
Polar Amplification Model Intercomparison Project – Main Results and Lessons Learned

Tido Semmler, Jan Streffing, Thomas Jung

Introduction

Everybody knows: **Arctic sea ice has been strongly declining** over the last 3 to 4 decades

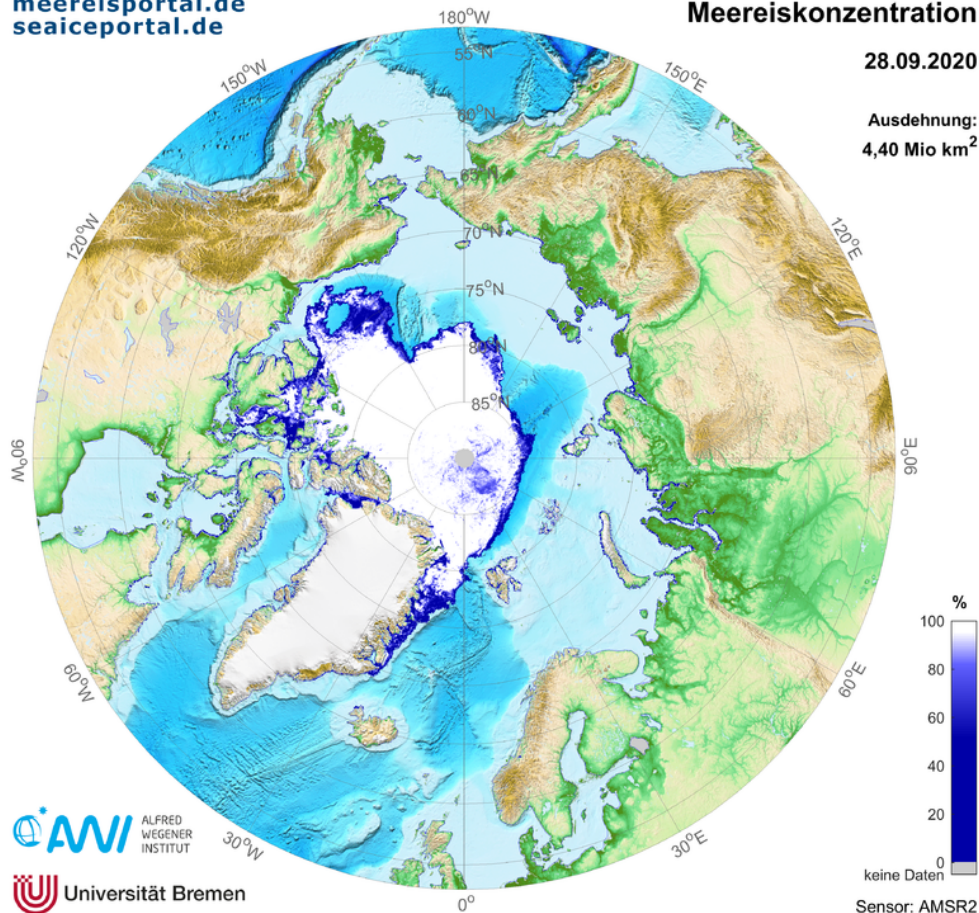
meereisportal.de
seaiceportal.de

Meereiskonzentration

28.09.2020

Ausdehnung:
4,40 Mio km²

Northeast passage free



Introduction



Many studies have investigated **the impact of such Arctic sea ice decline** on the Northern mid-latitude climate – obviously we want to know what the Arctic sea ice decline means for us

Already in the 1970s to the 1990s **Arctic sea ice removal experiments** have been performed

While some response features have been well established there is lively discussion and controversy over some features owing to the strong internal variability of Arctic and mid-latitude weather and climate – call for coordinated experiments in a series of workshops

Early report: Warshaw and Rapp (1972)



R-908-ARPA
February 1972

An Experiment on the Sensitivity of A Global Circulation Model: Studies in Climate Dynamics for Environmental Security

M. Warshaw and R. R. Rapp

A Report prepared for
ADVANCED RESEARCH PROJECTS AGENCY

SUMMARY

The growth of small errors in numerical models of the atmospheric circulation destroys the detailed predictive capability of those models within a few days. Despite the failure of the models to produce accurate local predictions, it was hypothesized that a change in the equator-to-pole temperature gradient would produce discernable effects in average conditions. This Report presents the results of an experiment to test this hypothesis.

