The Polar Amplification Model Intercomparison Project PAMIP – Emerging Results and Lessons Learned

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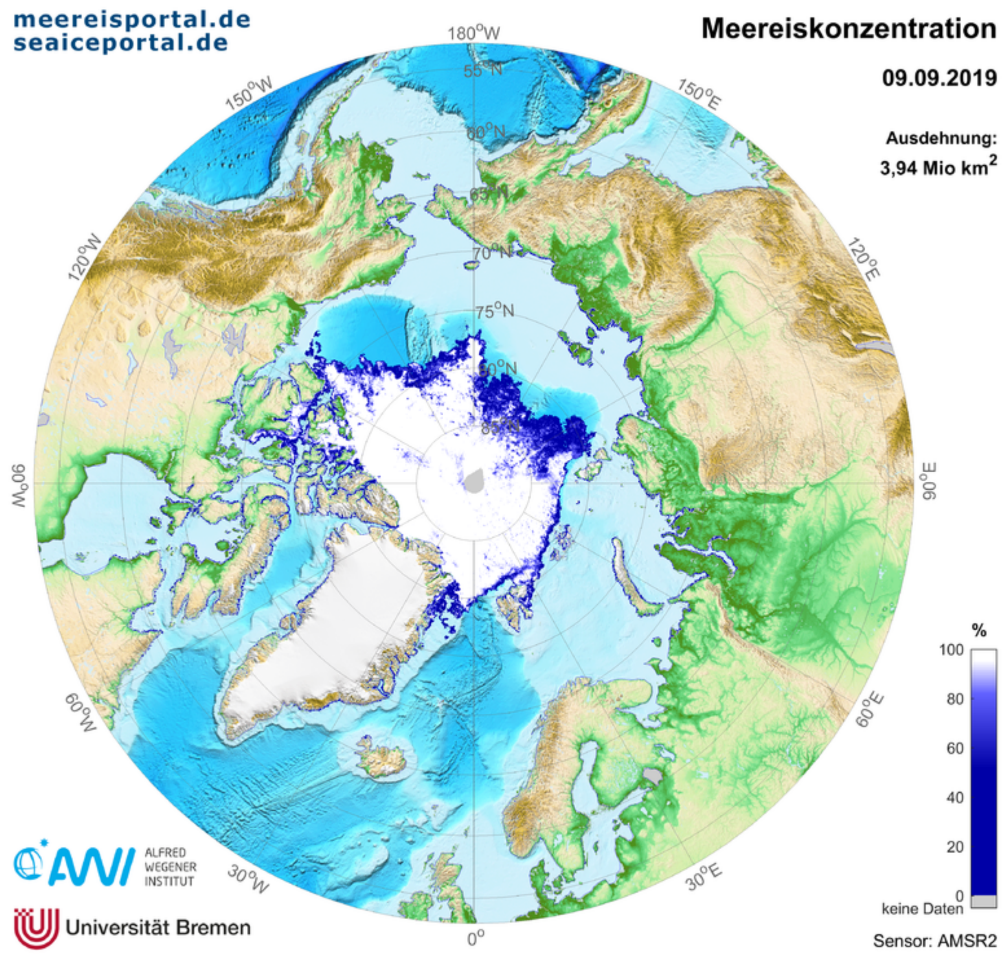
Introduction

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



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

Workshops

Barcelona 2014

Recommendations from the workshop (Jung et al., 2015):

Improved process understanding

Weather and climate forecasting (synergies)

Coordinated model Experiments

EU project APPLICATE based on these ideas

Year Of Polar Prediction (YOPP)
Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC)

