The climate response to sudden summertime sea ice loss in CCSM4

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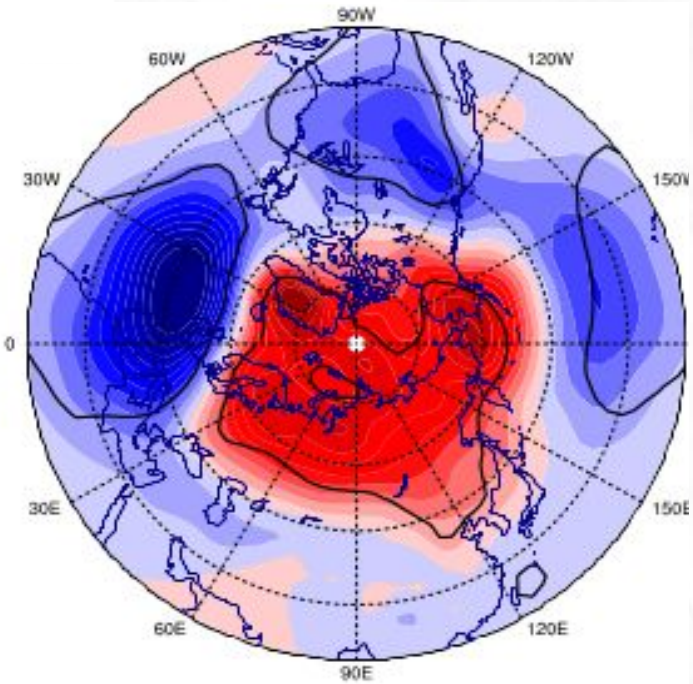
Background

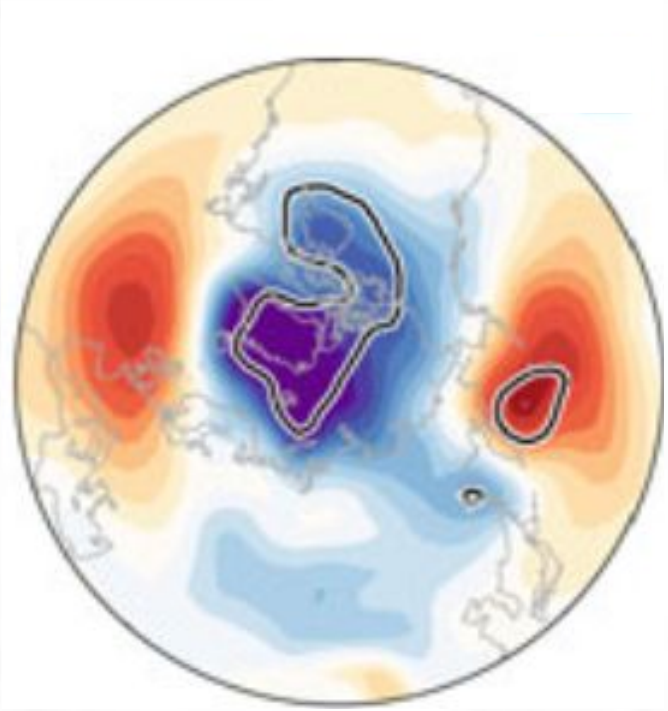
- The loss of Arctic sea ice may have a big impact at both high and mid-latitudes
- Link between sea ice and atmosphere in observations are difficult to make because of short time series, internal variability, changes in aerosols, greenhouse gases and other forcings
- Most modelling studies are done by forcing an atmospheric model with prescribed SSTs and low sea ice concentrations

Background

- Very little agreement between modelling studies...