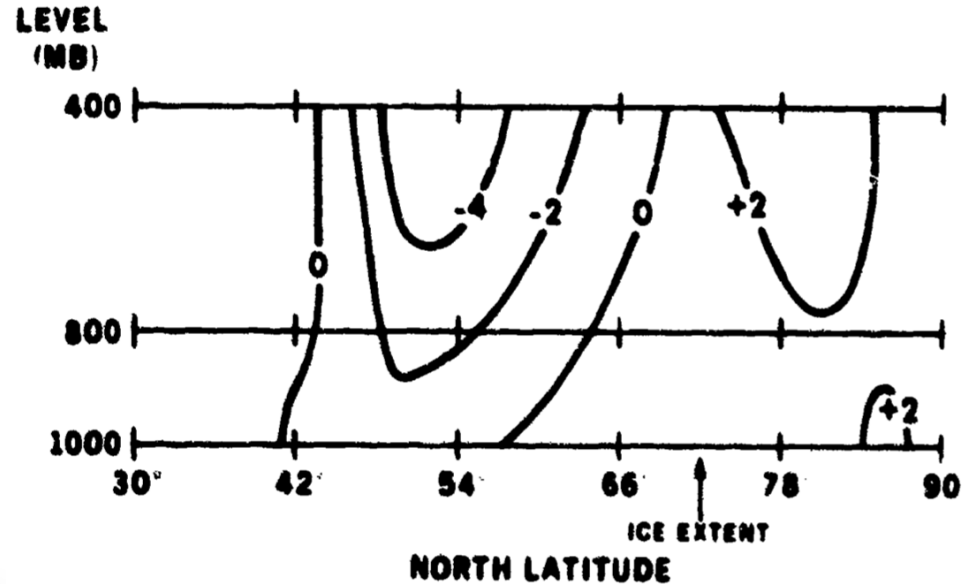


Fig. 8 -- East/west wind differences (n/sec); (ice out) - (ice in).

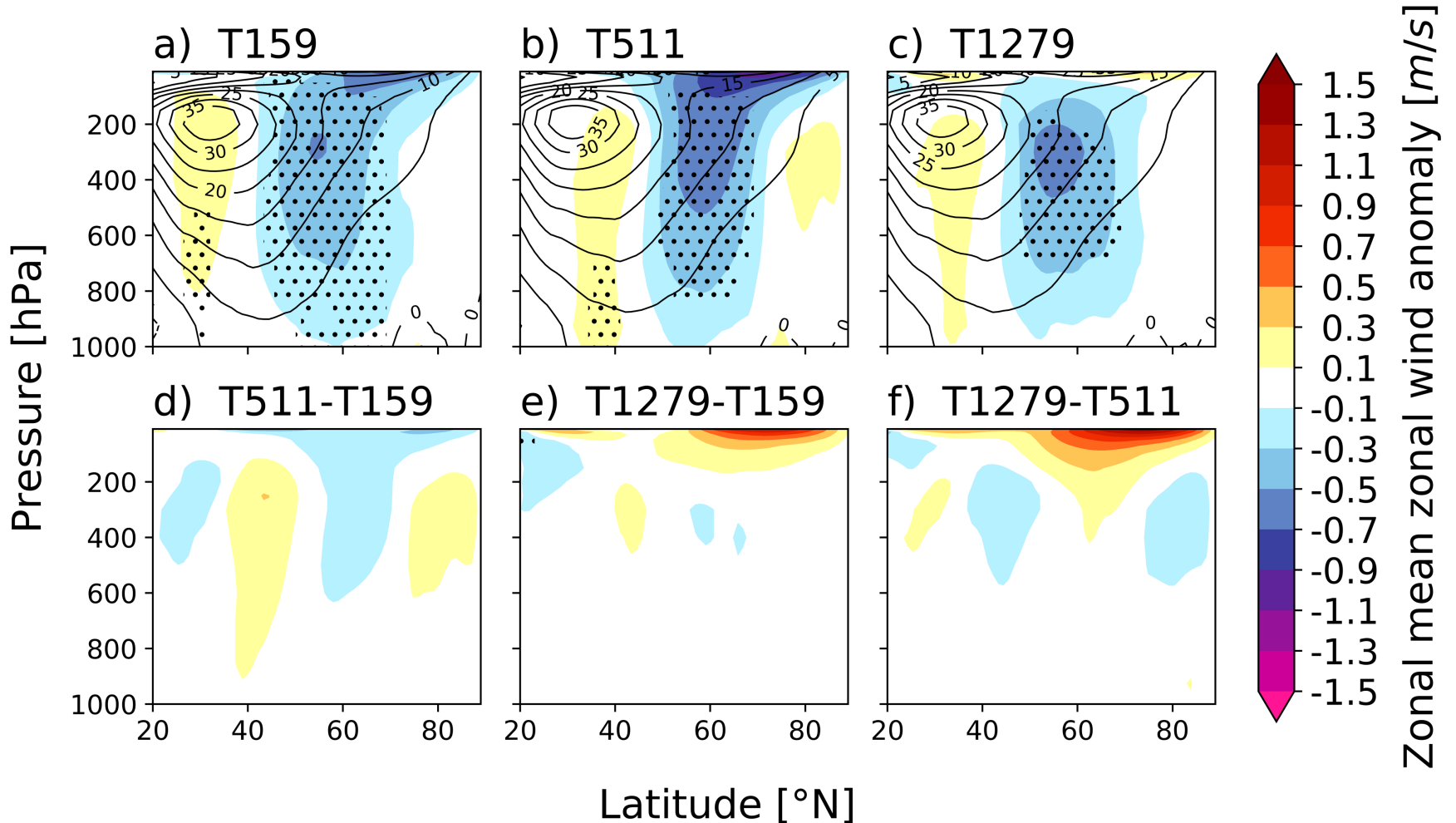
Report based on findings of a two-level global circulation model



