APPLICATE.eu
Advanced prediction in polar regions and beyond

General Assembly 2019 and Early Career Event 28 January - 1 February 2019
ECMWF Shinfield Rd, Reading RG2 9AX, United Kingdom

The interactions between the Arctic and the midlatitudes from atmospheric relaxation experiments

Kunhui Ye[1], Thomas Jung[12] and Tido Semmler[1]

[1] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research

[2]University of Bremen, Bremen, Germany

January 29th, 2019, Reading, UK

Acknowledgement: Thanks to Felix for helpful discussions and Luisa for project support

APPLICATE.eu
Advanced prediction in polar regions and beyond

The idea of Arctic influence on mid-low latitudes

- Relatively new
- In direct competition with the tropical influence (e.g., ENSO)
- Controversial and still hard to prove
- **But has a promising future**

The relaxation experiments and relaxation equation

$$dx/dt=F(x)-\alpha(x-x_{ana})$$

X: state vector of the model
α: relaxation coefficient (0.1)
$X_{ana:}$ state vector of ERA-Interim data
Buffer zones: about 5° in latitude and 100 hPa in pressure

ECMWF atmospheric model (T_L255L60); Relaxation towards ERA-Interim data; 35 winters and summers with 9 members each;

Relaxed variables: Temperature, *horizontal wind* and *surface pressure*.

These relaxation experiments can be used to study 'teleconnected' influences, but they cannot be used to study the impacts of boundary forcing like sea ice loss.

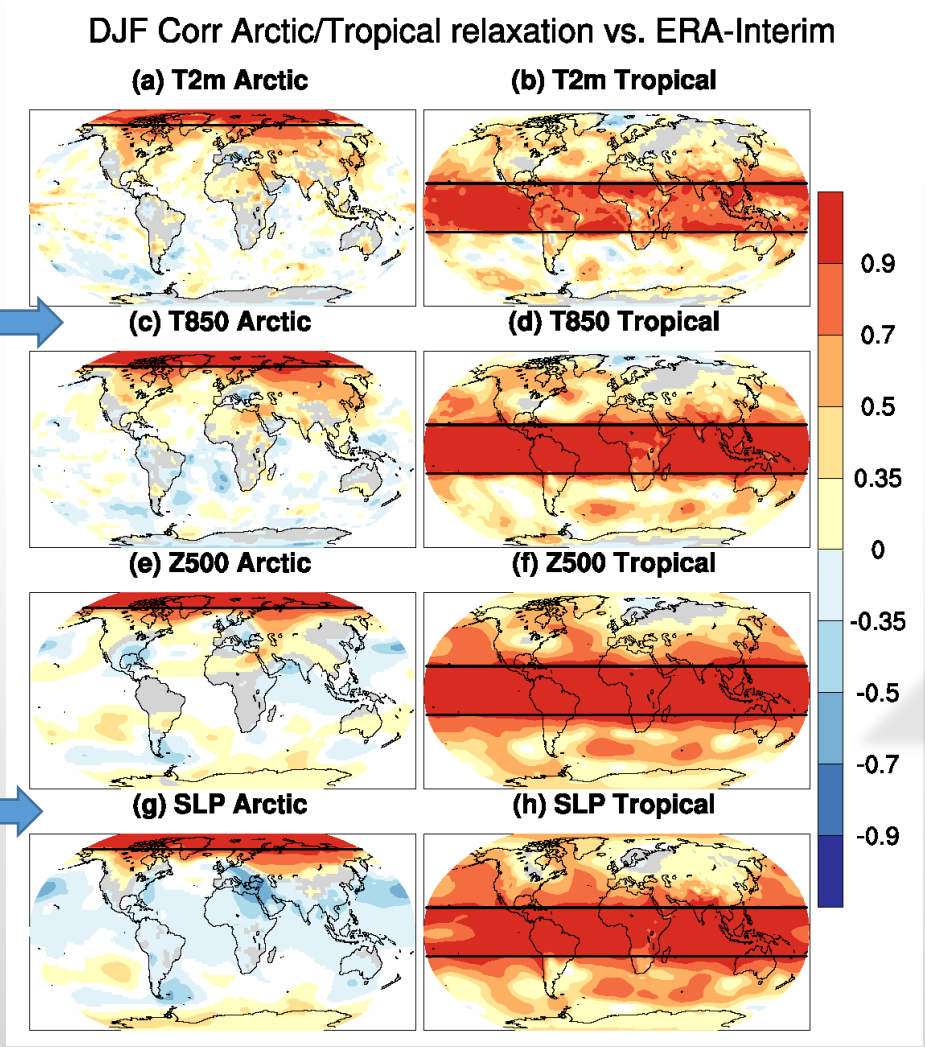
Summary of the relaxation experiments

Name of experiment	Boundary conditions	With relaxation	Horizontal area with relaxation	Vertical extent with relaxation
SST-SeaIce-Obs	Observed SST/Sea ice	No	N/A	N/A
SST-SeaIce-Clim	Climatological SST/Sea ice	No	N/A	N/A
Arctic	Climatological SST/Sea ice	Yes	**70°N-90°N**	Surface to 300 hPa
Tropical	Climatological SST/Sea ice	Yes	**20°S-20°N**	Full atmosphere
TropMidlat	Climatological SST/Sea ice	Yes	**57.5°S-57.5°N**	Full atmosphere

Impacts on midlatitudes

Impacts on the Arctic

Impacts on the midlatitudes: The Arctic versus Tropics (detrended) Ye et al. 2018 JGR Atmos



