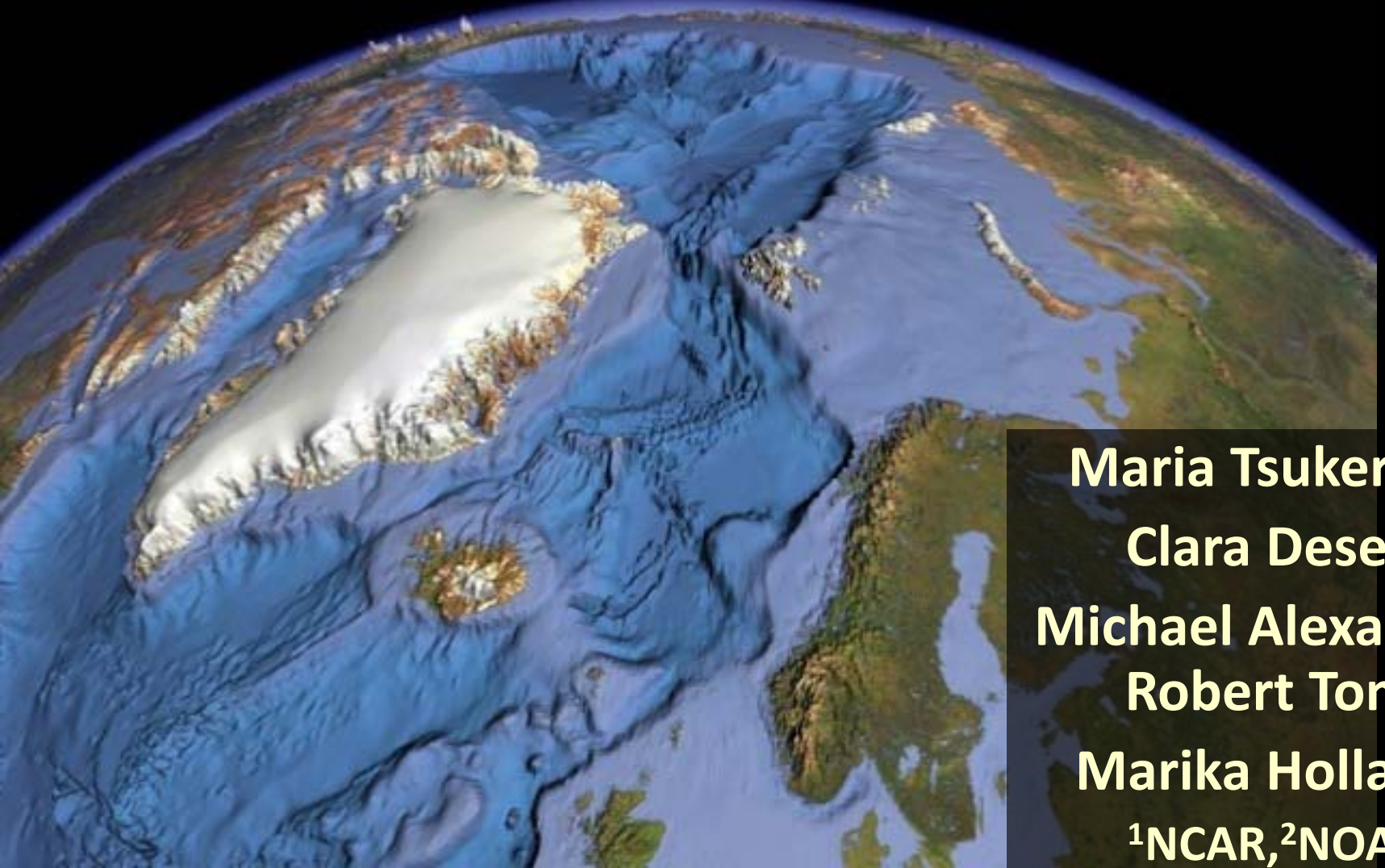
Atmospheric influences on Fram Strait sea ice export in observations and CCSM3



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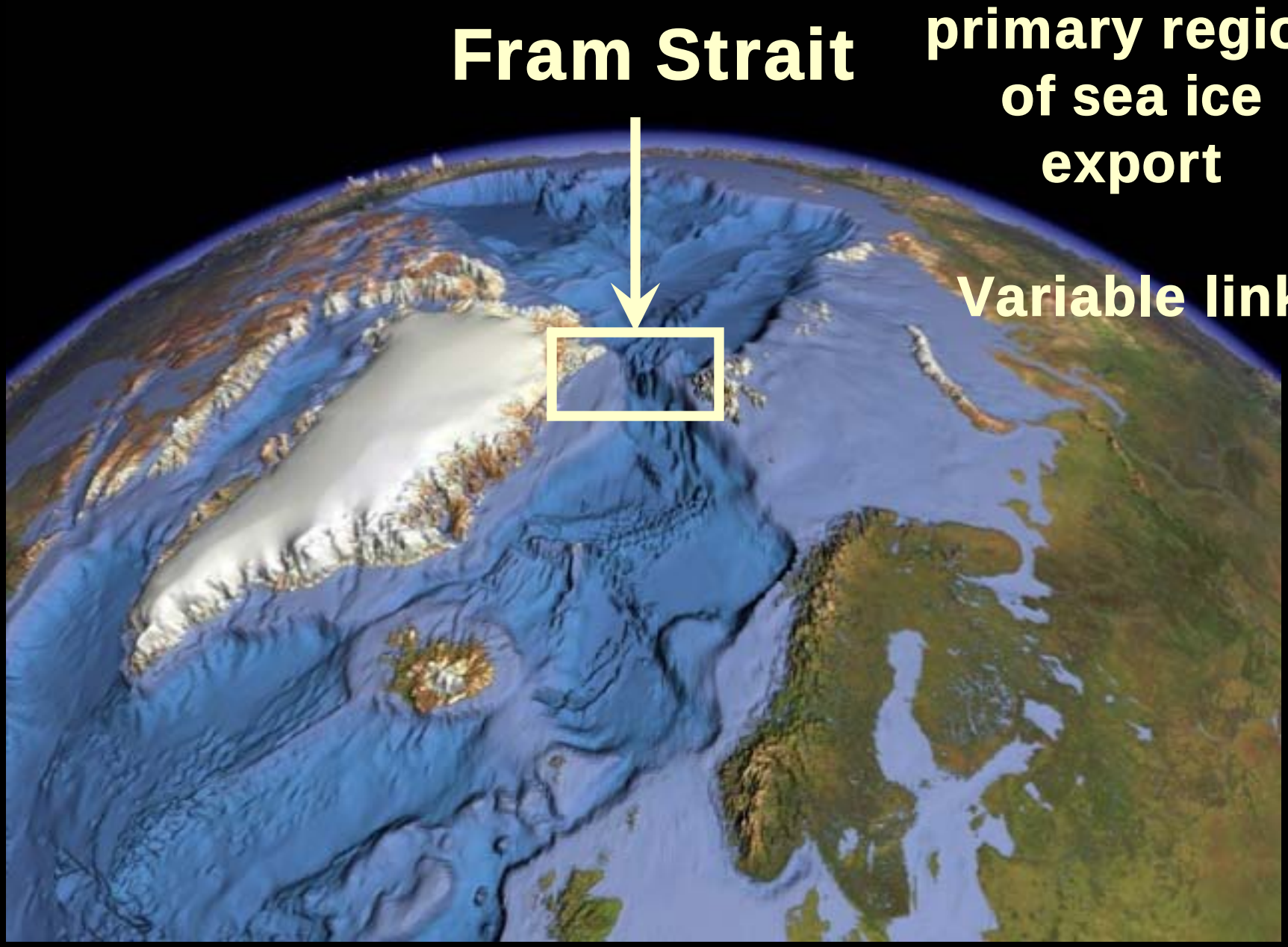
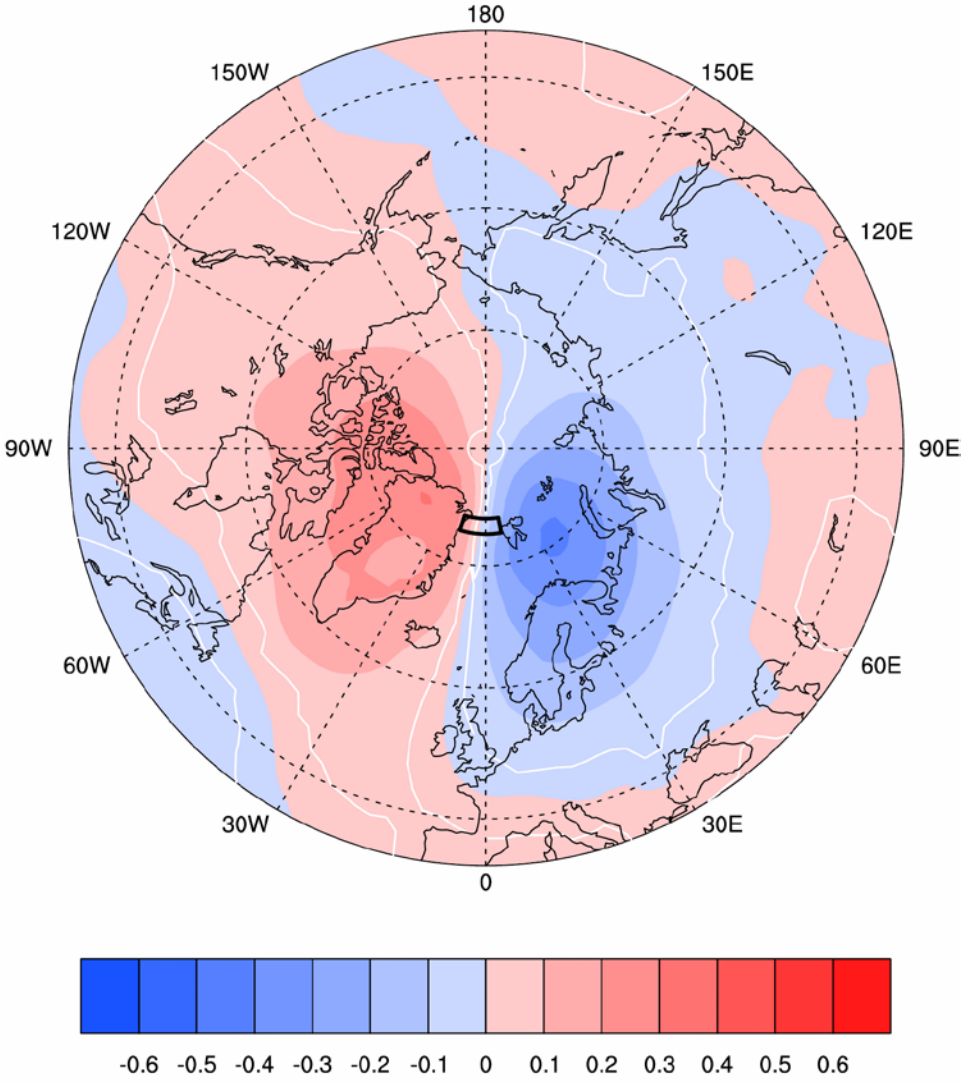


Courtesy of NASA

Data

- 1979-2006 daily data: 10227 days
- NCEP Sea level pressure (SLP)
- Sea ice motion from Polar Pathfinder product
- Fram Strait sea ice motion time series:
  20°W - 15°E, 79°- 81°N