Response zonal mean zonal wind (m/s)



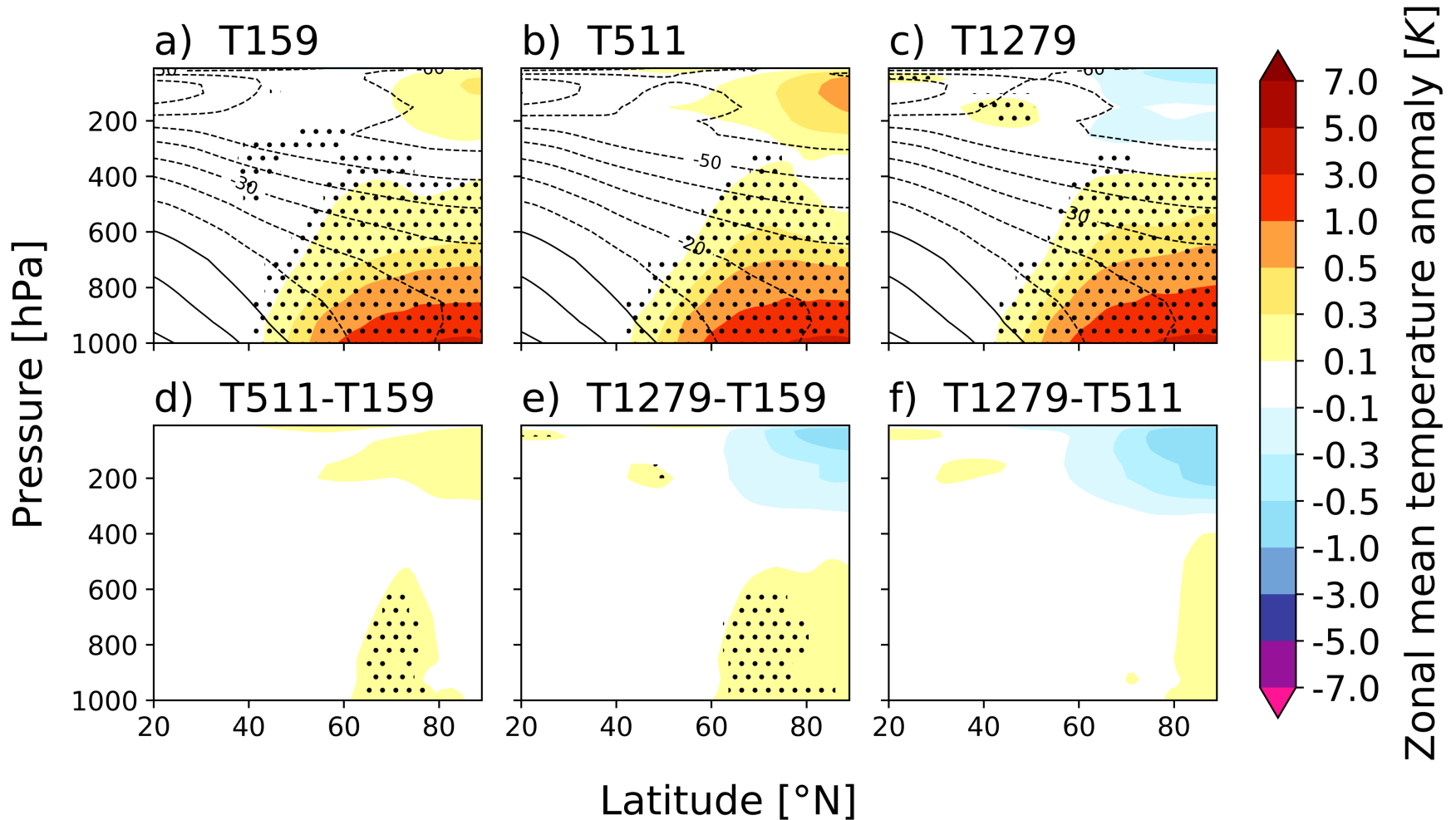
Question: is the response resolution dependent?



Response zonal mean temperature ($^{\circ}\text{C}$)

