Atmosphere - sea ice interactions in the Arctic. Non stationarity and implications for predictability

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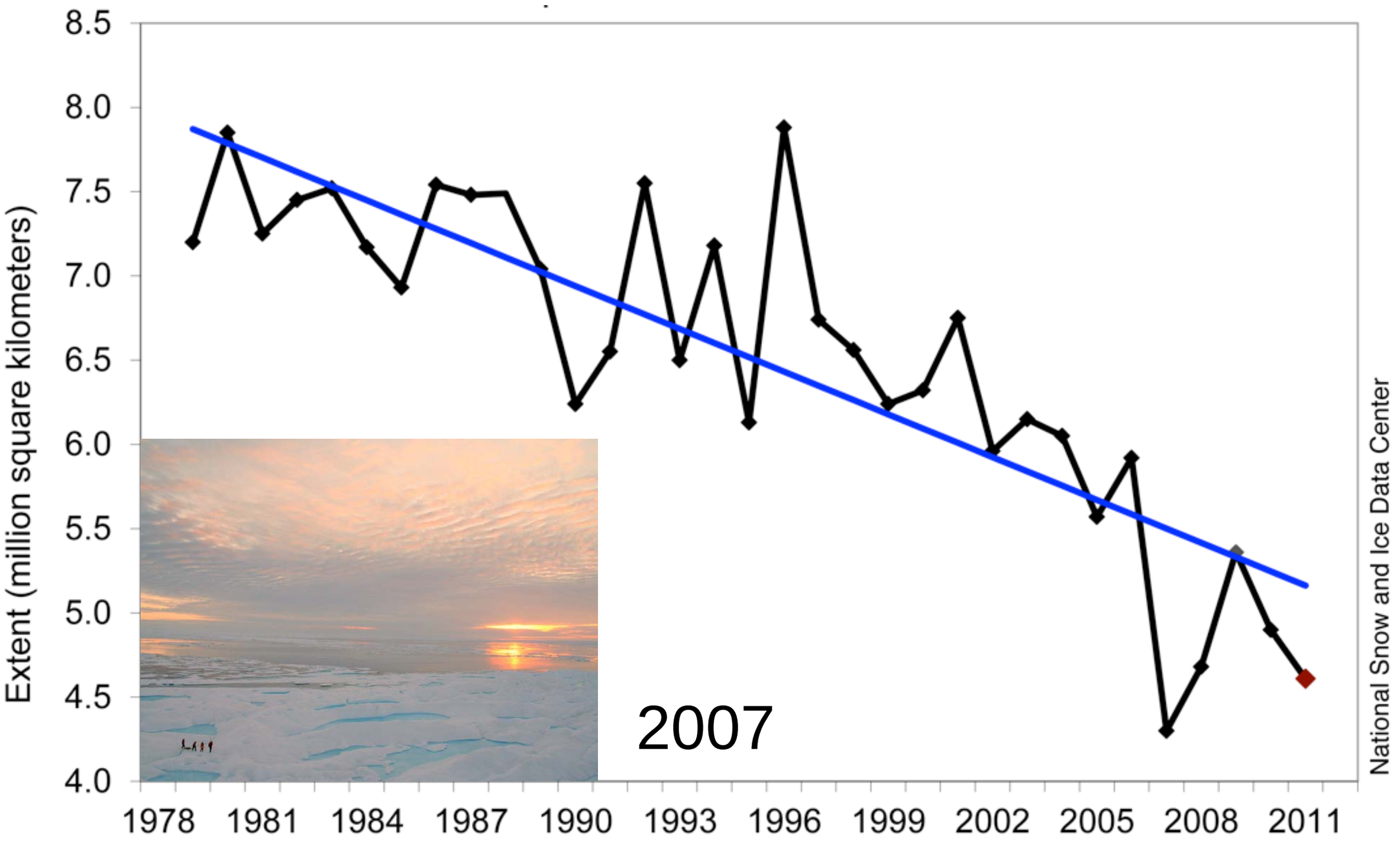
Outline

- Introduction & Motivation
- Focus on summer season
    - Controls on summer sea ice variability: the role of atmospheric heat flux
        - Model vs Observations.
- A brief (and incomplete?) history of time. Non stationarity, and implications for seasonal predictability.

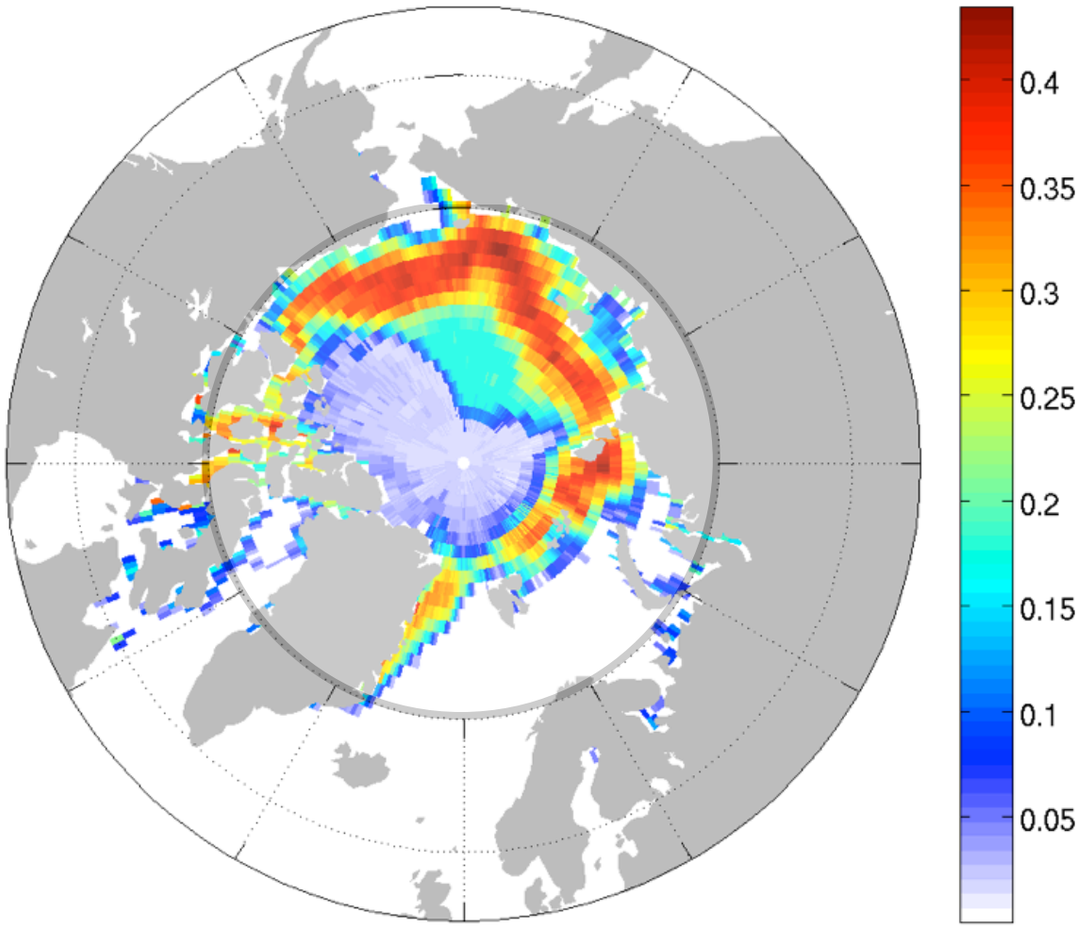
September Arctic Sea Ice Extent
1979-2011



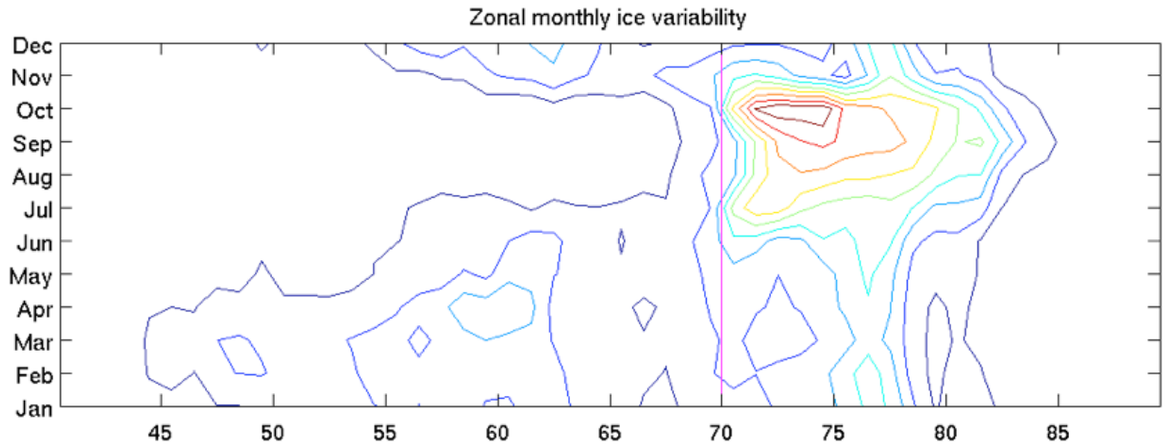
September Arctic Sea Ice Extent 1979-2011

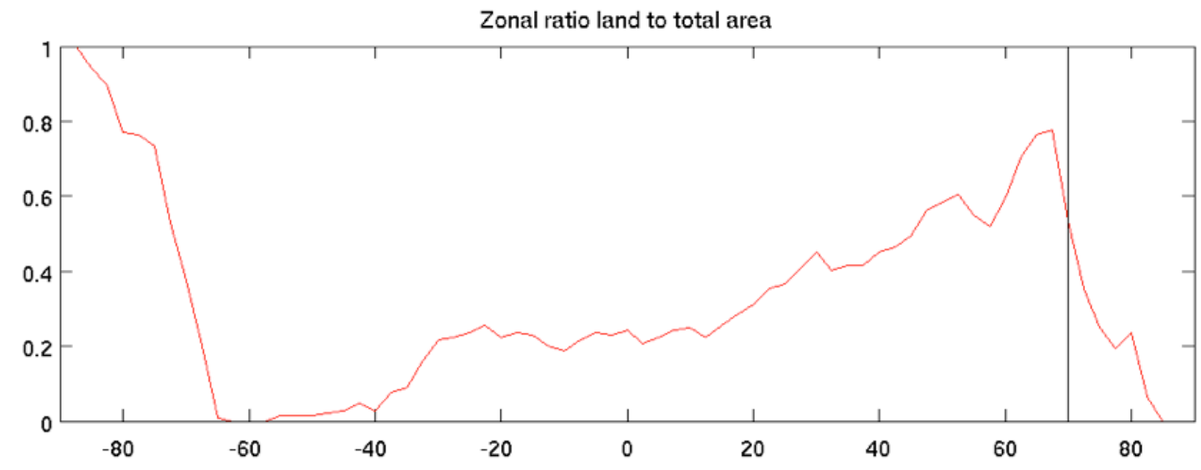
- Controls on interannual summer sea ice variability
  - Winds - both summer and winter through preconditioning (e.g. Rigor et al, 2002, Ogi et al 2008, 2010
  - Ocean currents (Polyakov et al 2005, Shimada et al 2006)
  - Radiative fluxes at the surface (Perovich 2007)
  - Energy redistribution within Arctic (Graversen et al, 2011)
  - Storm tracks (Screen 2012?)

