



**NAO related extreme climate
events in a warming climate**

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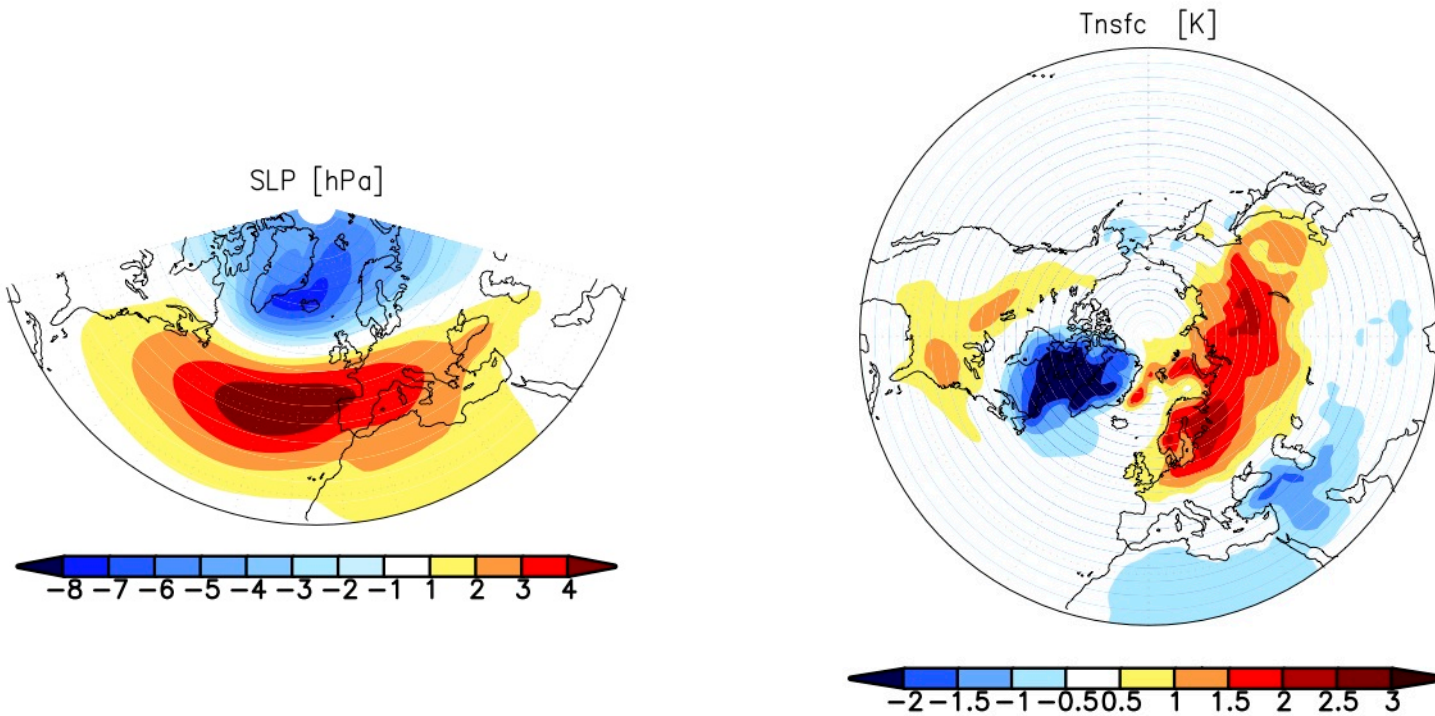
Marty Hoerling, Randy Dole

NOAA ESRL/PSD

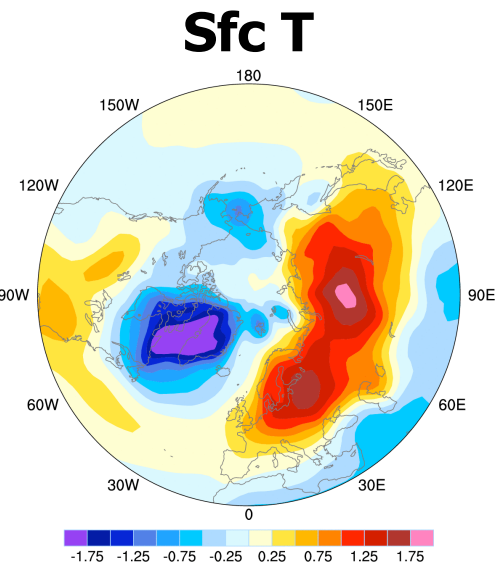
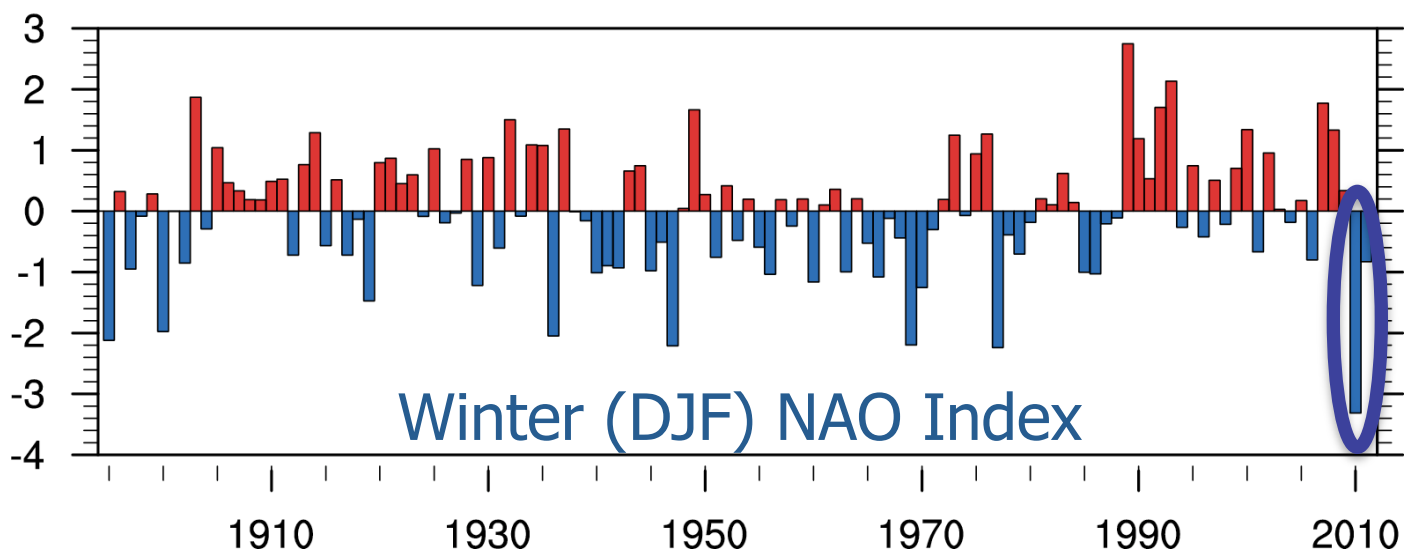
Jim Hurrell and Clara Deser