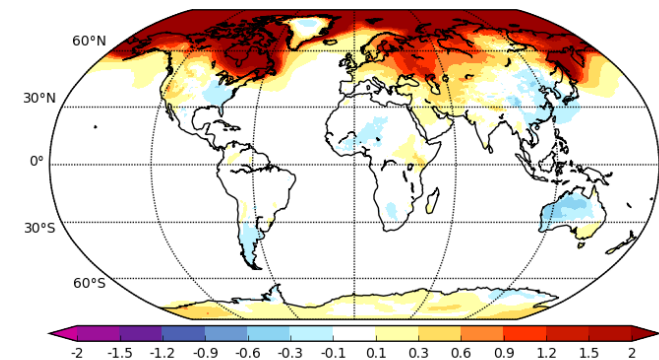
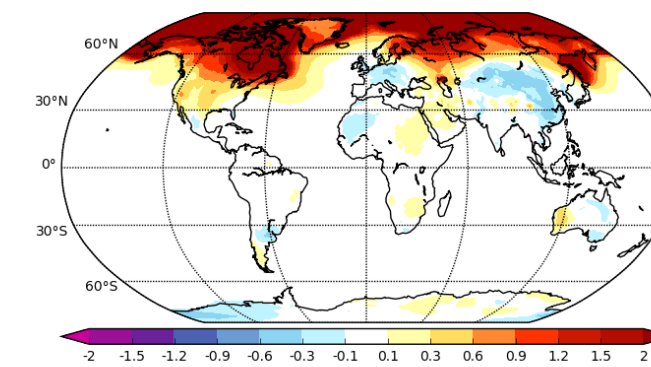
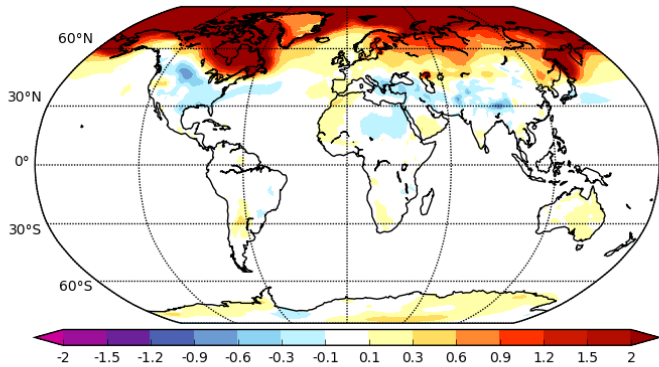
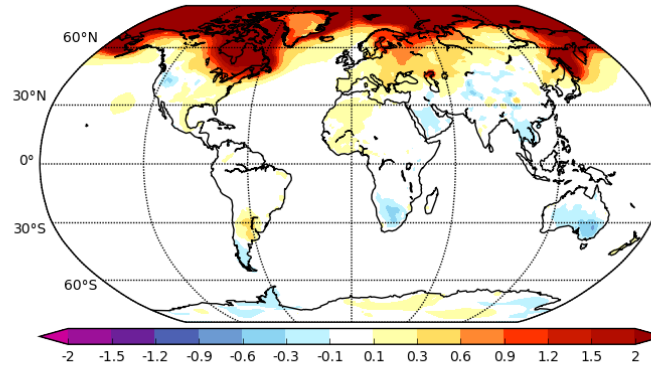
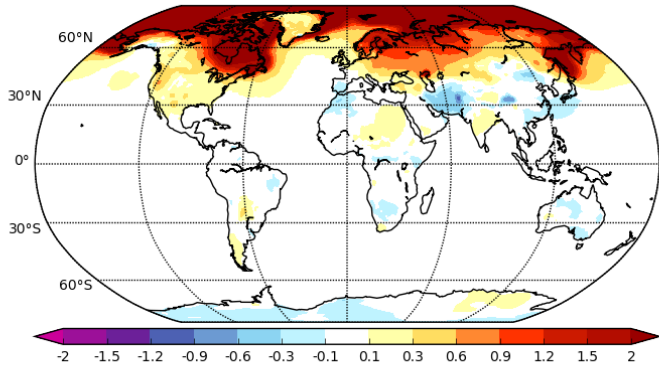


Question: is the response resolution dependent?