- What (if any) is the role of atmospheric heat flux into the Arctic in summer months? How should one calculate this metric?



Standard deviation of September sea ice concentration





- A little background on Arctic heat fluxes. Overland and Turet (1994)

Variability of the Atmospheric Energy Flux Across 70°N Computed from the GFDL Data Set

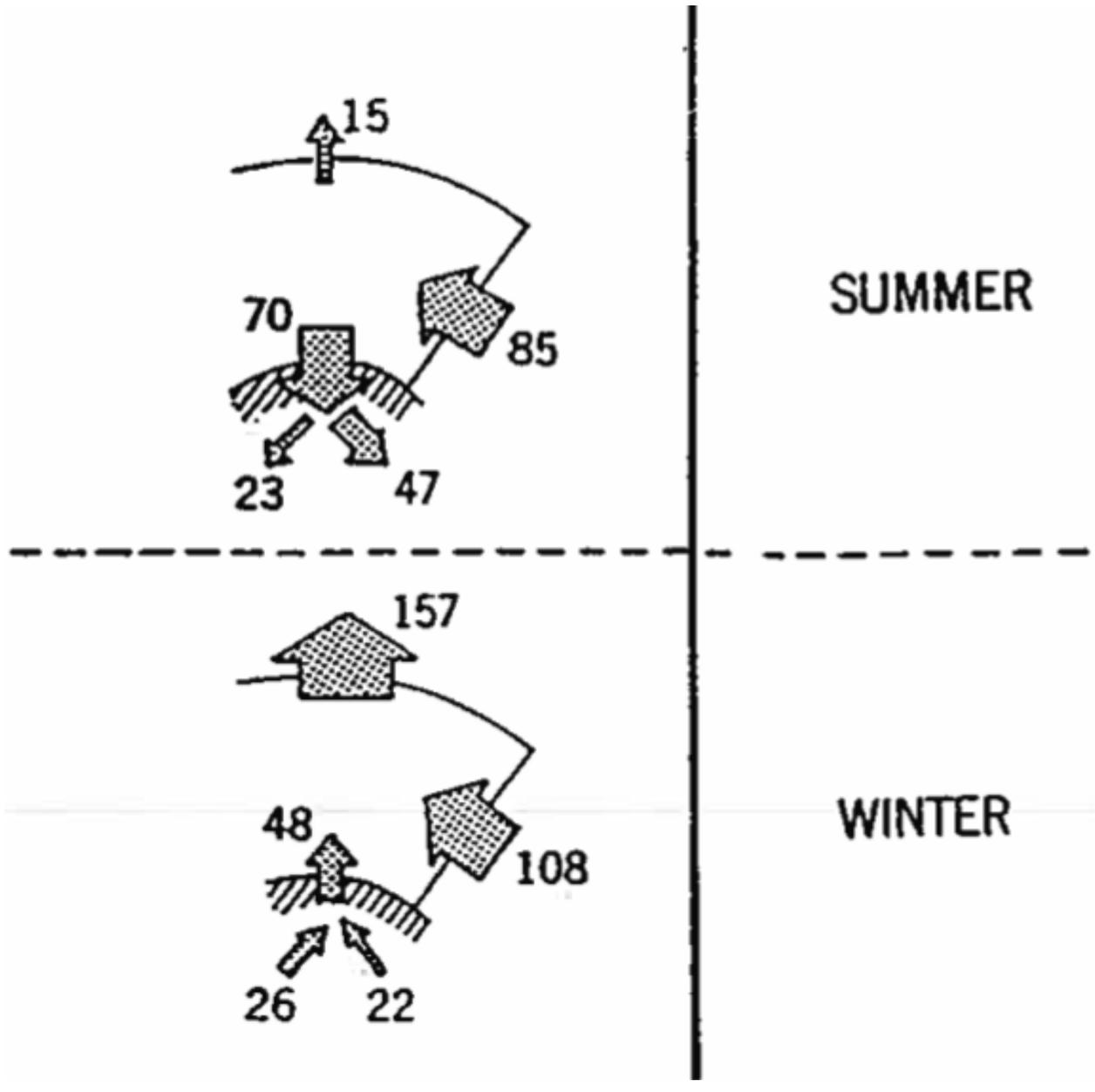
James E. Overland

Pacific Marine Environmental Laboratory/NOAA, Seattle, Washington

Philip Turet

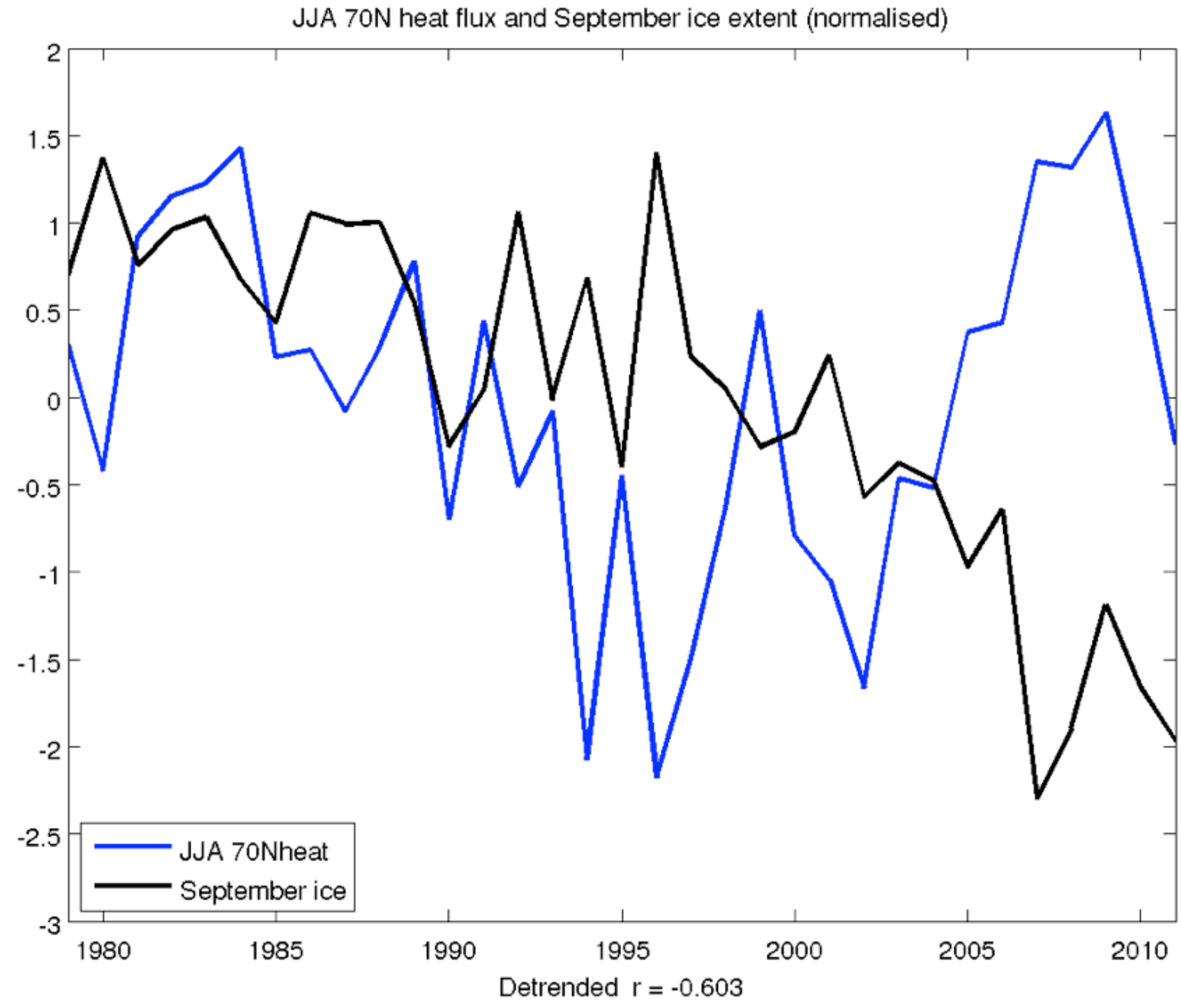
Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle

- A little background on Arctic heat fluxes. Overland and Turet (1994)



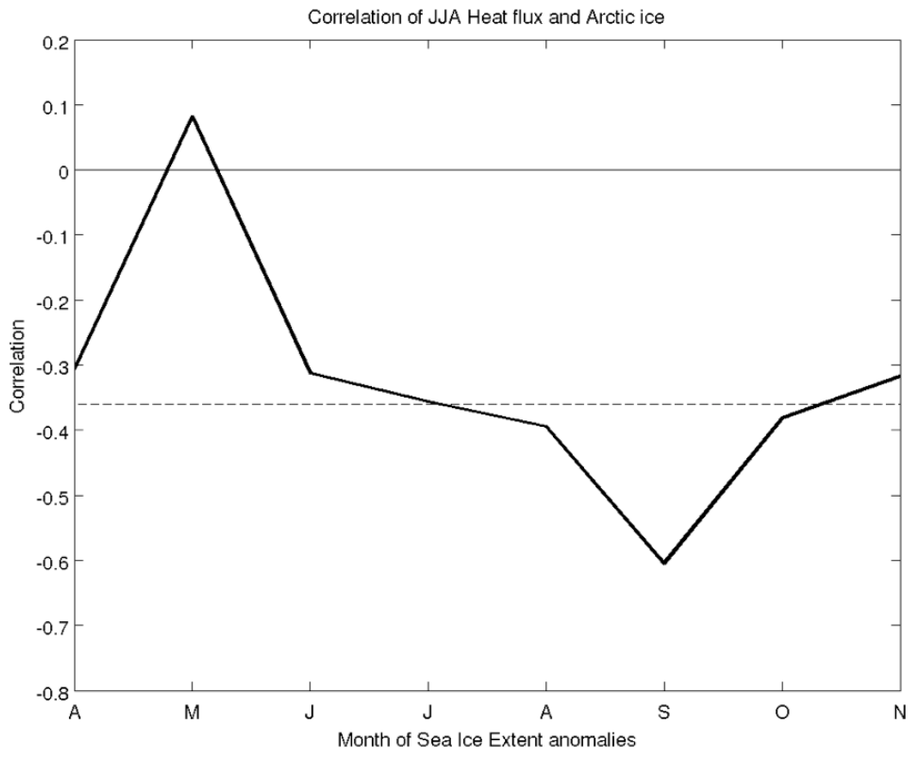
In summer, a large part of atmospheric heat flux (at 70N) is radiated downwards