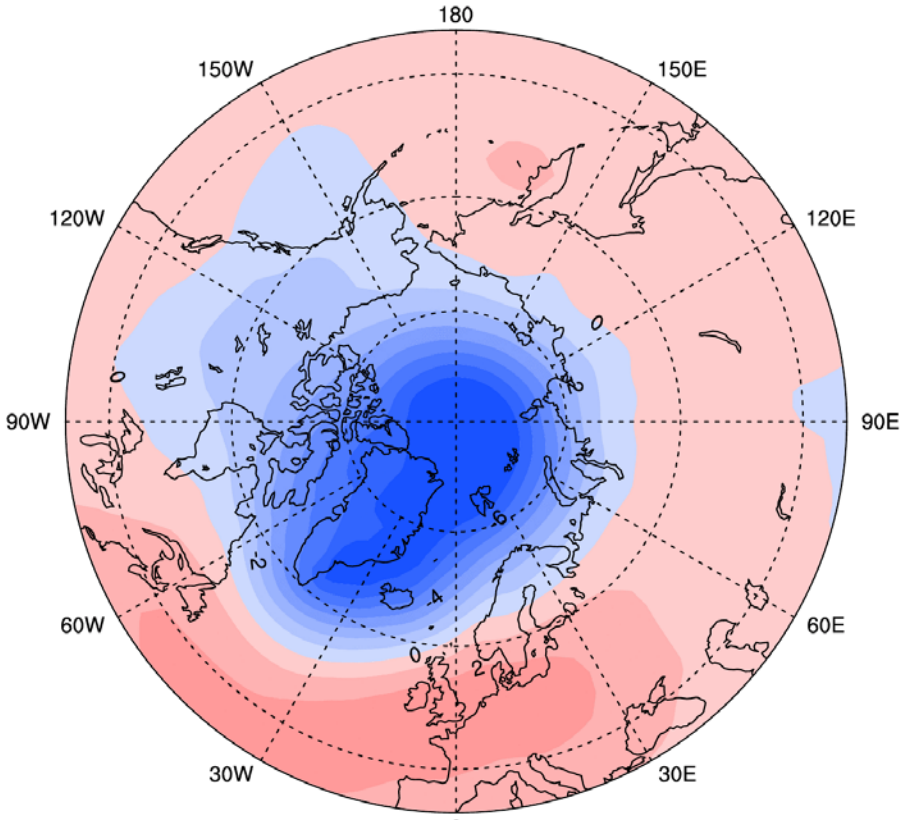
Correlation pattern: An east-west dipole



- ✓Barents and Greenland centers-of-actions
- ✓SLP gradient across Fram Strait
- ✓Northerly geostrophic wind anomalies
- ✓Physically realistic
- ✓Synoptically observed
- ✓Statistically significant

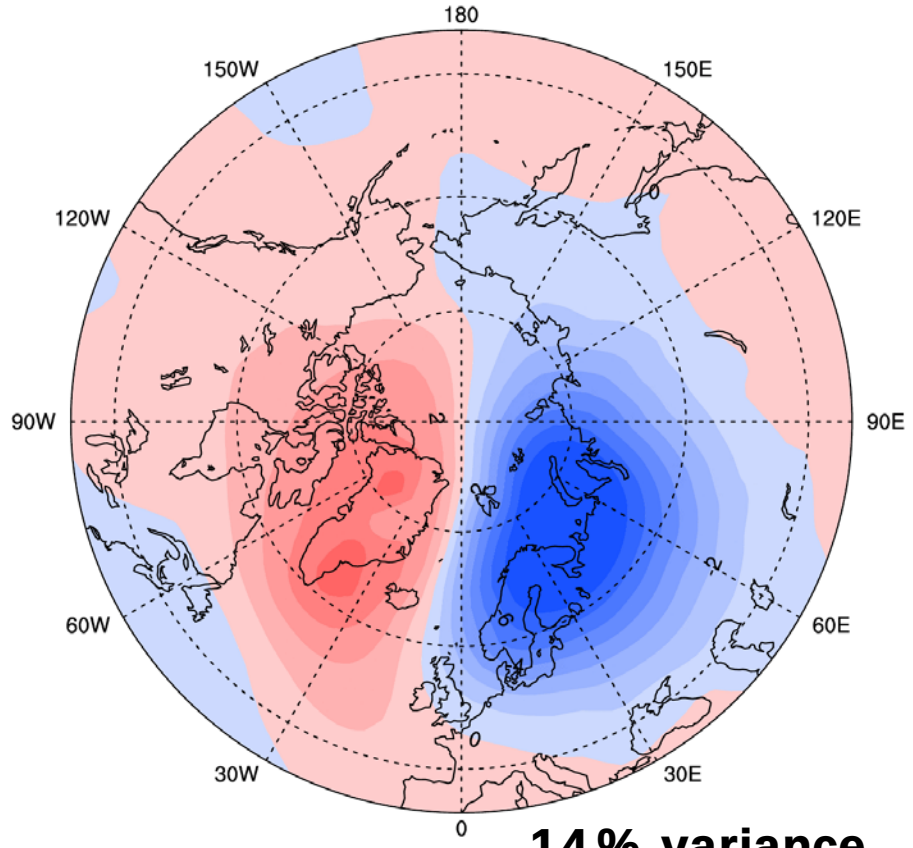
Daily EOFs

1st EOF (NAO)

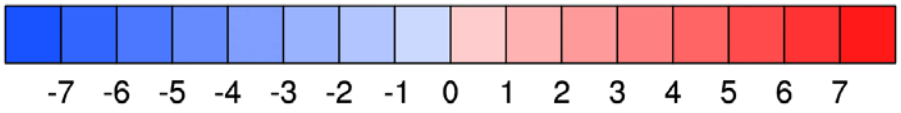


31% variance

2nd EOF (east-west dipole)



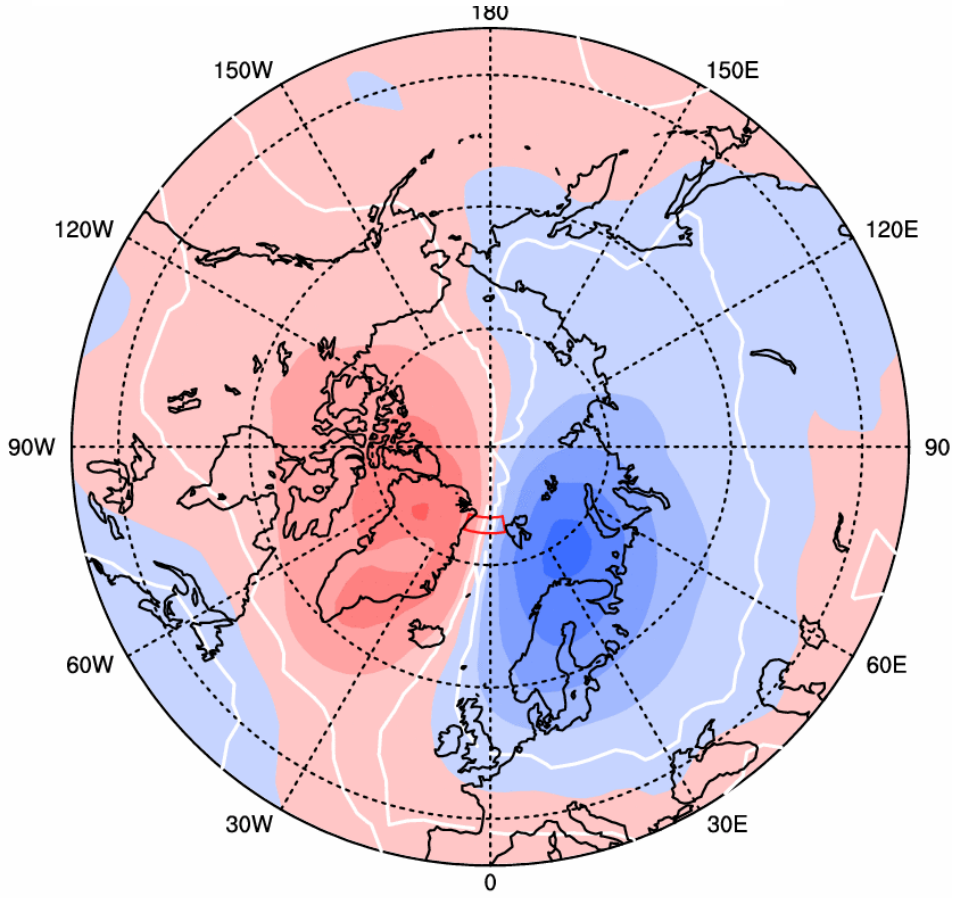
14% variance



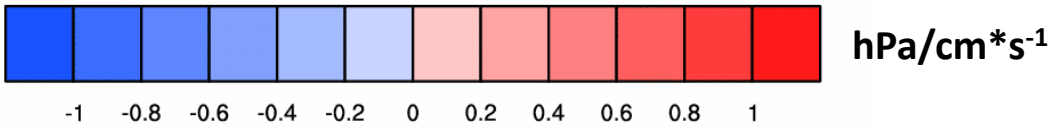
Daily EOFs computed for the Atlantic sector (90°W-90°E, 45-90°N)

Regression of SLP on sea ice motion in winter

winter (October 15 – April 14) hPa/cm/s



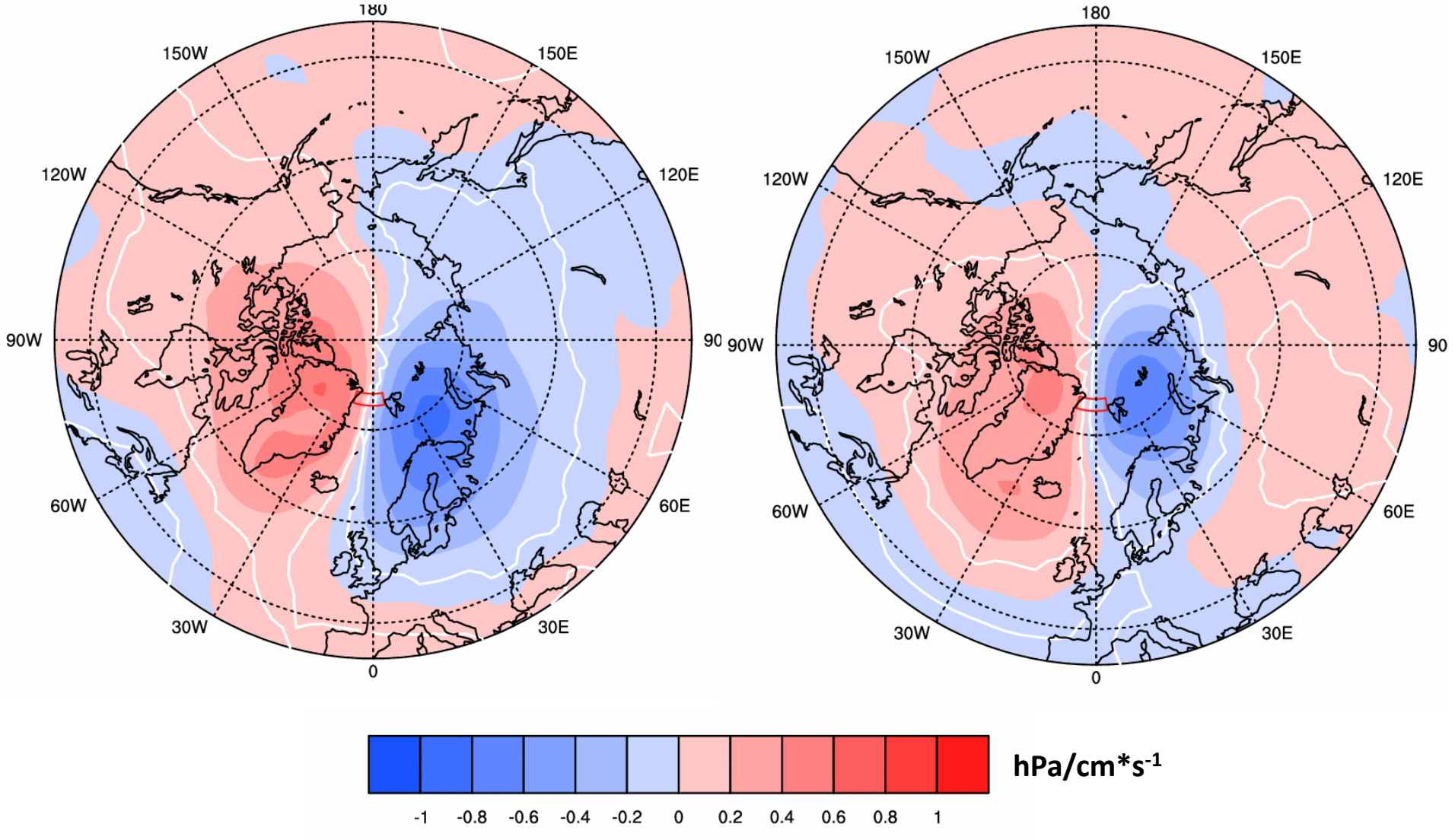
- ✓**Very similar to year-round pattern**
- ✓**East-west dipole**



