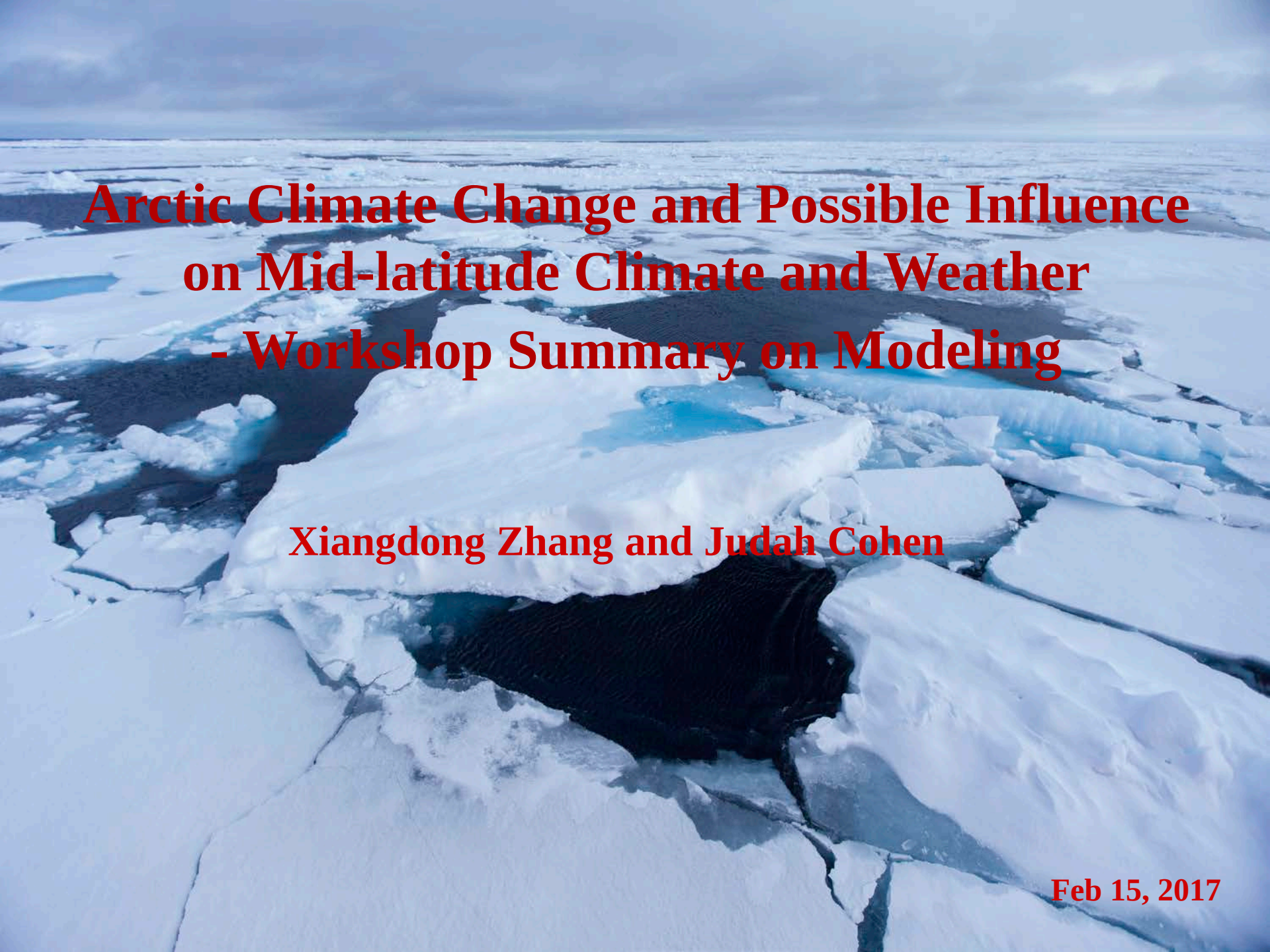
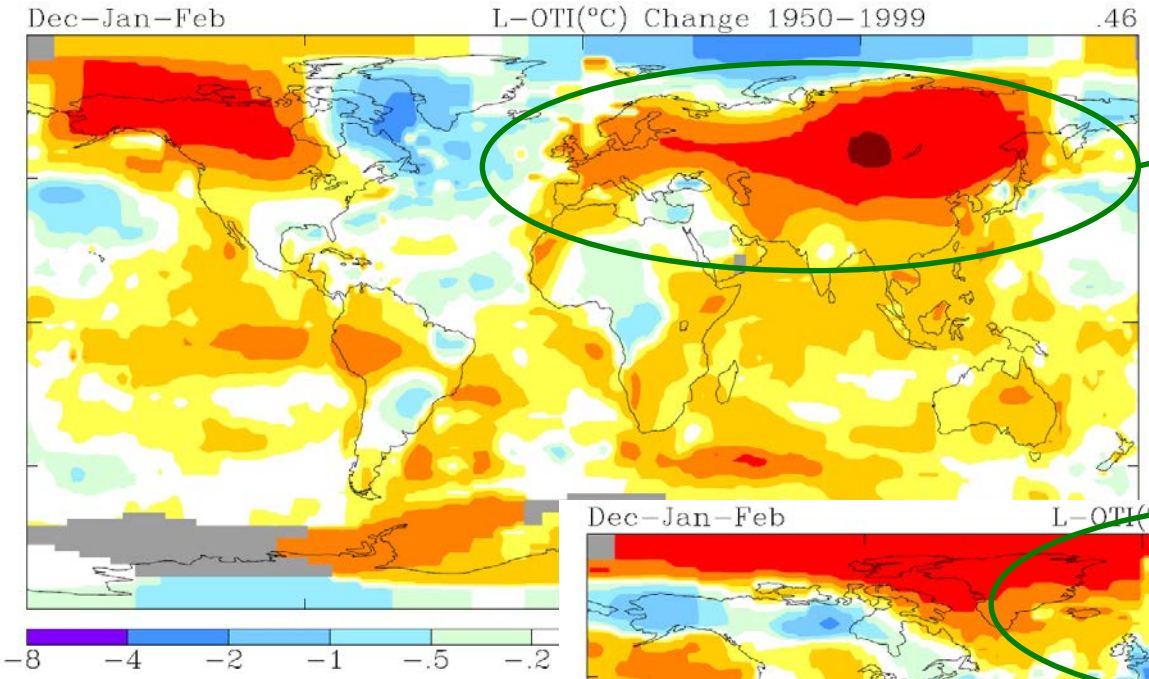