Summer heat flux into the Arctic

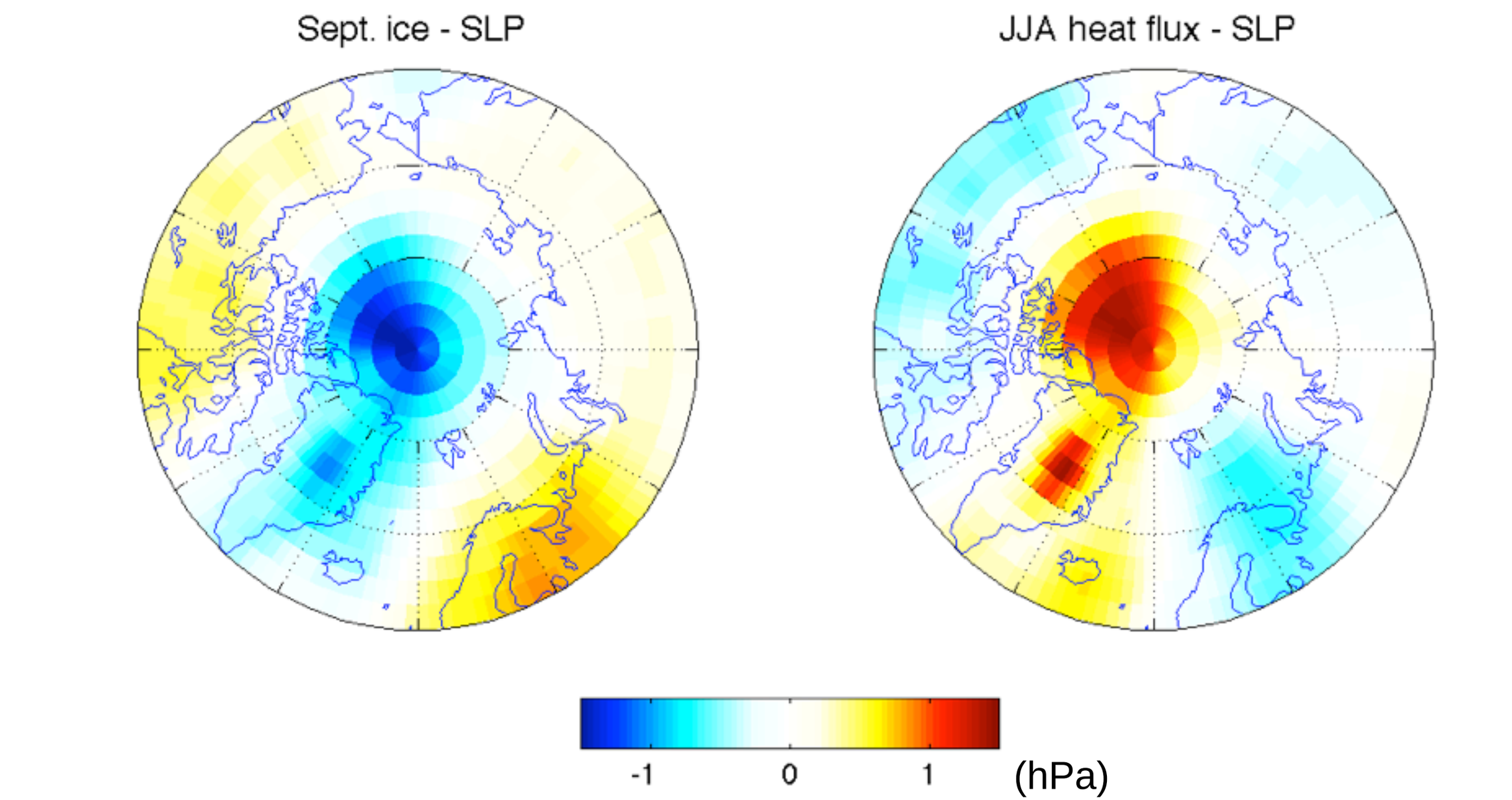


Mean 70N heat flux =80W/m2

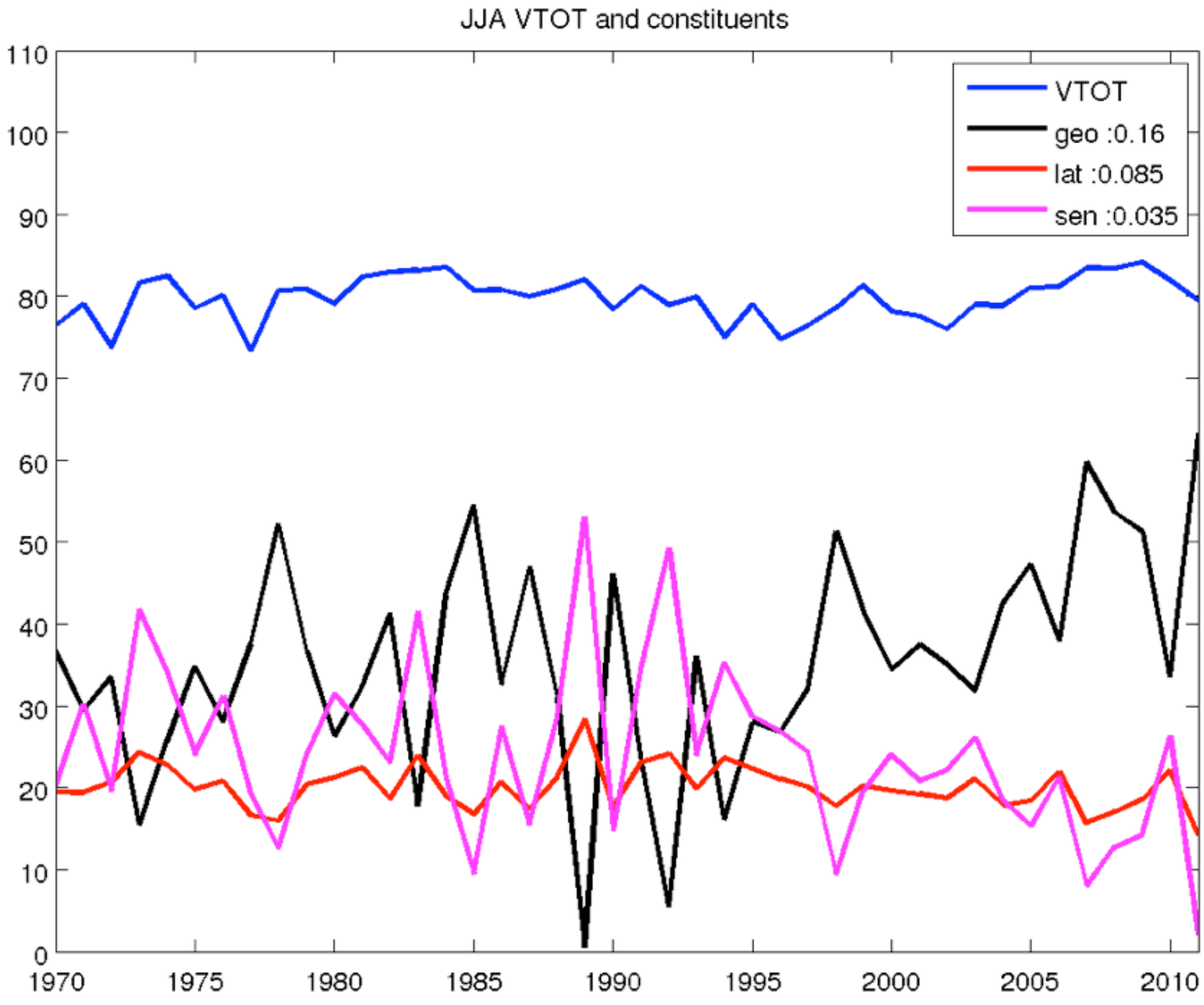
StDev of heat flux = 3 W/m2



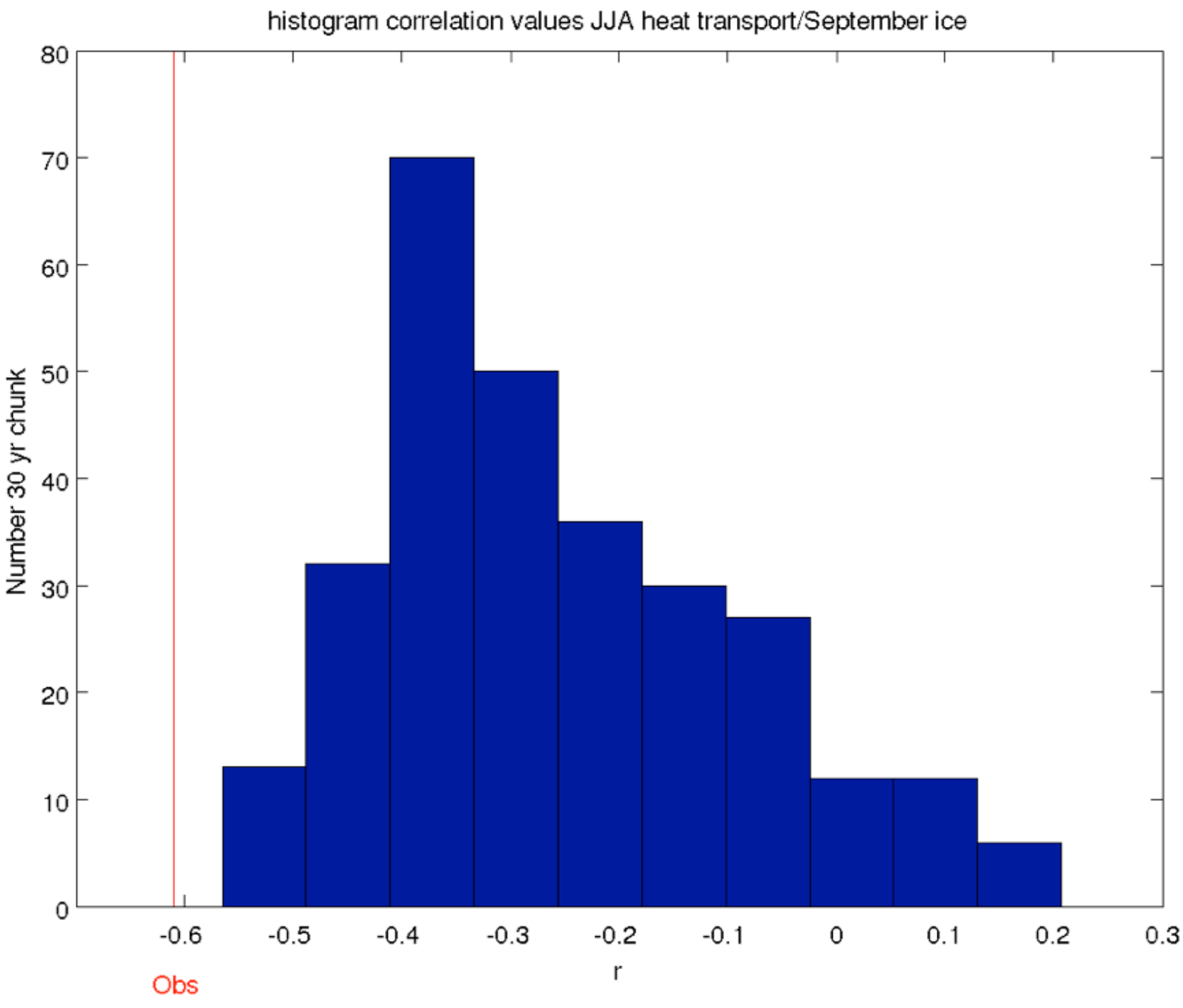
Spatial patterns



Summer heat flux into the Arctic



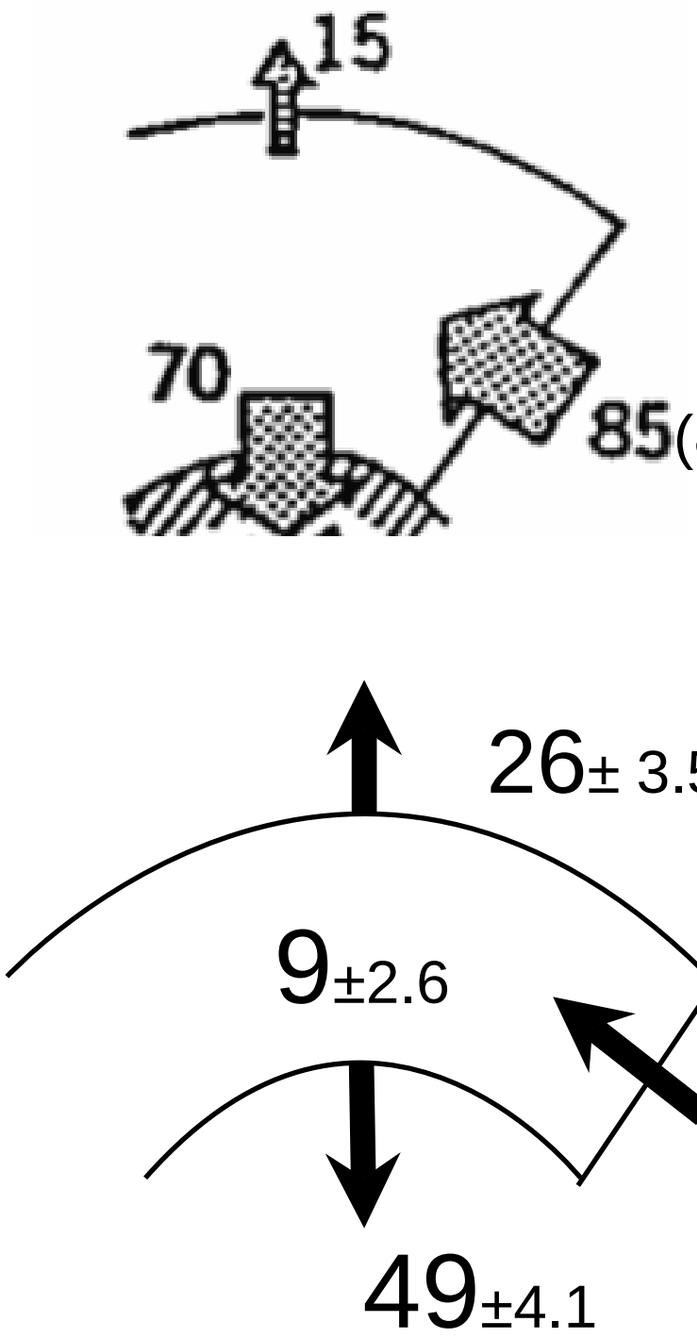
Summer heat flux into the Arctic



Blue: CCSM control run

r=-0.34

Summer heat flux into the Arctic

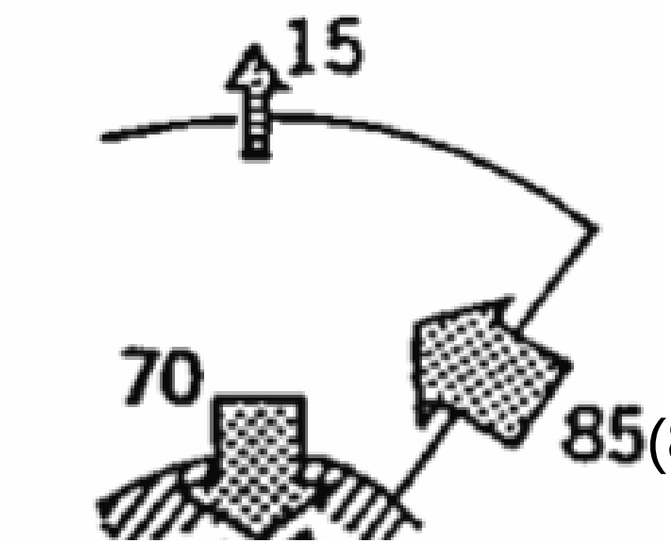