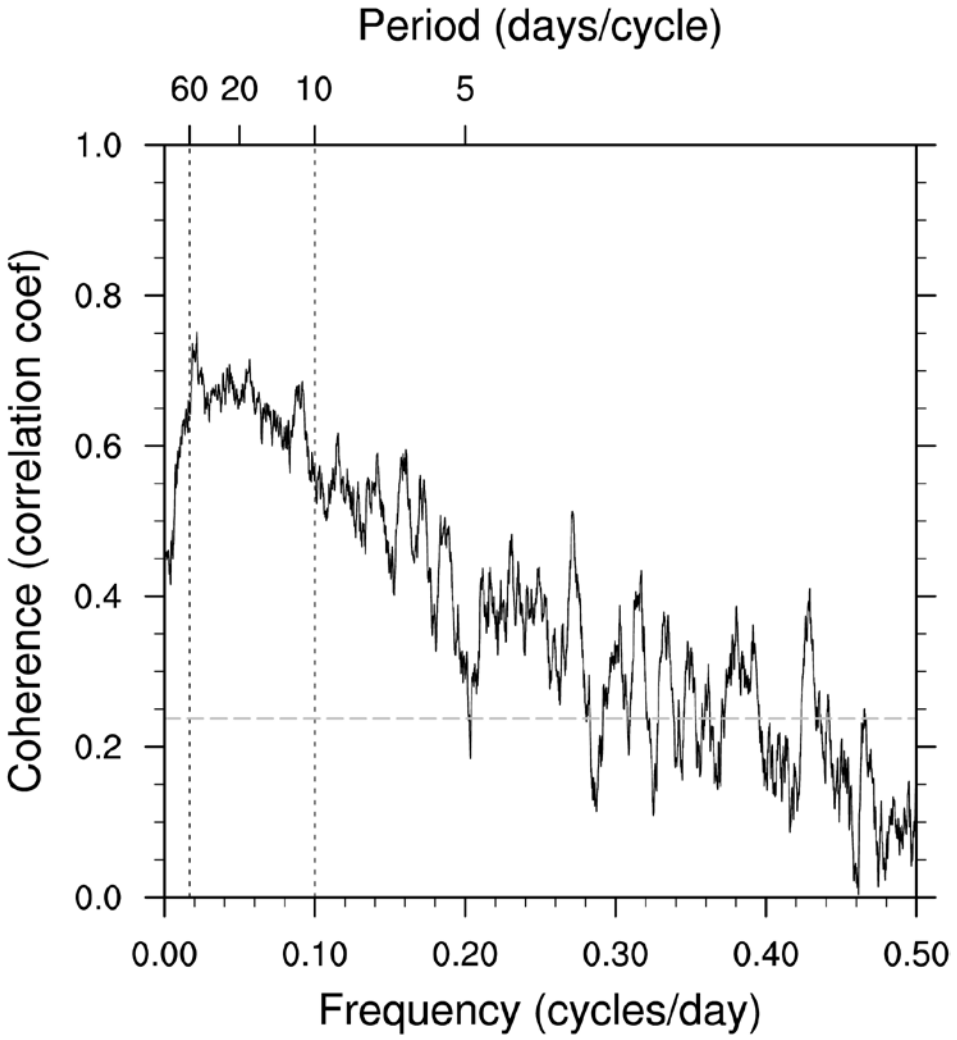
Regression of SLP on sea ice in winter and summer: An east-west dipole is present year-round

winter (October 15 – April 14) hPa/cm/s

summer (April 15 – October 14) Pa/cm/s



Coherence: correlation at different frequencies



- ✓**Coherence values peak at 10-60 day band**
  - **vertical dotted lines**
- ✓**Phase near zero**
  - **not shown**
- ✓**Coherence values drop after ~100 days**
- ✓**Similar results for winters and summers**
  - **not shown**

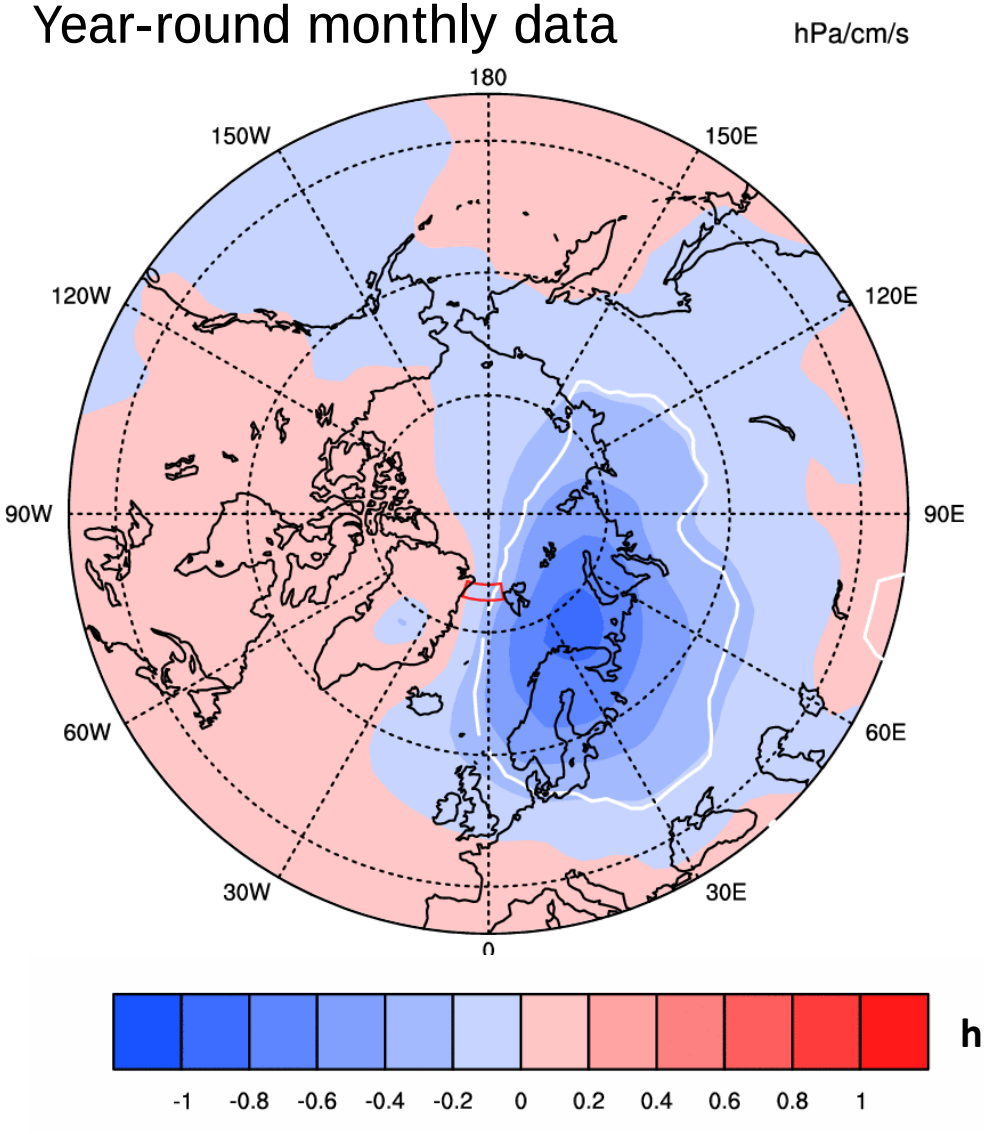
99% significance is outlined by dashed gray line

Results I: daily data

- East-west SLP dipole pattern is crucial for sea ice transport
- Dipole forcing present throughout the year
  - winter relationship is slightly stronger
- Highest coherency on 10-60 day timescale
  - Monthly data cannot fully resolve this timescale

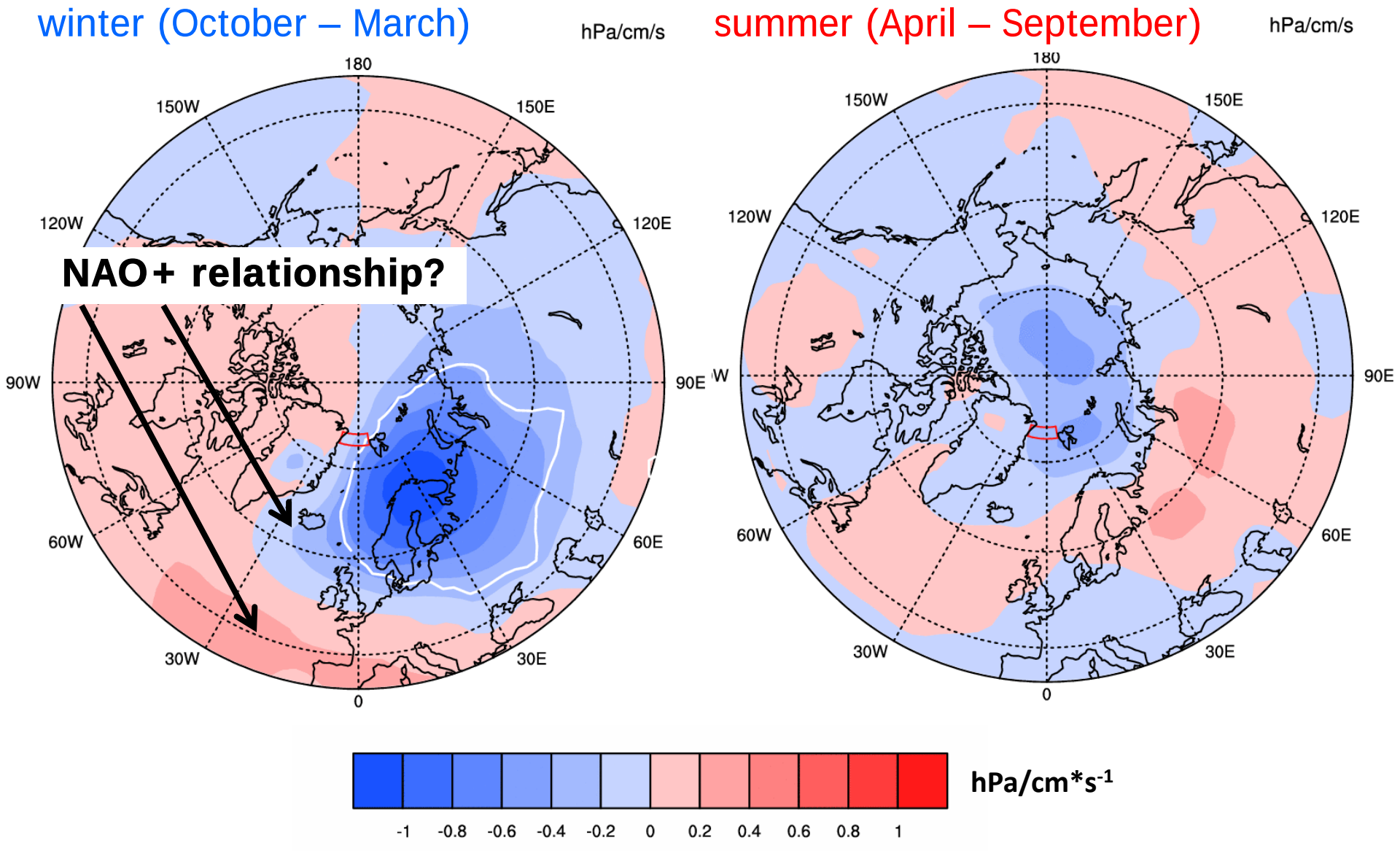
Regression of SLP on sea ice motion, monthly