Arctic Climate Change and Possible Influence on Mid-latitude Climate and Weather - Workshop Summary on Modeling

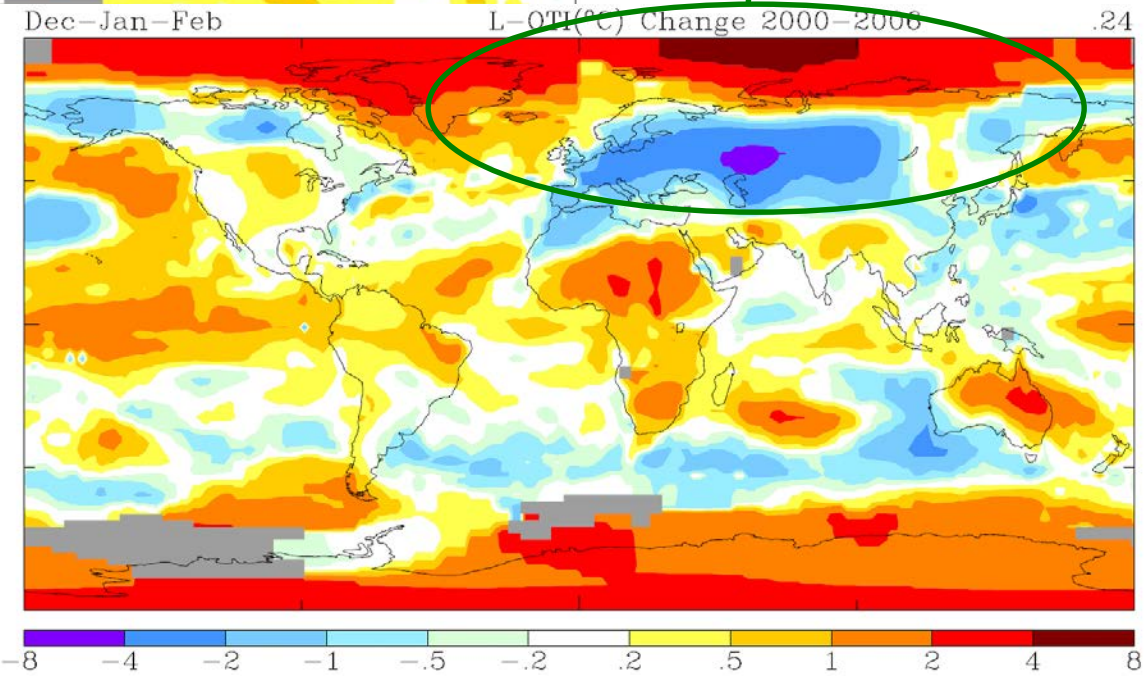
Xiangdong Zhang and Judah Cohen

Feb 15, 2017

Arctic amplification: A spatial pattern shift



Shift of SAT trend pattern



Note:
Winter: No sea ice and snow retreat induced albedo feedback

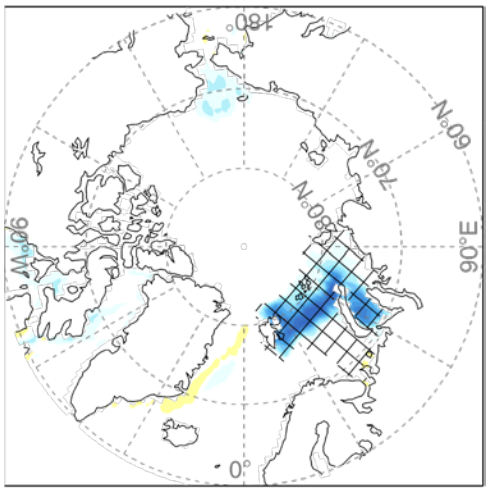
X. Zhang

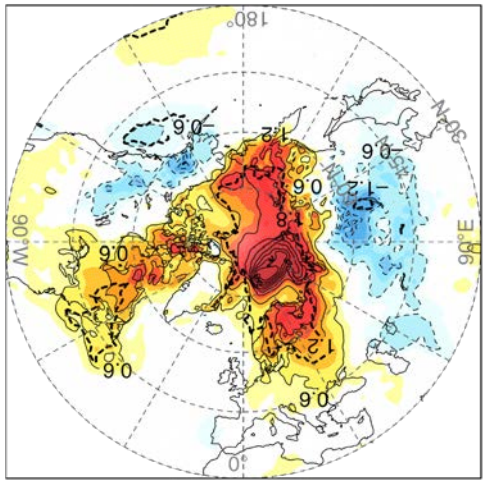
Sea ice anomaly forced changes in SAT and atmospheric circulation