Liu et al. 2012

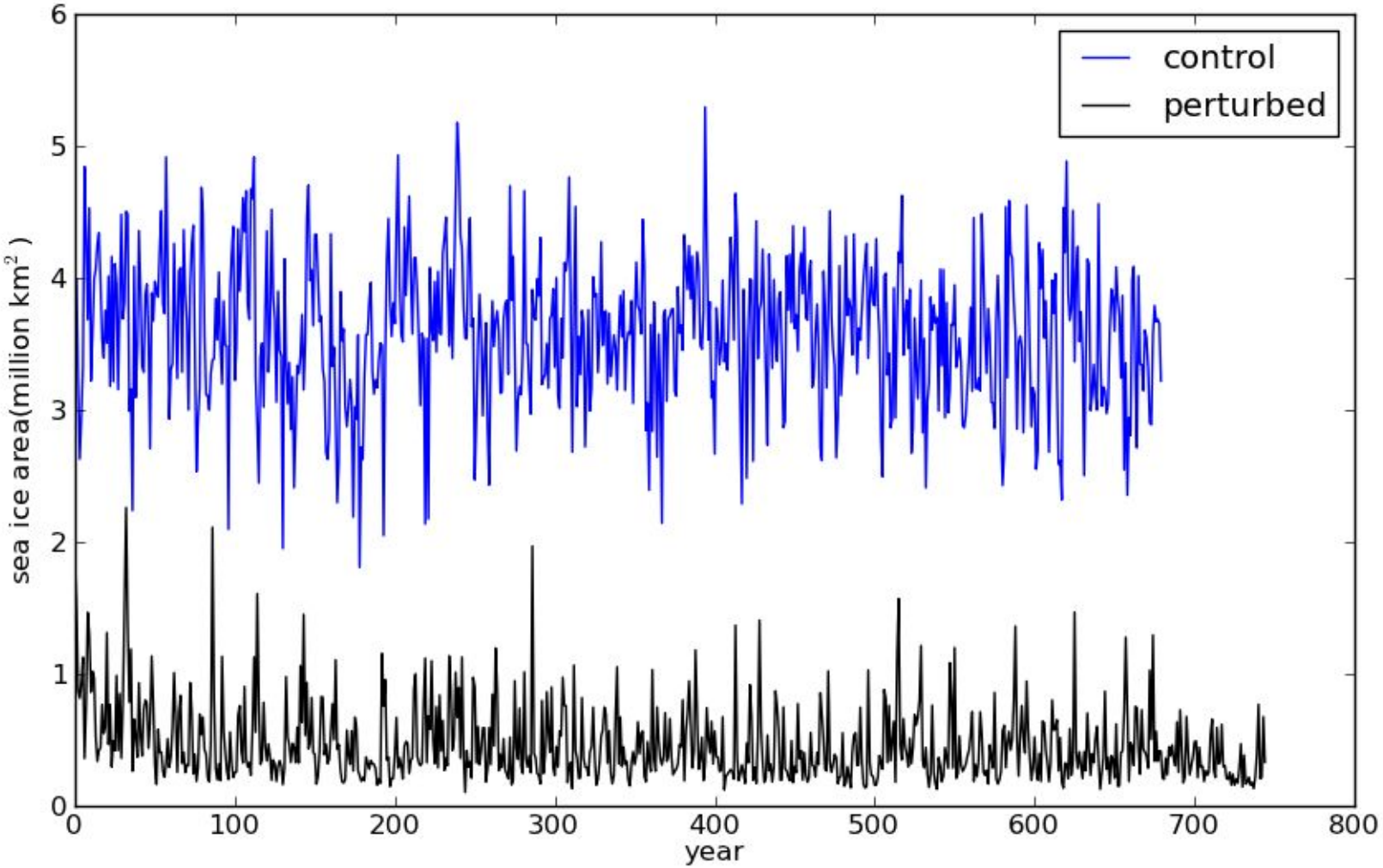


Screen et al. 2013

Experiment design

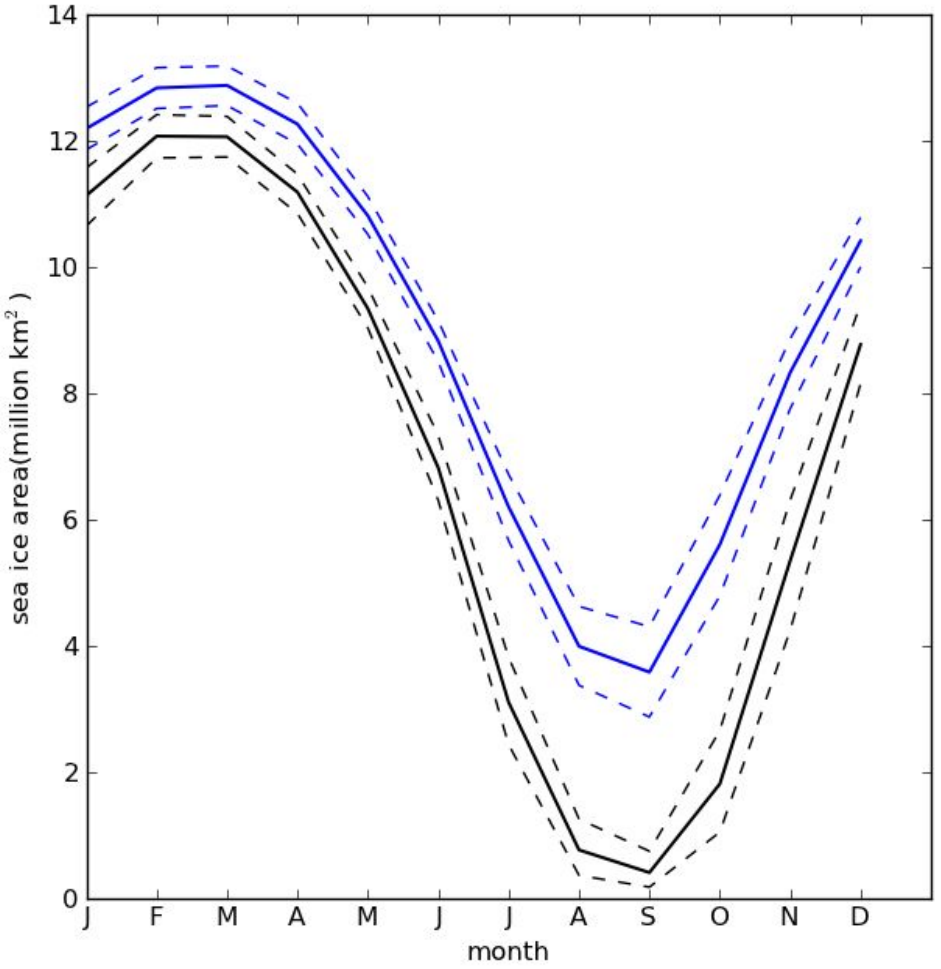
- 800 year long present day control run of CCSM4 at 1° resolution
- We changed the properties of the sea ice model which caused a decrease in the albedo and melted the sea ice in the summer
- 8 perturbed realizations branched from the control run 50 years apart
  - 1 x 800 years
  - 2 x 350 years
  - 5 x 50 years