Year-round monthly data



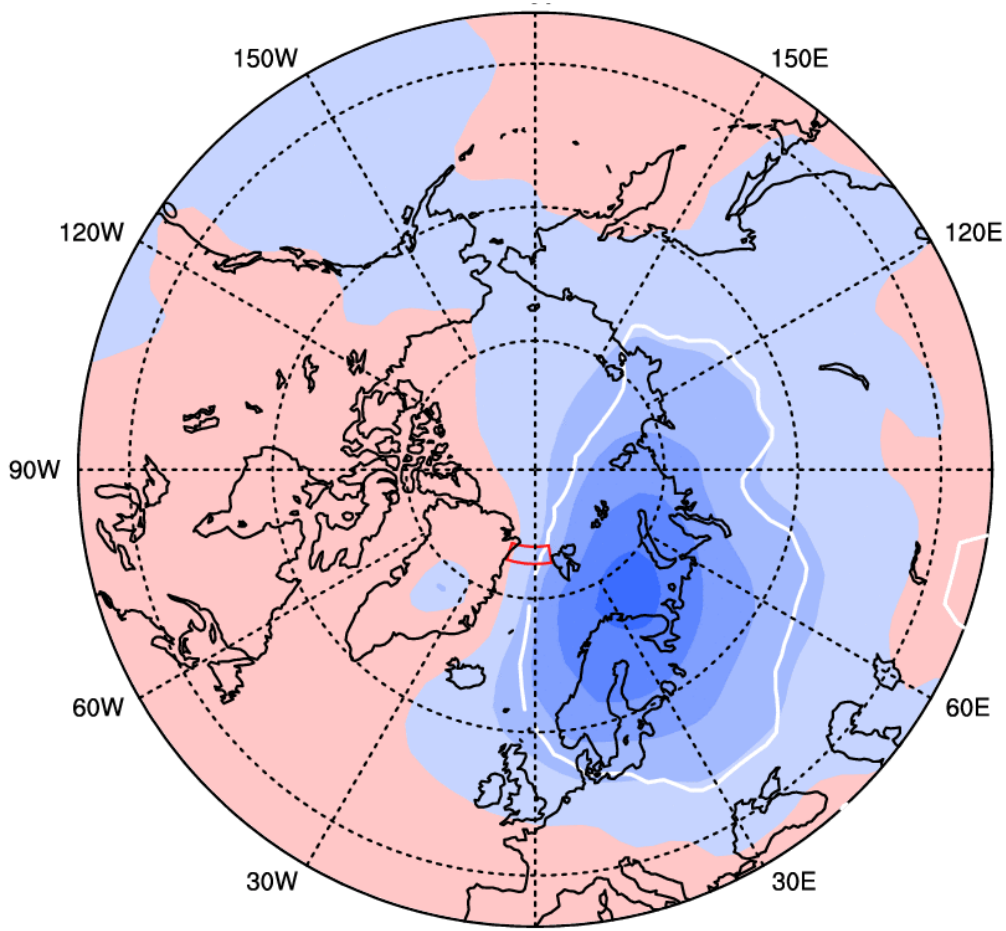
- ✓ **No east-west dipole**
- ✓ **No Greenland center**
- ✓ **Barents center-of-action**
- ✓ **SLP gradient across Fram Strait**

Regression of SLP on sea ice motion, monthly

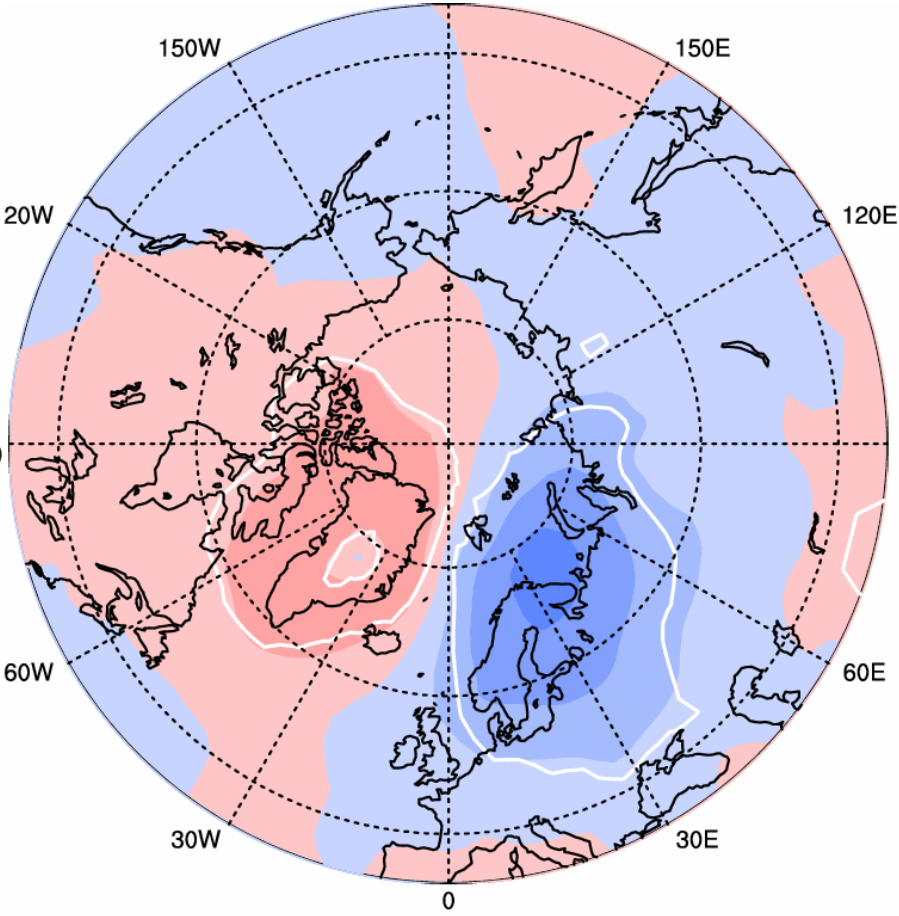


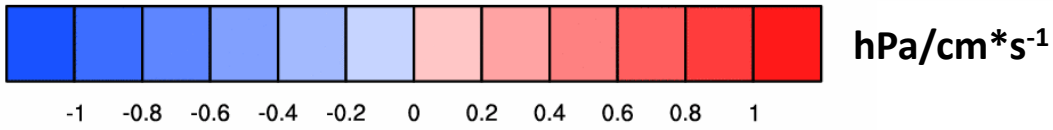
Regression of SLP on sea ice motion, monthly with and without the NAO (1st EOF)

Year-round monthly data



1st EOF removed





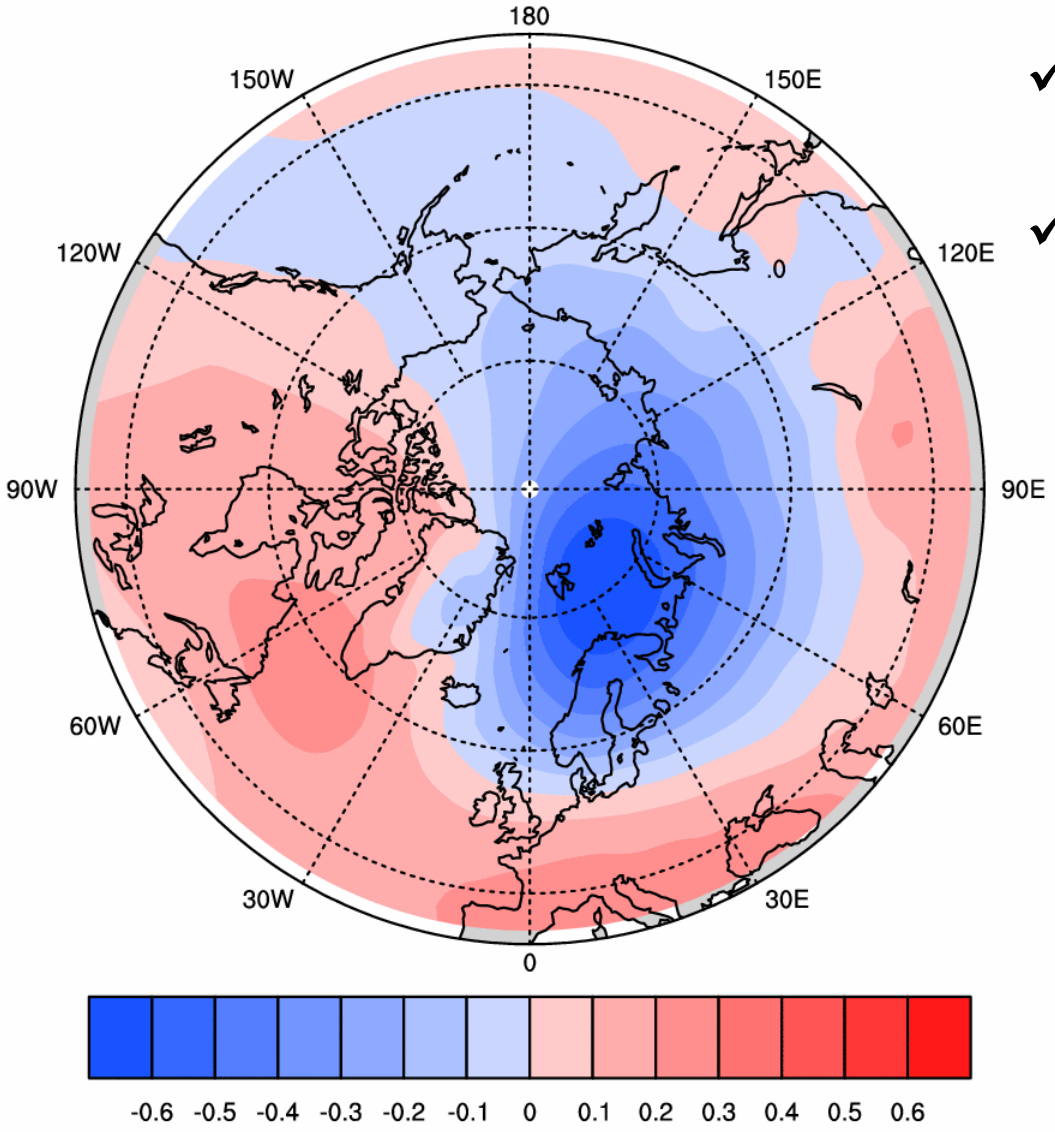
Results II: monthly data

- NO east-west dipole pattern
  - Barents center-of-action
  - No significant relationship observed in summer
- Removal of the NAO reveals the dipole