Strategy

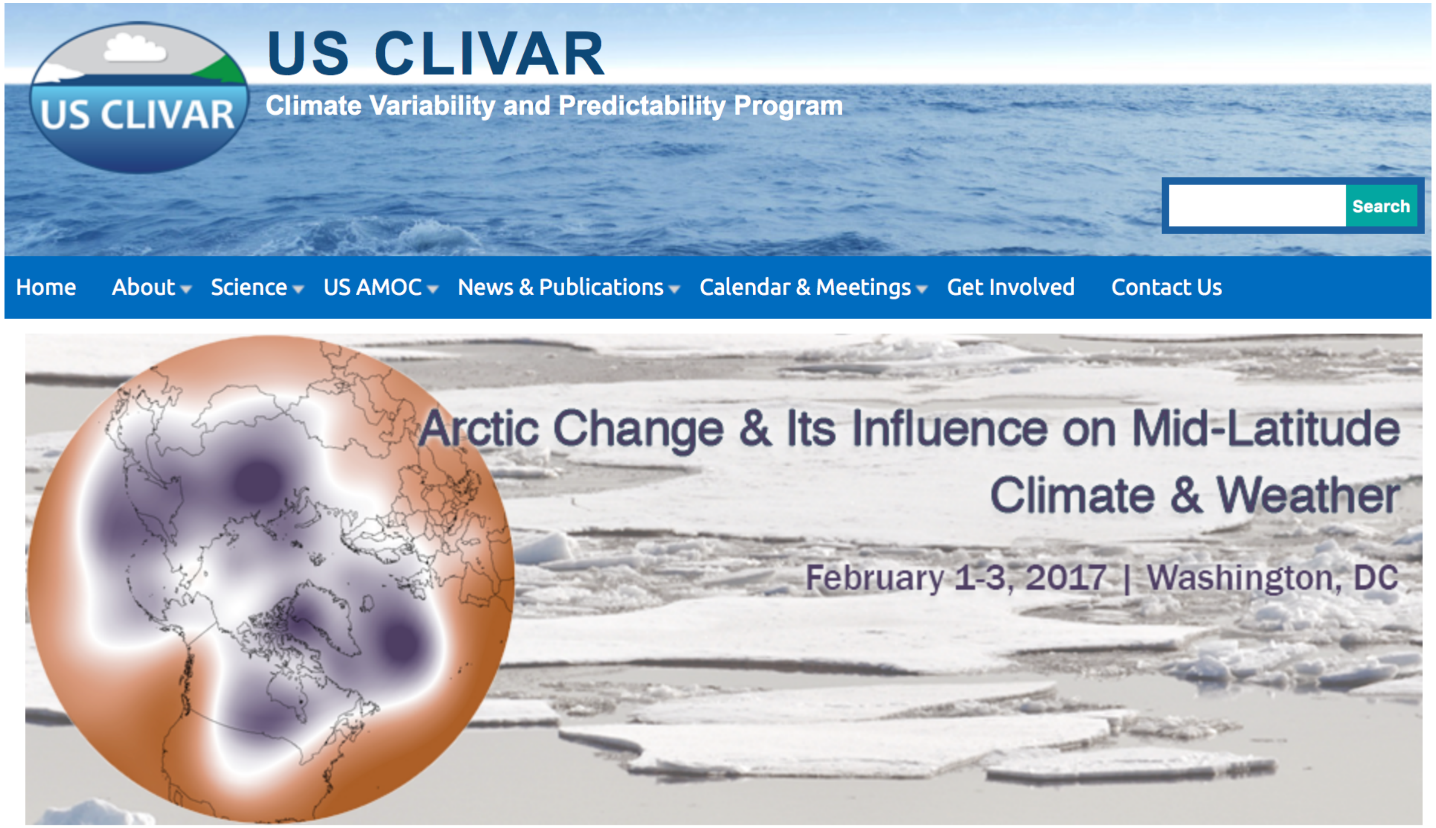
APPLICATE.eu
Advanced prediction in polar regions and beyond

Understand Arctic-midlatitude linkages

- Coordinated multi-model approach (CMIP6-PAMIP)
- Employ atmosphere-only *and* coupled models
- Study linkages also from a short-term prediction perspective
- Repeat some of the experiments with enhanced models

Workshops

Washington, D.C. 2017



Recommendations from the workshop (Cohen et al., 2018):

Synthesis of available observations

Use paleo data

Coordinated model experiments (using the full range of models: conceptual to full earth system)

PAMIP within CMIP6

PAMIP workshop Totnes (2019)

Participants of the PAMIP workshop in the surroundings of Exeter, UK (photo: Jinro Ukita, Niigata University, Japan).

First PAMIP workshop held close to Exeter, UK to exchange first results of the coordinated model experiments

Outcome: groups of scientists established who work on multi-model analysis of specific aspects