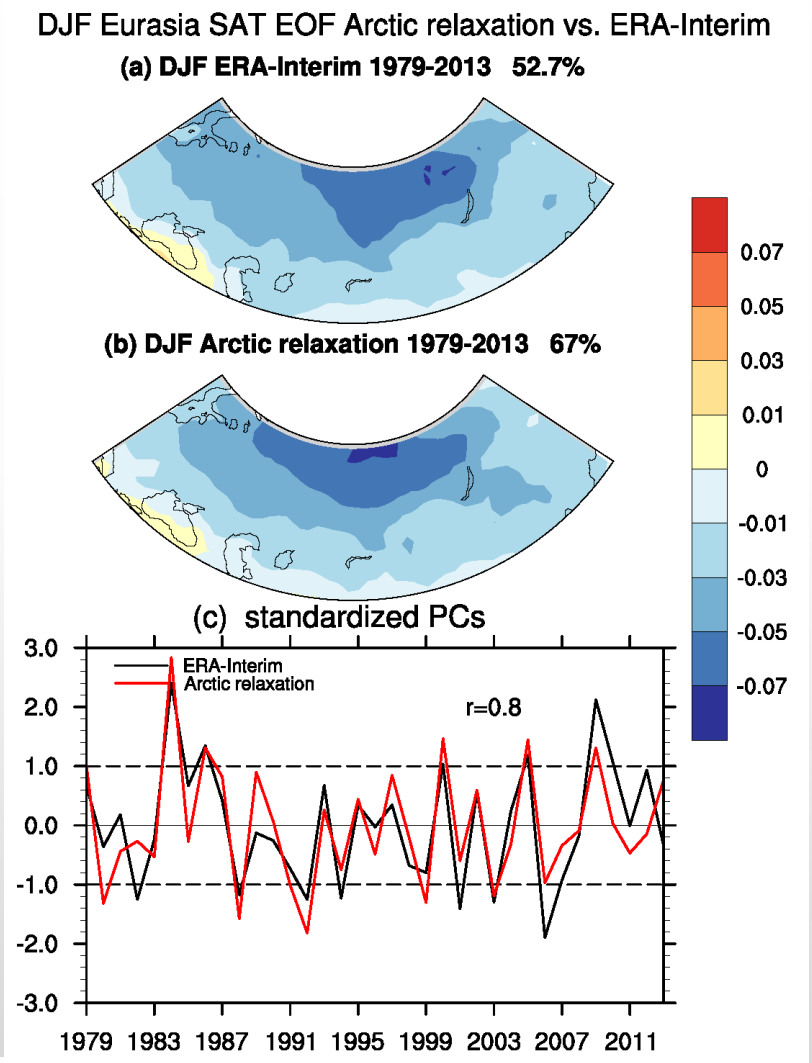
Temperature

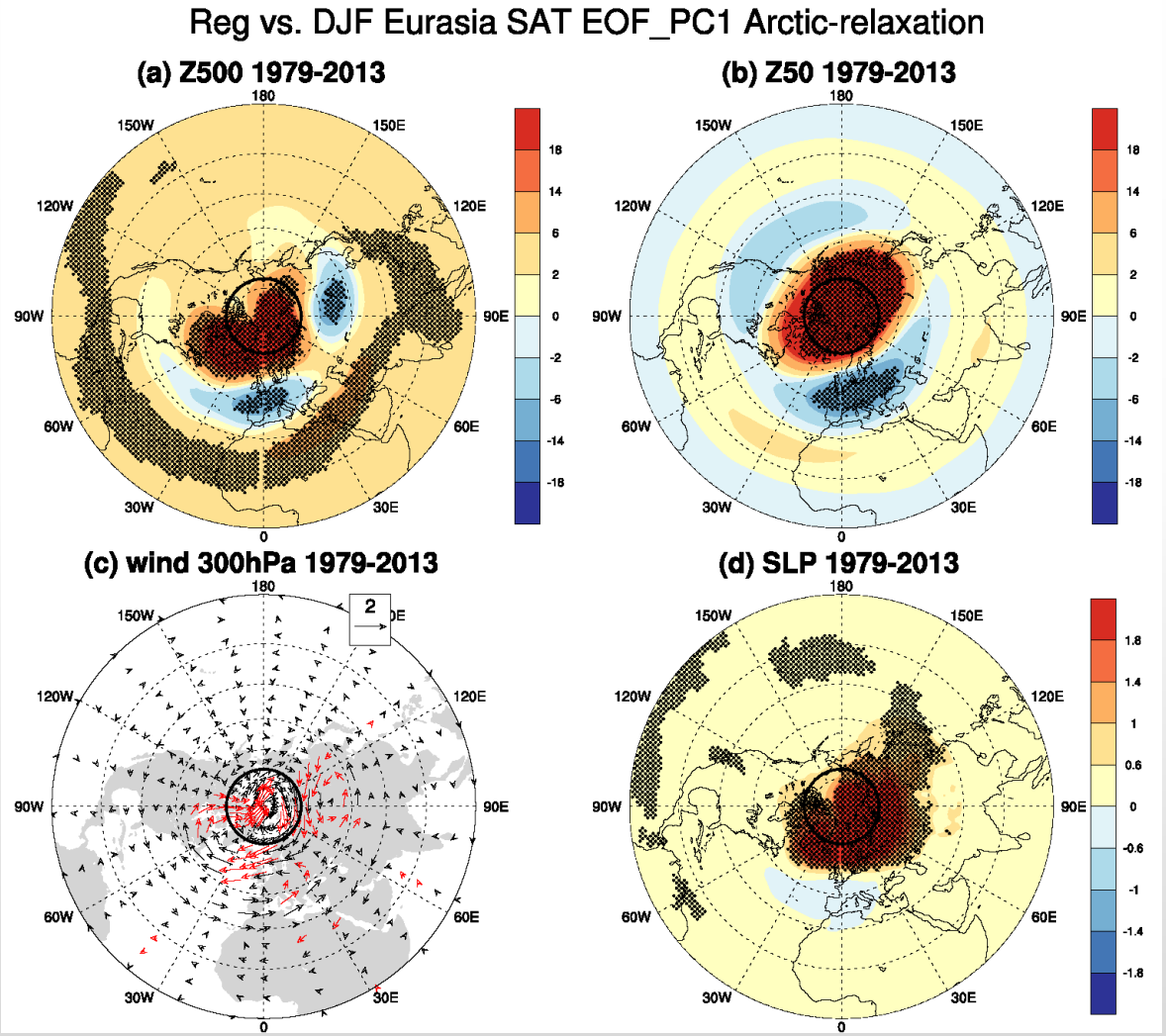
Circulation

The Arctic has a potential to influence the midlatitudes during boreal winter;

Such influence over Northern Eurasia might be even more significant than by the tropics.