Community Climate System Model 3.0

- Coupled climate model
- T85 resolution
- 20^{th} century run and 21^{st} century A1b run
- Natural and anthropogenic forcings
- Two runs analyzed (b30.030a / b30.040b):
  - Monthly data: 1560/1200 months
  - SLP
  - Sea ice motion
  - Sea ice volume

Correlation b/w SLP and ice motion CCSM 3.0 20th century run 1870-1999

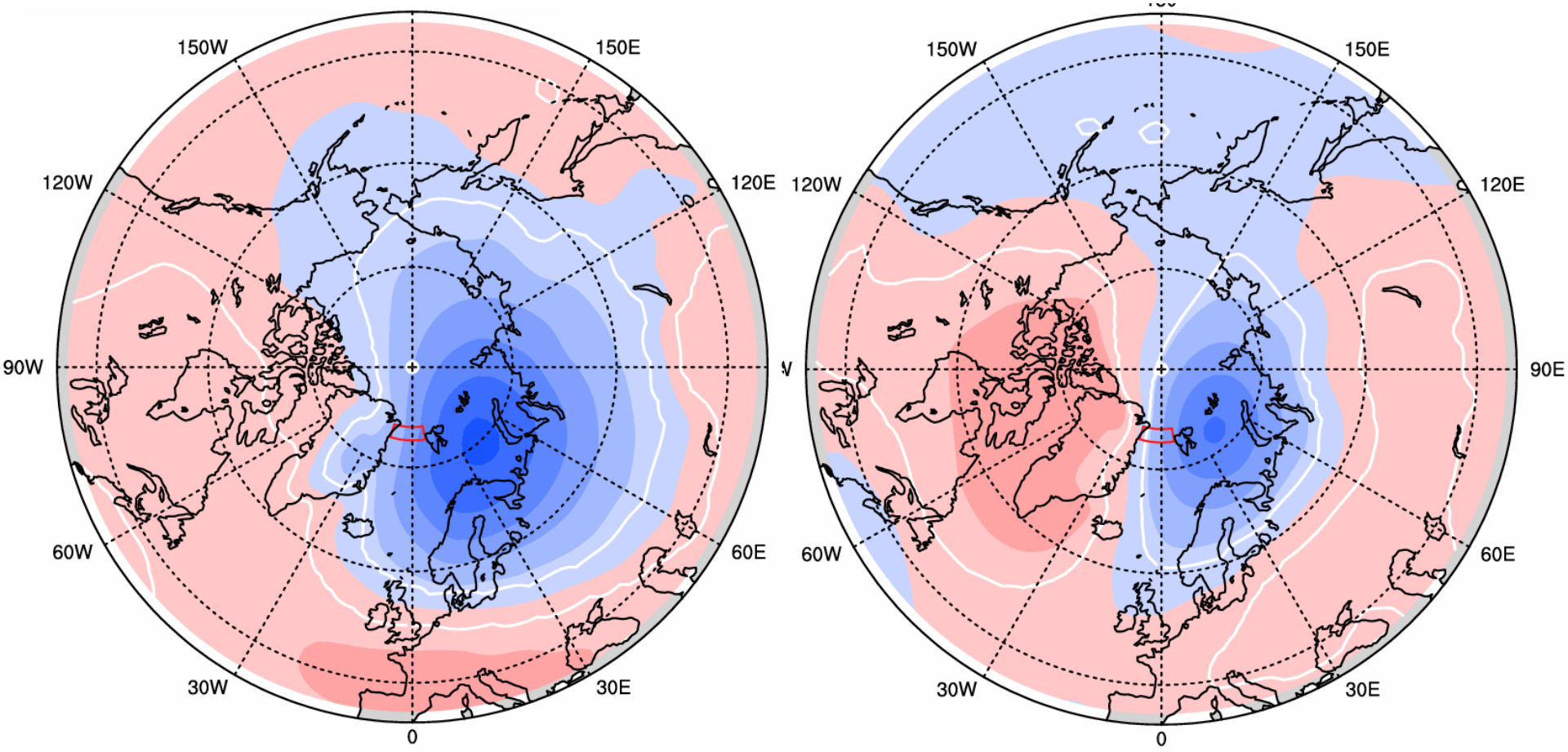


- ✓Barents center of action
- ✓Similar to observations

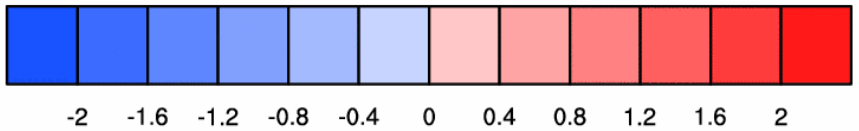
Regression of SLP on sea ice motion, monthly CCSM 3.0 20th century run 1870-1999

winter (October – March)

summer (April – September)



hPa/cm*s^{-1}

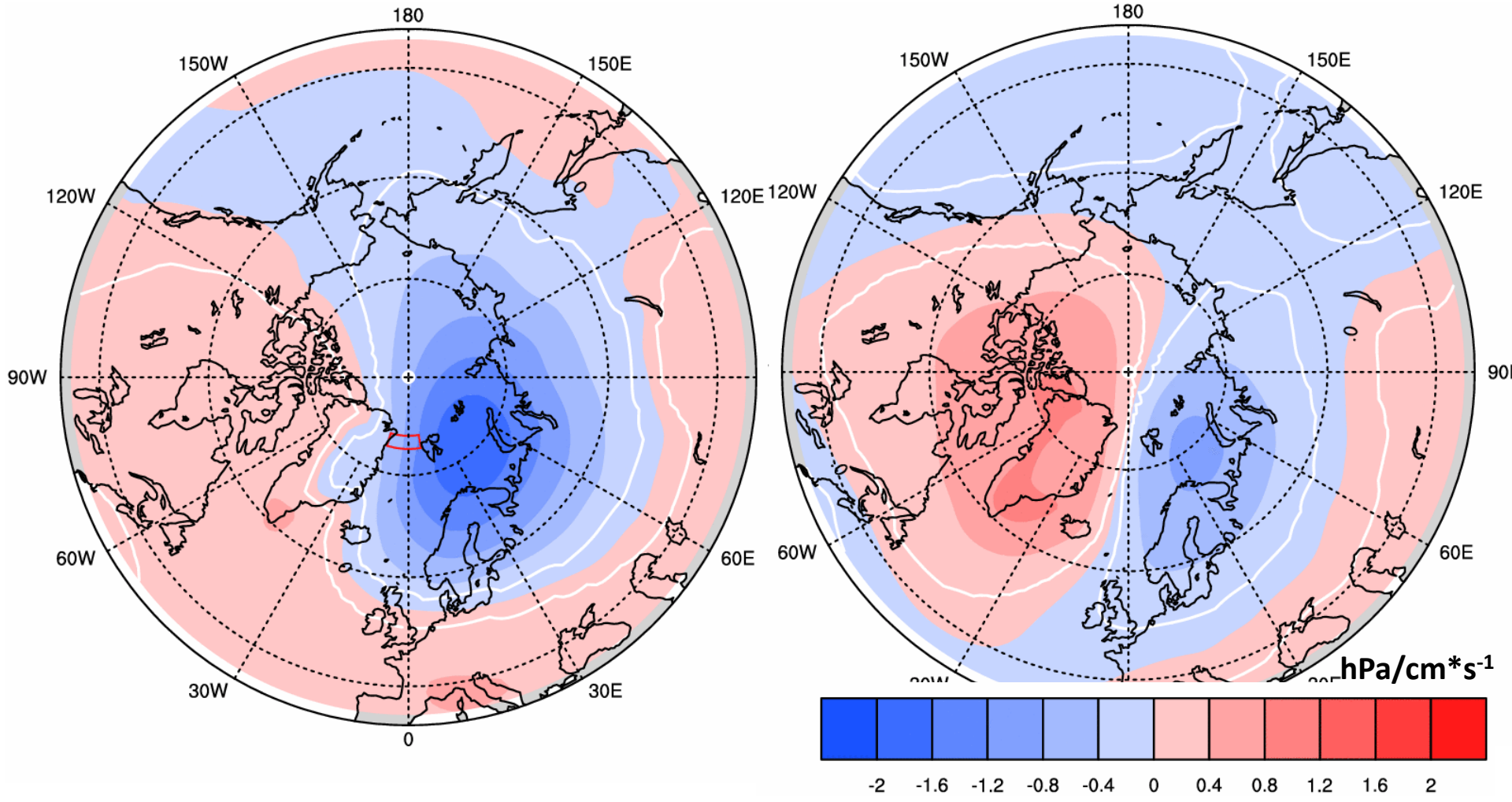


Note an increase in regression values (as compared to observations):

Regression of SLP on sea ice motion, monthly with and without the NAO (1st EOF) CCSM 3.0 20th century run 1870-1999

Year-round monthly data

1st EOF removed



Results III: CCSM 20th century

- Sea ice motion and sea ice volume produce similar results

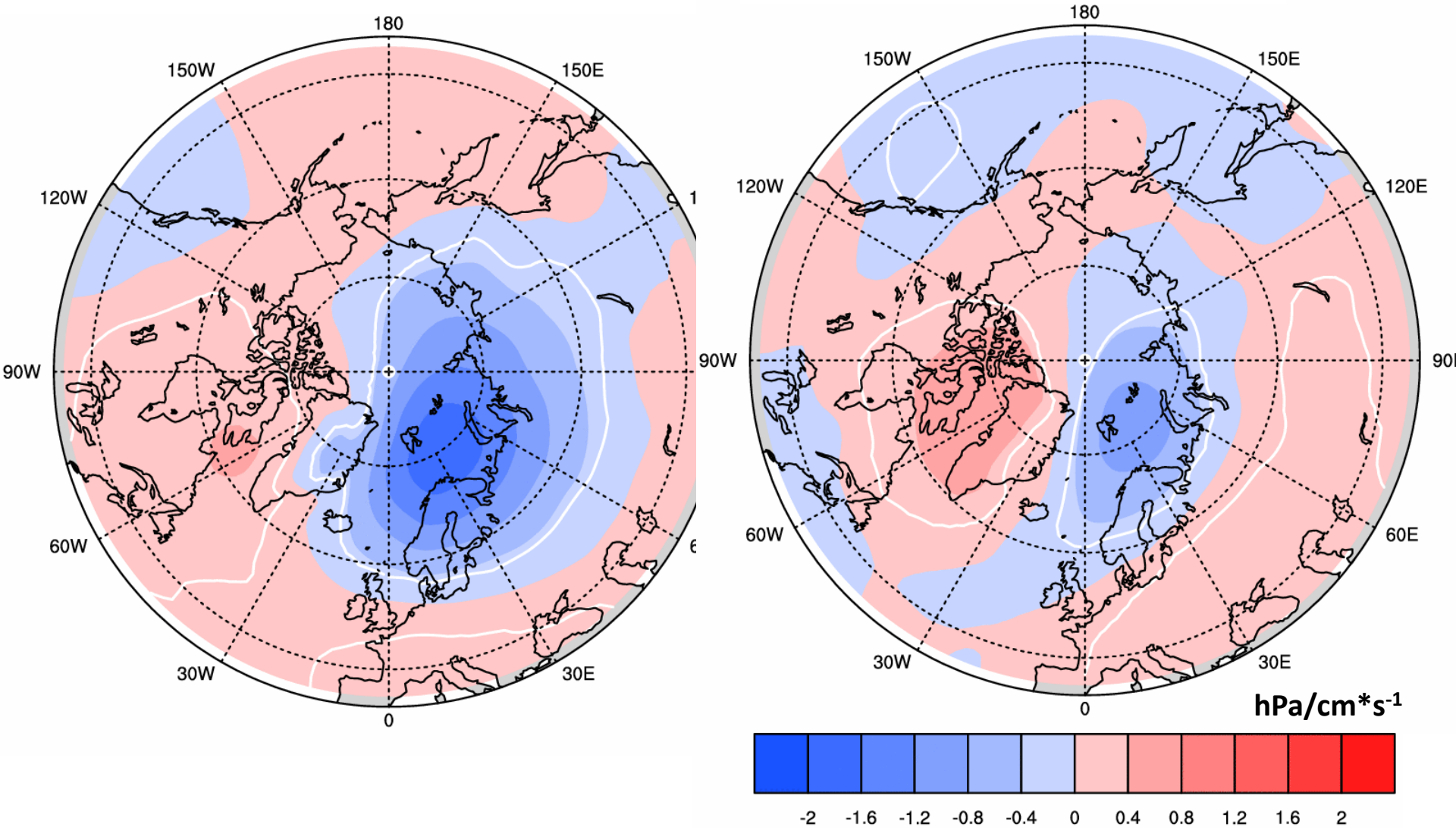
- Barents center-of-action is crucial in winter
- Summer shows a significant dipole