Series of papers planned on this basis

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

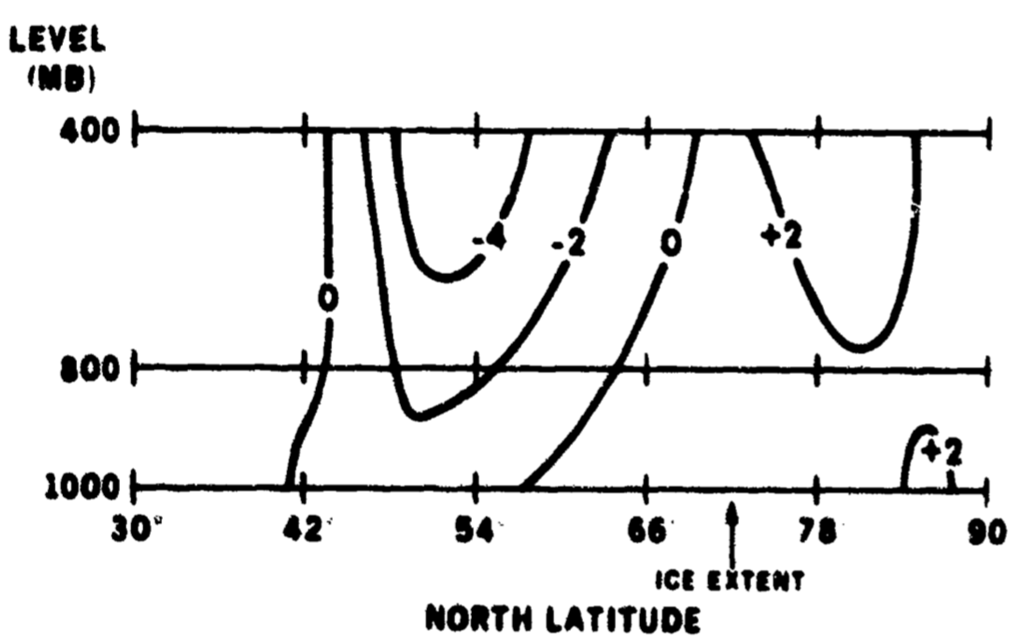


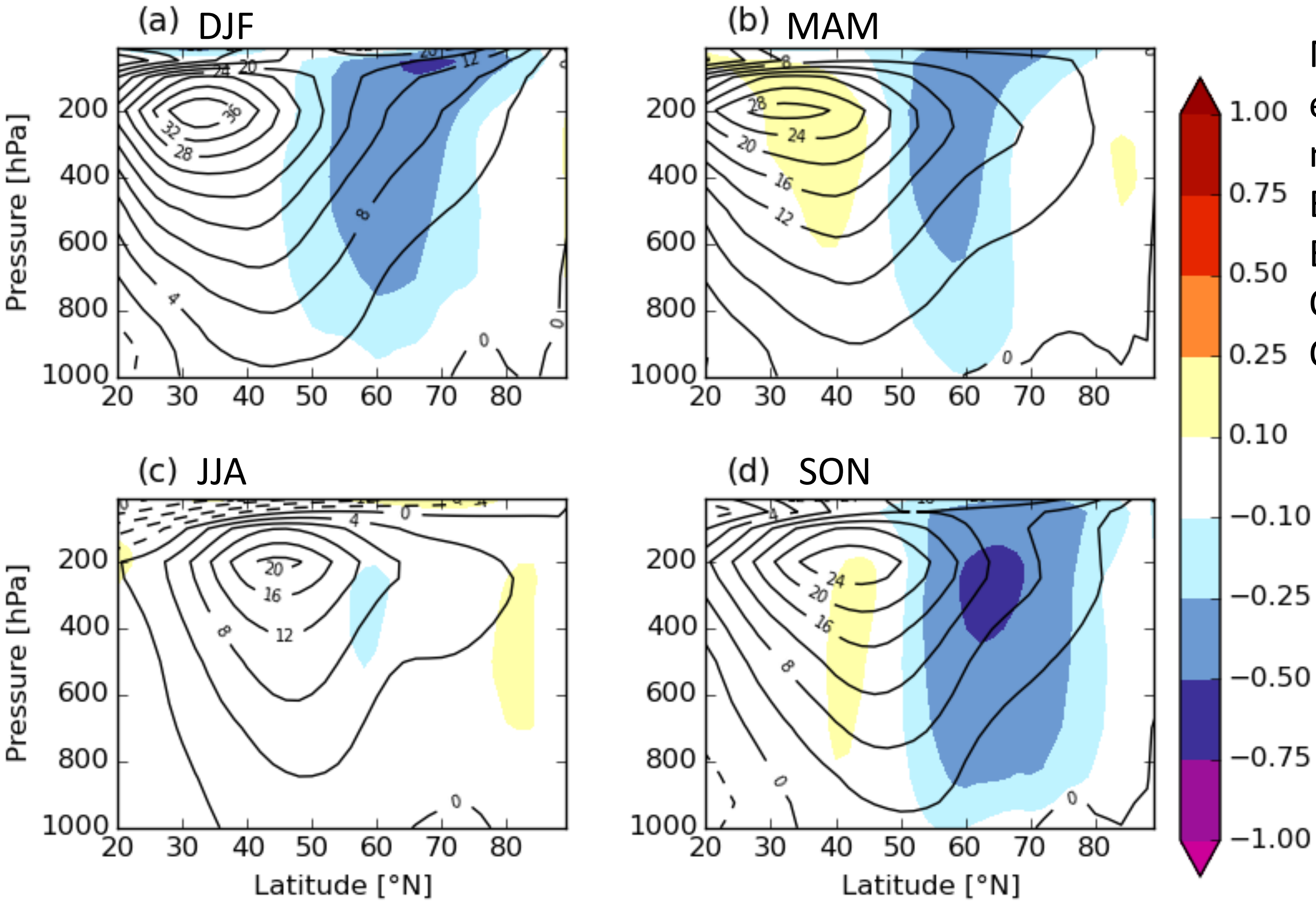
Fig. 8 -- East/west wind differences (m/sec); (ice out) - (ice in).

