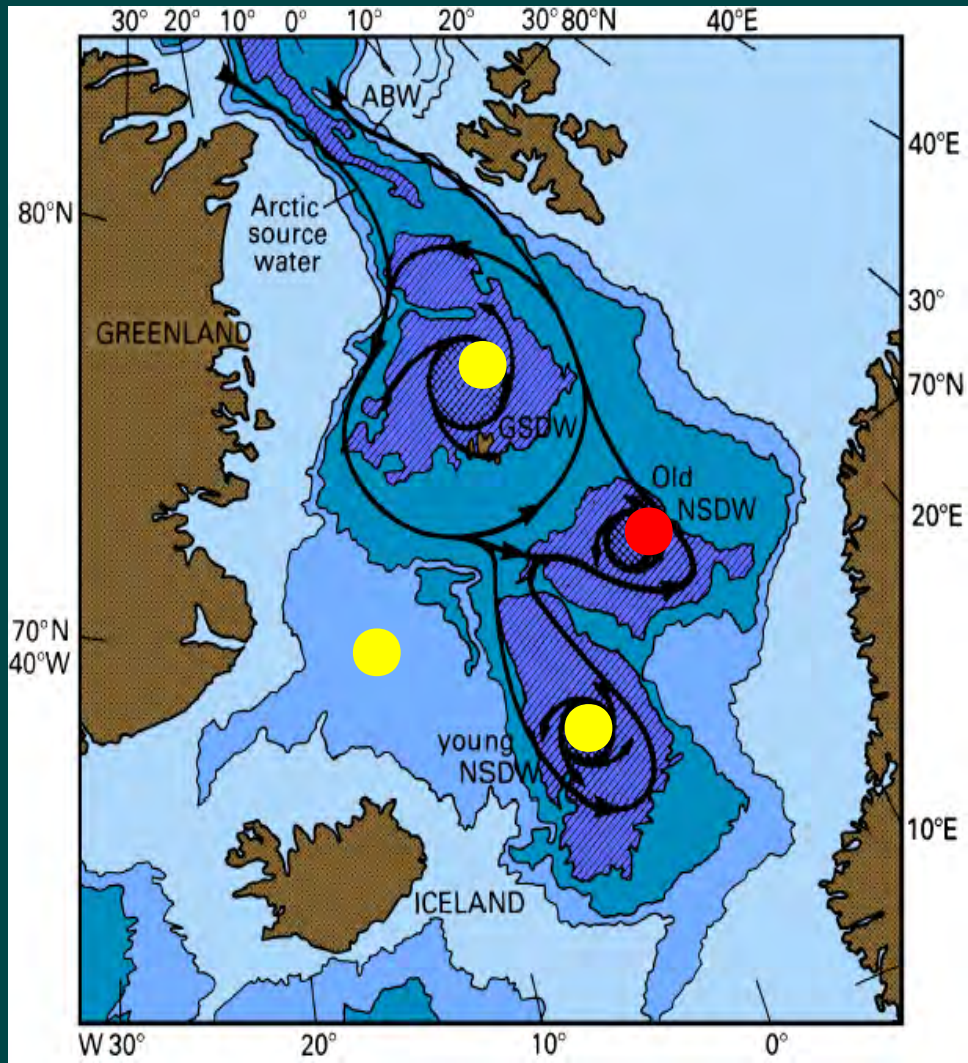


(3) Questions remaining

- by correlation analysis, the percentages of atmosphere and ocean cannot be determined.
- It is possible that the AO is driven by atmospheric process, and the ocean is just a response and feedback.
- the key issue is how large the feedback is ?

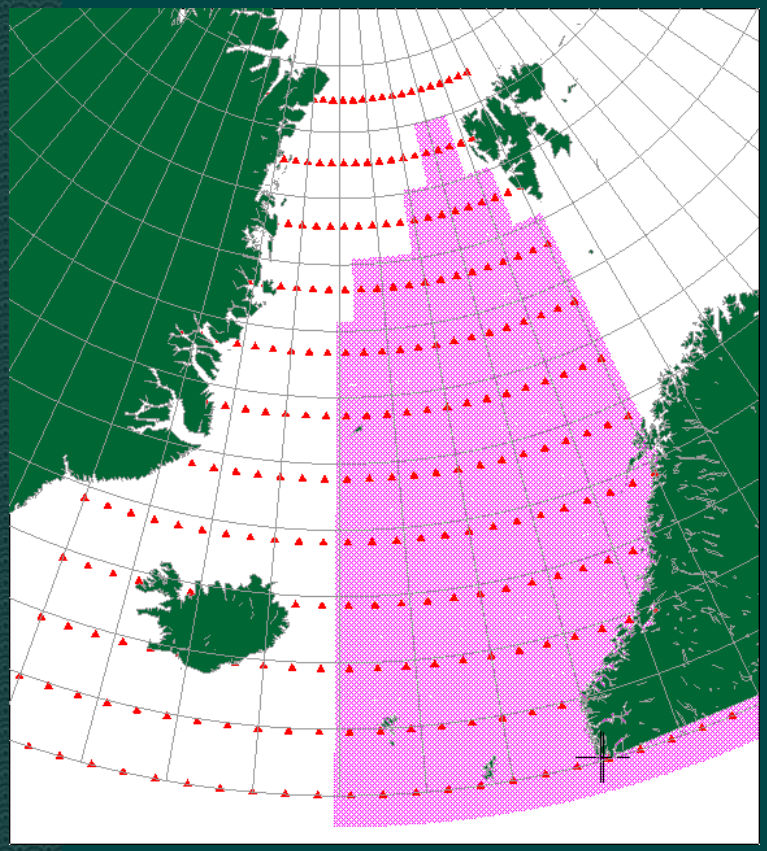


To deploy air-sea coupling buoy in Lofton Basin in 2012



(5) Upward short-wave radiation and correlation with AO index

3 months leading of AO



Correlation coefficient = 0.64