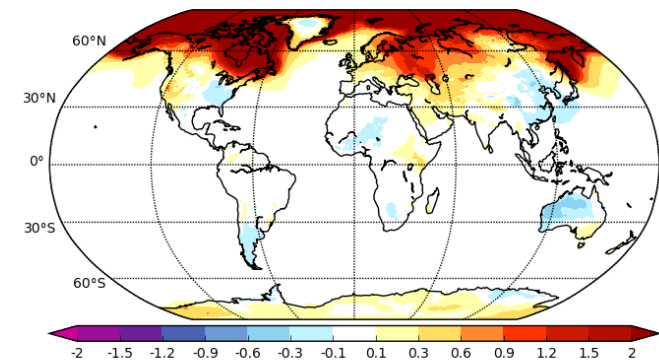
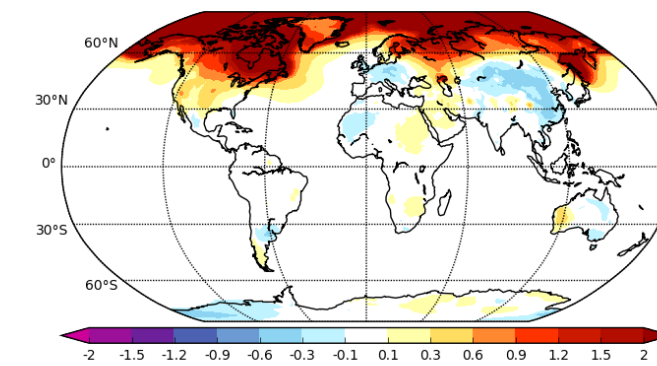
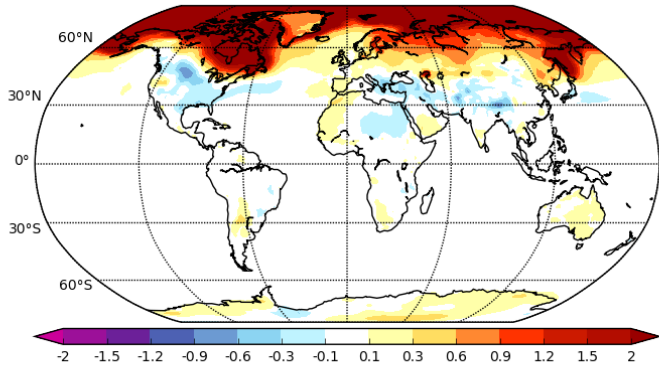
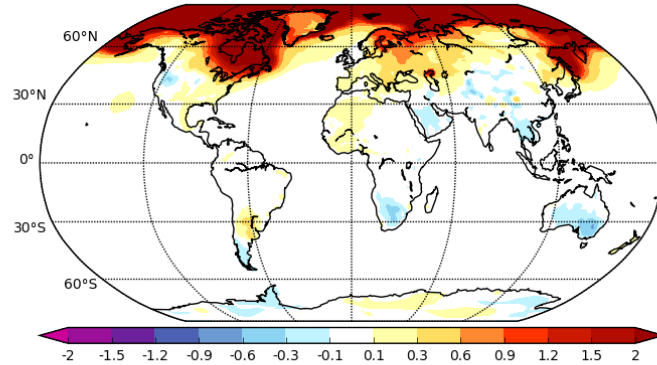
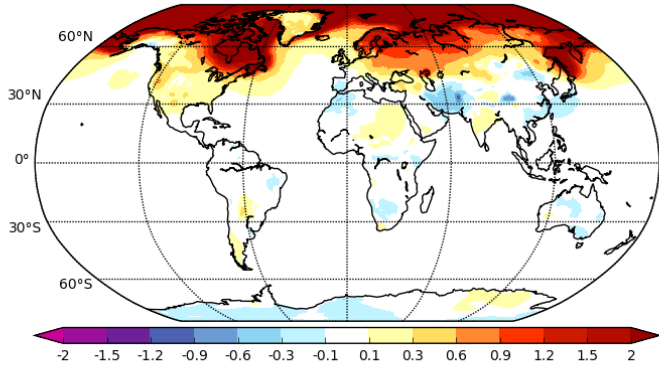
Response 2 m temperature (°C)

Question: is the response resolution dependent?



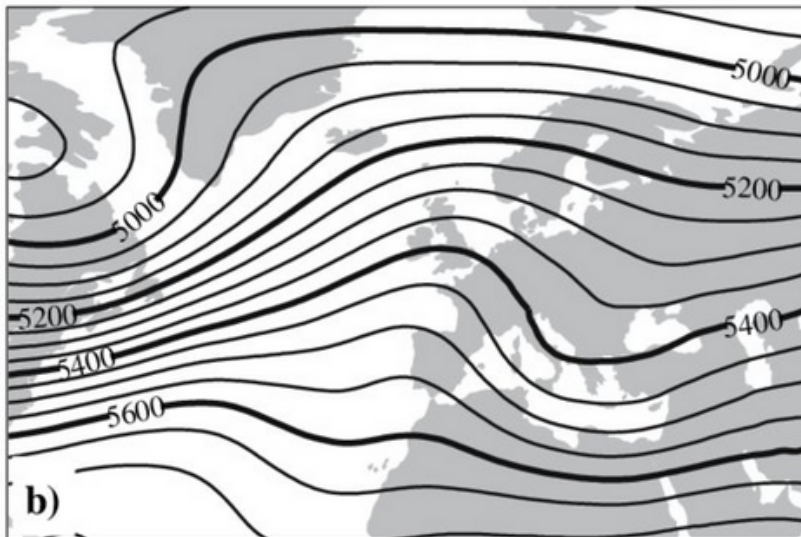
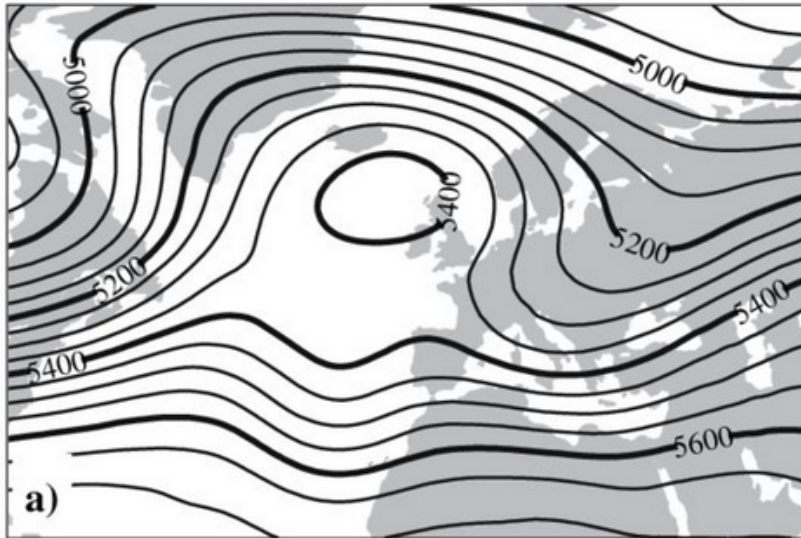
Response 2 m temperature (°C)

Answer: no!