The atmospheric pathway for the Arctic influence

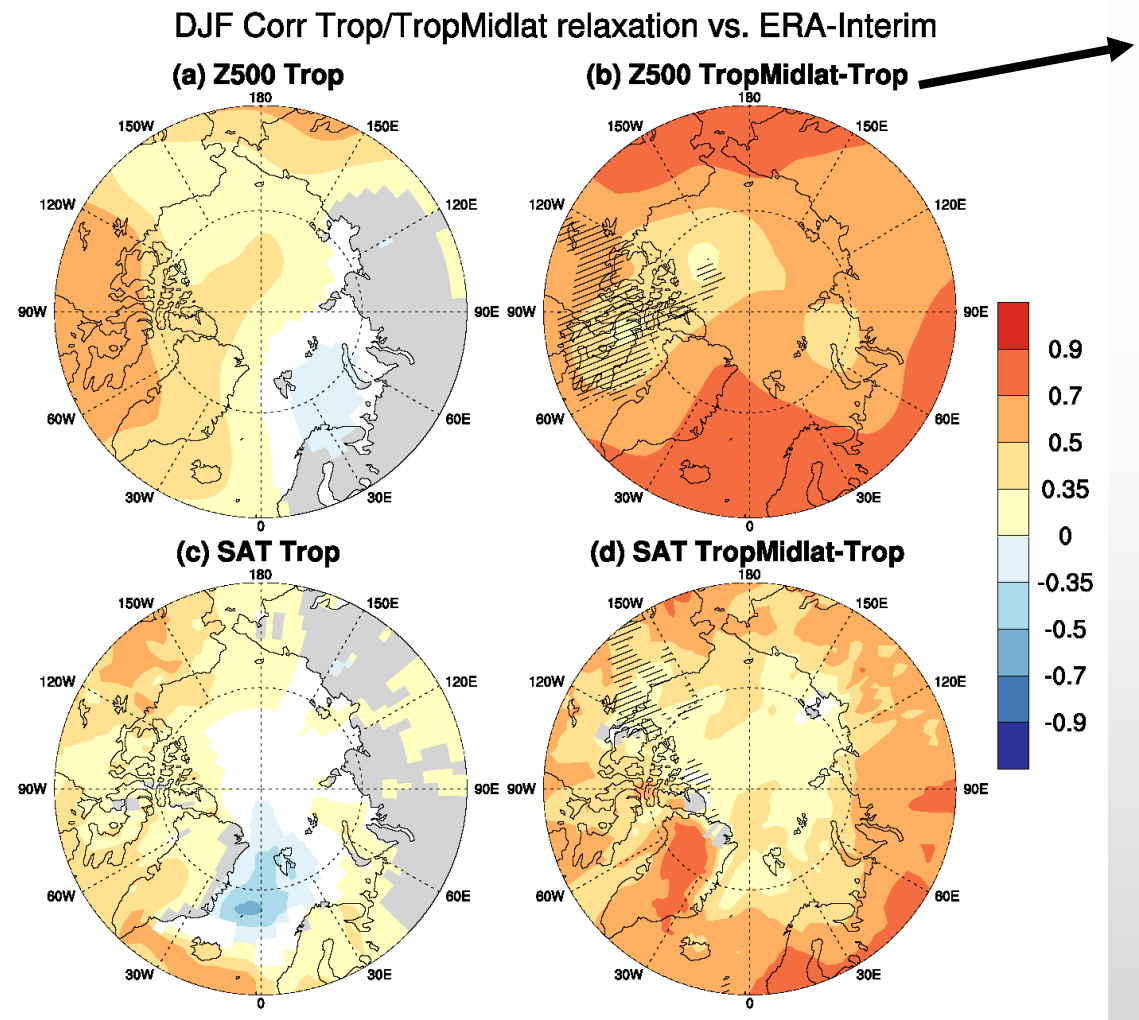




Relaxation of the Arctic troposphere

- ✓ Has some strong impacts on the surface temperature at midlatitude continent particularly Northern Eurasia
- ✓ Leads to some significant changes to the zonal winds (also geopotential height) at mid-high latitudes
- ✓ Has some strong impacts on the intensity of the Siberian High (important component of the East Asian winter monsoon)

Impacts of the tropics versus midlatitudes on the Arctic



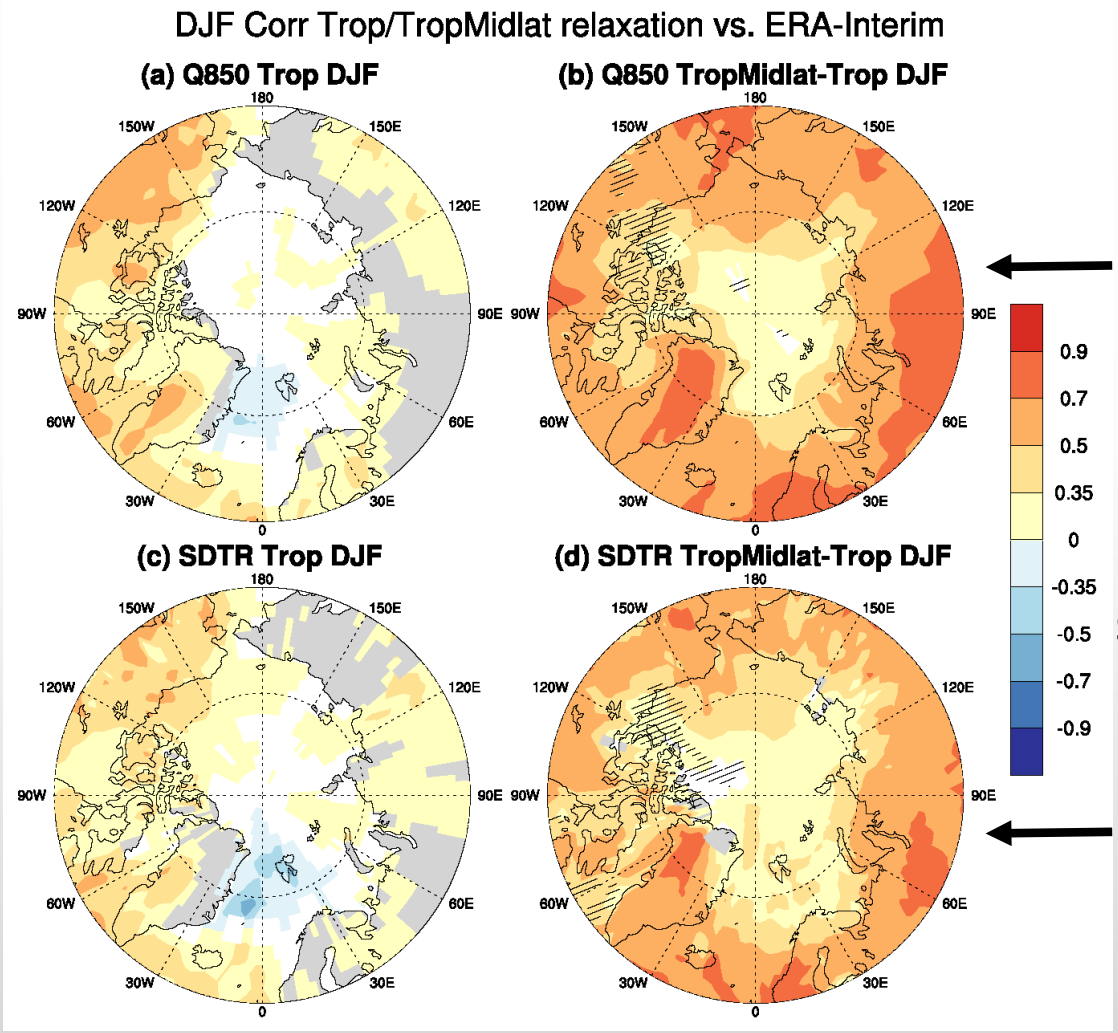
"midlatitude relaxation experiment"