NCAR

NAO and its temperature impact

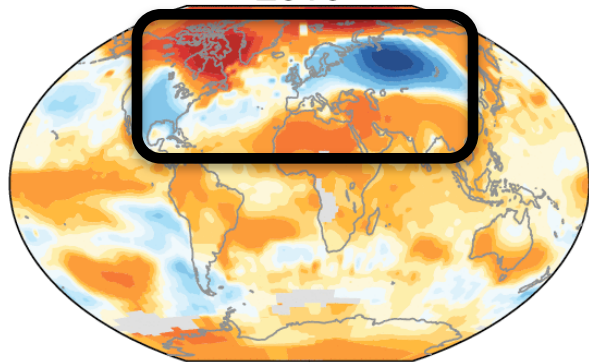


NAO impact during winter 2009/10



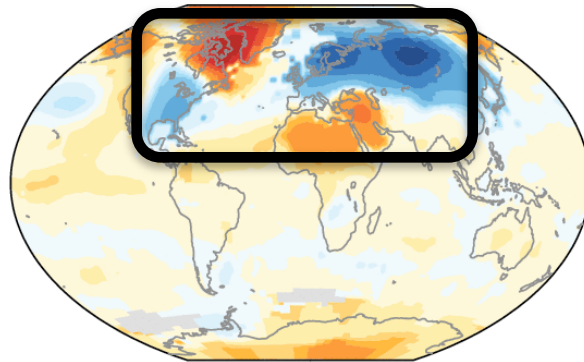
Total Observed

2010



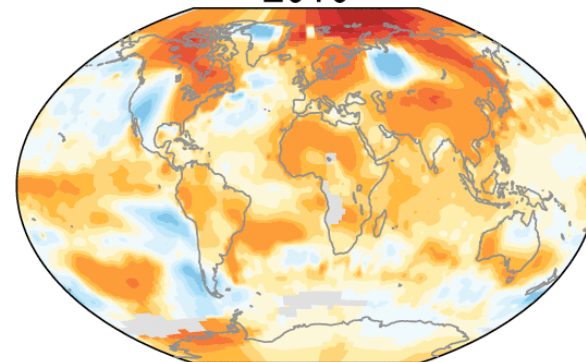
NAO Influence

2010



Residual

2010

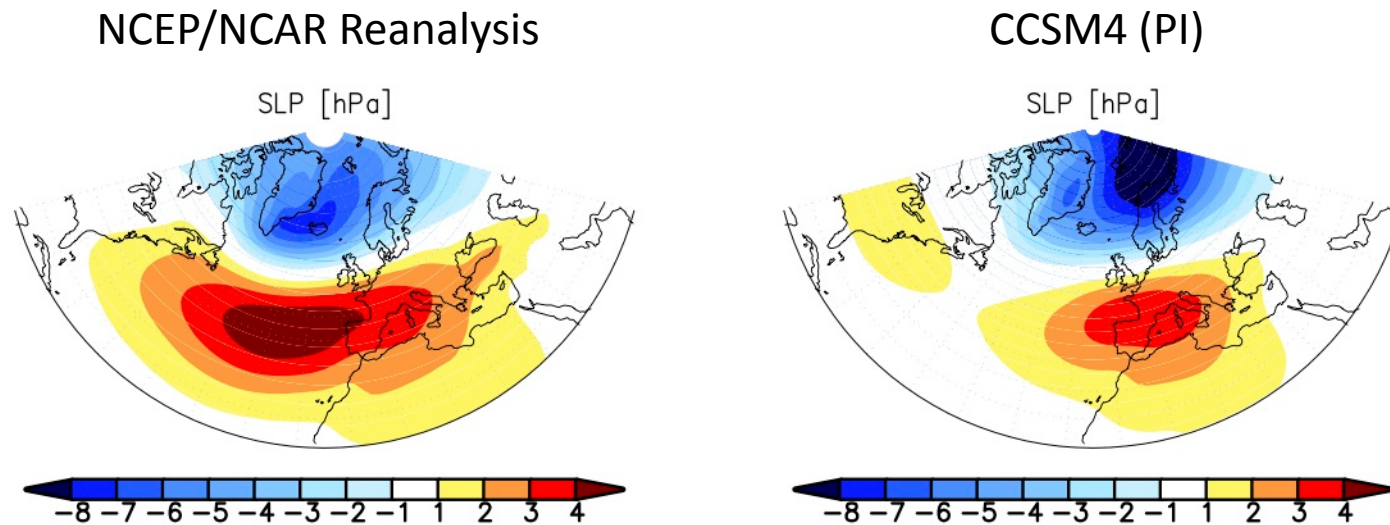


How is the NAO and its impact on near surface temperature projected to change due to increasing GHG concentrations?