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.

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

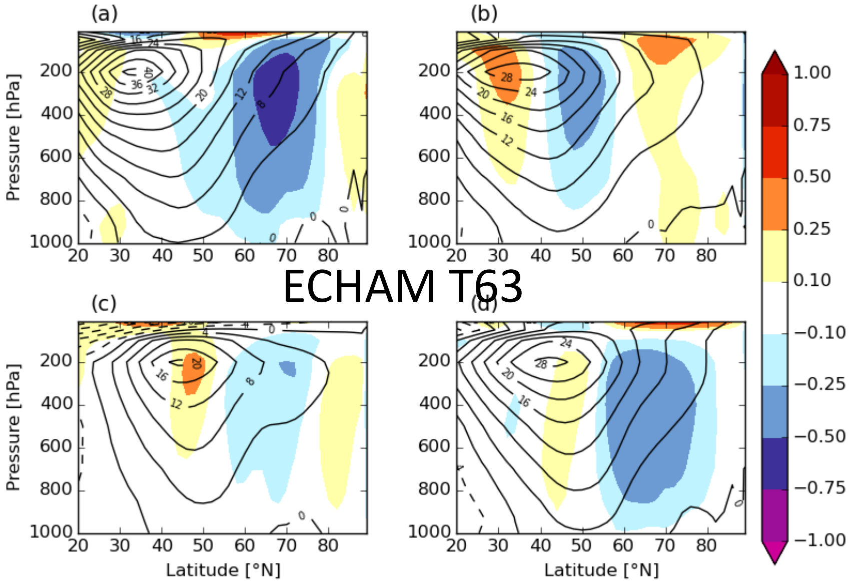
Response zonal mean U (m/s)

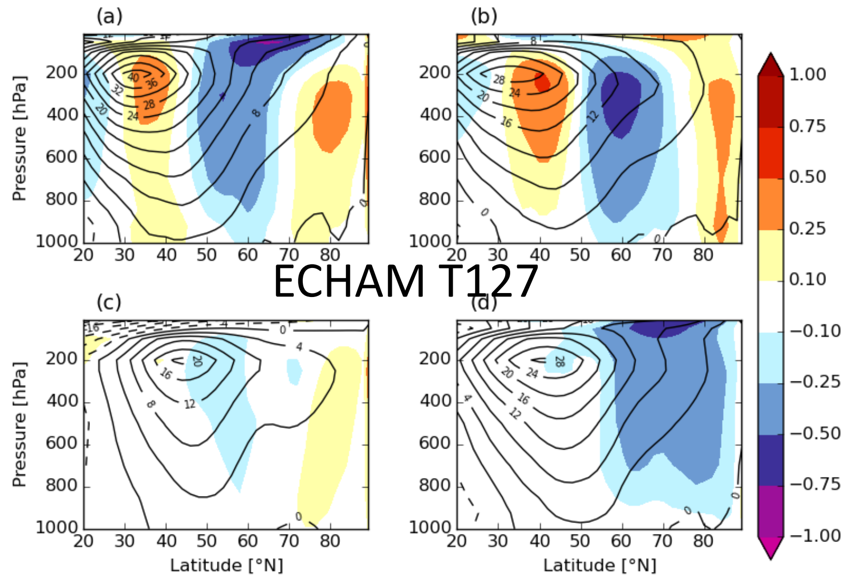


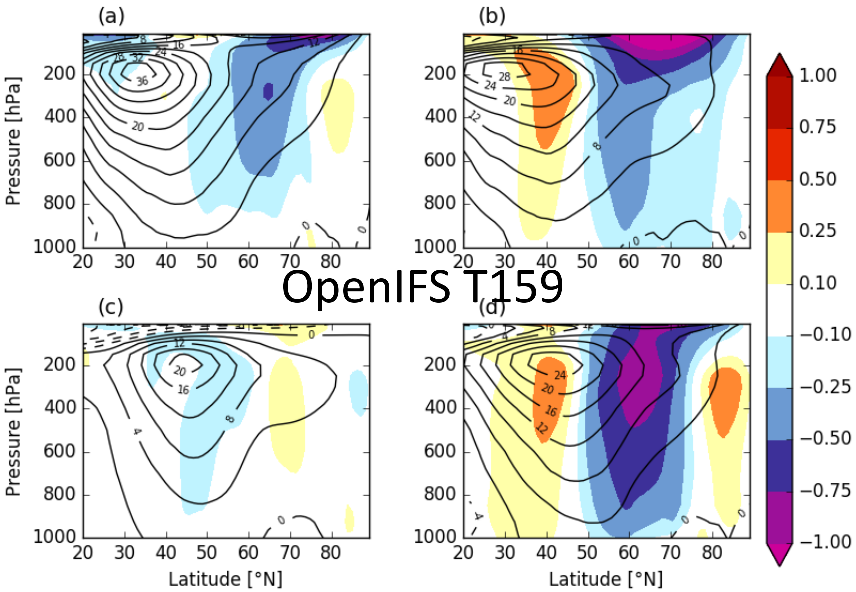
Multi-model ensemble mean: ECHAM6 T63, ECHAM6 T127, OpenIFS T159, OpenIFS T511