Tropics: important pathway over North America

Midlatitudes: important pathways over North Atlantic, west Eurasia, North Pacific

Impacts on temperature: weaker constraints than circulation; Midlatitudes more important

Impacts of the tropics versus midlatitudes on the Arctic

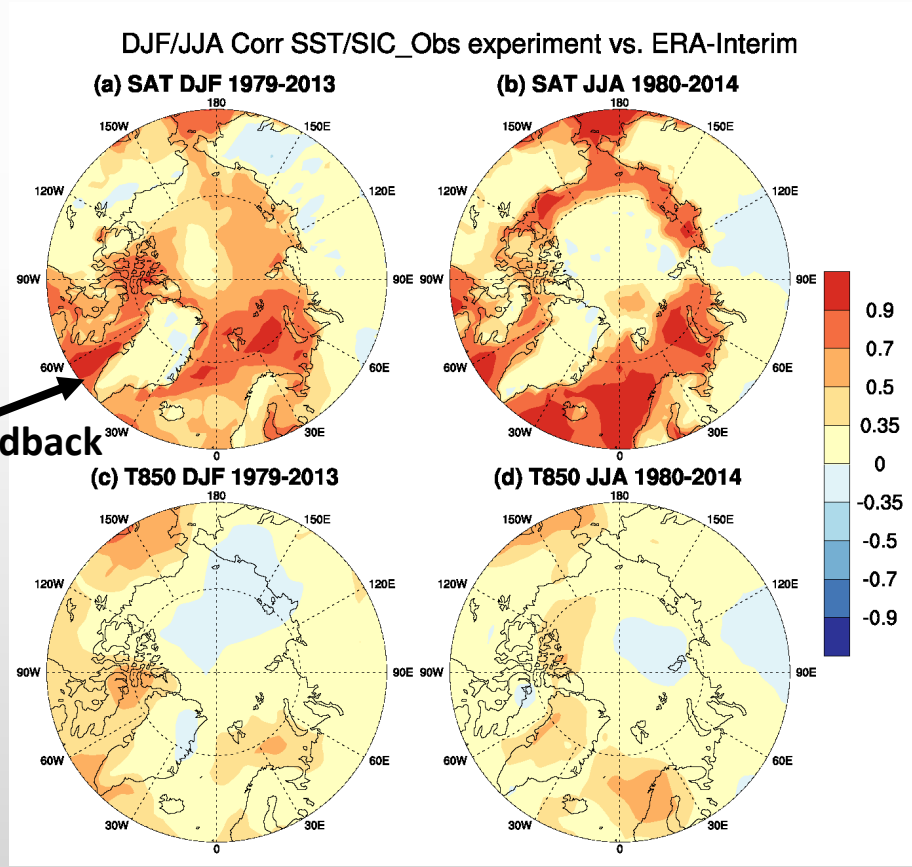


Humidity

Sea ice/SST feedback

Surface downward thermal radiation

In addition to the lack of interannual variability of sea ice/SST, the local radiative/cloud processes may be a key to explaining the poor temperature constraints