Data and approach

- Analysis of a suite of coupled atmosphere-ocean simulations (NCAR CCSM4)
 - 1300 year pre-industrial simulation
 - 1850-2005 historical simulations (5 member ensemble)
 - 2005-2100 RCP 8.5 future projection (5 member ensemble)
- Study is based on monthly data (Dec to Mar)
- NAO is defined by leading pattern of sea level pressure variability over North Atlantic area during winter months (Dec-Mar)

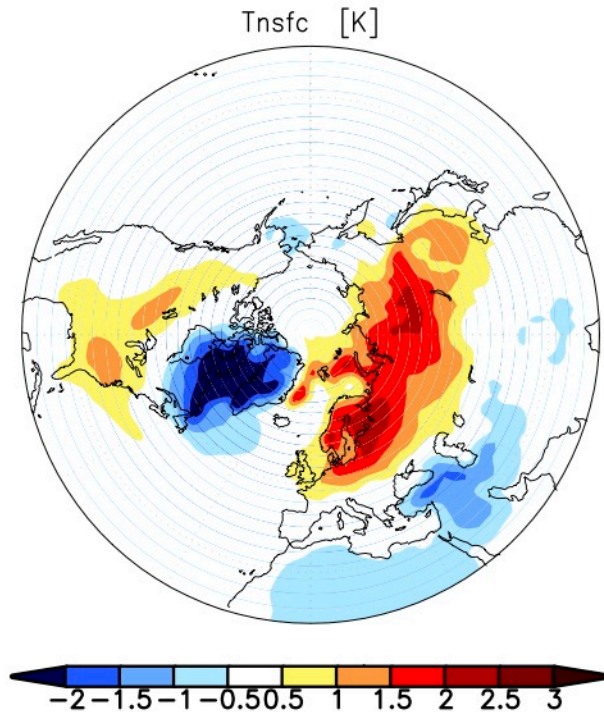
Spatial structure of NAO in reanalysis and CCSM4



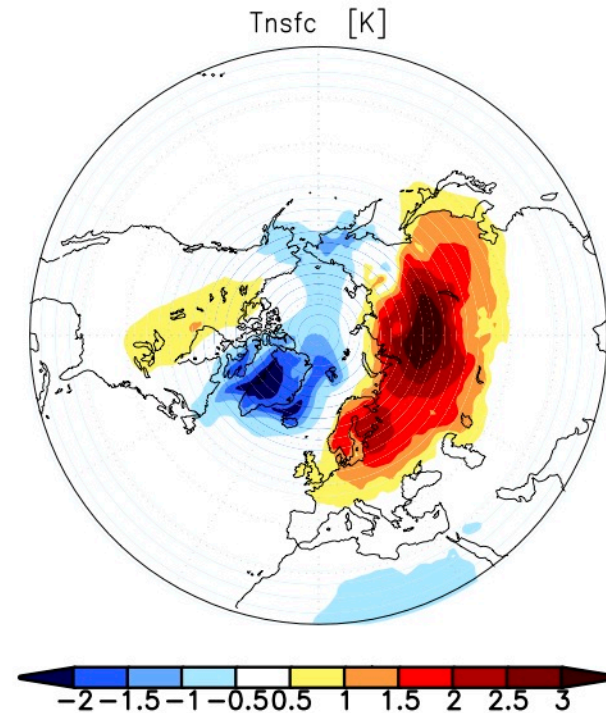
The model reproduces the meridional pressure seesaw but the simulated centers of action are shifted to the east.