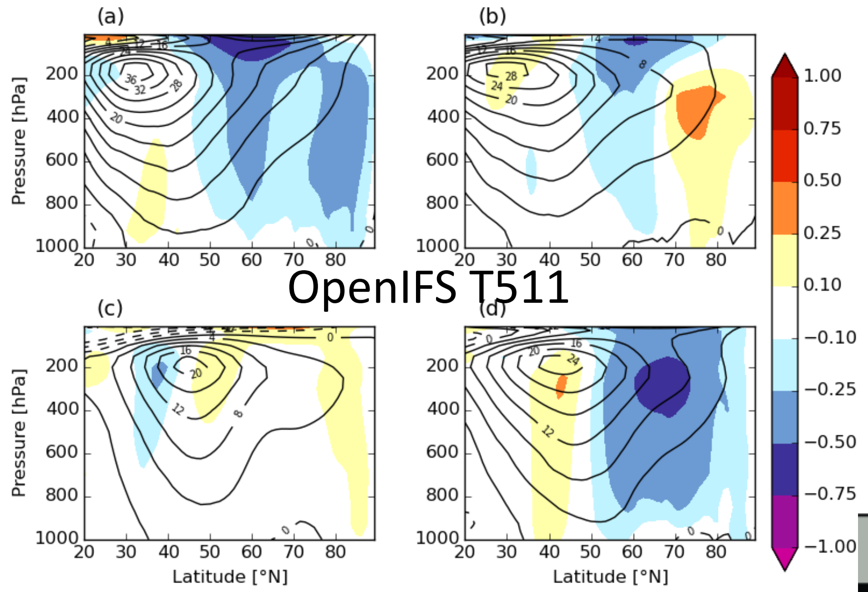
Largest response in autumn; no response in summer

Response zonal mean U (m/s)
Individual simulations (each simulation: 100 ens members)