Principle findings

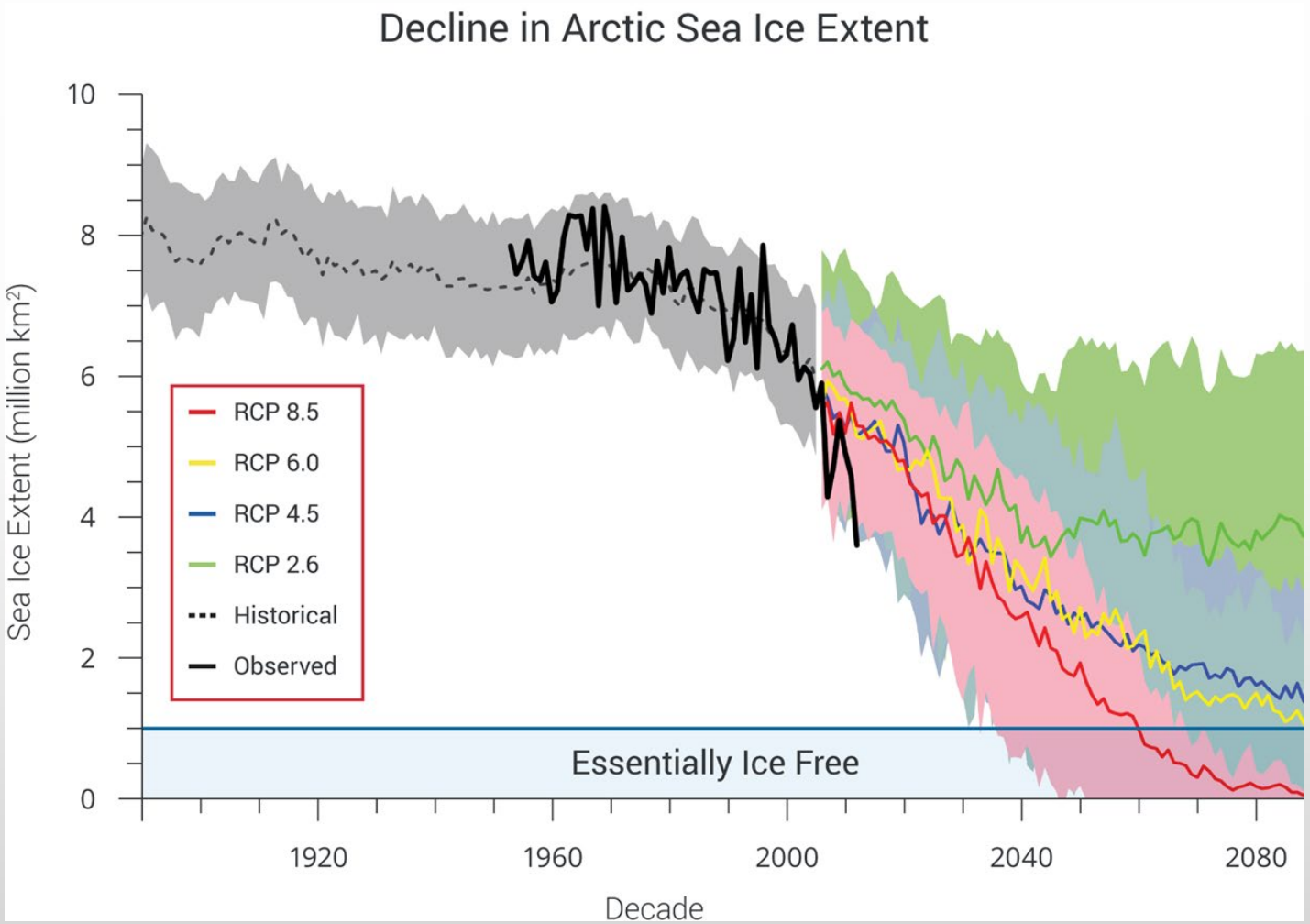
✓The Arctic has strong influences on the climate variability over the midlatitude continent particularly Northern Eurasia

✓ The primary pathways include modulation of zonal winds/jet stream and the Siberian High

❖ **In terms of forcing of the Arctic climate/circulation, the tropics and the midlatitudes have different pathways**

❖ **The local radiative/cloud processes are seemingly important**

Recent climate changes in the Arctic and midlatitudes



Ice-free?

Stroeve et al. 2012

Recent climate changes in the Arctic and midlatitudes

Arctic Amplification (AA)

Midlatitude cooling (also global warming hiatus)