Near surface temperatures regressed onto NAO-index

NCEP/NCAR Reanalysis

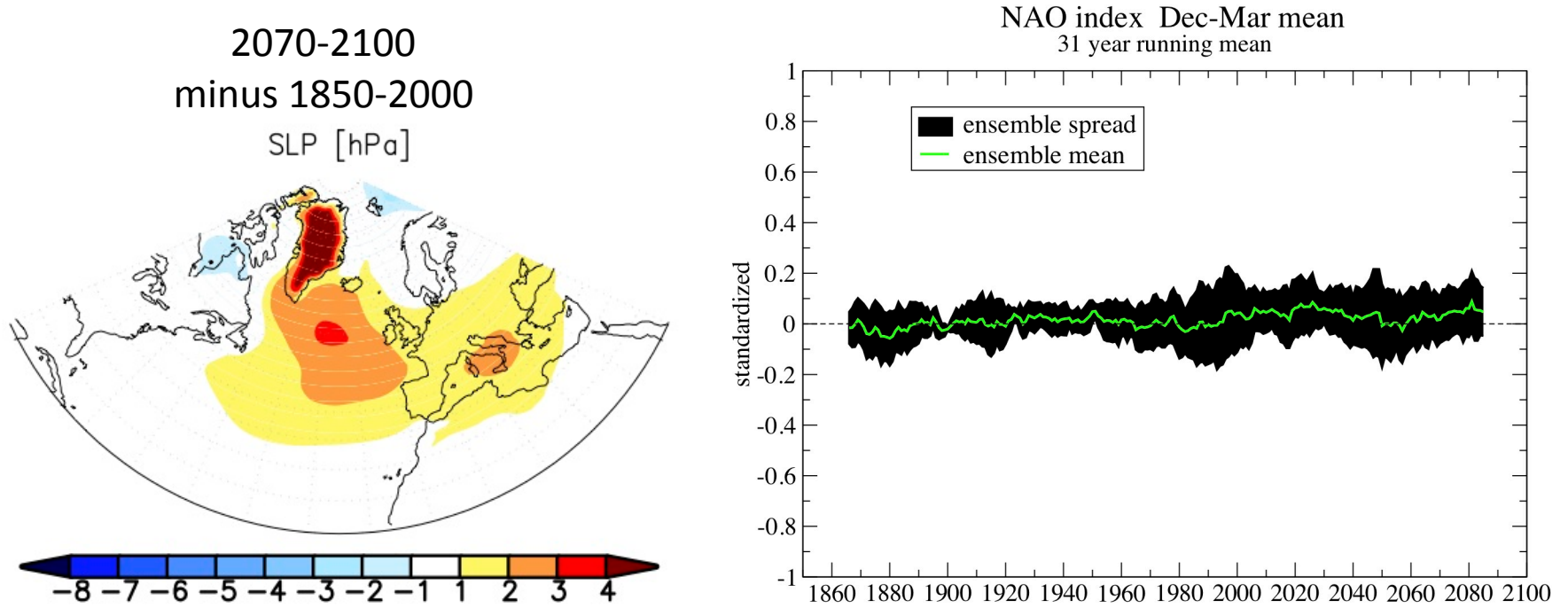


CCSM4 (PI)



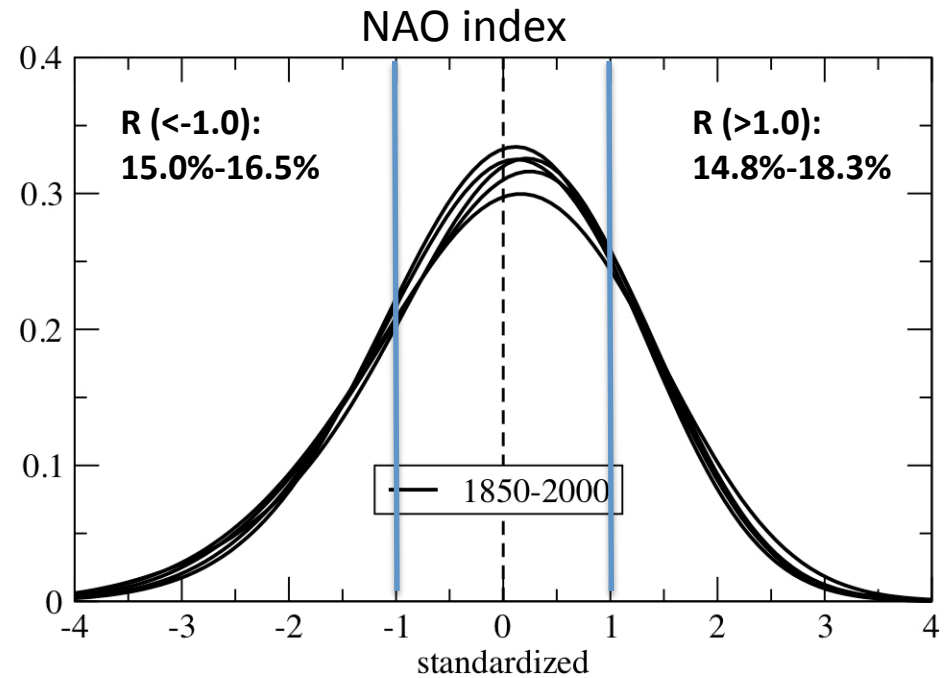
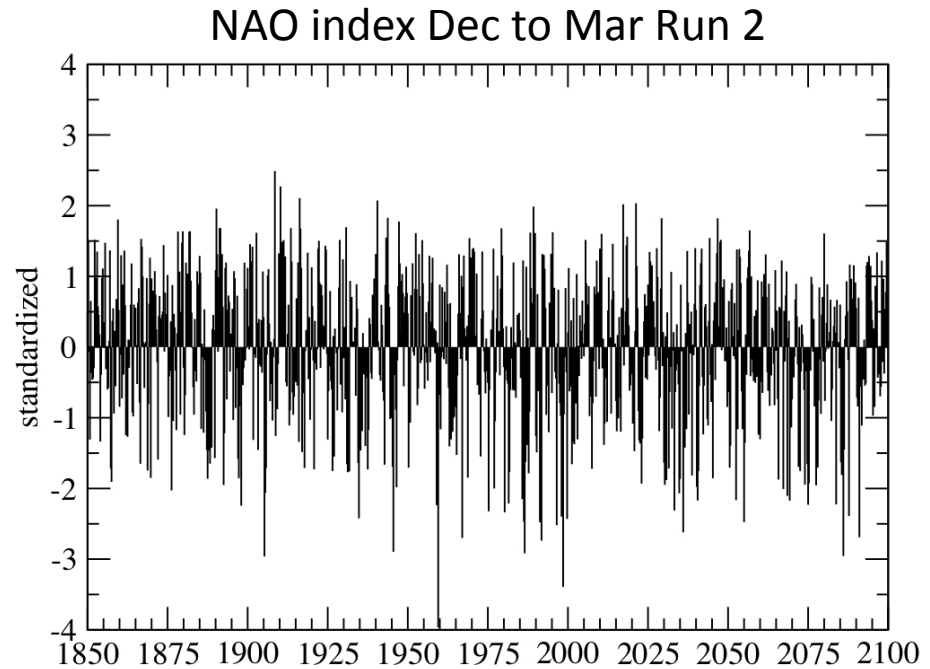
The model captures the NAO related impact on Eurasian temperatures.

Is there a mean SLP change in the CCSM4 that projects onto the NAO?