Furthermore lesson learned: even with 100 ensemble members internal variability is not averaged out!

Atmospheric blocking

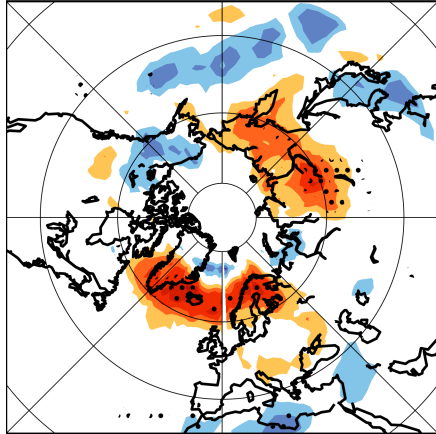


Atmospheric blocking is a recurrent mid-latitude weather pattern identified by a large-amplitude, quasi-stationary, long-lasting, high-pressure anomaly that blocks the westerly flow forcing the jet stream to split or meander (Rex, 1950)

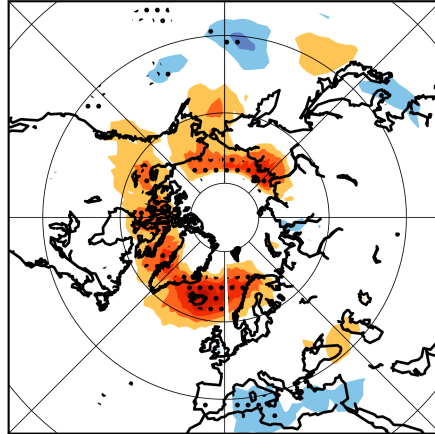
Figure from Croci-Maspoli et al., 2007: Illustrative example of the January 1963 Z500 for (a) the monthly mean of all days and (b) the monthly mean without blocking days

Response blocking frequency (%)

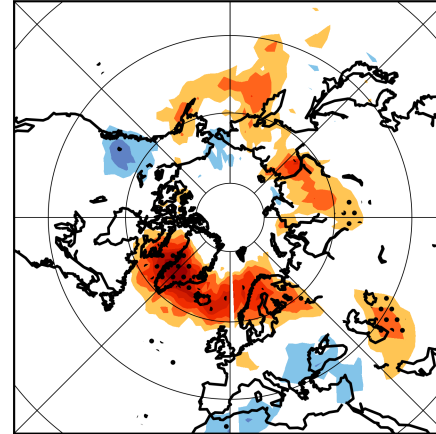
a) T159



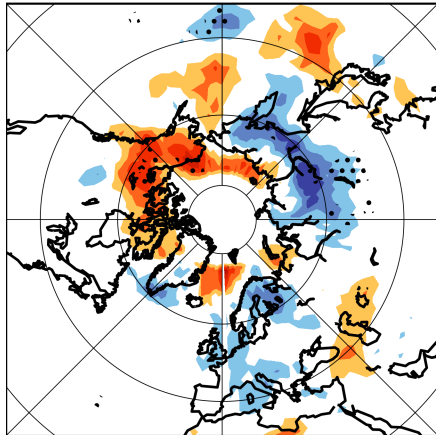
b) T511



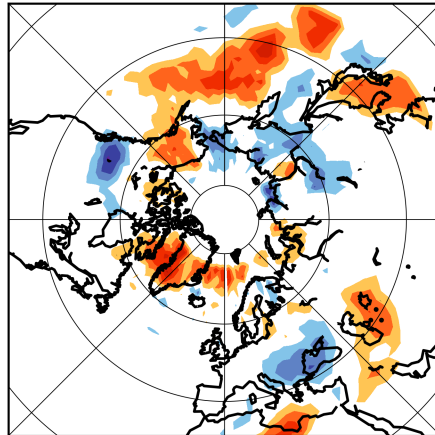
c) T1279



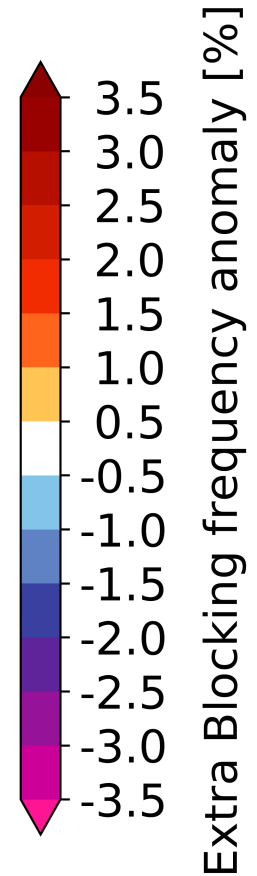
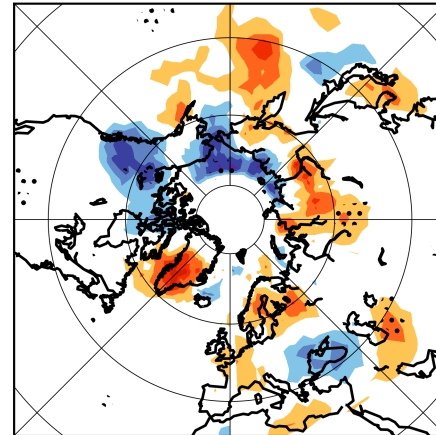
d) T511-T159