More extreme events

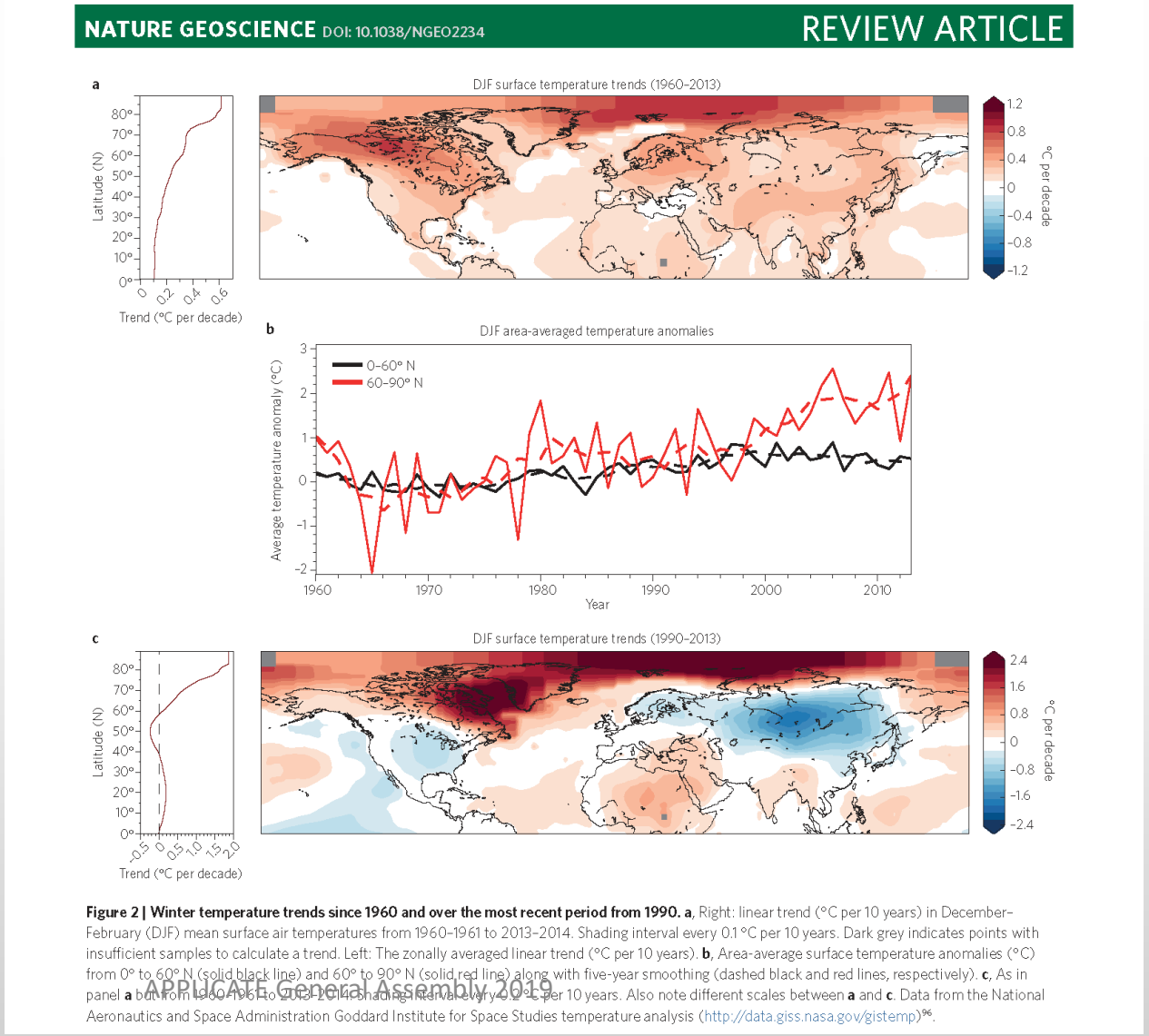
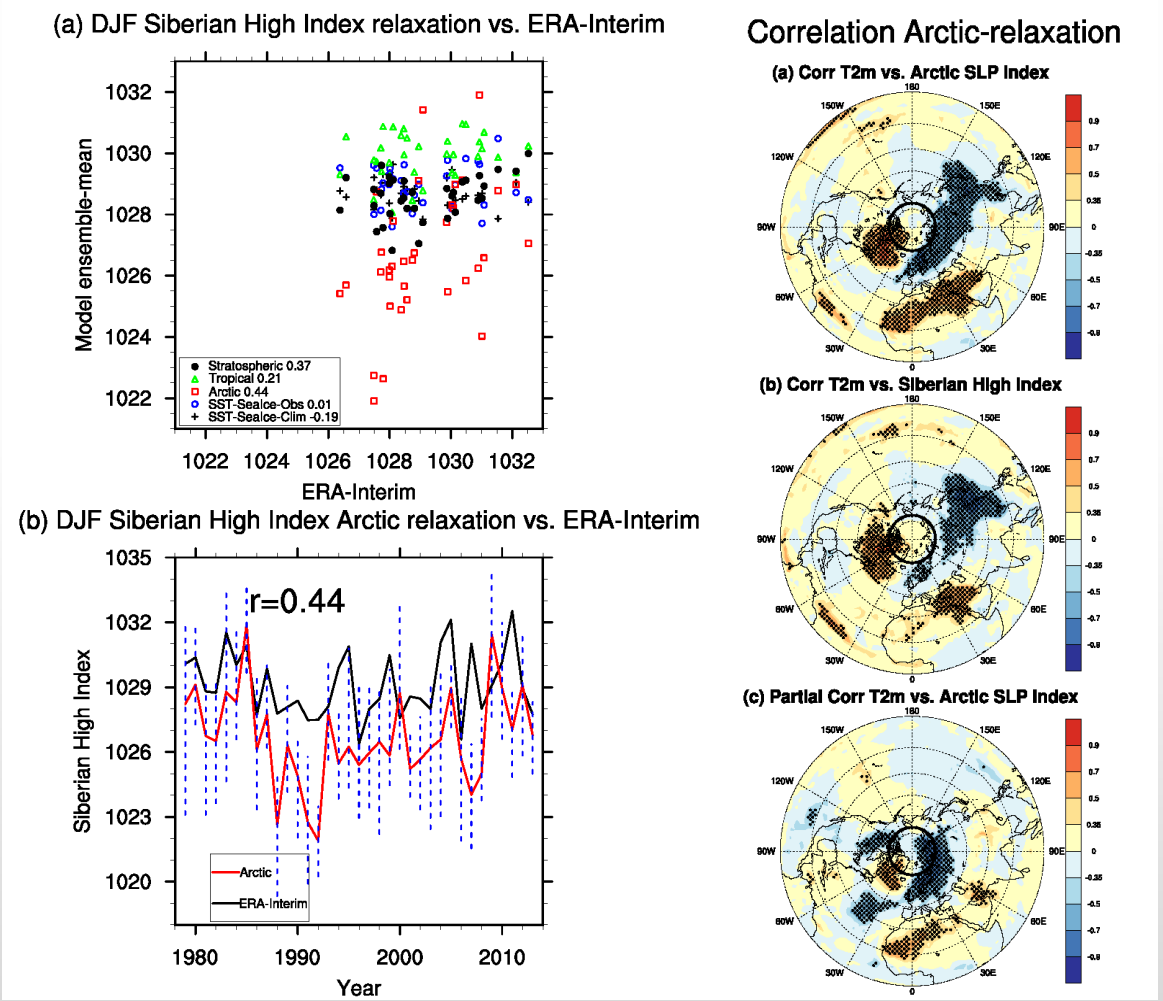


Figure 2 | Winter temperature trends since 1960 and over the most recent period from 1990. a, Right: linear trend (°C per 10 years) in December–February (DJF) mean surface air temperatures from 1960–1961 to 2013–2014. Shading interval every 0.1 °C per 10 years. Dark grey indicates points with insufficient samples to calculate a trend. Left: The zonally averaged linear trend (°C per 10 years). **b**, Area-average surface temperature anomalies (°C) from 0° to 60° N (solid black line) and 60° to 90° N (solid red line) along with five-year smoothing (dashed black and red lines, respectively). **c**, As in panel **a** but from 1990–1991 to 2013–2014. Shading interval every 0.2 °C per 10 years. Also note different scales between **a** and **c**. Data from the National Aeronautics and Space Administration Goddard Institute for Space Studies temperature analysis (http://data.giss.nasa.gov/gistemp)[96].

Cohen et al. 2014

Strong Impacts of the Arctic relaxation on the Siberian High



Modulation of the Siberian High may extend the Arctic influences further south

Future work

How might the air-sea coupling have contributed to the Arctic-midlatitude linkages (comparing the uncoupled and coupled experiments)?