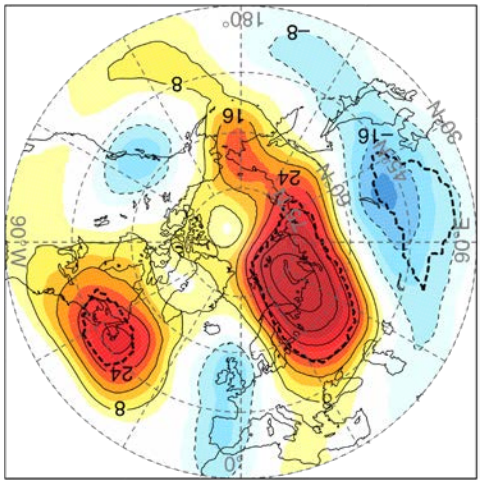
ΔSIC

ΔSAT

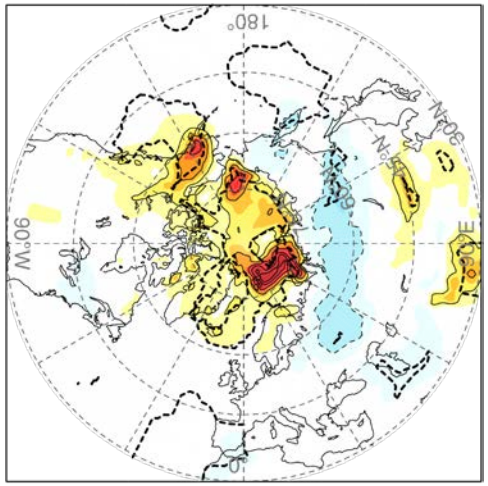
ΔZ@500 hPa

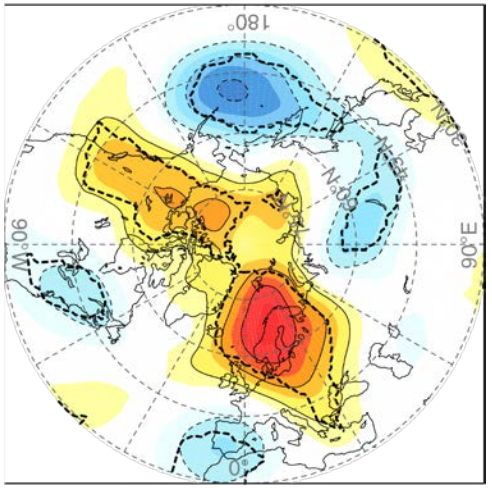