(80±3 from reanalysis)

In CESM-CAM5, less (more) energy fluxed into surface (space) than in ‘observations’.

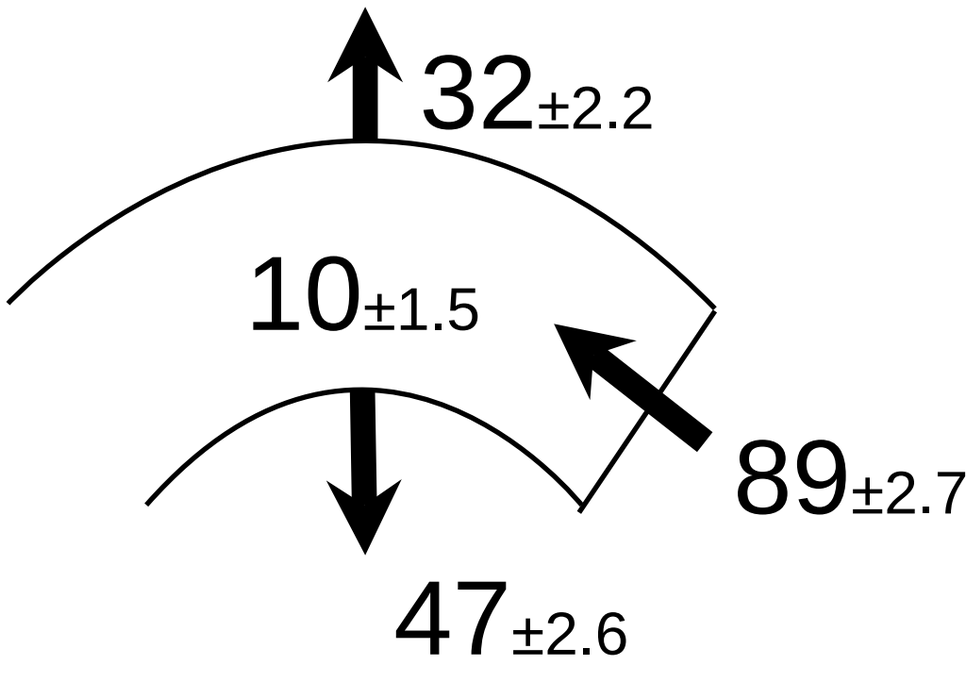
Additionally, 9 W/m^2 of heat added to atmosphere throughout summer

Summer heat flux into the Arctic



(80±3 from reanalysis)

In slab ocean - CAM4 experiments with identical ICs in spring, similar mean state.

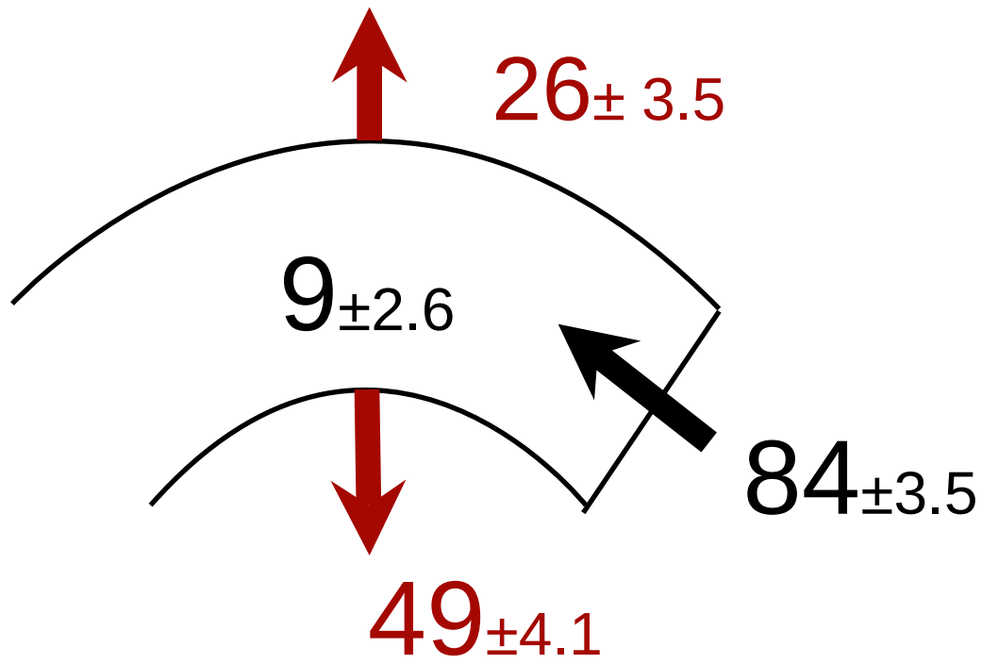


Also, low coupling heat transport / september sea ice (not shown)