Overview

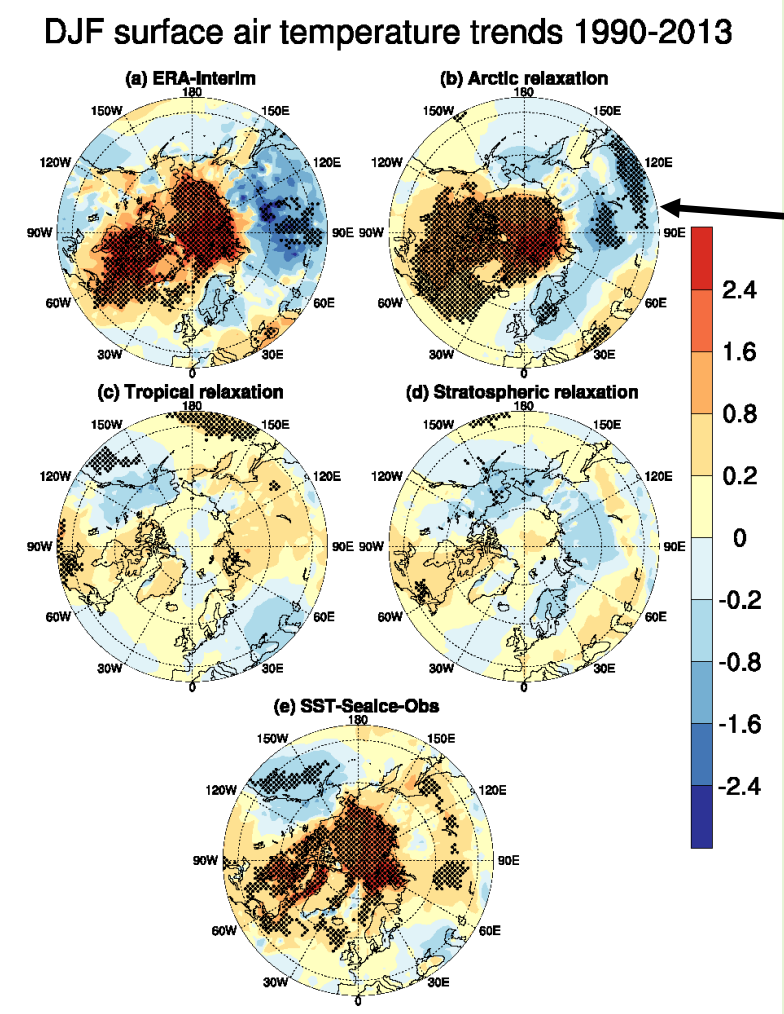
1 Recent climate changes in the Arctic and midlatitudes

2 Impacts of the Arctic versus tropics on the midlatitudes

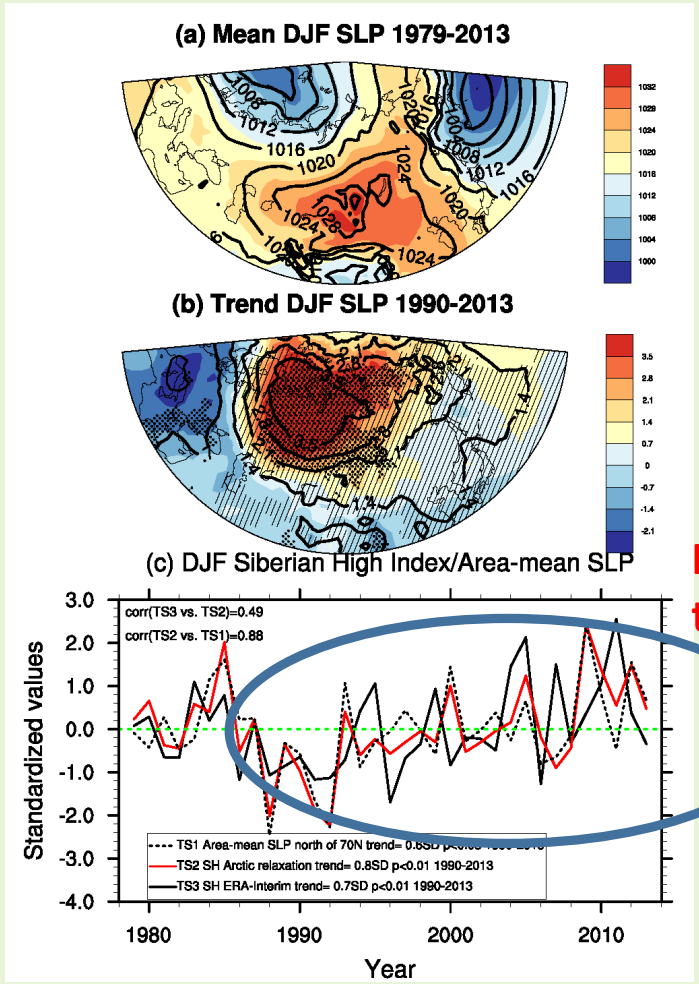
3 Impacts of the tropics versus midlatitudes on the Arctic