Obs

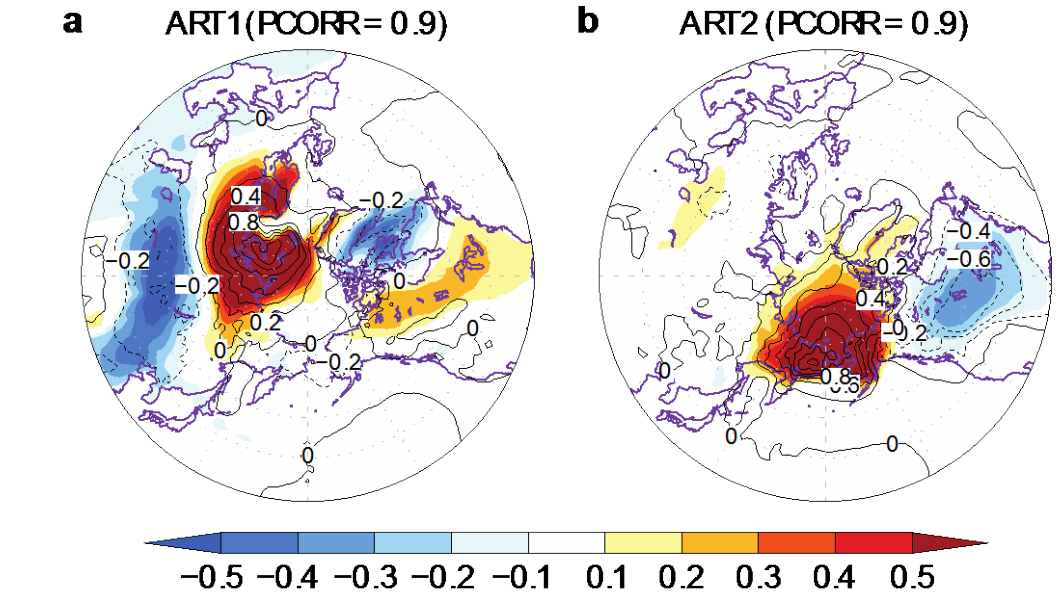


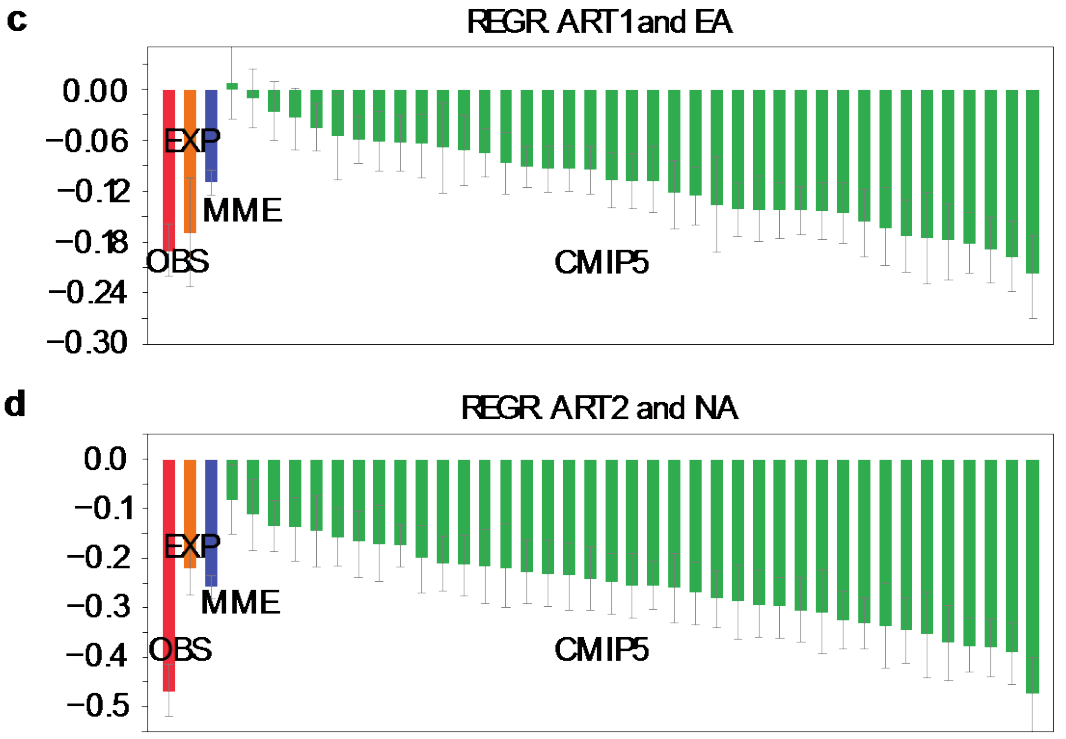


Modeling (CAM5)