- NAO removal reveals an east-west dipole in winter

Correlation b/w SLP and sea ice motion
CCSM 3.0 21st century A1b 2000-2099

winter (October – March)

summer (April – September)

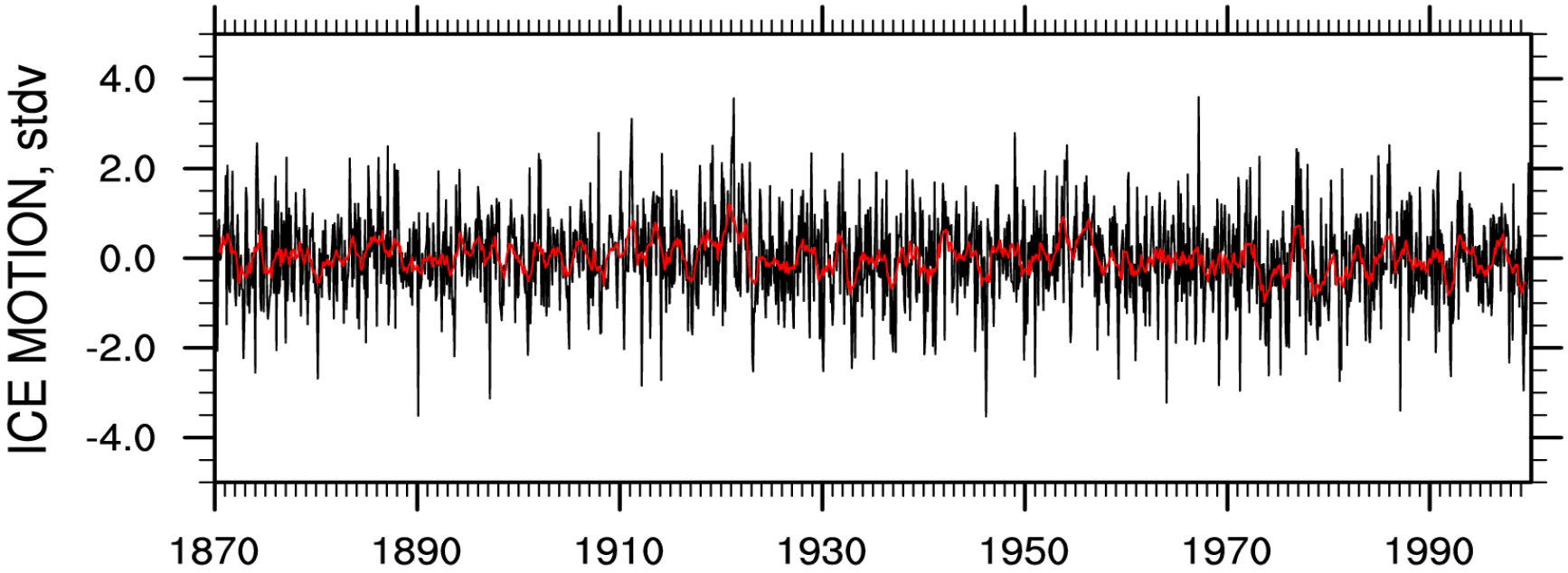


Results IV and future directions:

- 21st century patterns are similar, but weaker
- Sea ice behavior changes
- Less atmospheric forcing required to flush out sea ice?
  - Results from observations and CCSM

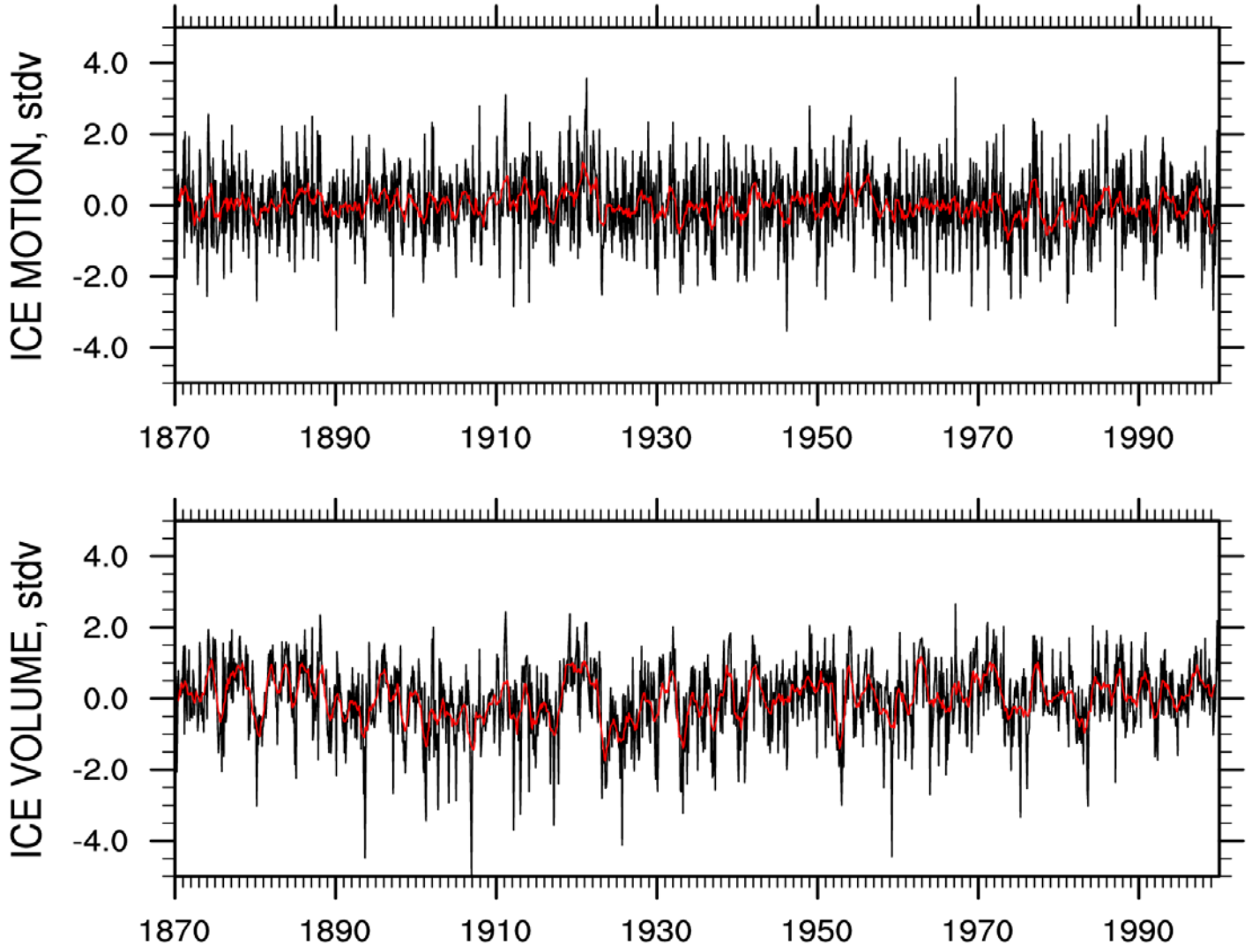
Thank you !

Ice motion time series in CCM3



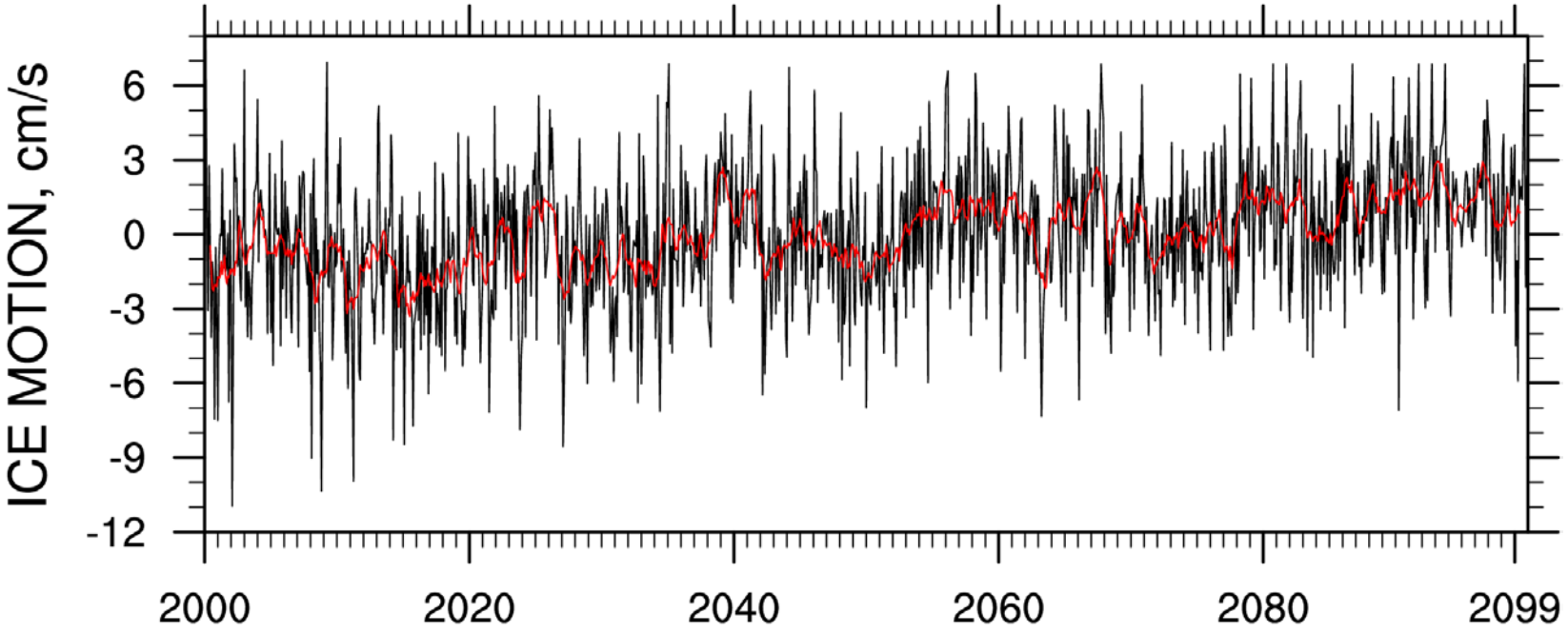
Courtesy of Marika Holland

Adding sea ice volume:



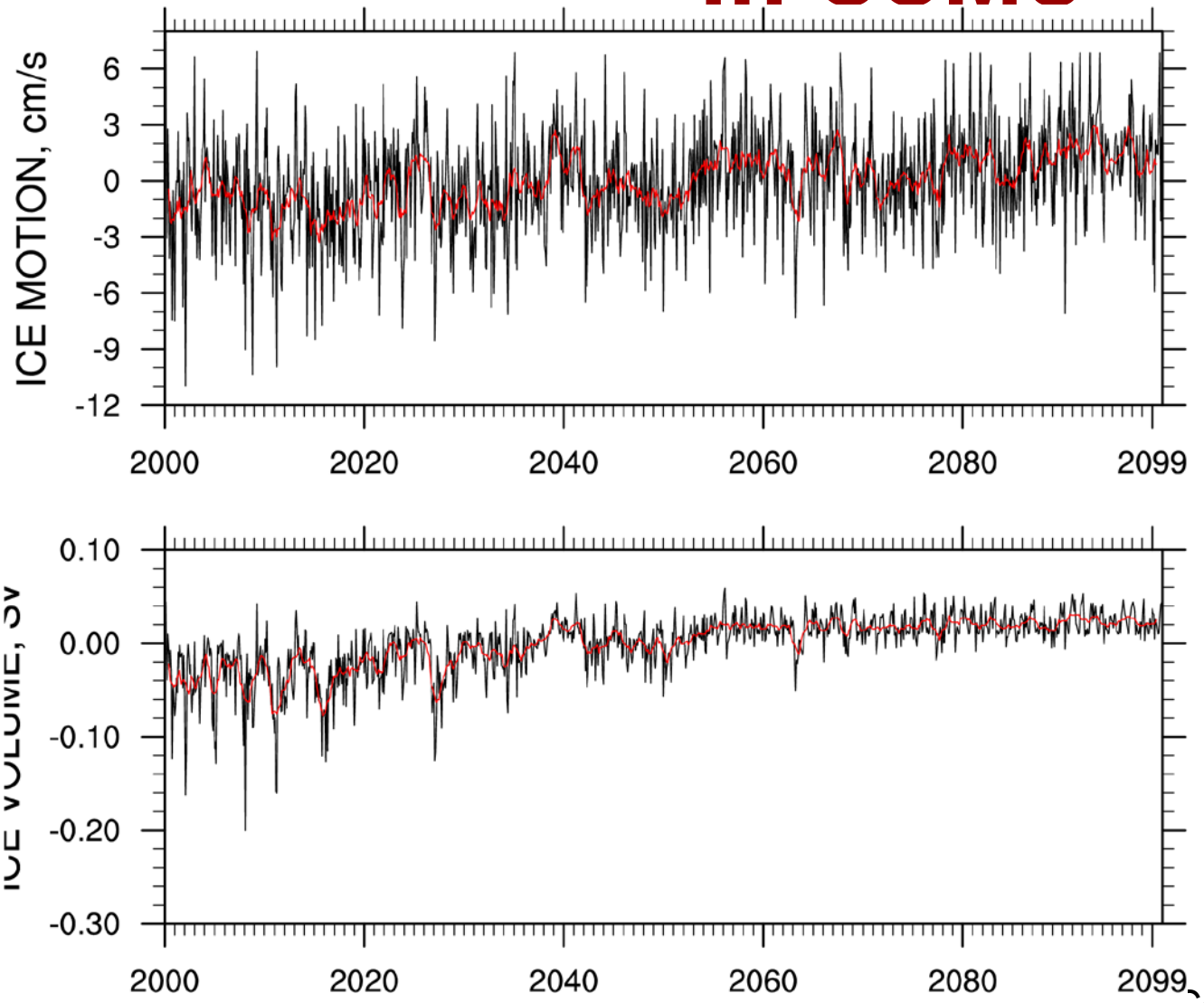
Correlation b/w ice motion and volume: 0.74

Ice motion time series in CCM3



Courtesy of Marika Holland

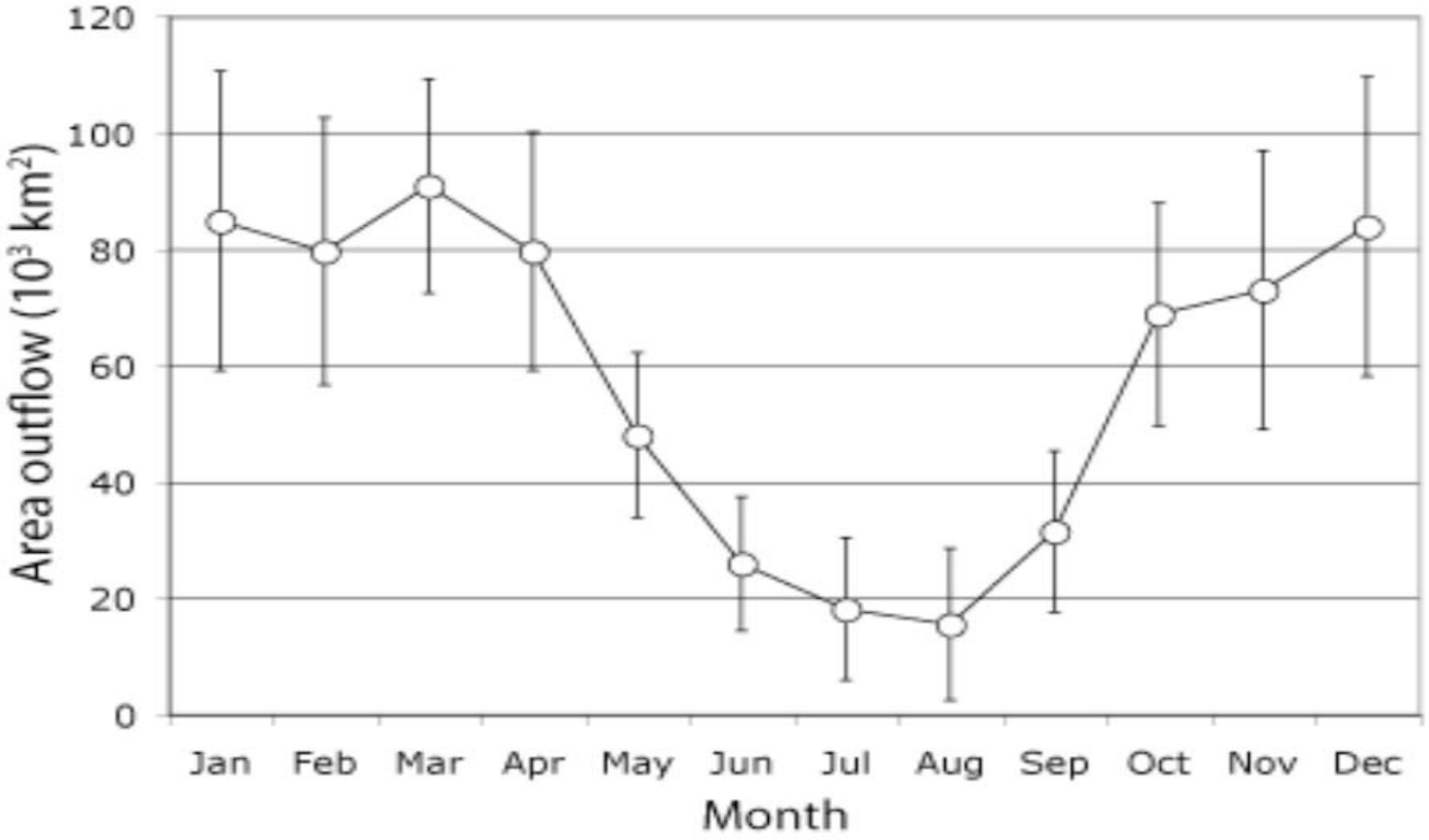
Ice motion time series in CCM3



Courtesy of Marika Holland

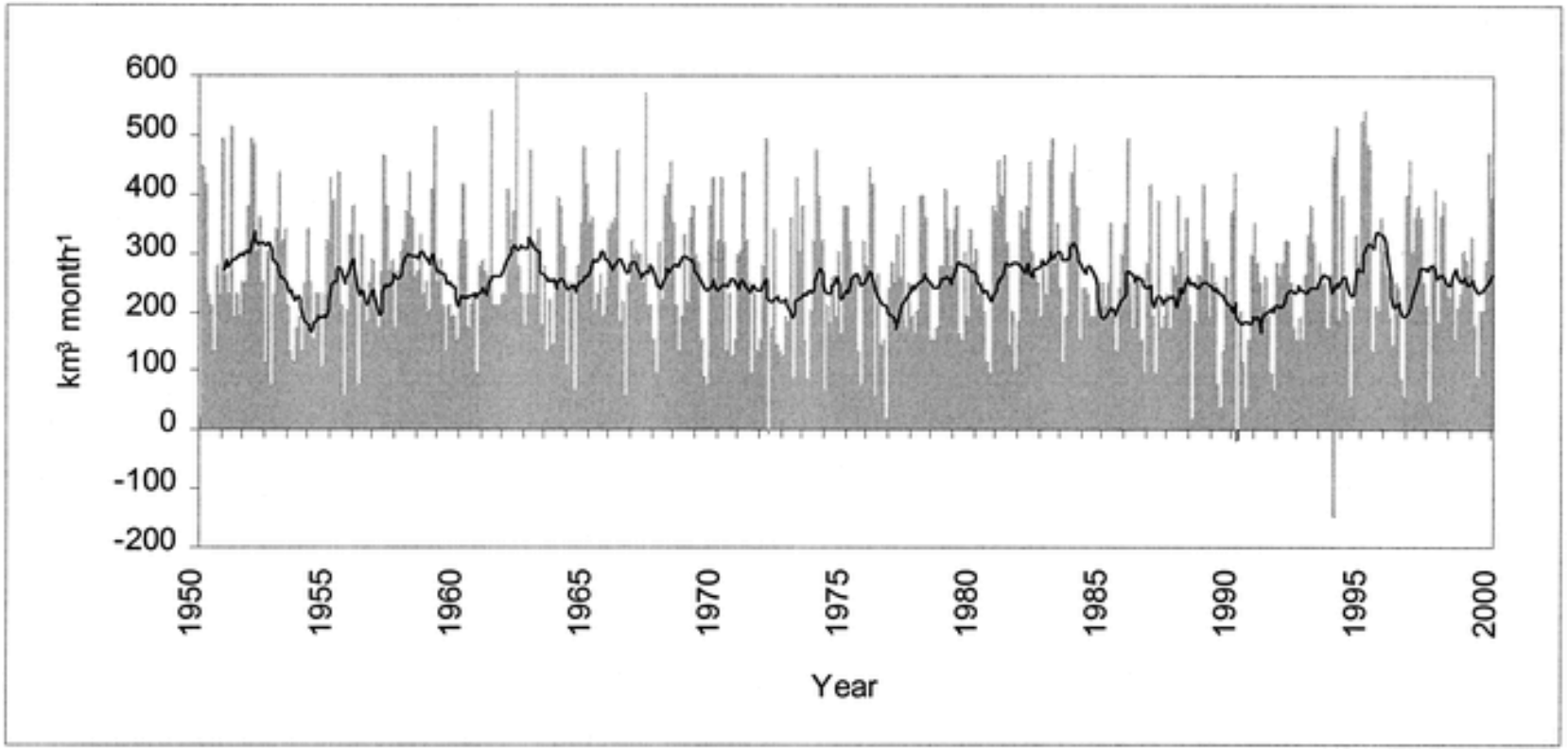
Seasonal variability in sea ice area

- **Kwok et al. 2009**
  - **Satellite derived motion product 1978-2007**
  - **Winter outflow larger and more variable than summer**