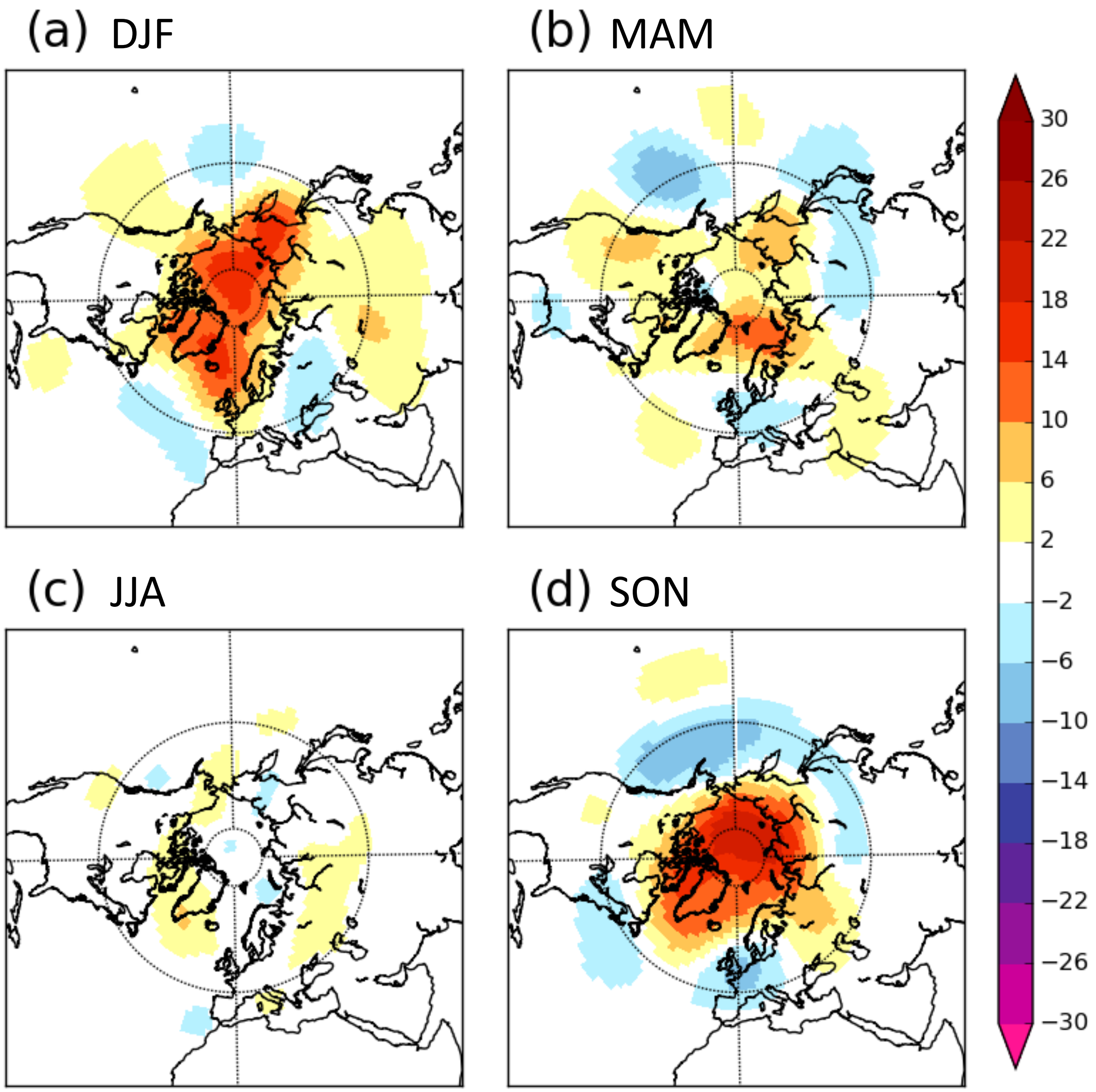








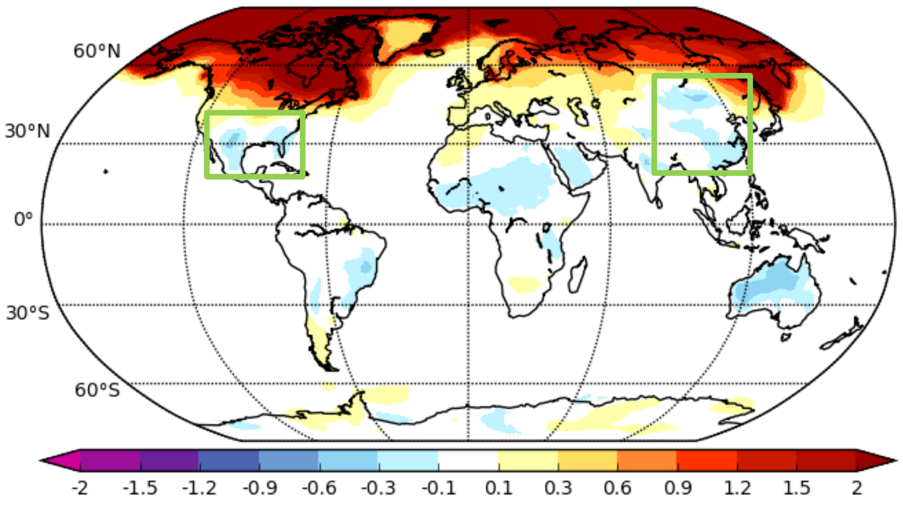
Response Z500 (m)



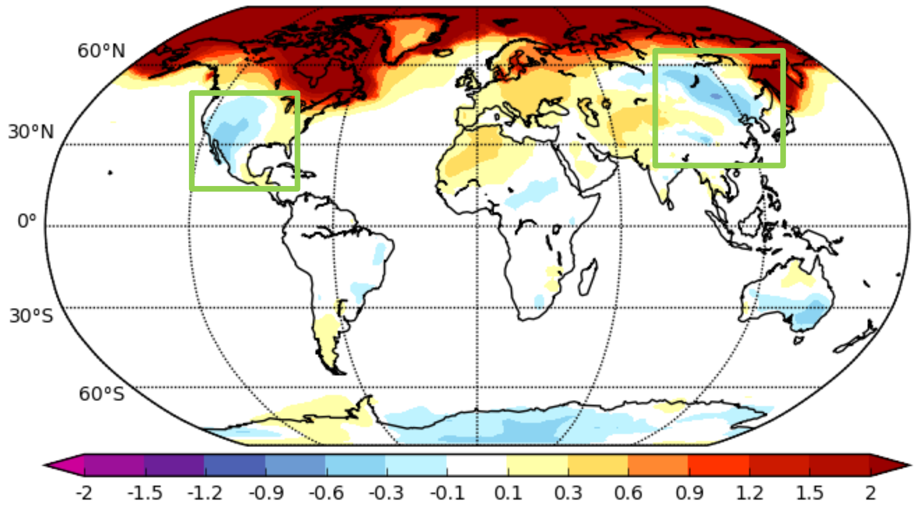
Multi-model ensemble mean: ECHAM6 T63, ECHAM6 T127, OpenIFS T159, OpenIFS T511