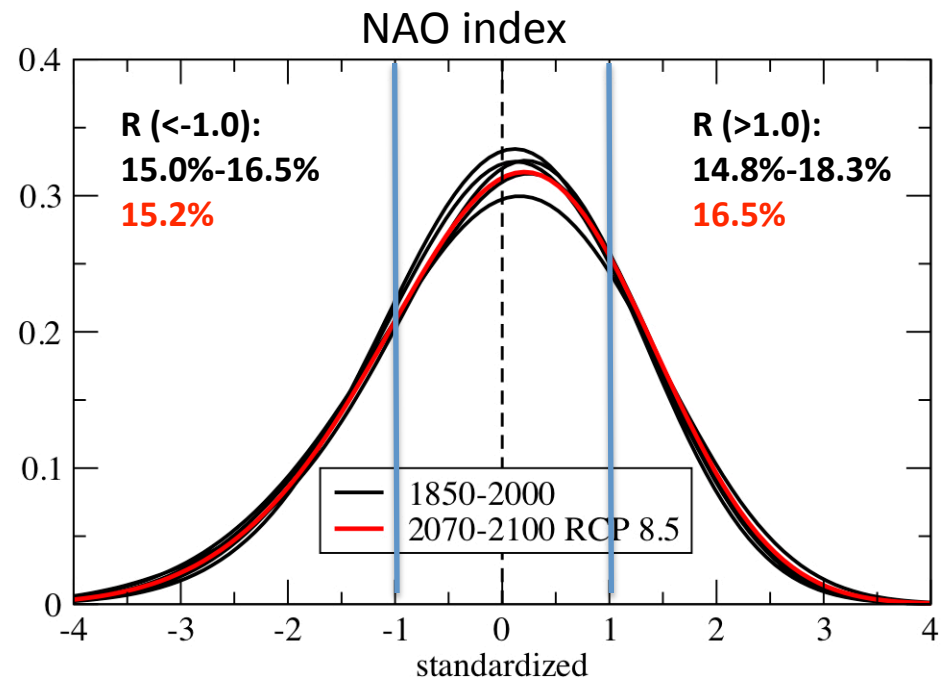
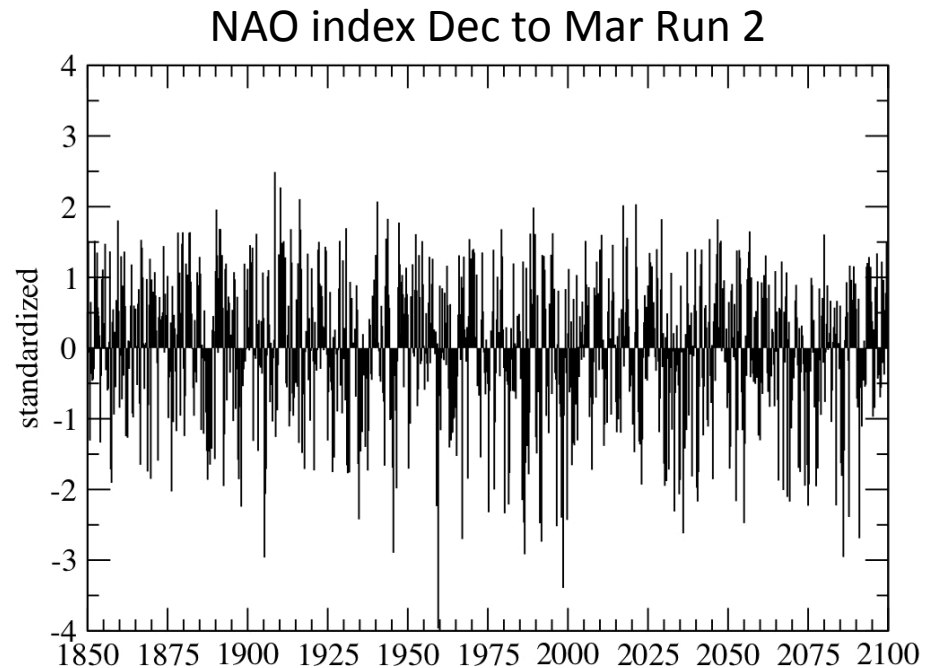
No. The simulated SLP change pattern does not project significantly onto the NAO pattern.

Is the frequency of occurrence of extreme NAO events projected to change in CCSM4?