September sea ice area

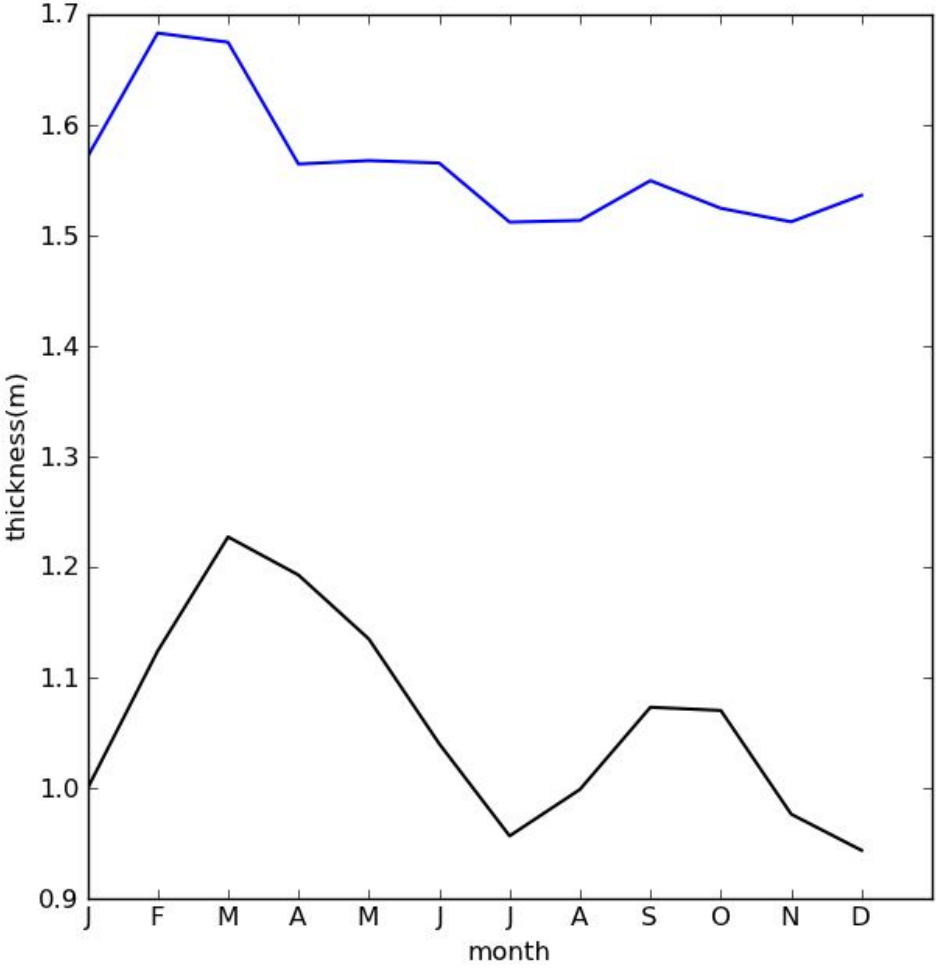


Seasonal cycle

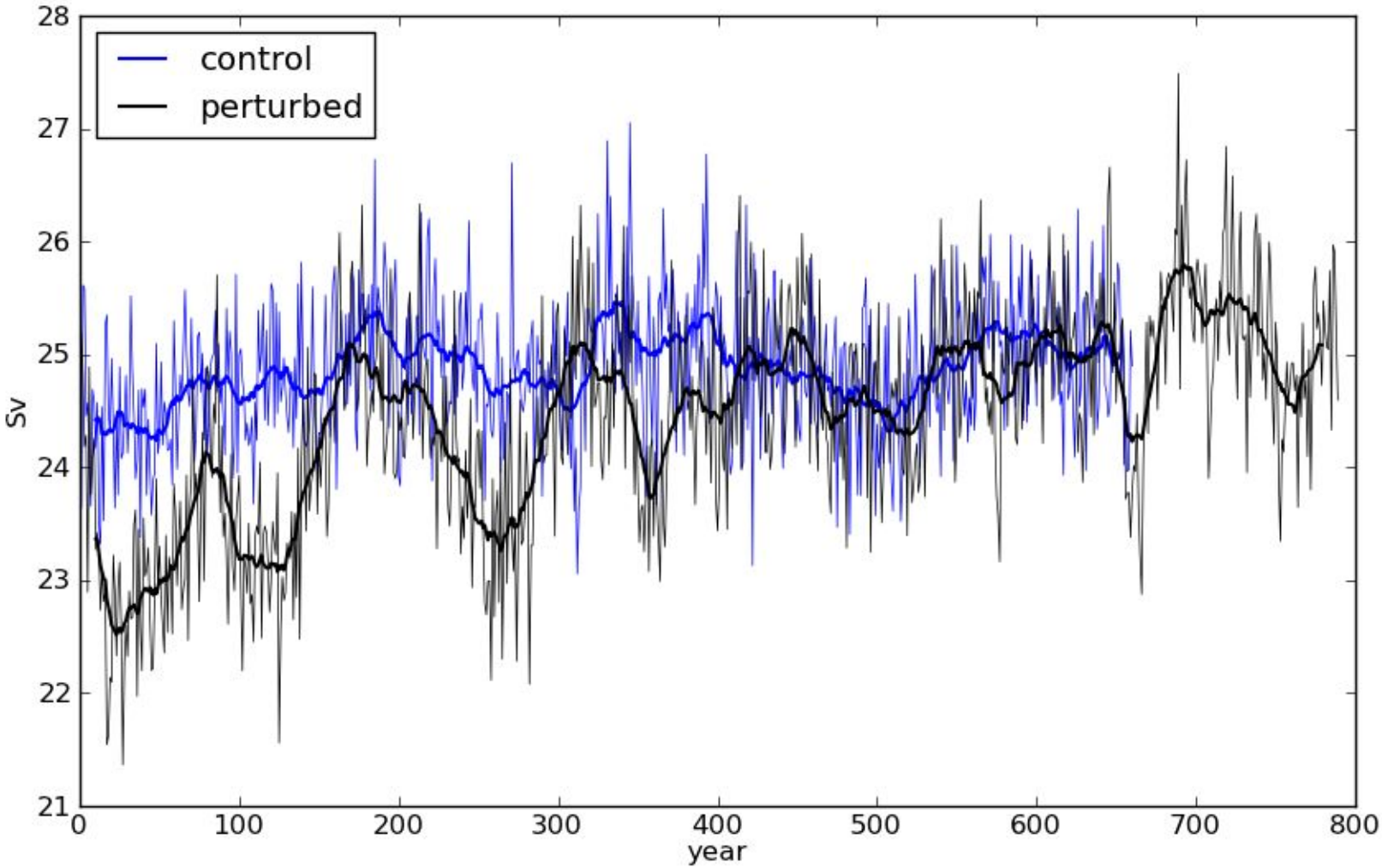
Sea ice area



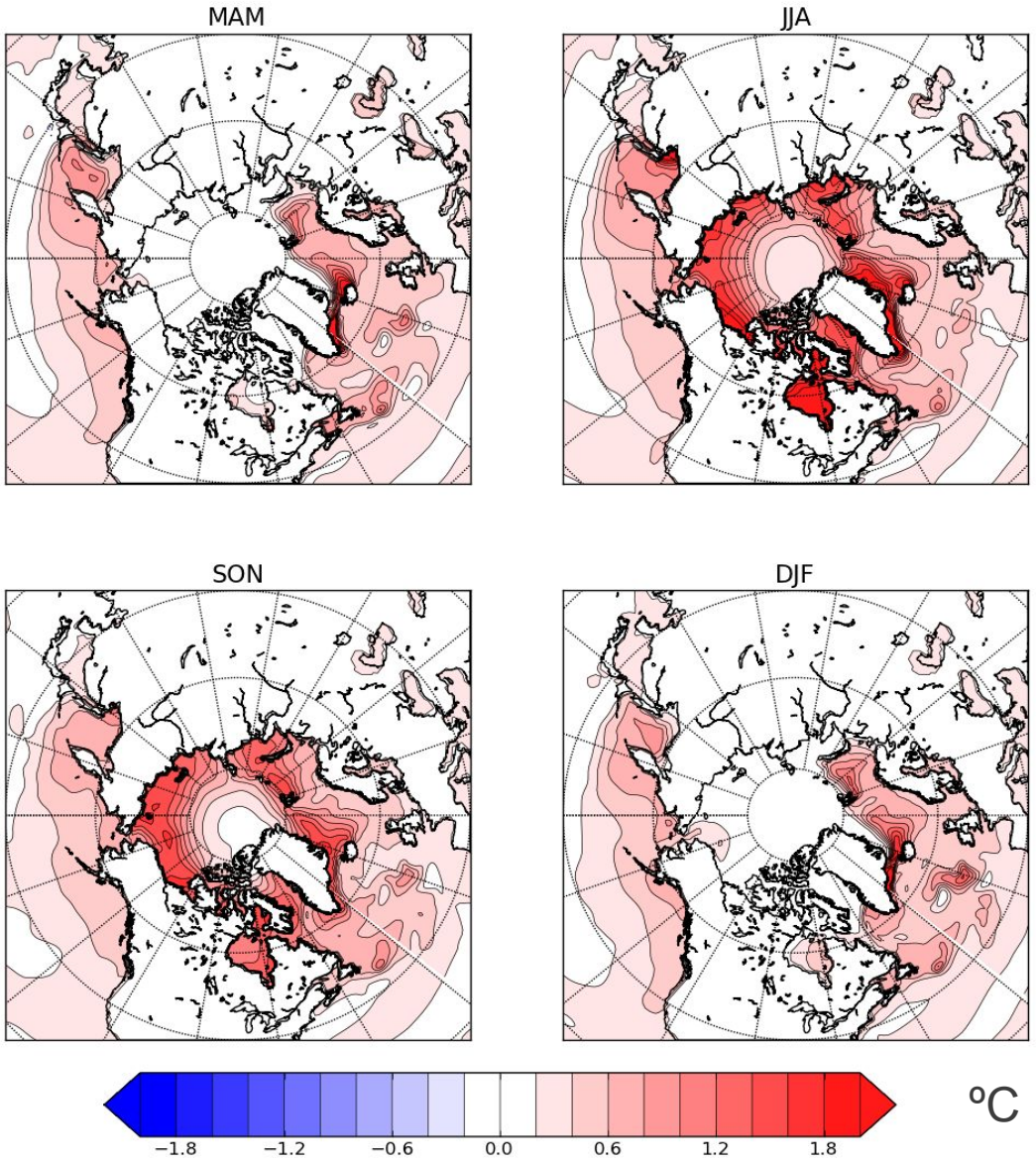
Sea ice thickness



AMOC response

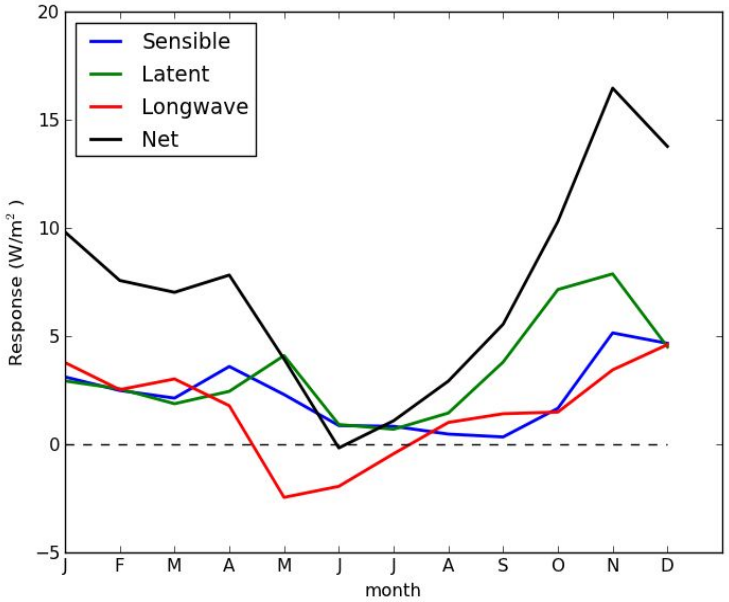


Equilibrium SST response