Largest response in autumn; no response in summer

DJF 2 m temperature change future Arctic sea ice minus present-day



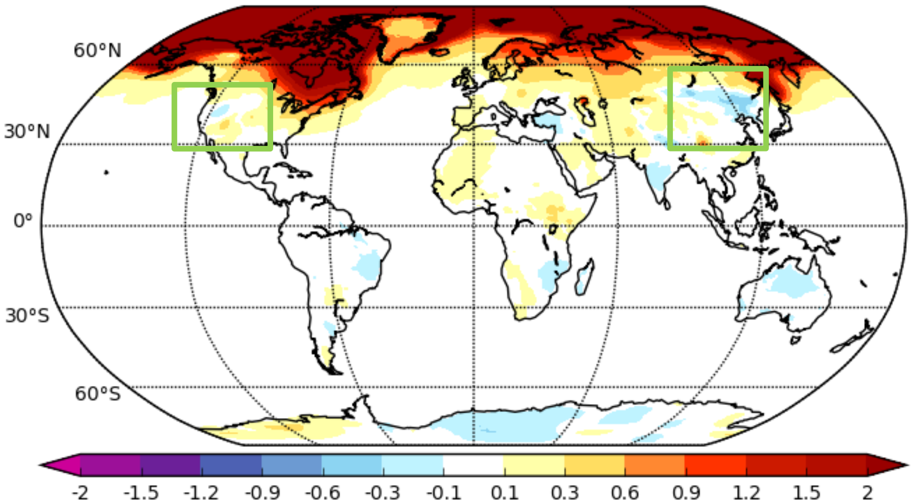
ECHAM6 T127



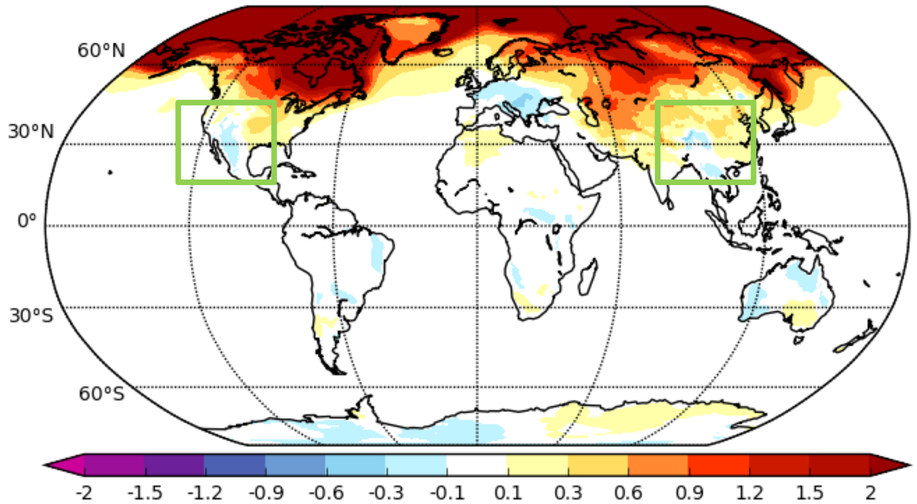
ECHAM6 T127 with SWIFT (stratospheric ozone chemistry)

Stratospheric ozone chemistry amplifies local cooling response

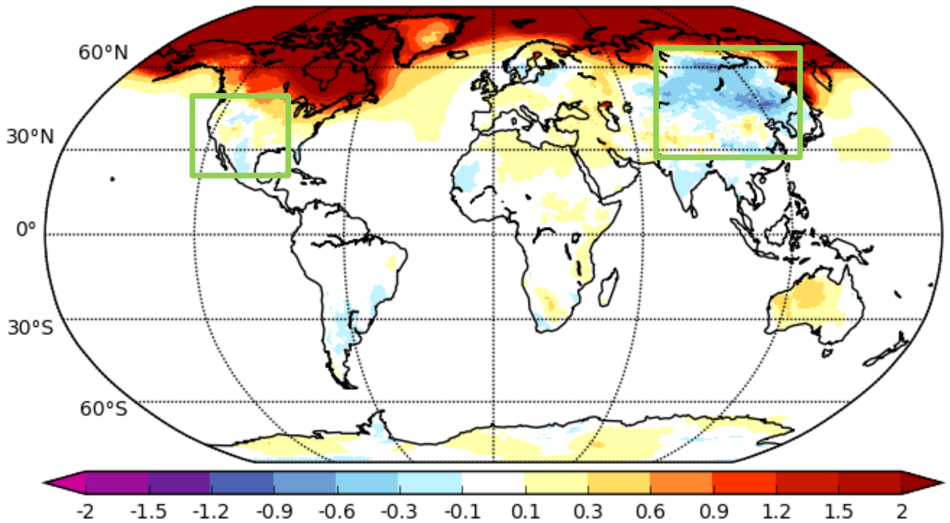
DJF 2 m temperature change future Arctic sea ice minus present-day