Kim et al. 2014

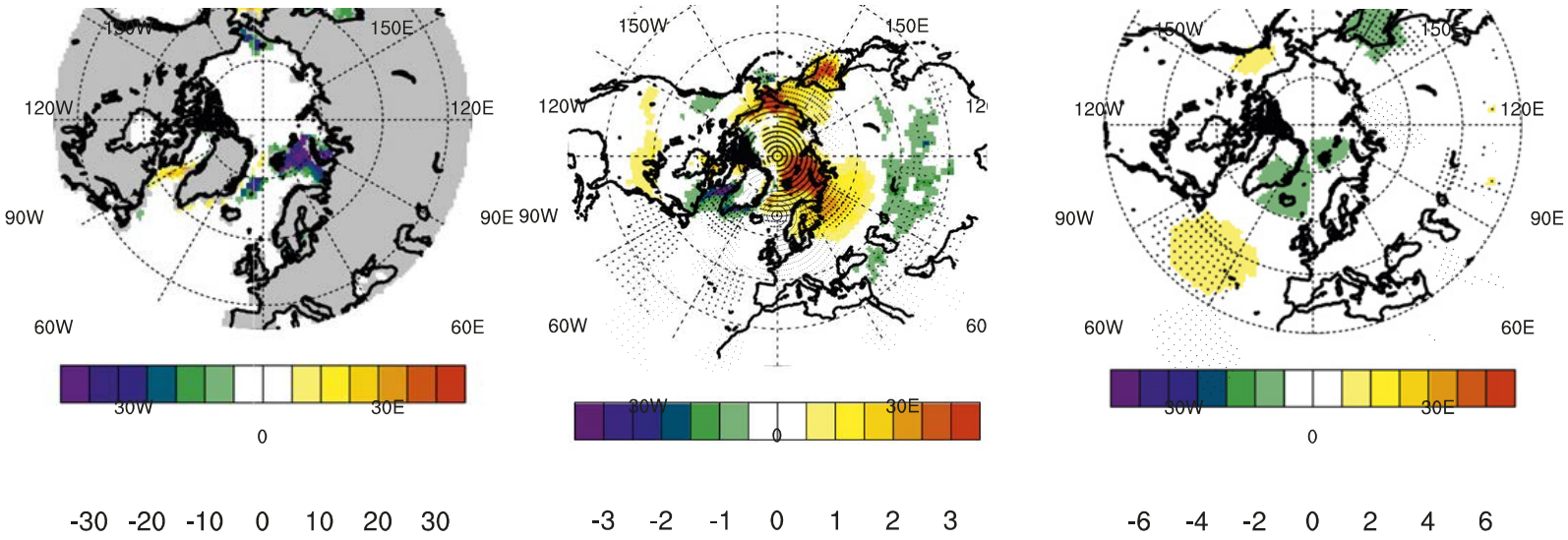
Arctic warming forced changes in SAT





Kug et al. 2015

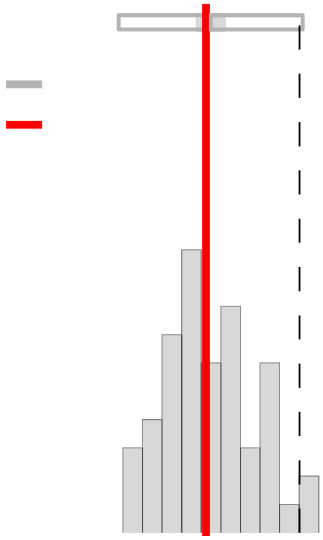
However, other model simulations show diversified results



Peings and Magnusdottir 2014

Screen 2014

However, other model simulations show diversified results

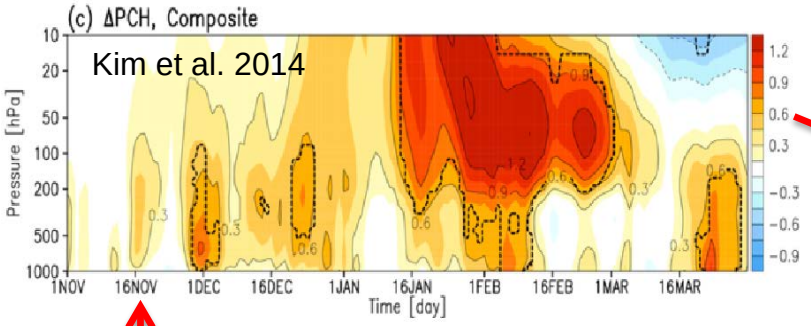


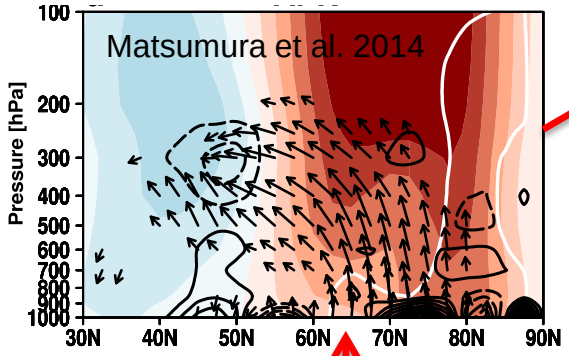
McCusker et al. 2016

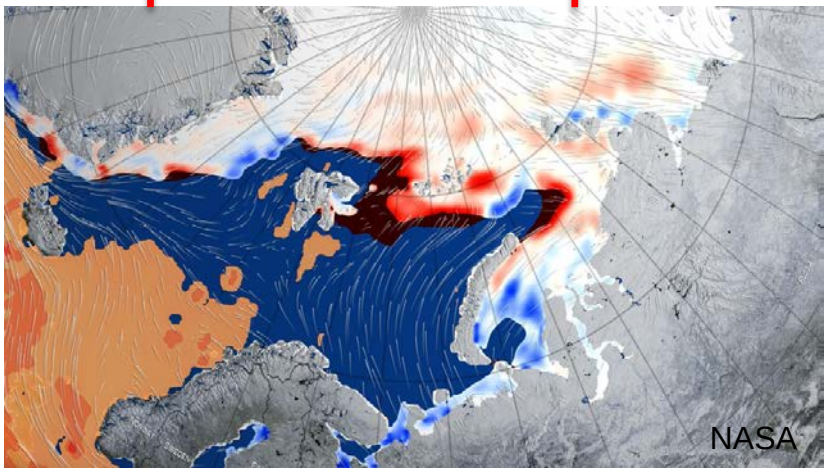
However, other model simulations show diversified results