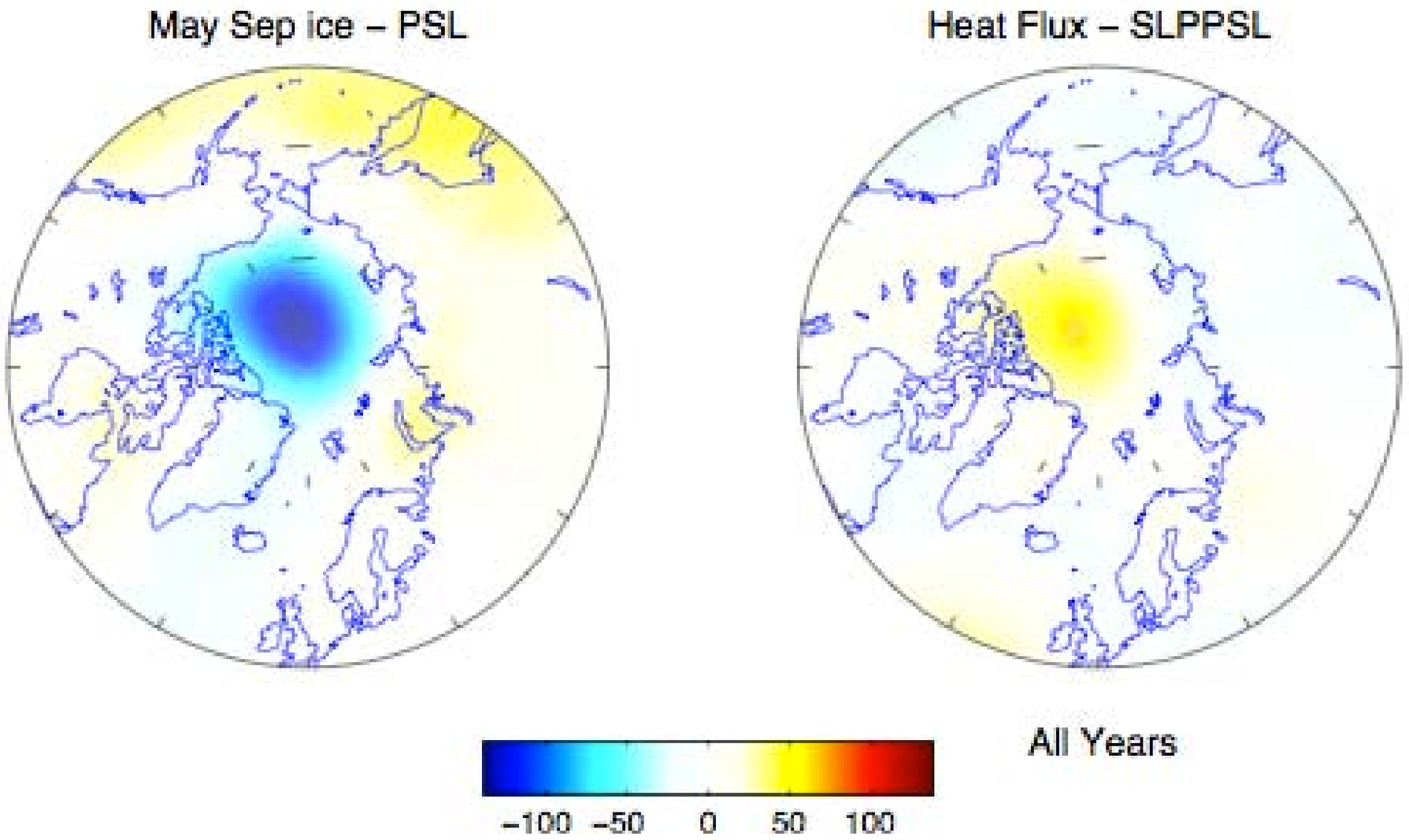
CCSM-CAM4 control shows the same low coupling

Energy

	Fwall	Fsur	Ftoa	E.sto
Fsur	0.36		0.93	0.16
Ftoa	0.11			0.05
E.sto	0.90			
Sep.ice	-0.34	-0.83	-0.82	-0.15

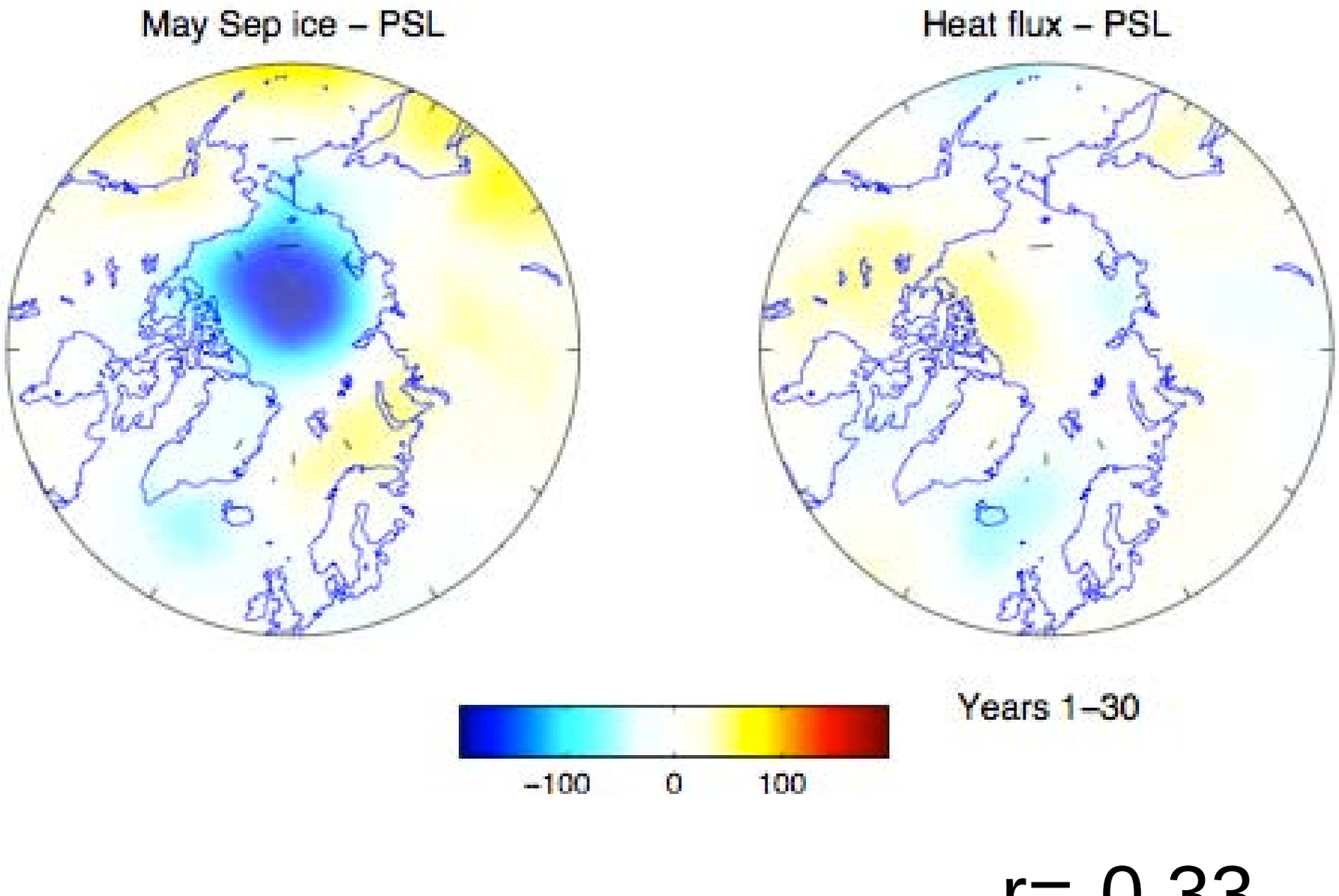


Non-stationarity of heat flux - sea ice coupling



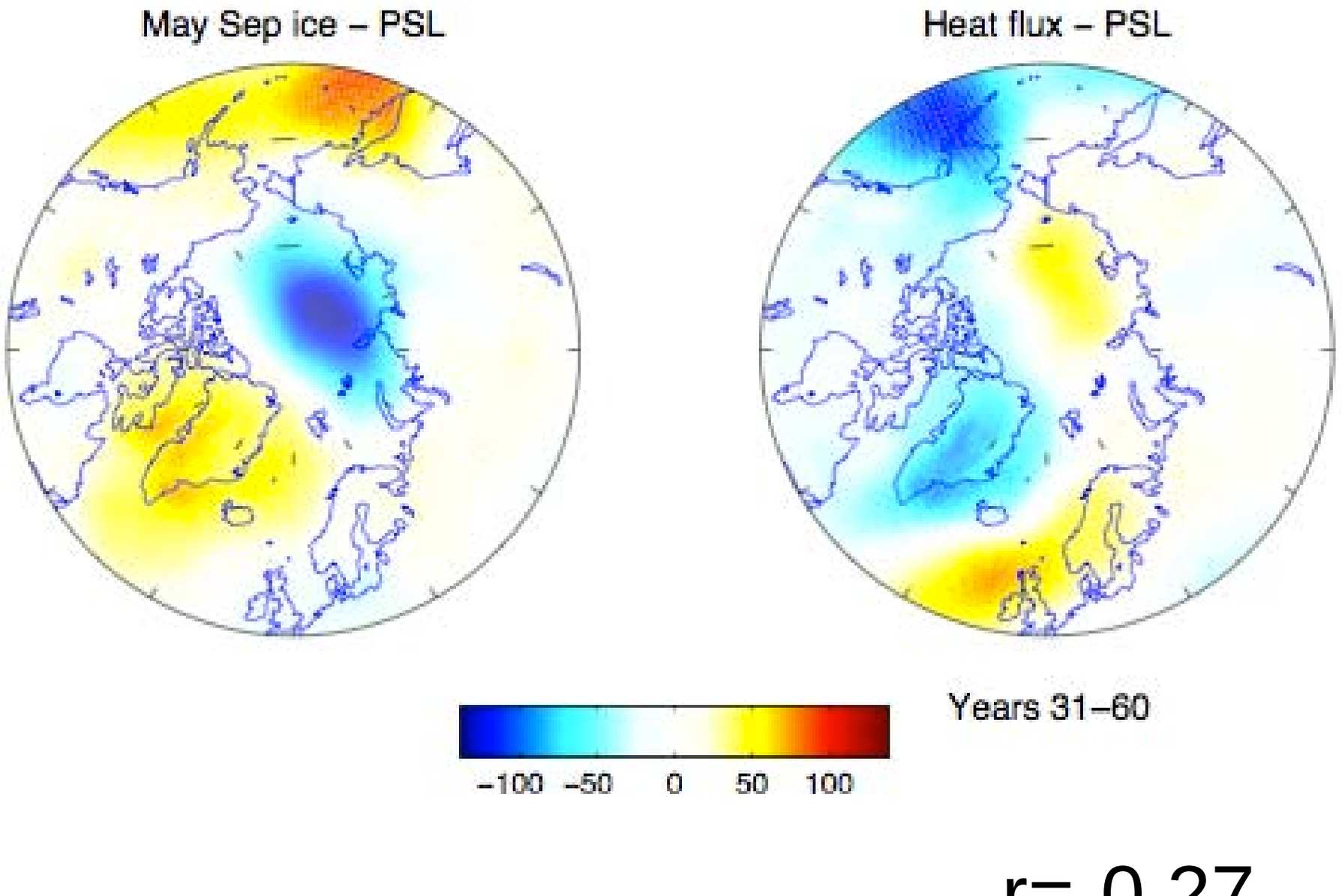
summer heat flux - september ice r=-0.34