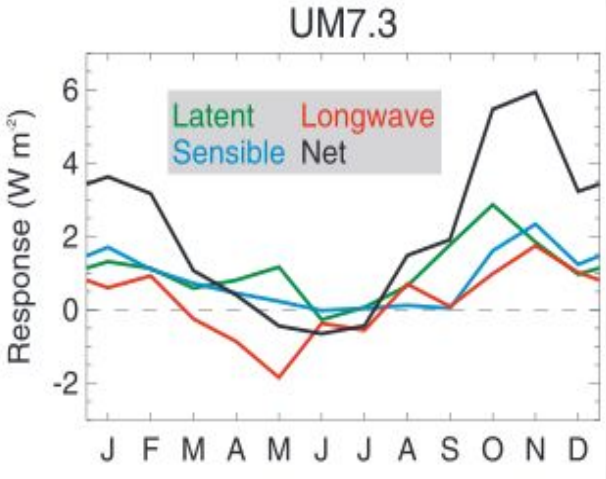


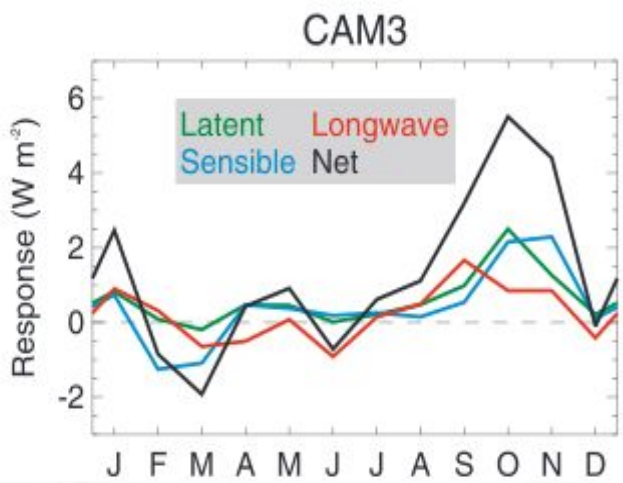
Arctic surface energy budget

CCSM4



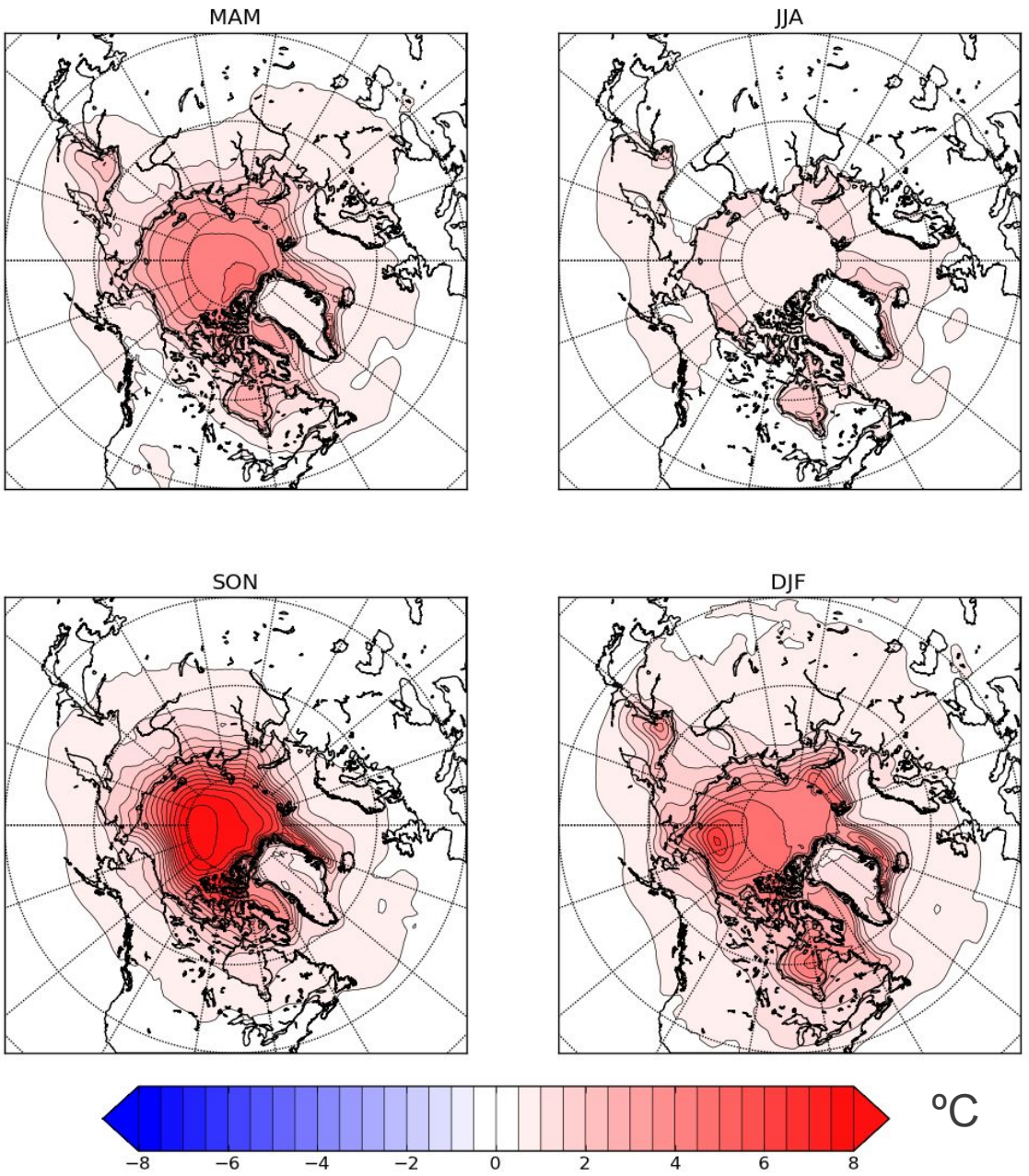
Prescribed sea ice experiments



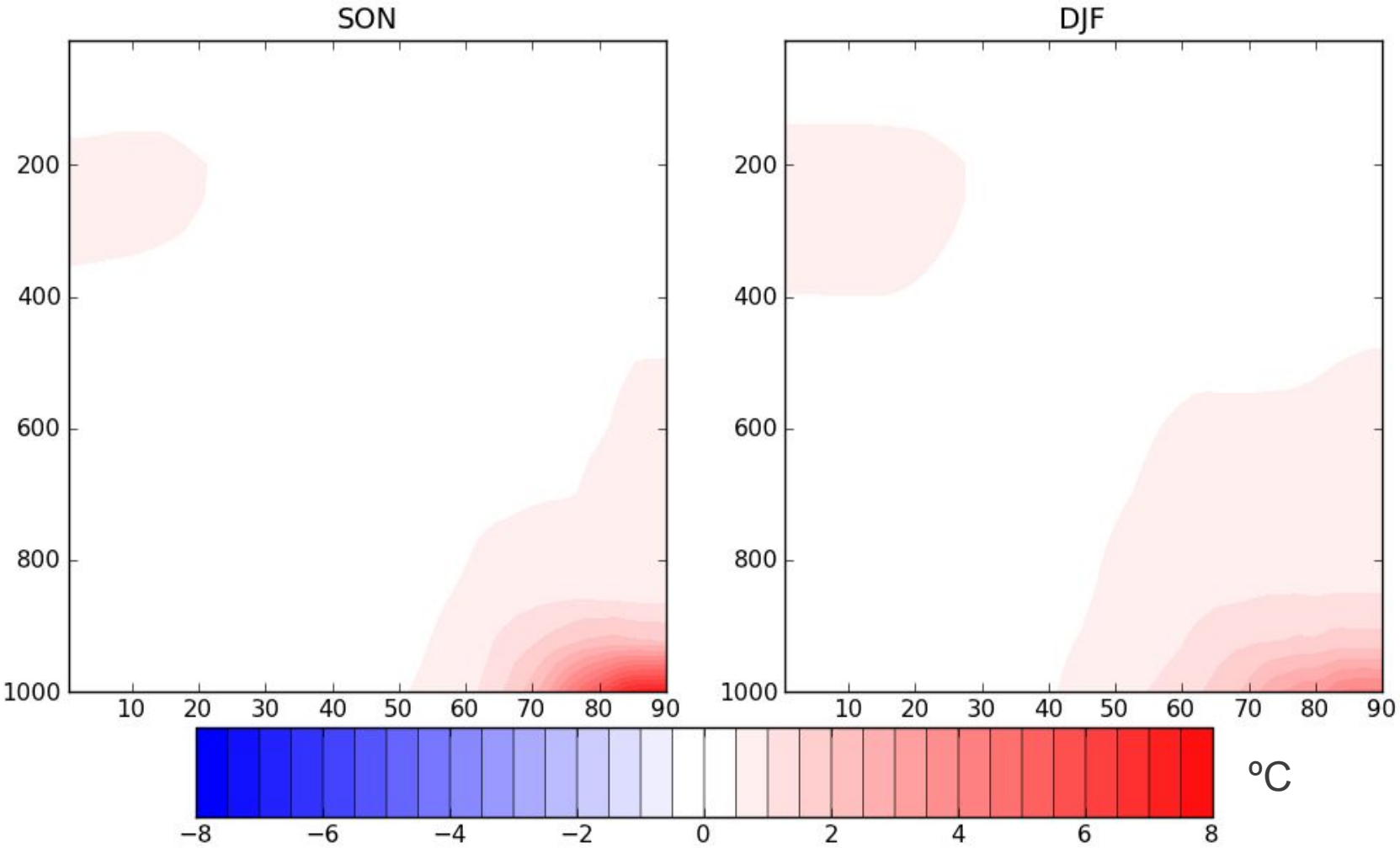


Screen et al. 2013

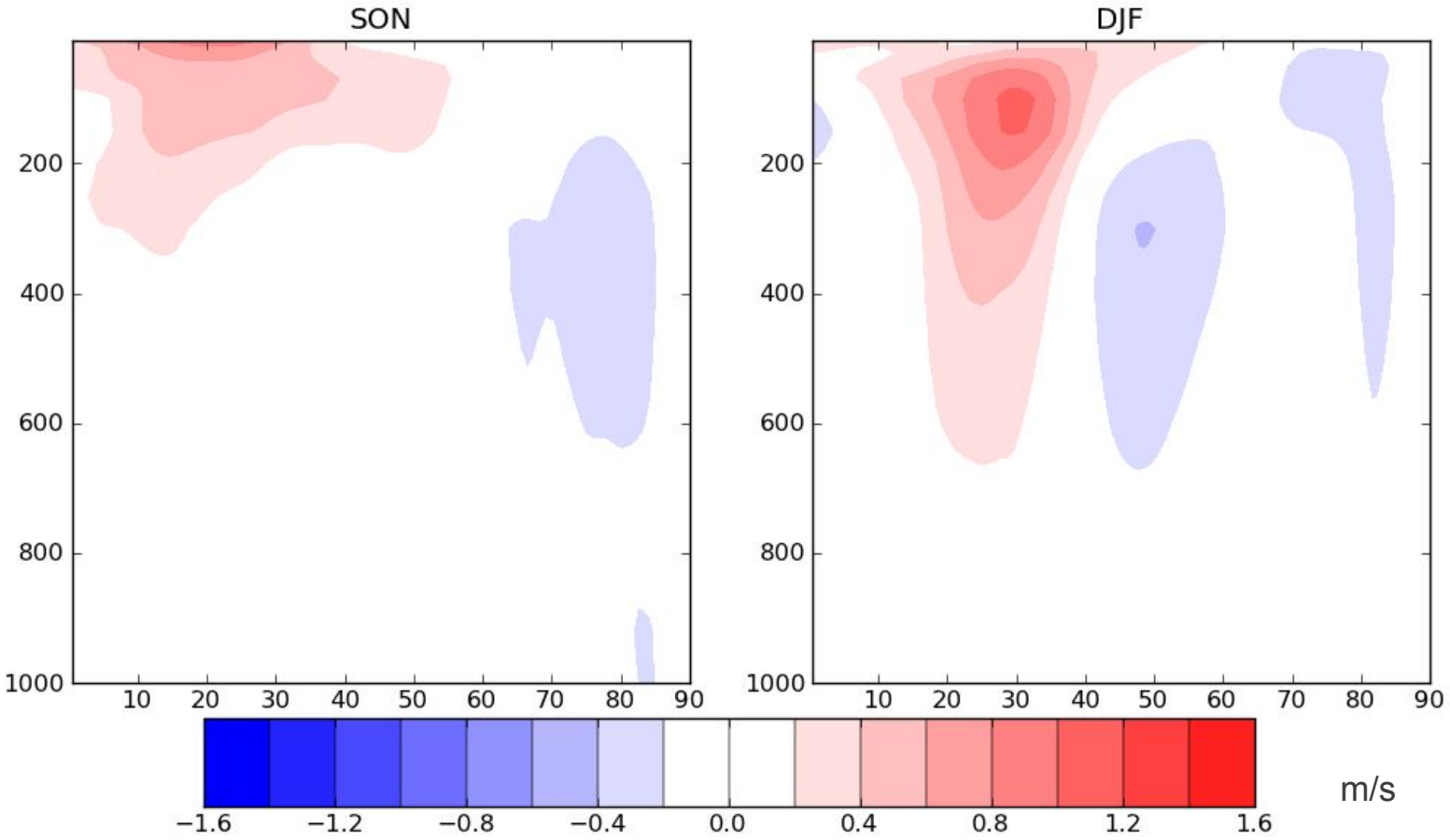