4 Summary and future work

The recent Eurasian cooling and the intensification of the Siberian High

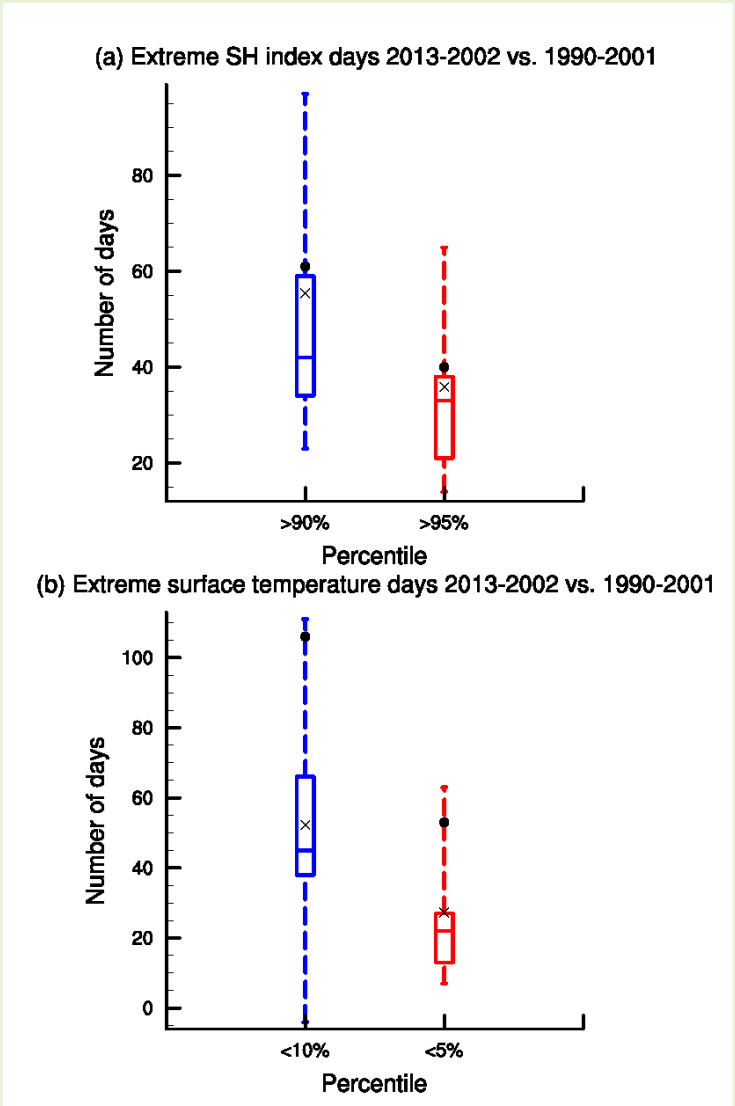


Reproduced Cooling trend

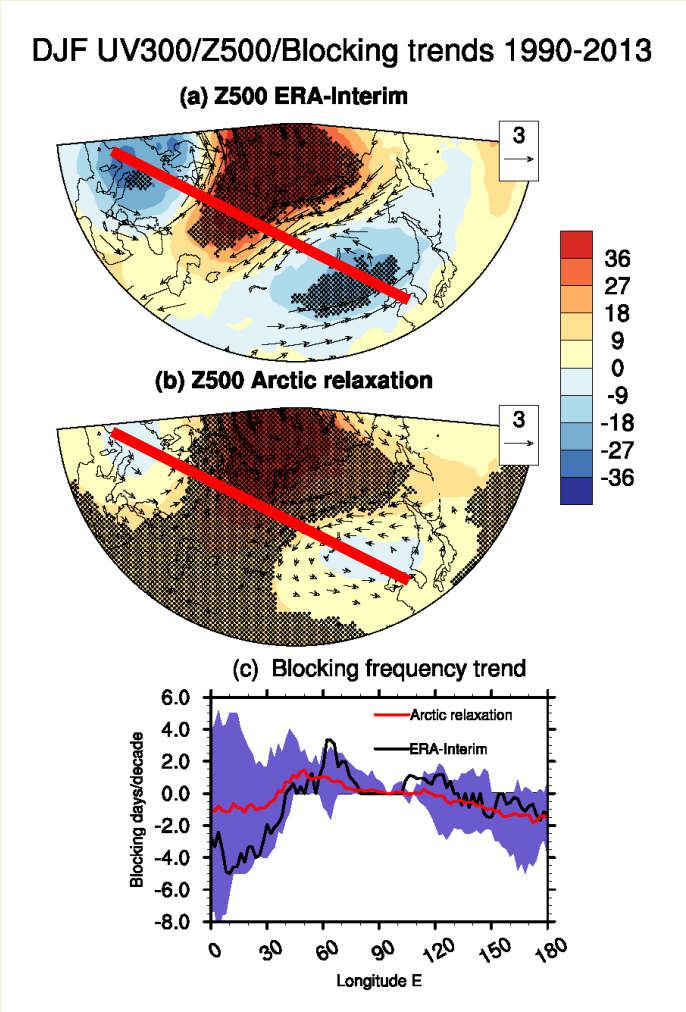


Intensification of the Siberian High

Increase in extremes of Siberian High index and Siberian surface temperature

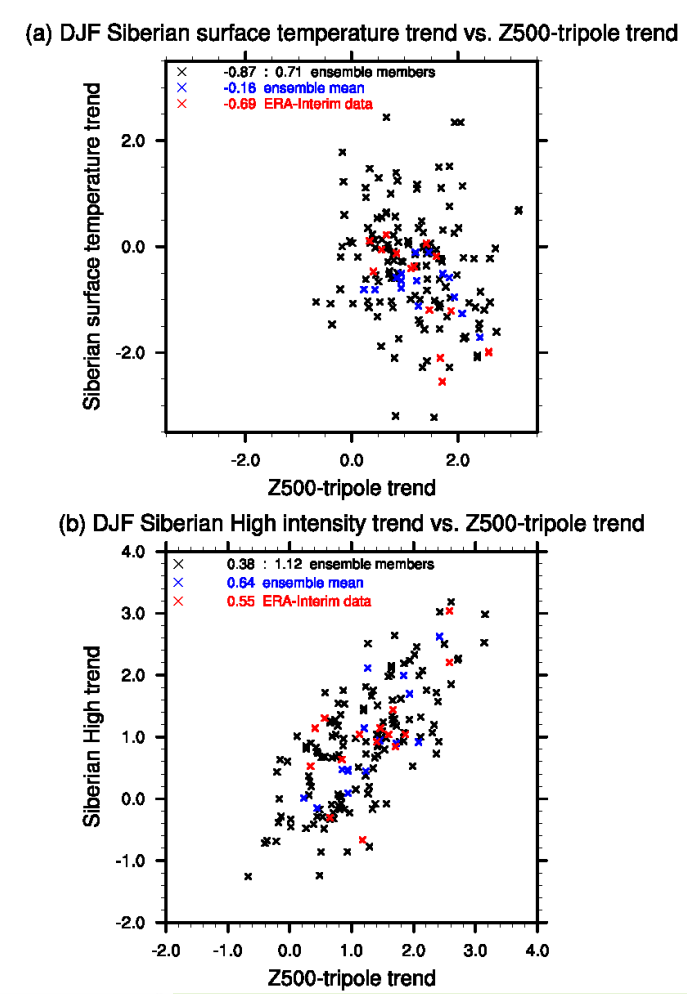


Tripolar Z500 circulation pattern



Recent Arctic climate changes and possible relation to the recent Eurasian cooling and the intensification of the Siberian High

Ten(10)-year overlapping trend trend



- ✓ A large part of the Siberian cooling trend is accounted for by the Z500 tripole circulation trend
- ✓ The enhanced activity of the tripole circulation is likely driven by the extra-tropical SSTs
- ✓ The recent intensification of the Siberian High and part of the Siberian cooling are driven by the decadal variations in the coupled atmosphere-ocean system
- ✓ Direct impacts of Arctic troposphere: possibly secondary

The roles of atmosphere-ocean coupling in the Arctic-midlatitudes linkage

Not Available

The APPLICATE Project

https://applicate.eu/about-the-project

Work Package 3 has two primary objectives:

To coordinate a suite of novel multi-model experiments designed to identify the oceanic and atmospheric linkages between the Arctic region and the northern mid-latitudes

To advance our understanding of the mechanisms by which mid-latitude weather and climate could respond to the substantial Arctic climate change that is expected in the coming decades