Non-stationarity of heat flux - sea ice coupling



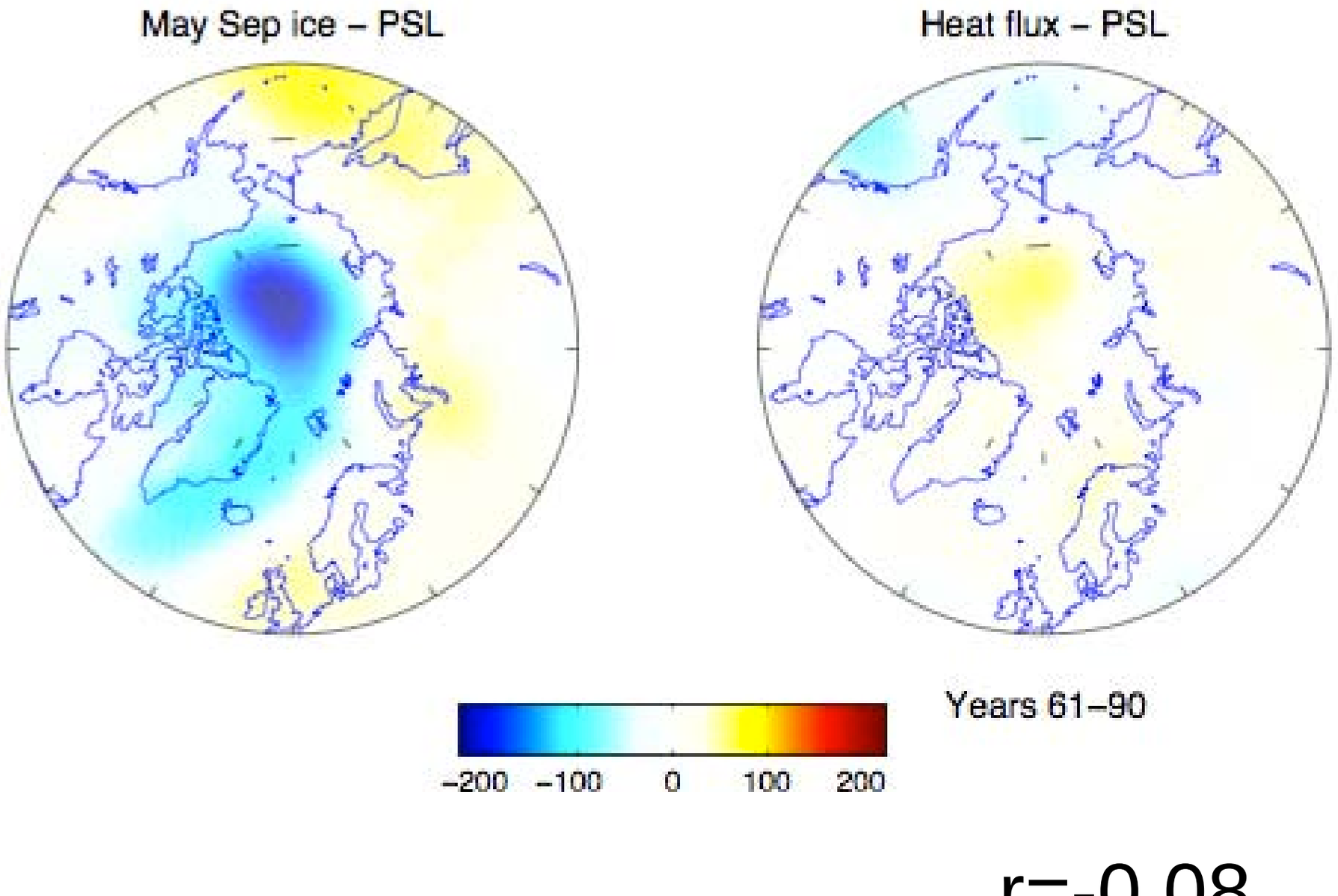
r=-0.33

Non-stationarity of heat flux - sea ice coupling



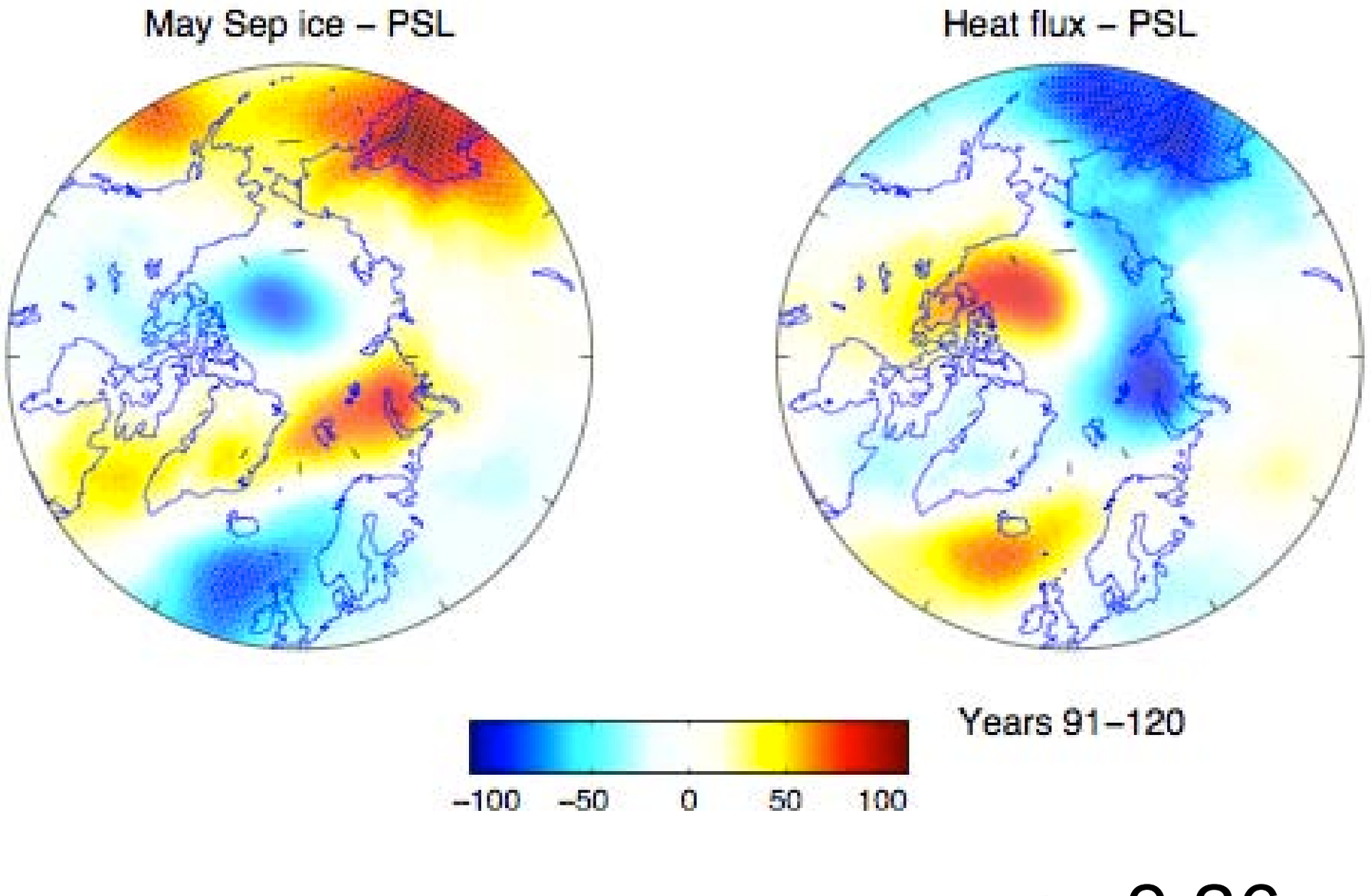
r=-0.27

Non-stationarity of heat flux - sea ice coupling



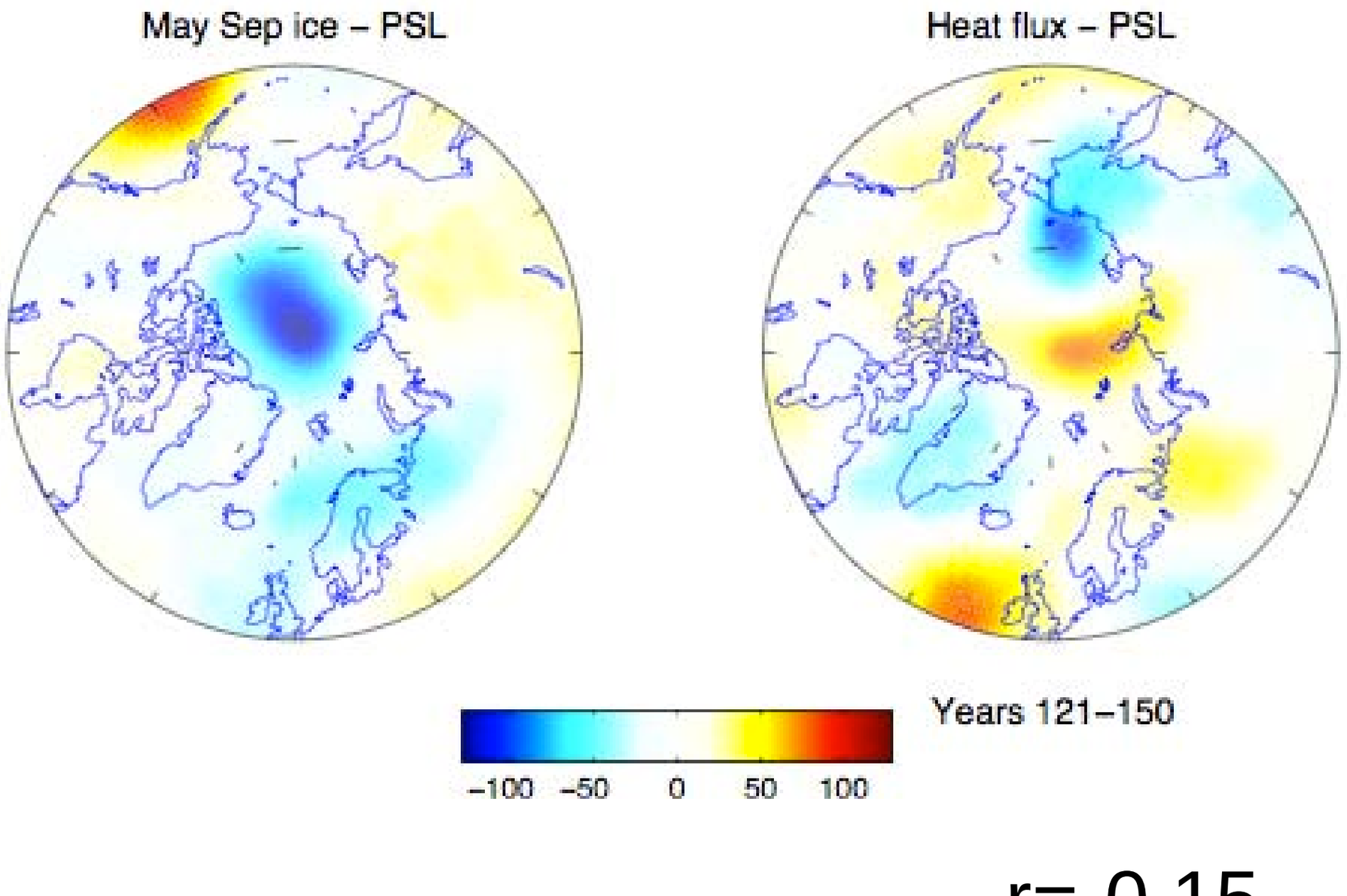
r=-0.08

Non-stationarity of heat flux - sea ice coupling



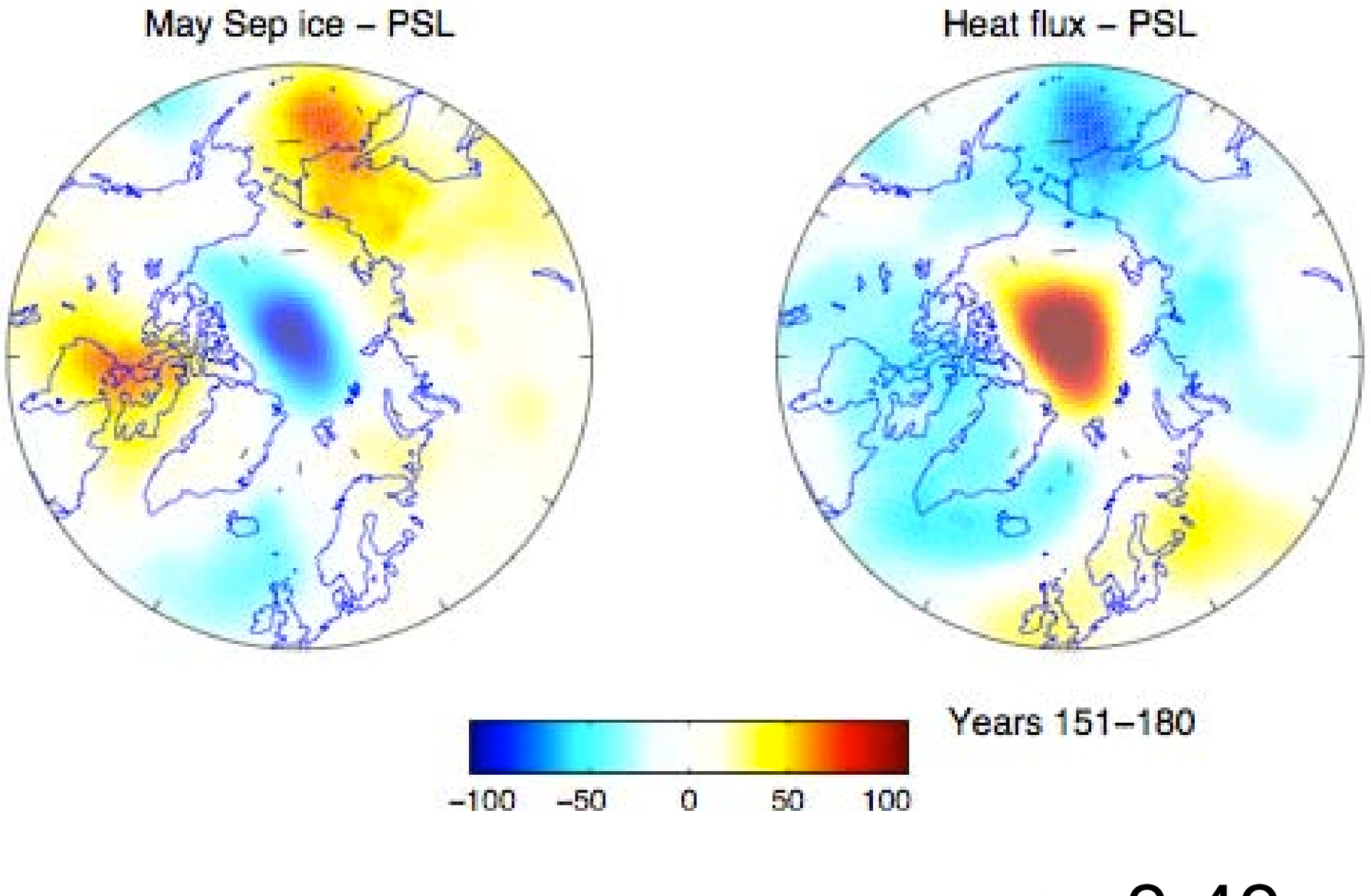
r=-0.36

Non-stationarity of heat flux - sea ice coupling



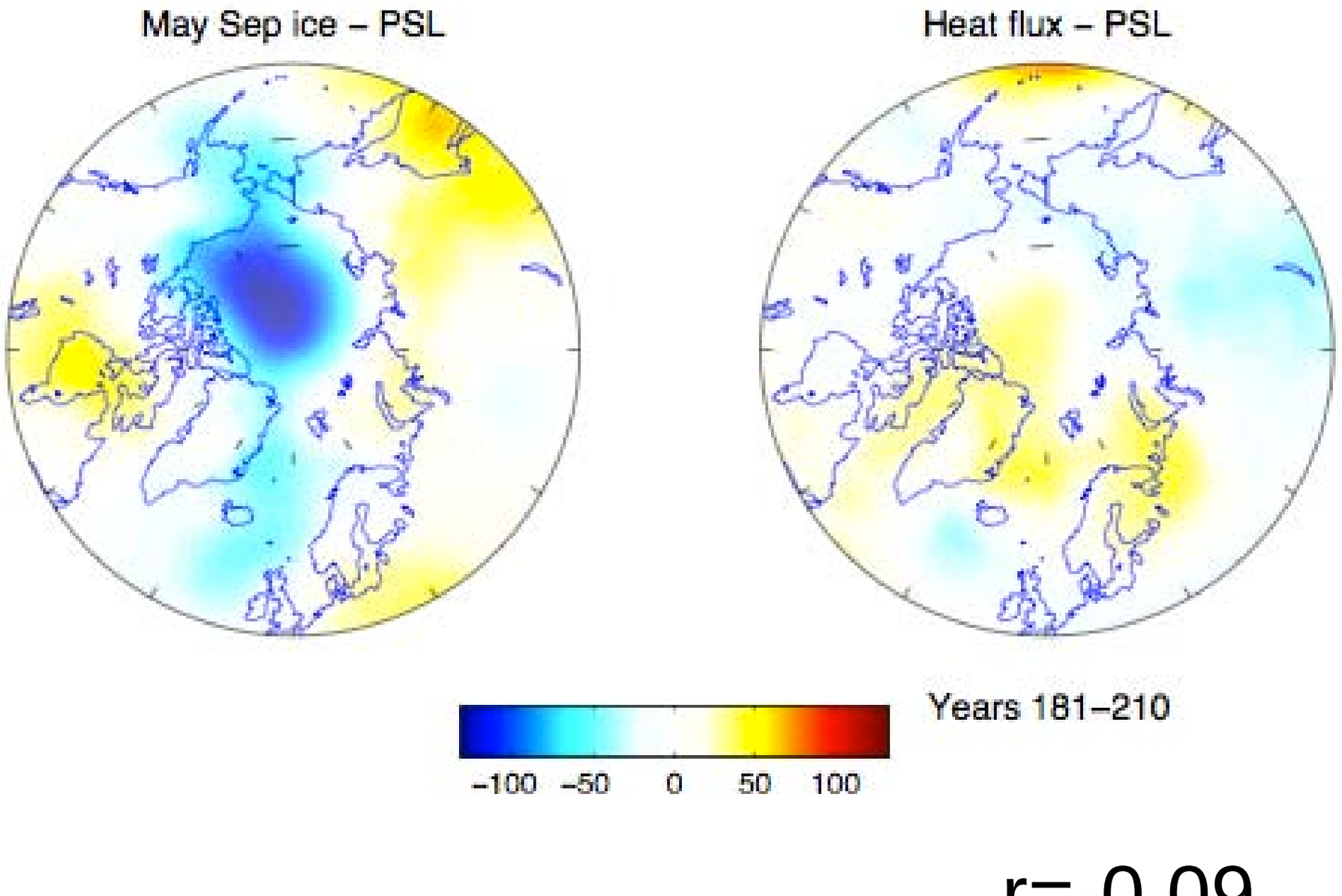