e) T1279-T159

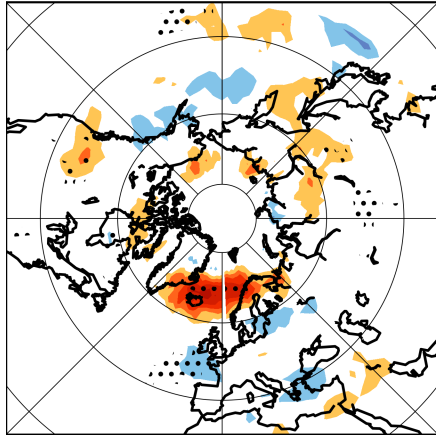


f) T1279-T511

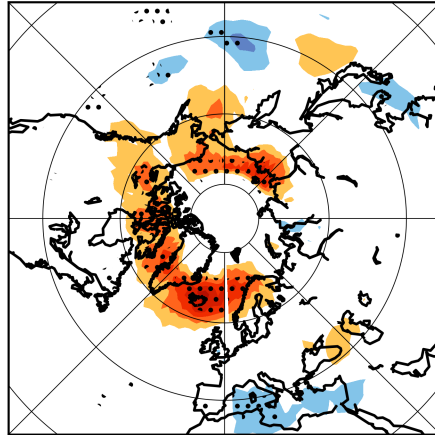


Response blocking frequency (%)

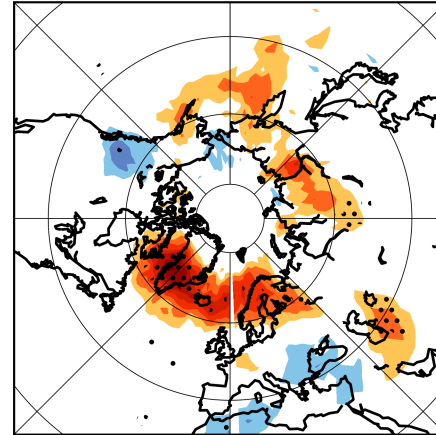
a) T159



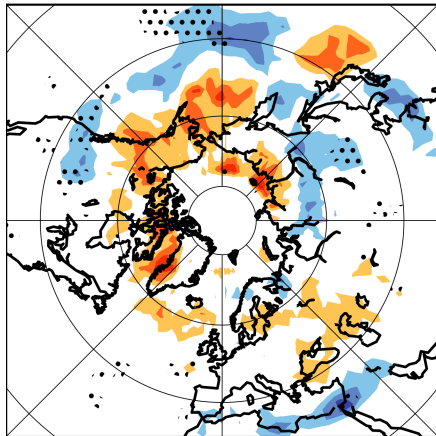
b) T511



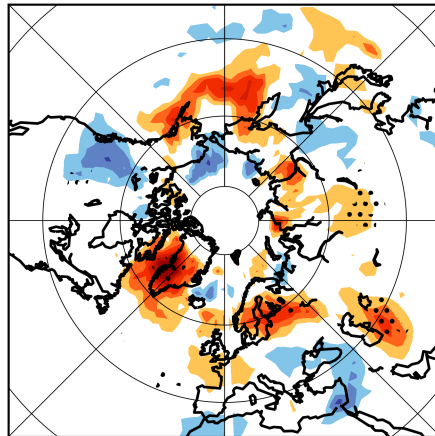
c) T1279



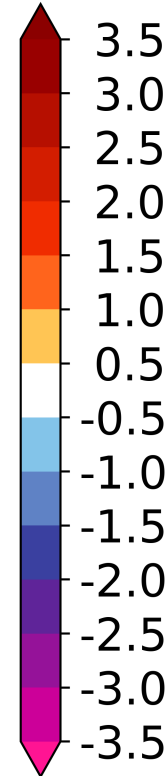
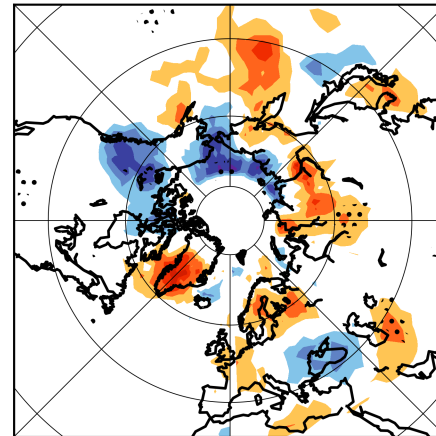
d) T511-T159