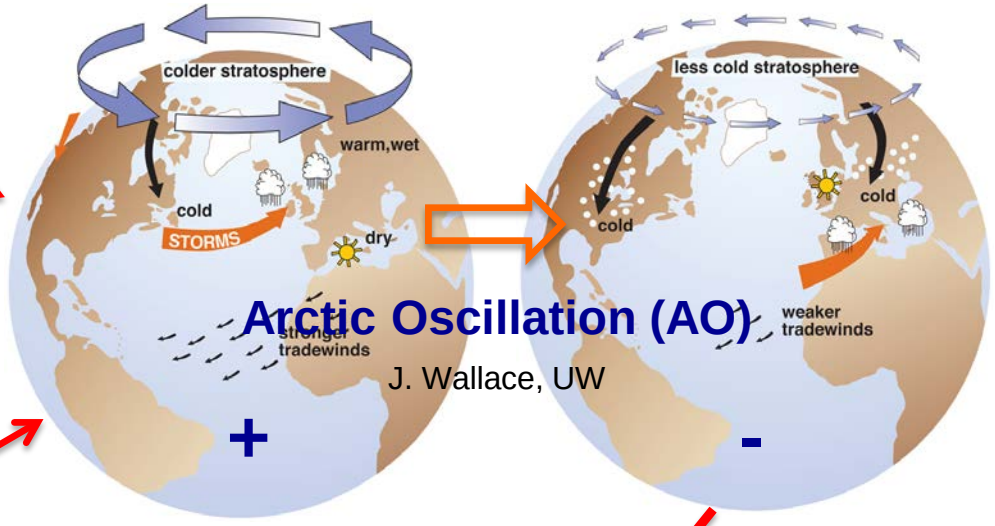
McCusker et al. 2016

Simulated atmospheric dynamics linking Arctic sea ice to midlatitude climate and weather







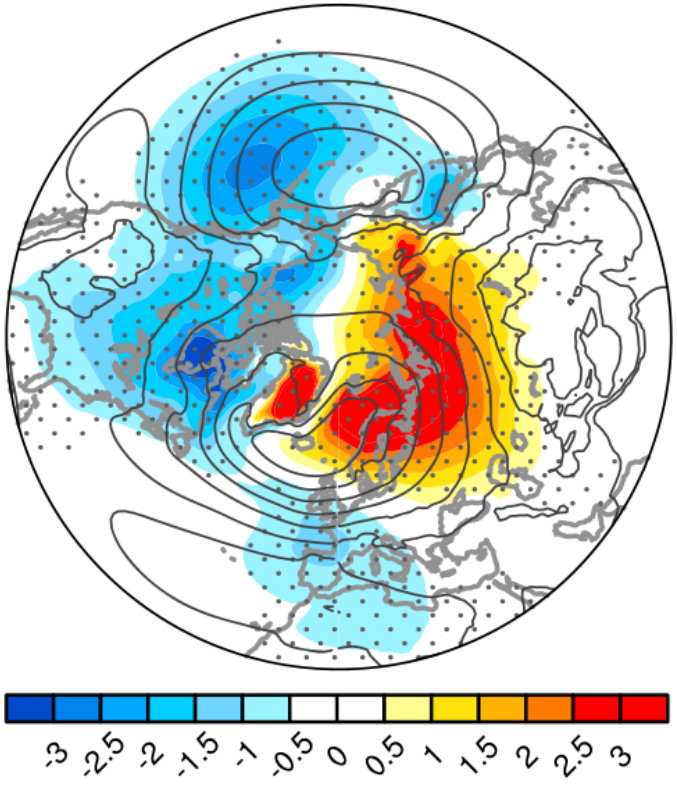


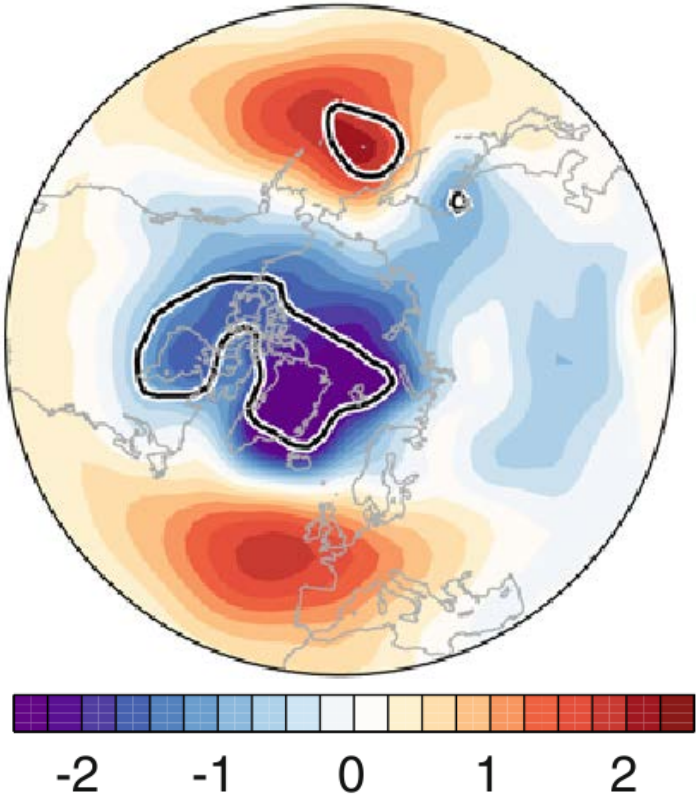
Arctic Oscillation (AO)

J. Wallace, UW

Eurasian cold winter

Non-robust AO/NAO responses (Doug Smith et al.)