2m Temperature



Zonal mean temperature

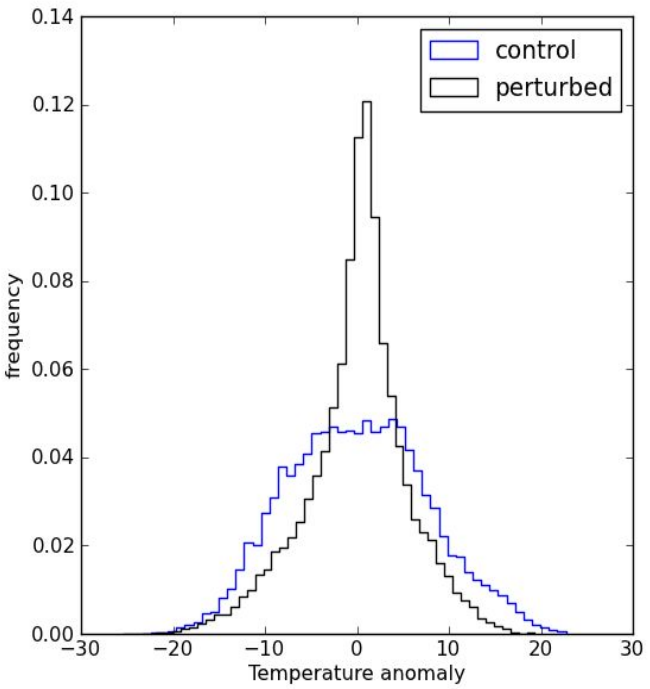


Zonal mean U

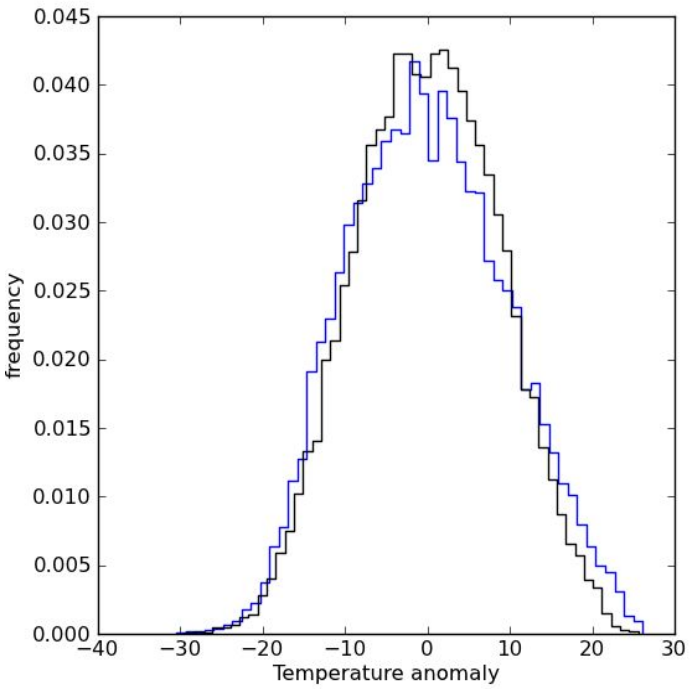

SON
DJF
200
400
600
800
1000
10
20
30
40
50
60
70
80
90
−1.6
−1.2
−0.8
−0.4
0.0
0.4
0.8
1.2
1.6
m/s

Daily 2m temperature distribution (DJF)