e) T1279-T159



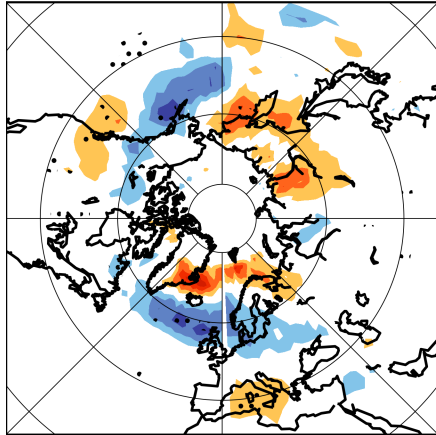
f) T1279-T511



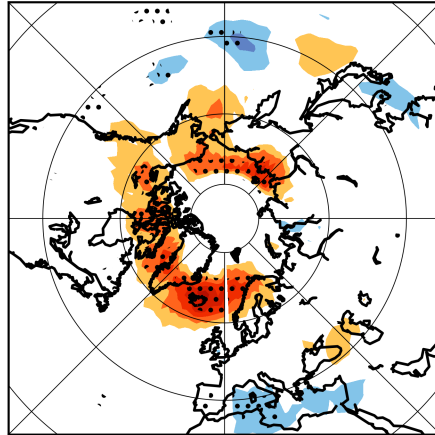
Extra Blocking frequency anomaly [%]

Response blocking frequency (%)

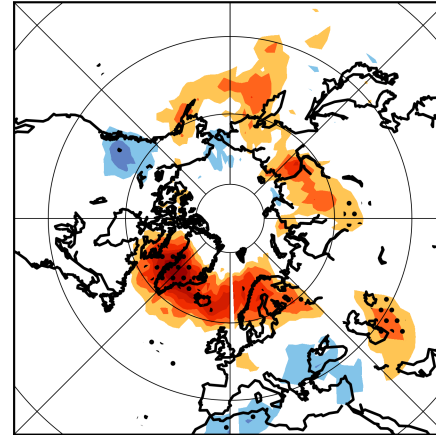
a) T159



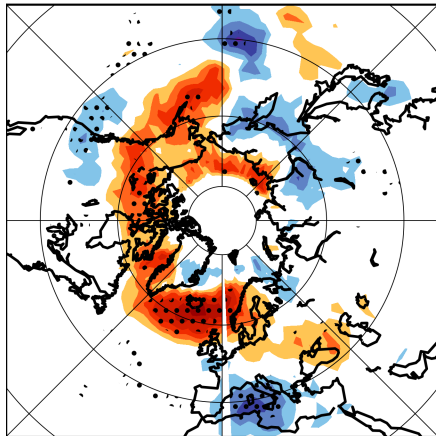
b) T511



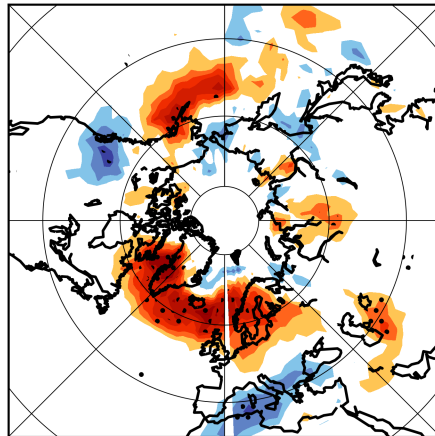
c) T1279



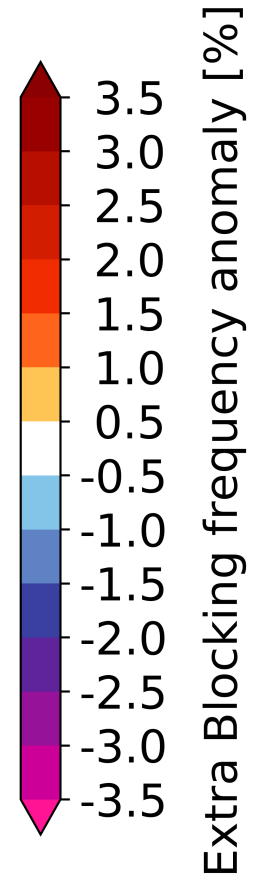
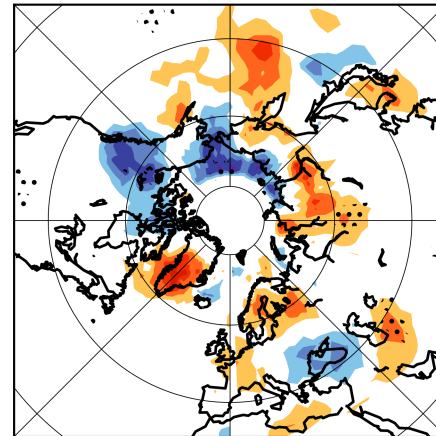
d) T511-T159



e) T1279-T159



f) T1279-T511



Conclusions



Some robust features from model simulations (weakening of westerlies, increase of Z500 over the Arctic) were known long before PAMIP and are confirmed to be robust features.

PAMIP: Unprecedented common simulation protocol enabling us to efficiently run very high resolution exps!

Very strong internal variability when it comes to regional details leading to inconclusive answers. Differences between 100 ensemble member packs as large as differences between different resolutions. For extreme events also different answers – sometimes even the sign is different.

Coupled experiments still to come but at this stage difficult to find common protocol.