r=-0.15

Non-stationarity of heat flux - sea ice coupling



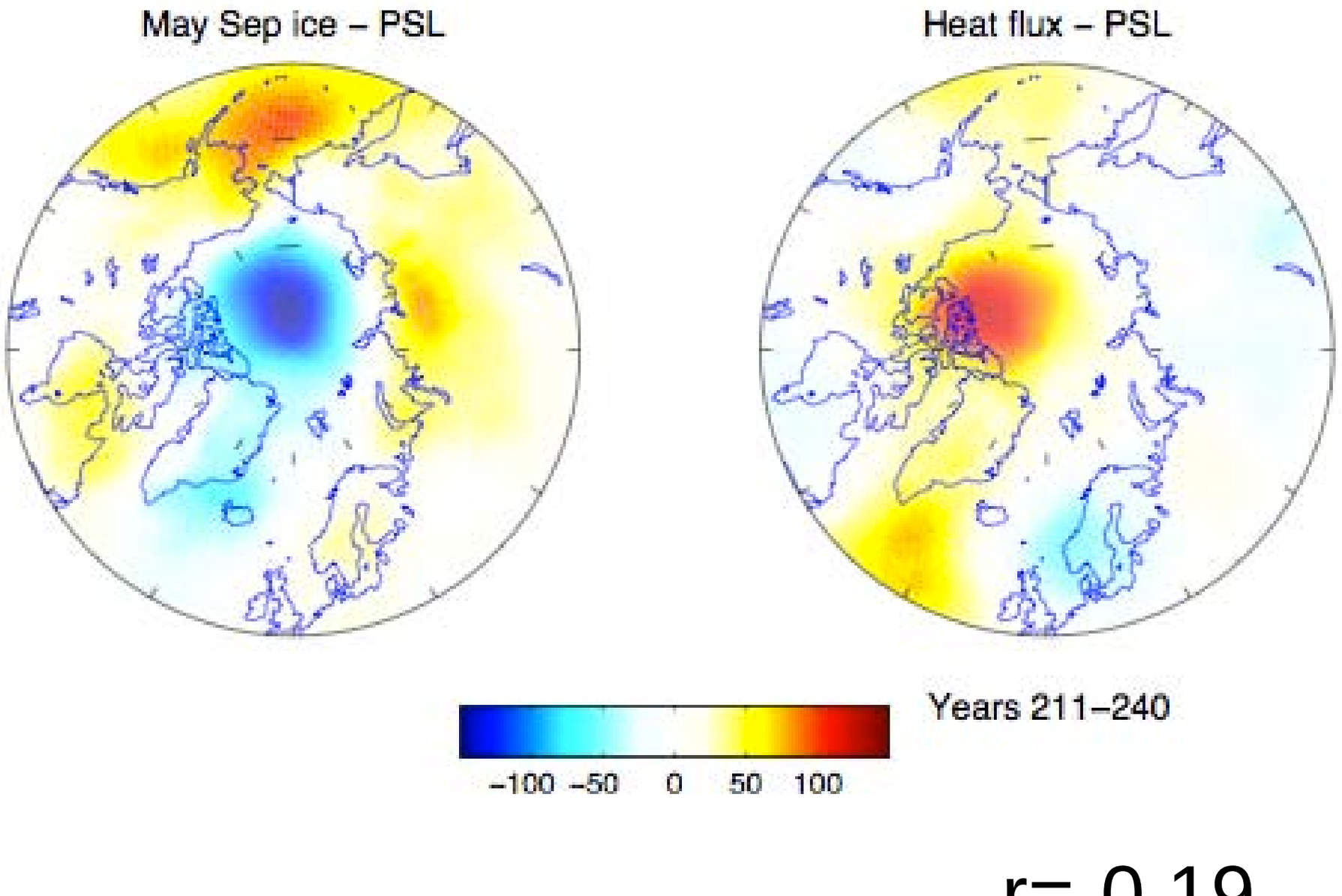
r=-0.40

Non-stationarity of heat flux - sea ice coupling



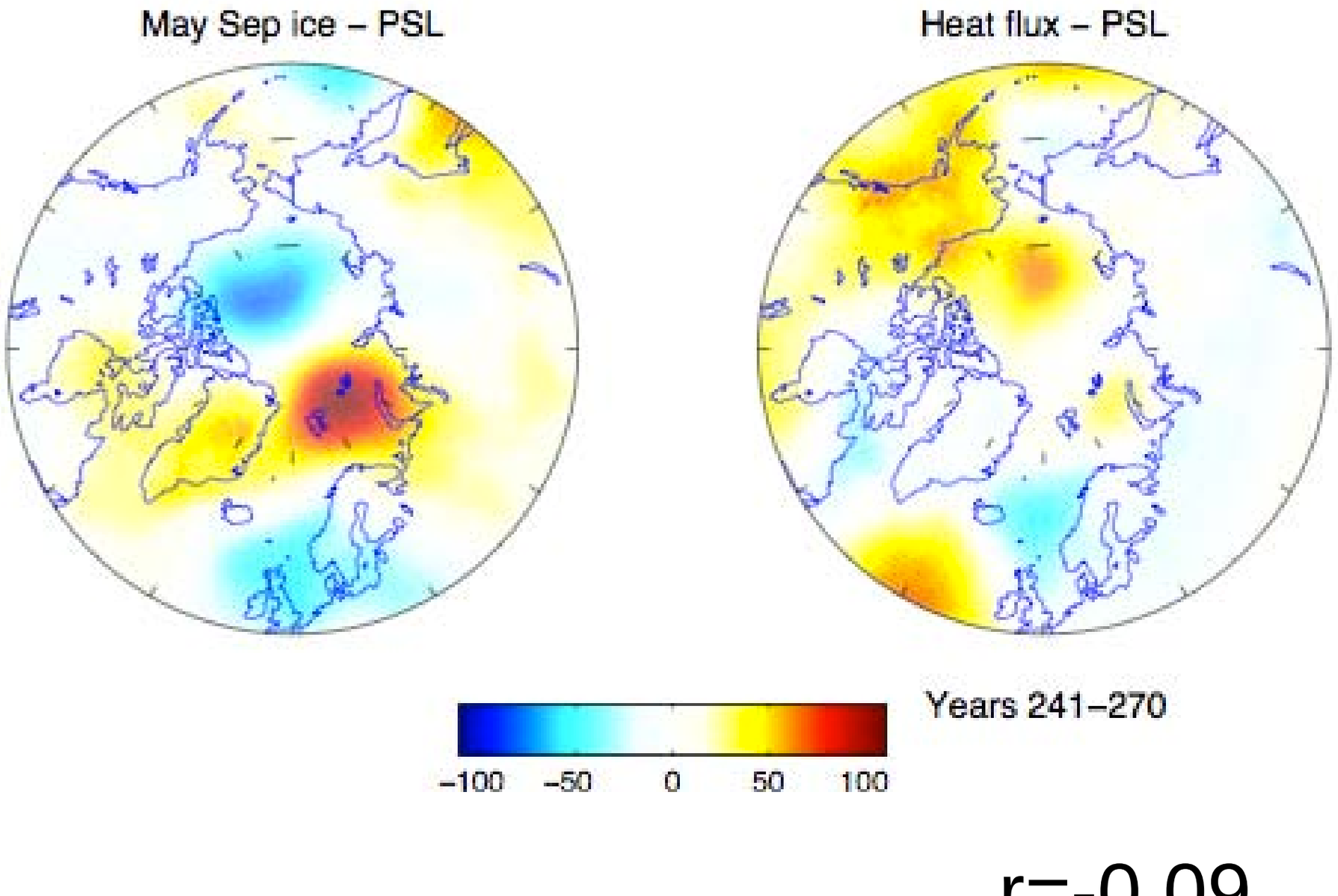
r=-0.09

Non-stationarity of heat flux - sea ice coupling



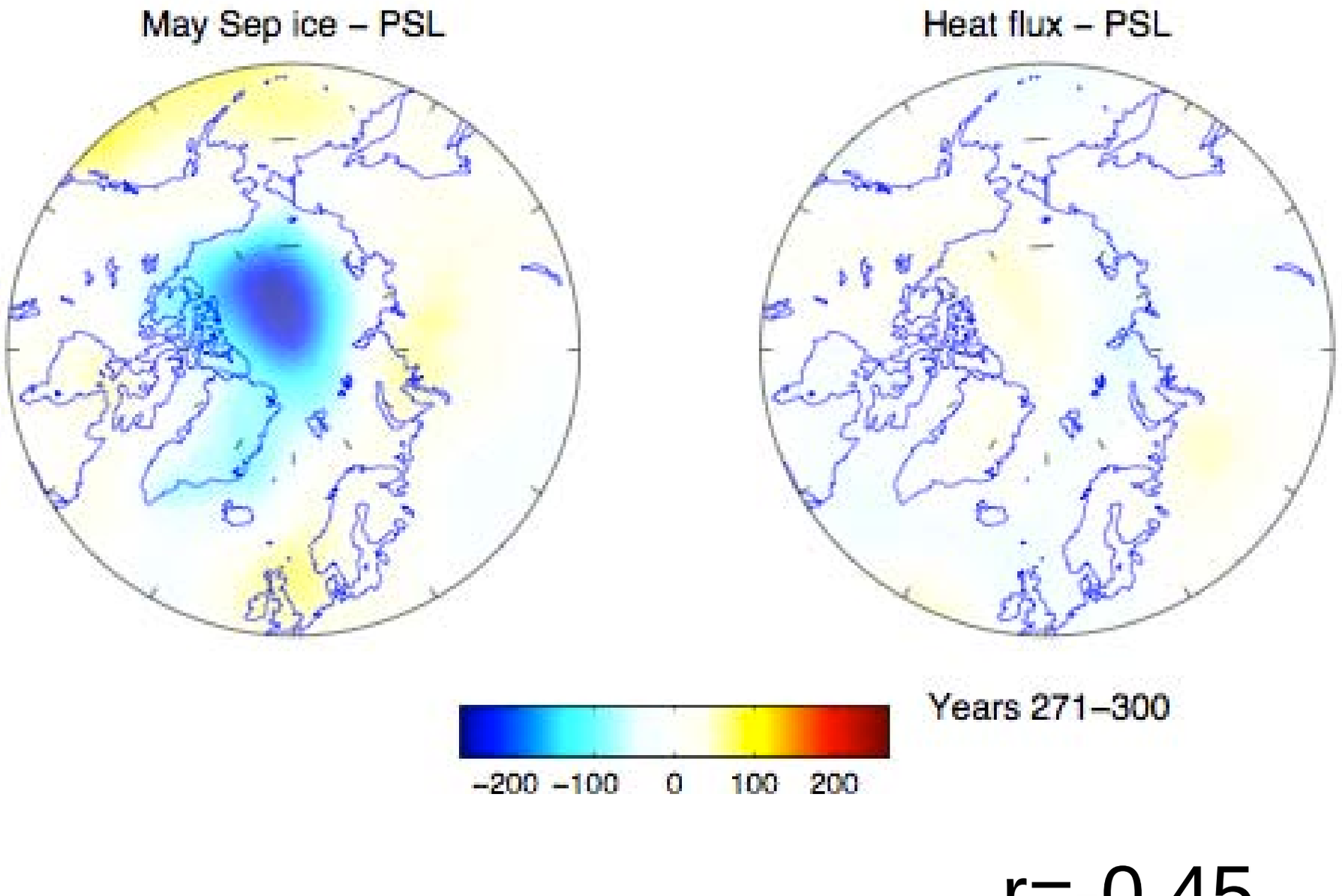
r=-0.19

Non-stationarity of heat flux - sea ice coupling



r=-0.09

Non-stationarity of heat flux - sea ice coupling



r=-0.45

Final thoughts...

- Does summer atmospheric heat flux help explain variability of summer sea ice?
  - Observations... strongly
  - Model... weakly
  - But in both cases, negative correlation.

- Are the model fluxes too ‘uncoupled’? What is the mechanism heat flux -> sea ice melt? How sensitive is it to mean state?

- Have we just ‘observed’ an uncommon period of ‘coupling’ between sea ice variability and heat flux?

- Background variability leads to non-stationary relationships between different fields... not a good thing for statistical predictions

r=-0.45