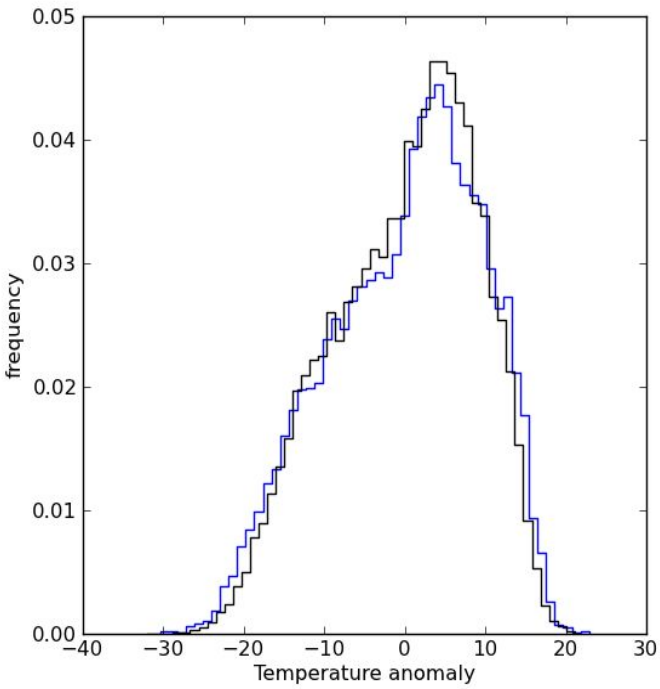
Arctic Ocean
74N 160W



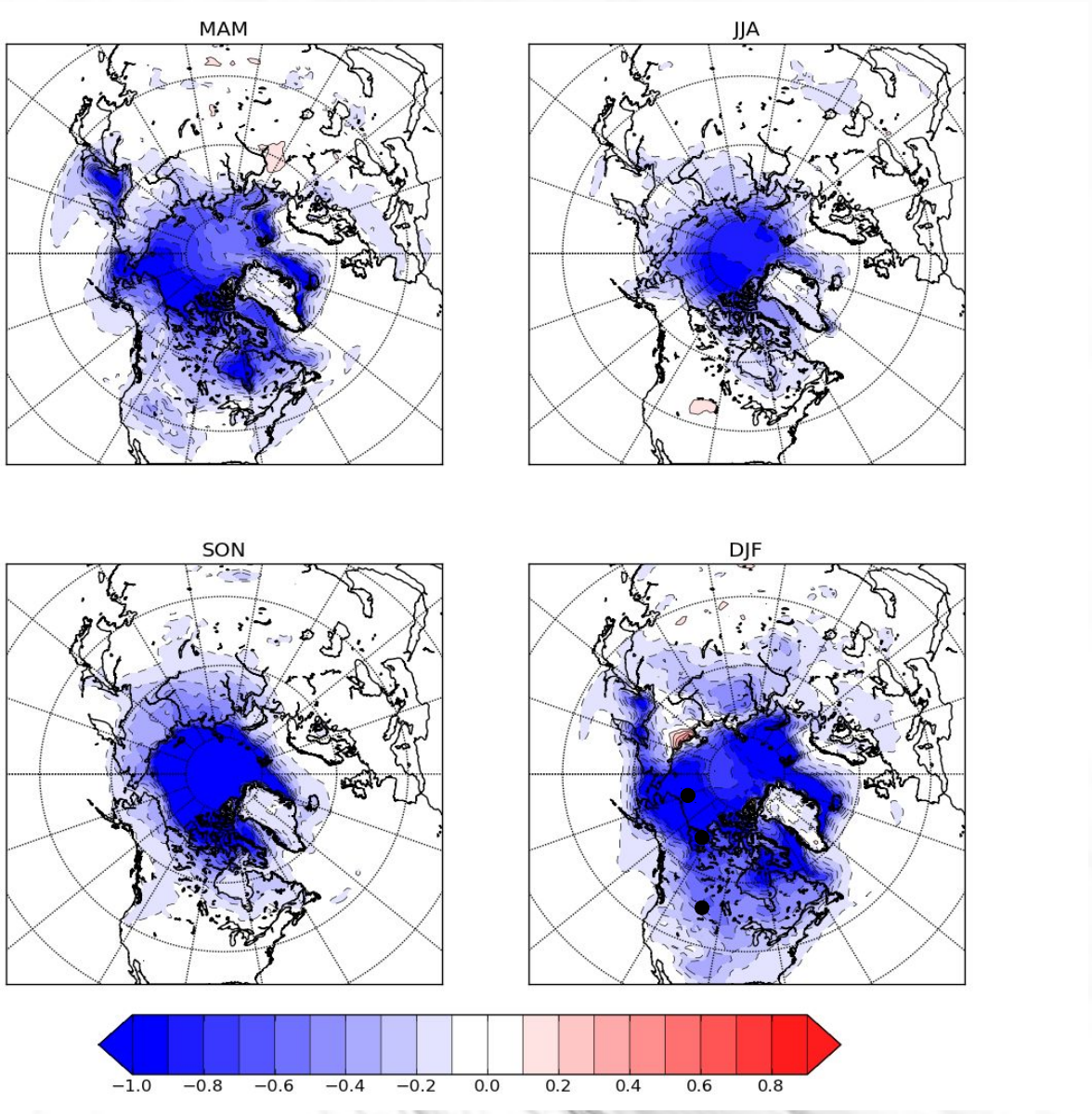
Arctic Coast
68N 130W



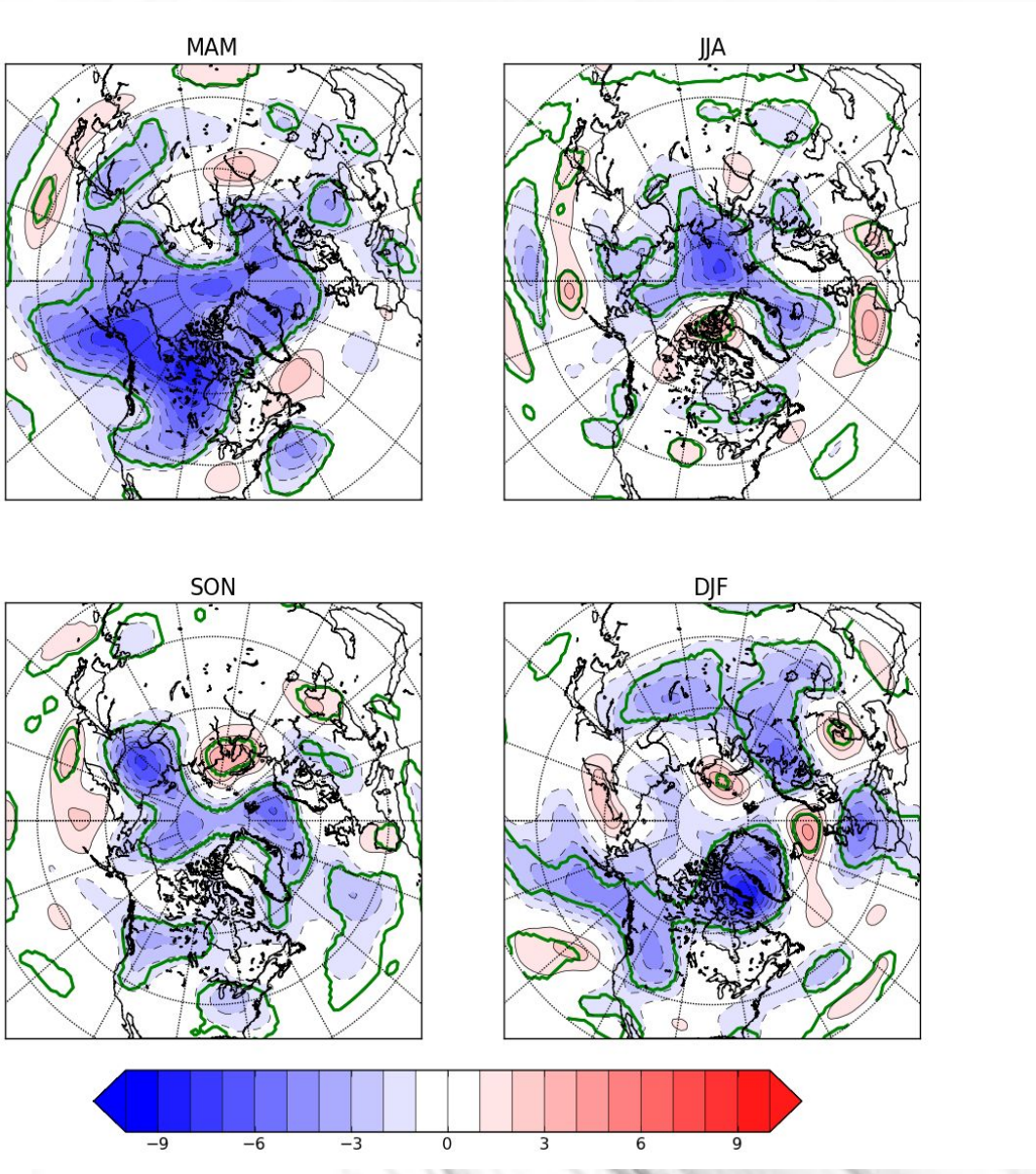
Inland (Saskatchewan)
54N 107W



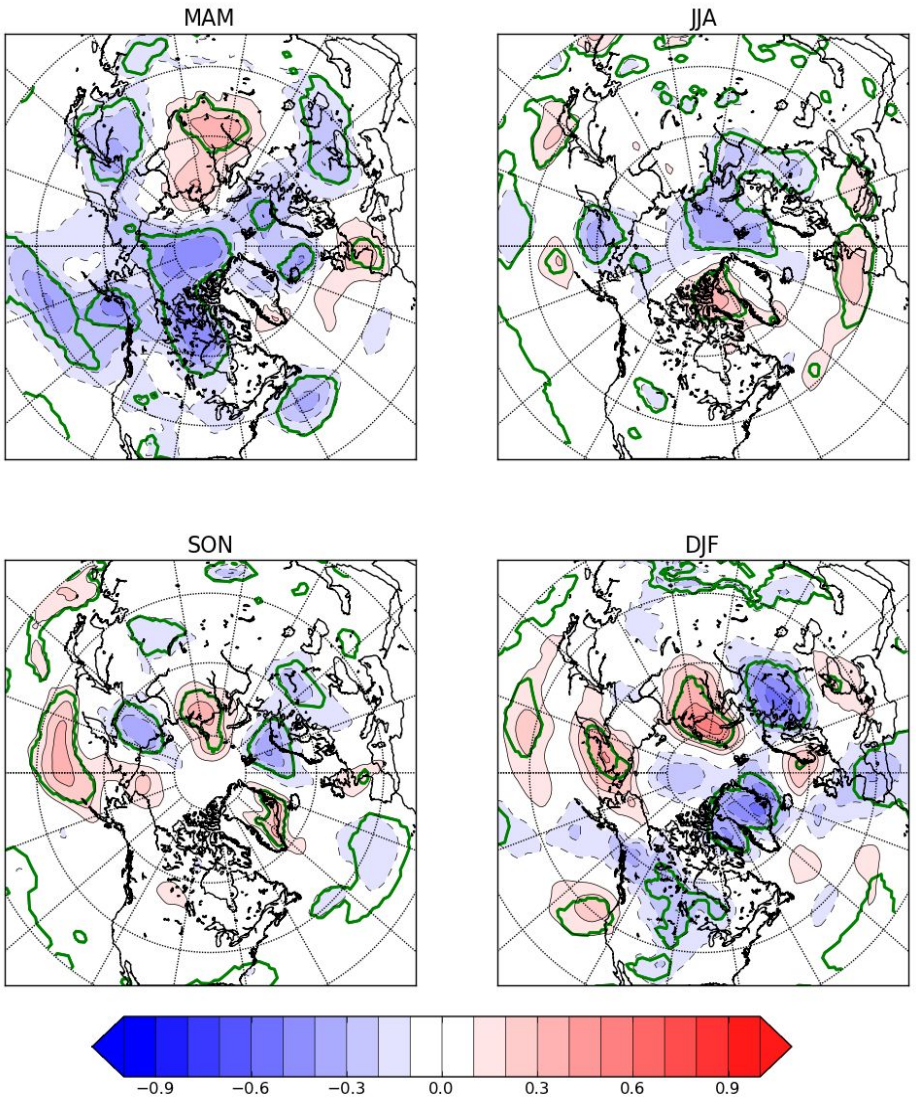