• **Negative NAO** (DJF, mslp, hPa)

• Deser et al 2016; Honda et al 2009; Seierstad and Bader 2009; Mori et al 2014; Kim et al 2014; Peings and Magnusdottir 2014; Nakamura et al 2015 …

• **Positive NAO**

• Screen et al 2014; Singarayer et al 2006; Strey et al 2010; Orsolini et al 2012; Rinke et al 2013; Cassano et al 2014 …

• **Little NAO response**

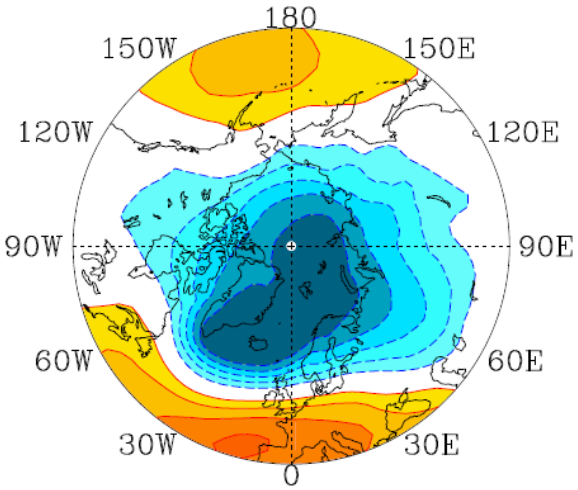
• Screen et al. 2013; Petrie et al 2015; Blackport and Kushner 2016 …

• **NAO response that depends on the forcing**

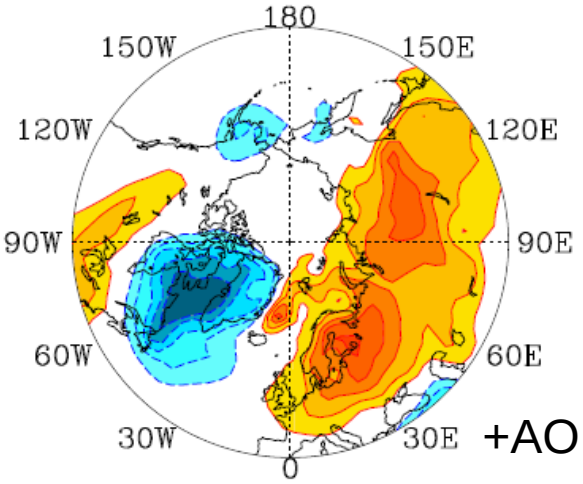
• Alexander et al 2004; Petoukhov and Semenov 2010; Sun et al. 2015; Pedersen et al 2016; Chen et al 2016 ...

Does AO/NAO really plays a role in linking Arctic and midlatitude?

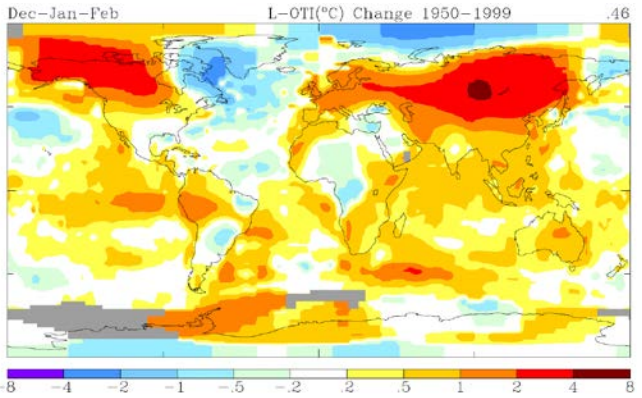
SLP (1958-1996)



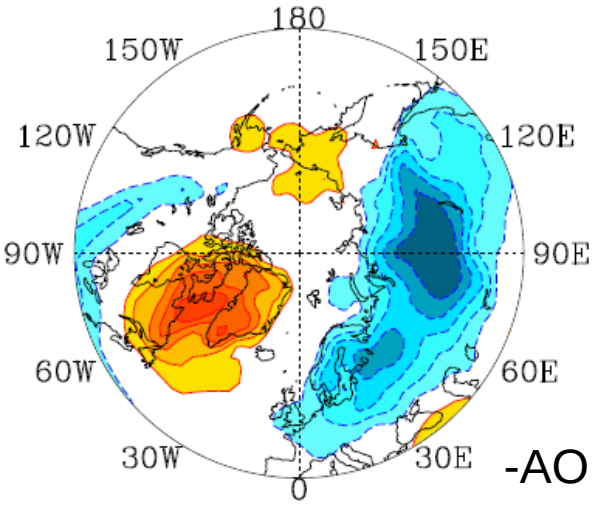
SAT(1958-1996)