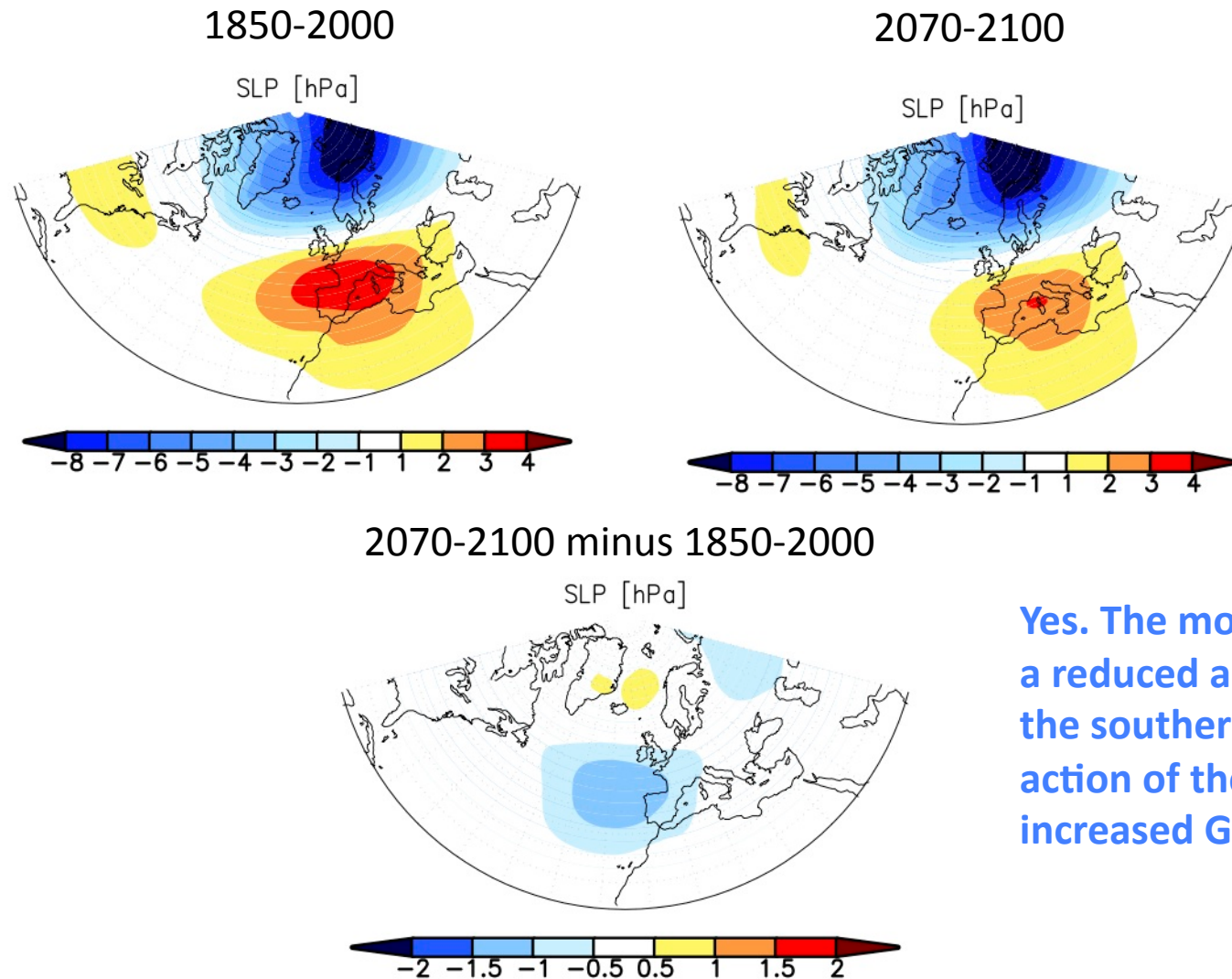


Is the frequency of occurrence of extreme NAO events projected to change in CCSM4?

No. The simulated frequency of occurrence of NAO extreme events during 2070-2100 lies well within the ensemble of historical distributions (1950-2000).



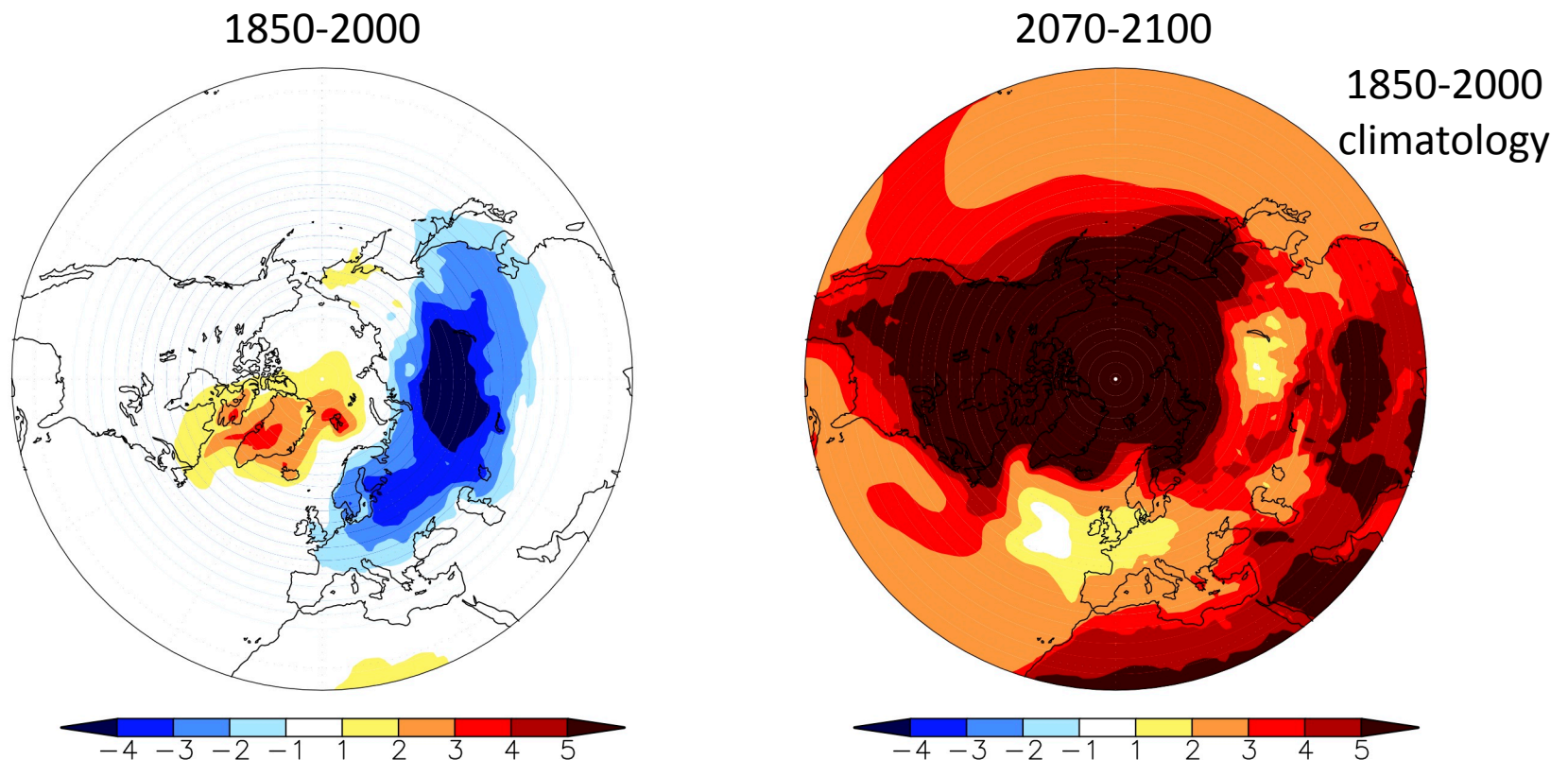
Is the spatial structure of the NAO projected to change?