Daily 2m temperature standard deviation



Z500 standard deviation

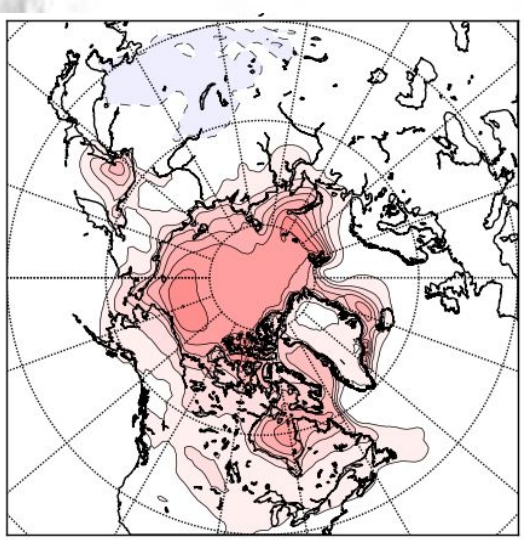


SLP standard deviation



Transient Response?

DJF 2m Temperature (years 1-50)



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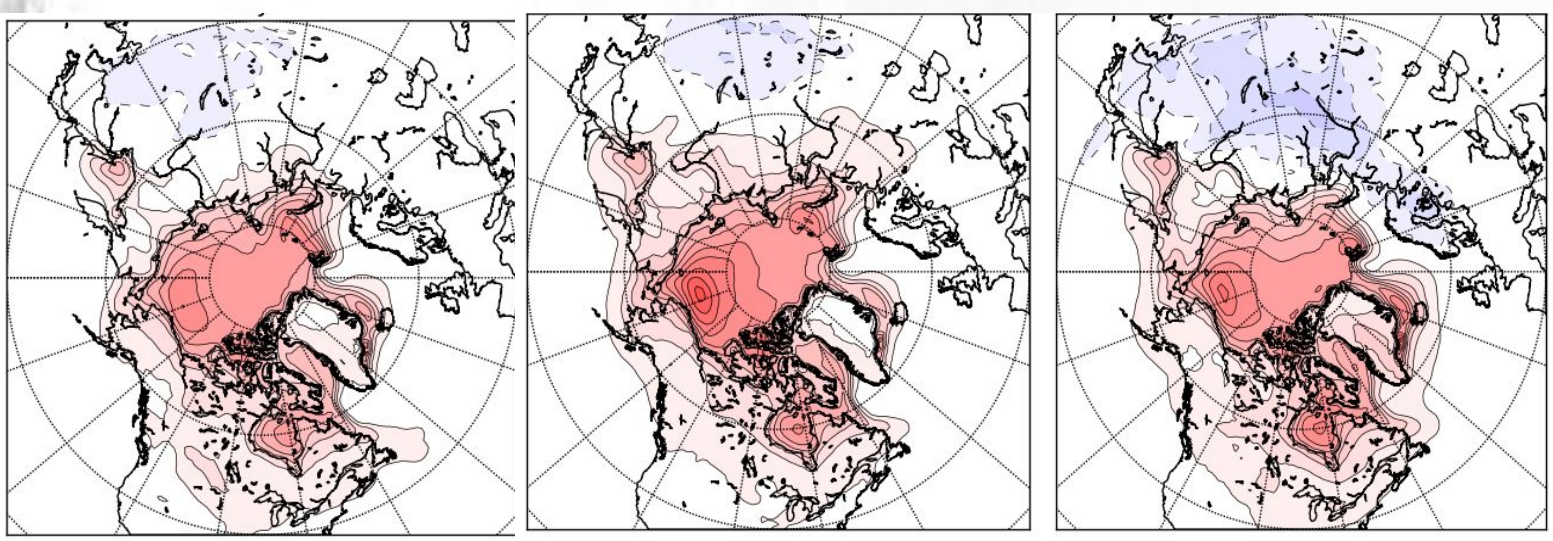