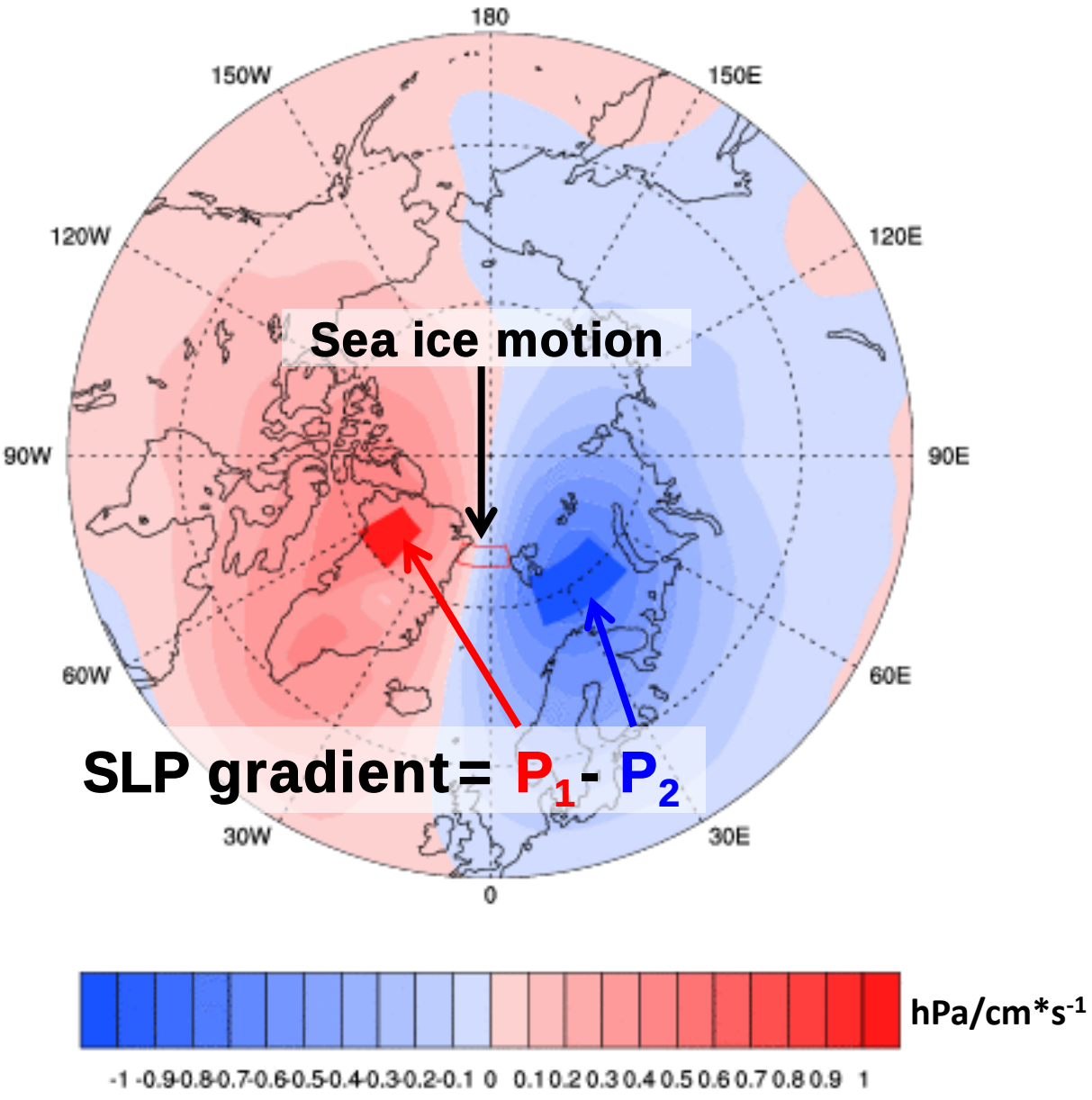


Long term variability in sea ice export

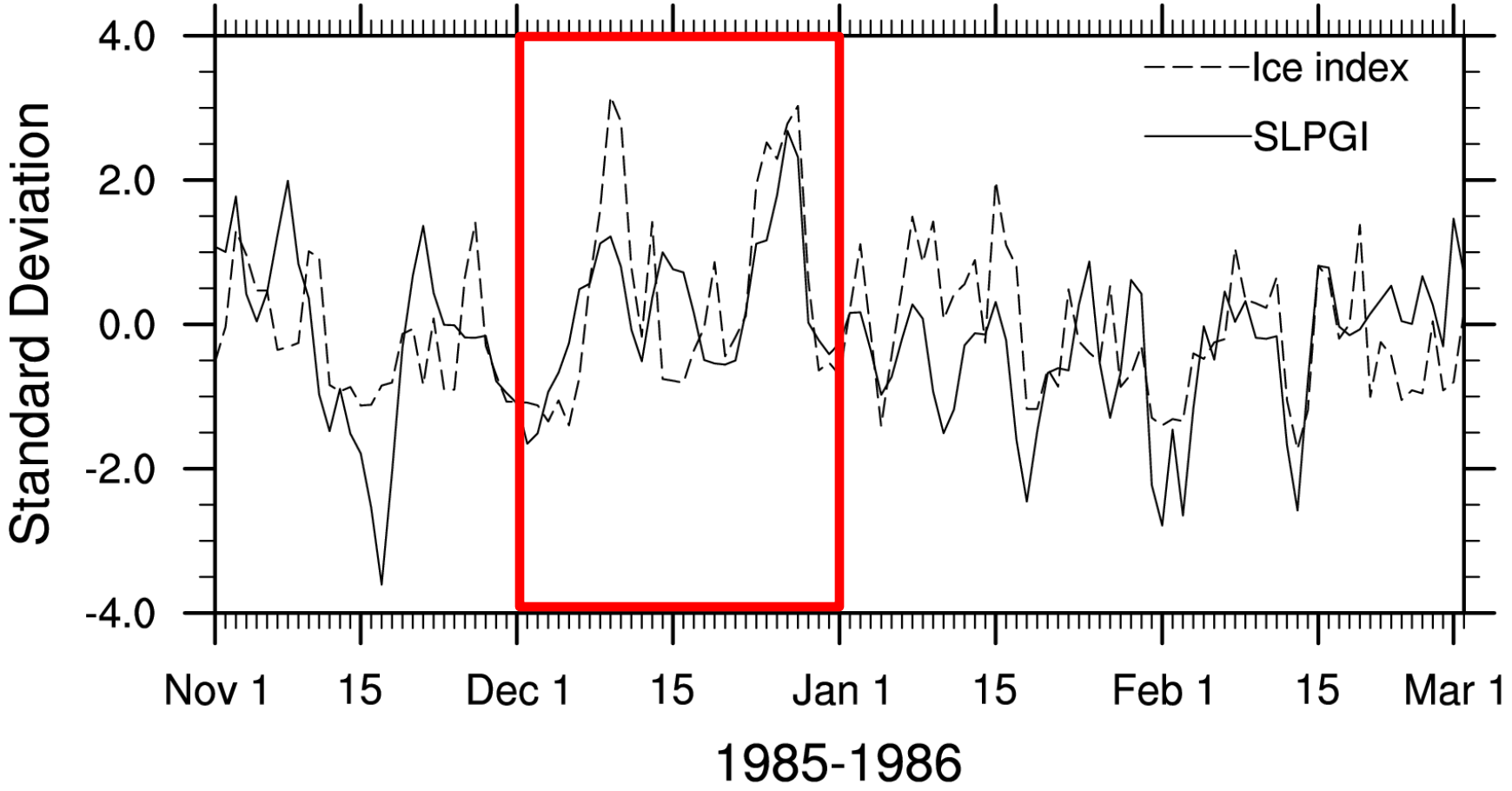
- **Vinje, 2001**
  - **Monthly estimates: upward looking sonar + proxies**
  - **high interannual variability**



SLP gradient index (SLPGI)

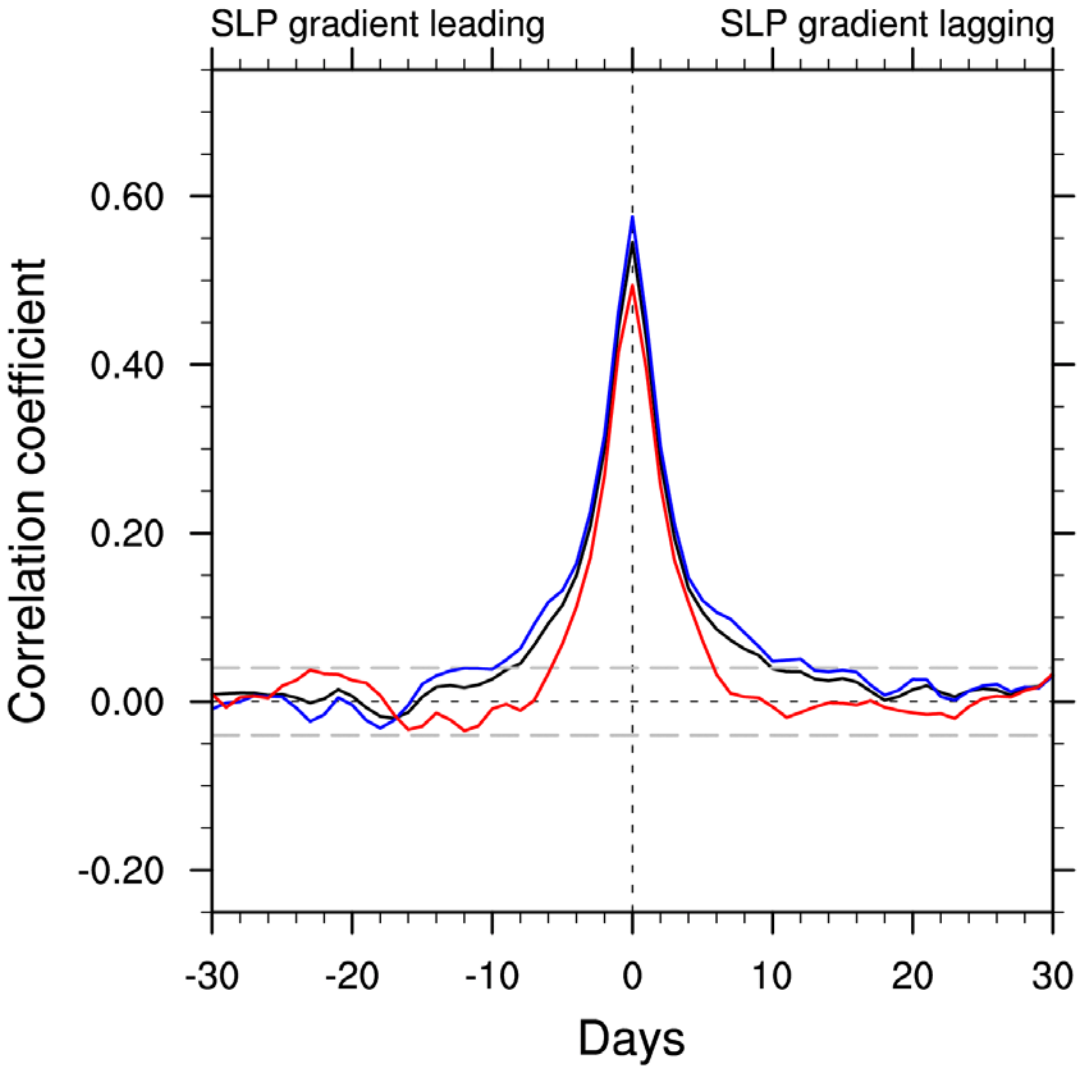


Time series



Correlation coefficient: 0.54

Lead/lag relationship between the SLPGI and sea ice motion



- ✓ **Strong correlation**
  - ✓ **Peaks at 0 lag**
  - ✓ **Strongest in winter**
  - ✓ **Weakest in summer**
  - ✓ **Extends for ~10 days**

BLACK: all record

BLUE: winters

RED: summers