Yes. The model simulates a reduced amplitude of the southern center of action of the NAO due to increased GHG effect.

Do increased GHGs affect the link between the NAO and North European temperatures in CCSM4?

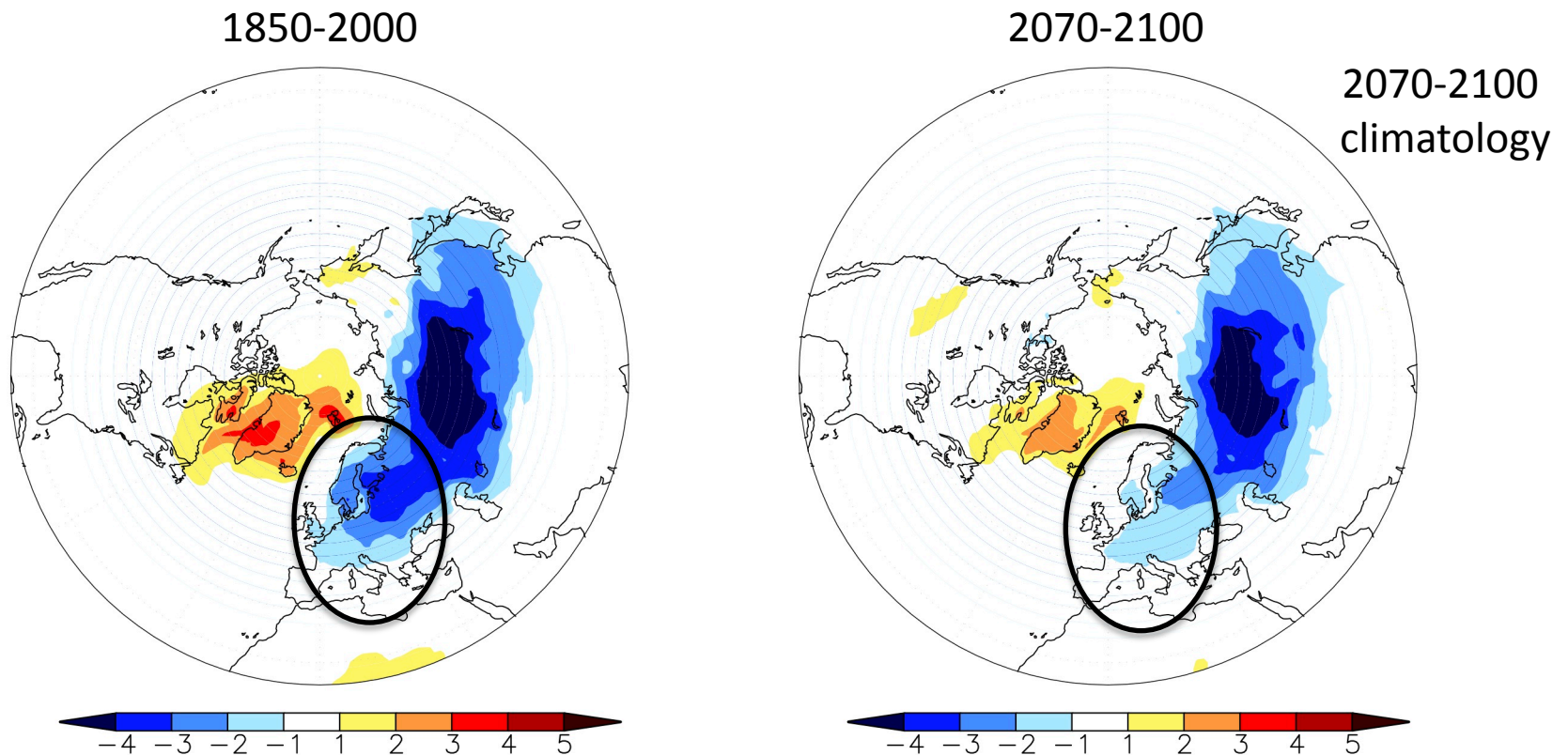
Temperature composite of extreme NAO events ($<-1.0 \sigma$)



1. Yes. Due to the background warming, NAO extreme temperature maps will have a very different look relative to today's climate.