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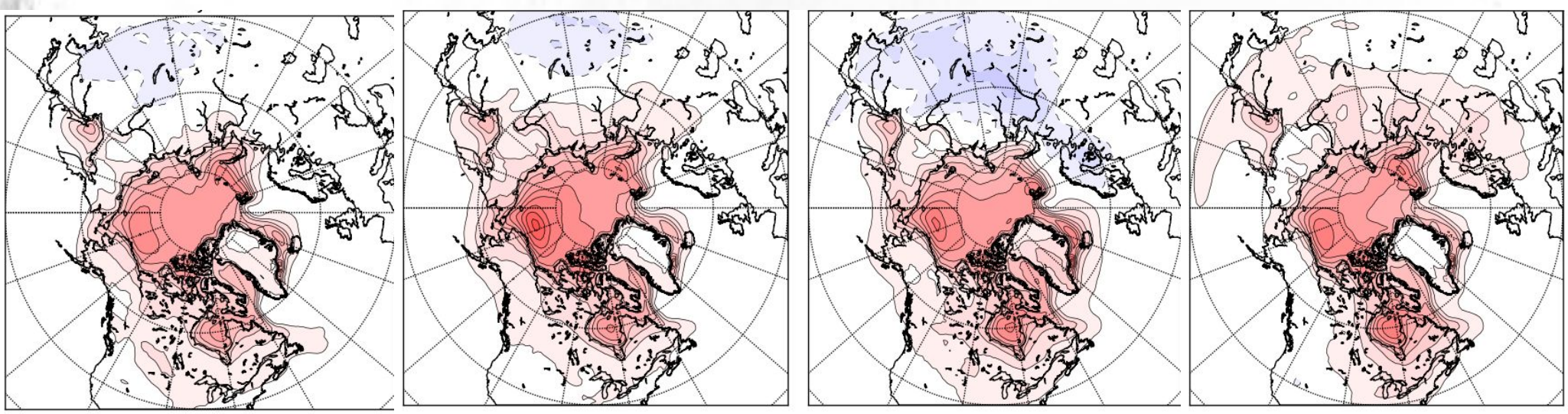
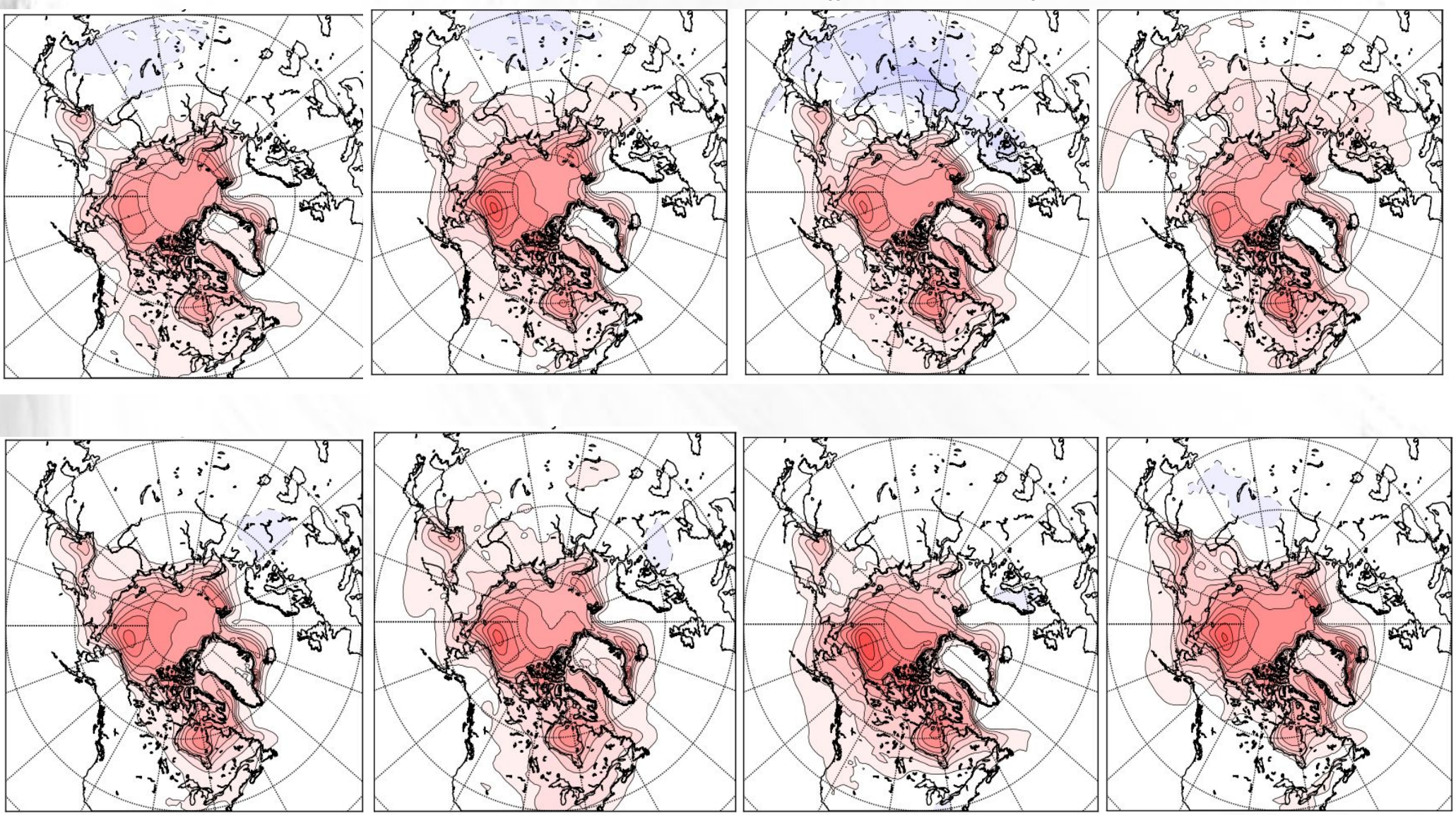
DJF 2m Temperature (years 1-50)

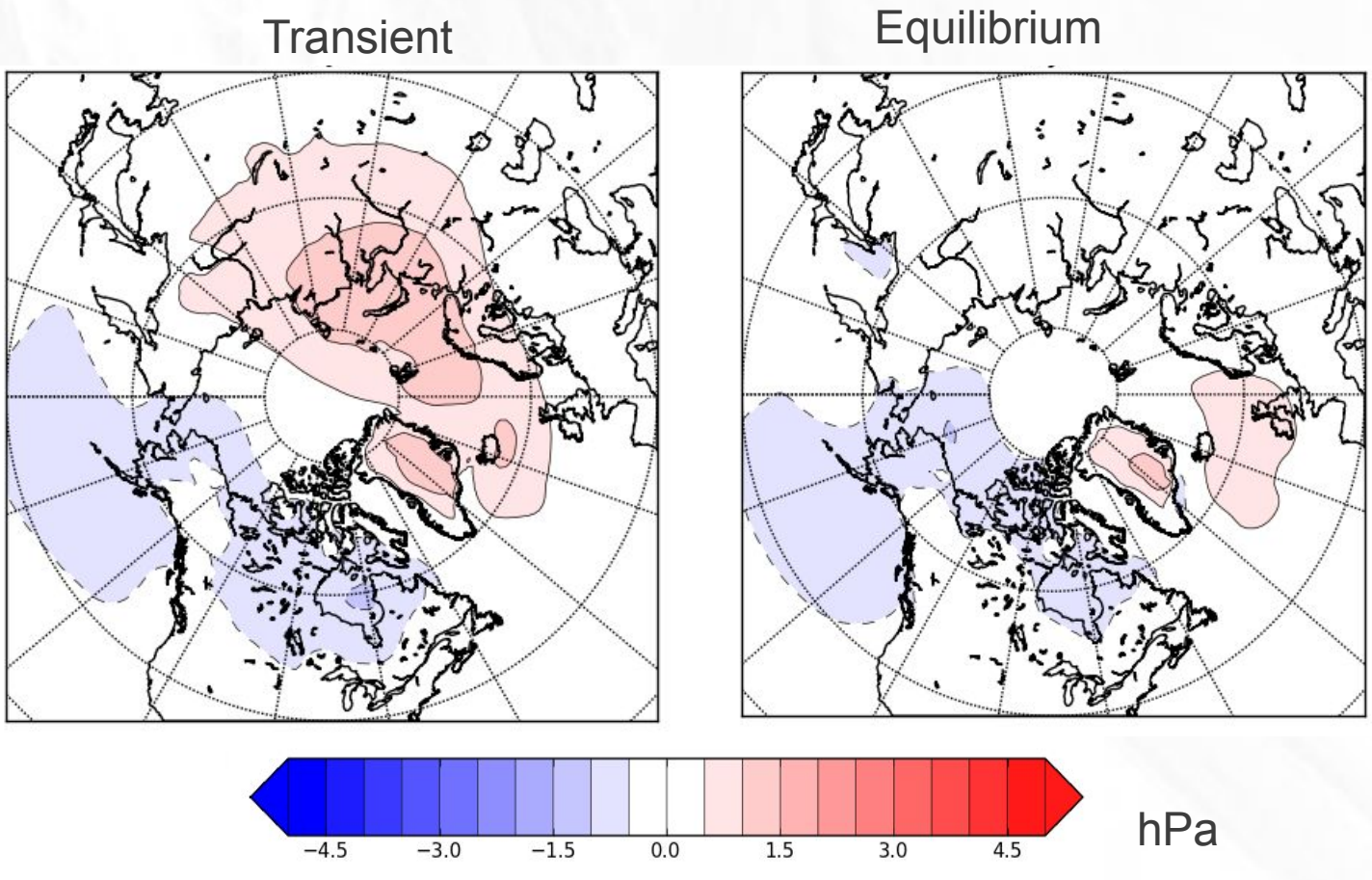


Transient Response?

DJF 2m Temperature (years 1-50)



DJF SLP



Summary

- We performed sea ice loss experiments in a coupled model (CCSM4) by decreasing the albedo of the ice
- We found very little change in the mean atmospheric circulation
- There was a decrease in daily temperature variability throughout the Arctic and most of the mid-latitudes
- There was a lot of variability between realizations in the transient response, but there were differences between the equilibrium and transient response in some fields