OpenIFS T159 – 100 km



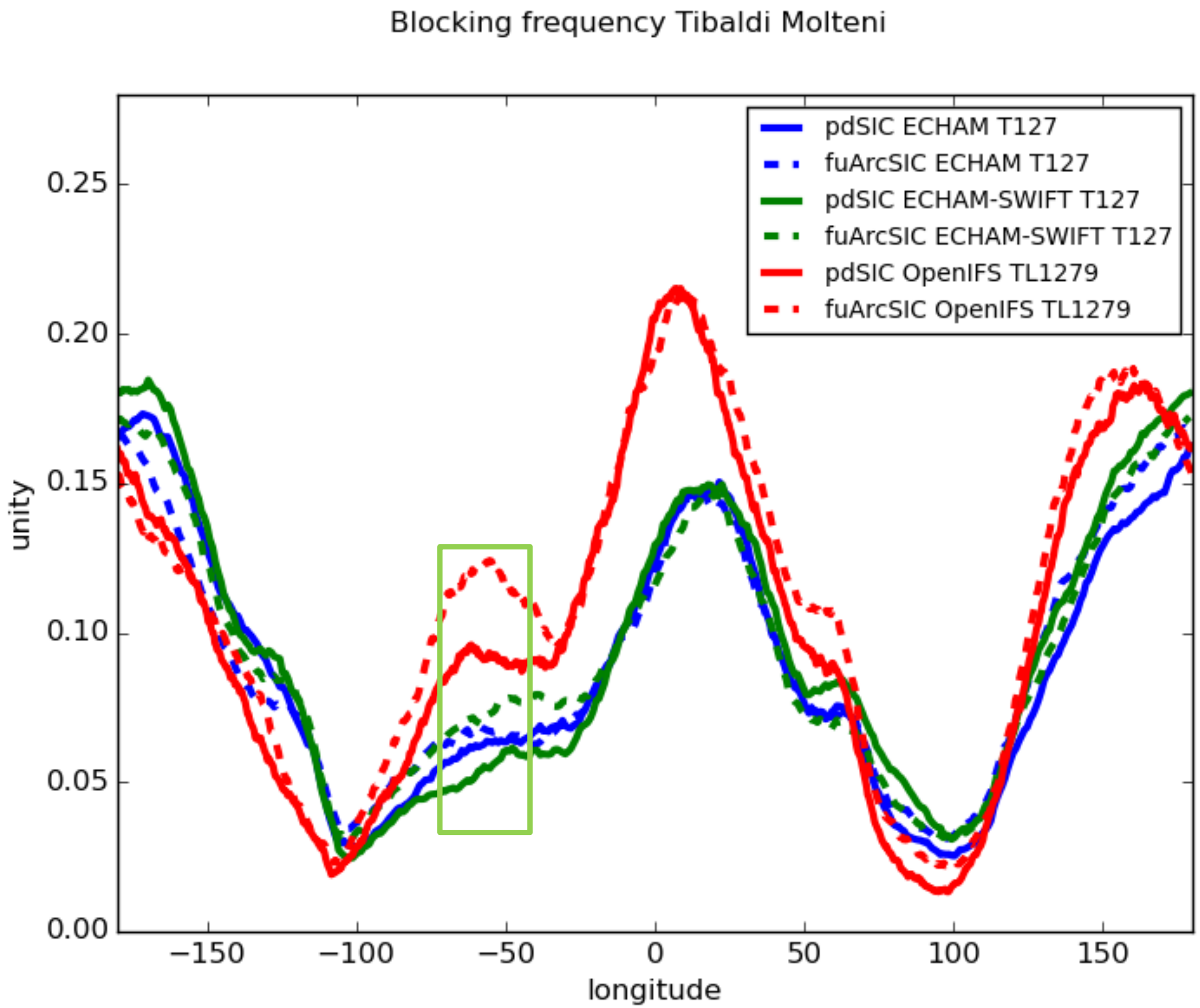
OpenIFS T511 – 40 km



OpenIFS T1279 – 15 km

Resolution increase amplifies local cooling response

DJF blocking index according to Tibaldi and Molteni



Greenland blocking frequency increase with decreasing Arctic sea ice is stronger for *high resolution* and with *stratospheric ozone chemistry*

Chen and Luo, GRL, 2017: Arctic sea ice decline and continental cold anomalies: Upstream and downstream effects of Greenland blocking

Upstream: North America
Downstream: Siberia

Conclusions

Some robust features from model simulations (weakening of westerlies, increase of Z500 over the Arctic) were known long before PAMIP

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

PAMIP has enabled us to pin down effects of high resolution and inclusion of processes on long discussed phenomena such as atmospheric blocking and cold temperature anomalies due to Arctic sea ice decline

Results are still preliminary since other models need to be evaluated. However, the feature of more robust responses with increased resolution has been found in other experiments. Now to find out why!