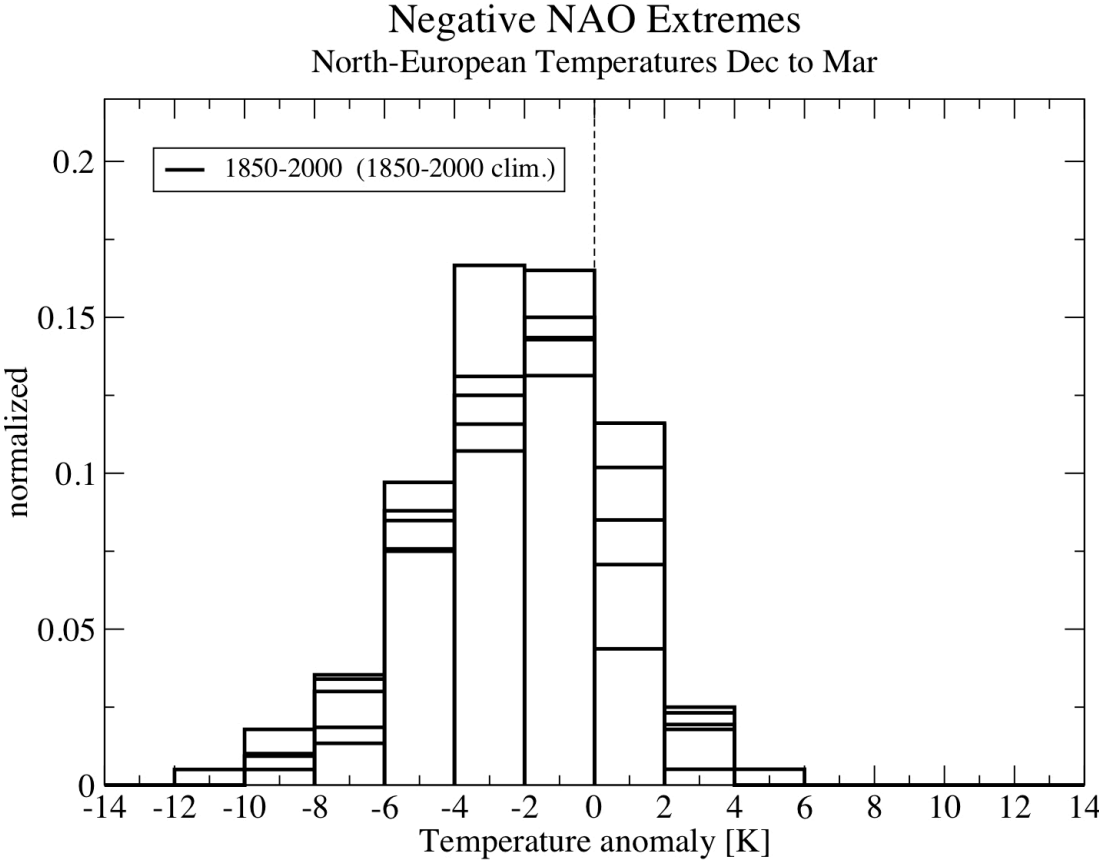
Do increased GHGs affect the link between the NAO and North European temperatures in CCSM4?

Temperature composite of extreme NAO events ($<-1.0 \sigma$)

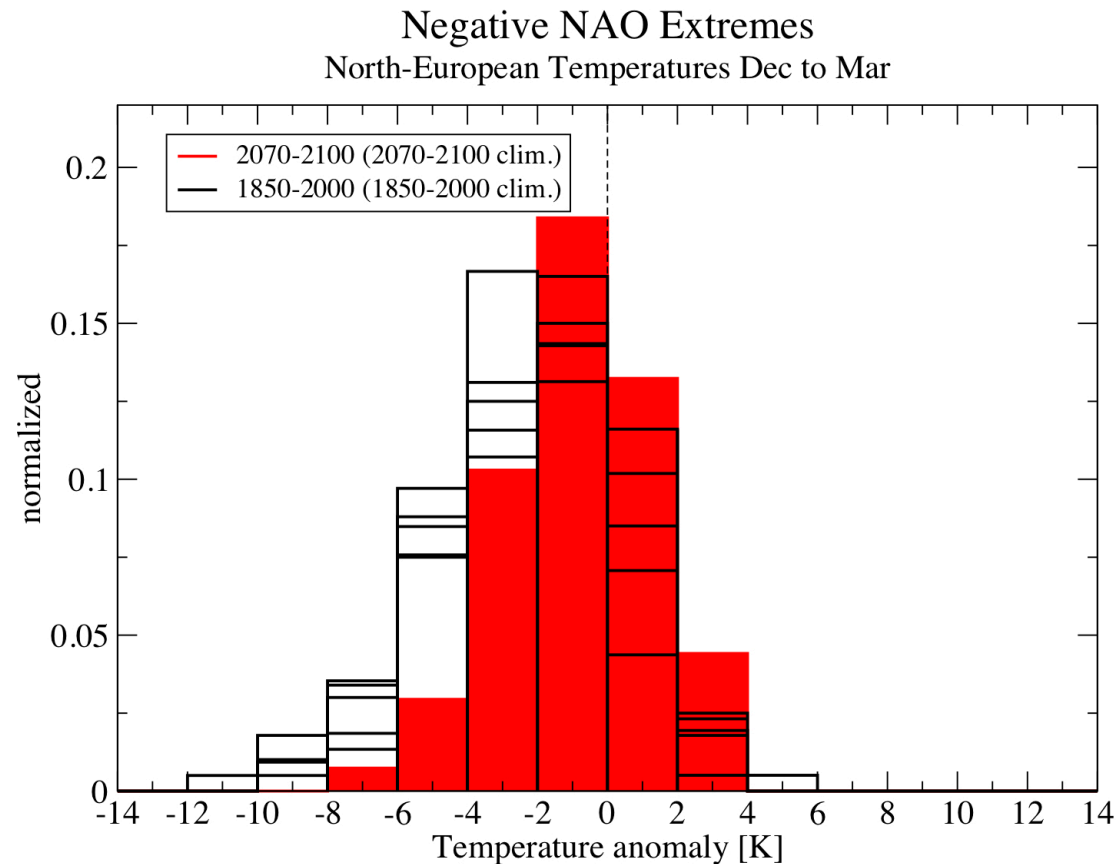


2. The NAO temperature impact on Northern Europe is projected to be reduced.

Do increased GHGs affect the link between the NAO and North European temperatures in CCSM4?



Do increased GHGs affect the link between the NAO and North European temperatures in CCSM4?



3. Yes, the model projects a reduction of cold temperature extremes in Northern Europe during negative NAO phase.

How is the NAO and its impact on near surface temperature projected to change due to increasing GHG concentrations?

- CCSM4 simulations suggest:
 - No significant change in mean and extremes of NAO index
 - Increasing GHG concentrations are projected to influence the spatial structure of NAO and modify the NAO impact on North European climate

NAO impact during the last two winters