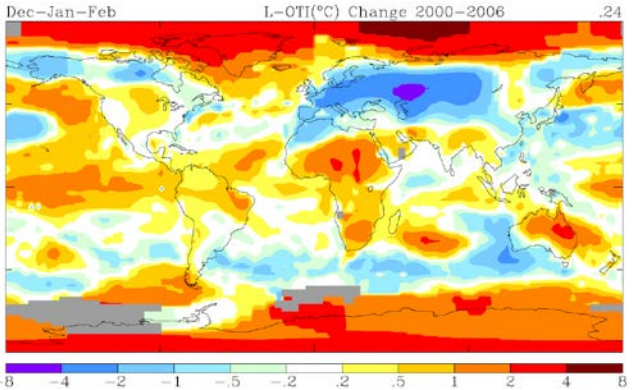
+AO



SAT(1997-2016)



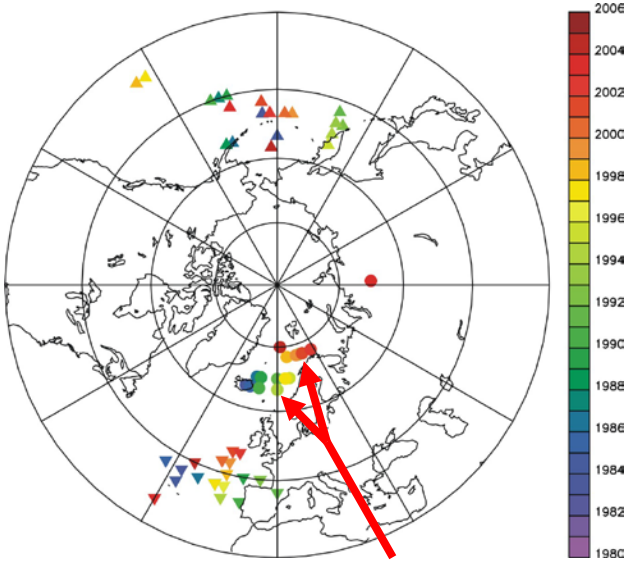
-AO



AO-driven temperature change do not capture the warming pattern shift, or Arctic amplification, or warm Arctic-cold Eurasia.

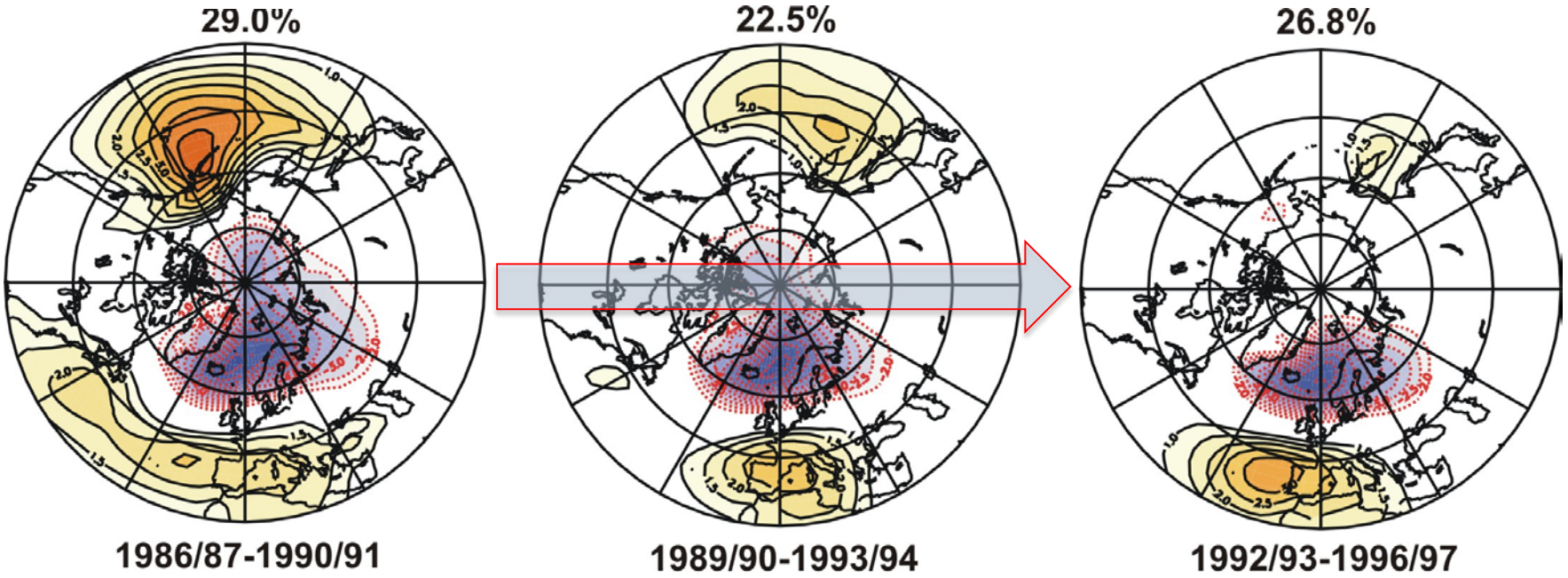
Atmospheric circulation dynamics: A spatial pattern shift and the Arctic Rapid change Pattern (ARP)

The rapidly changed Arctic from the mid-1990s to the early 2000s provide an opportunity to detect this circulation change signal.

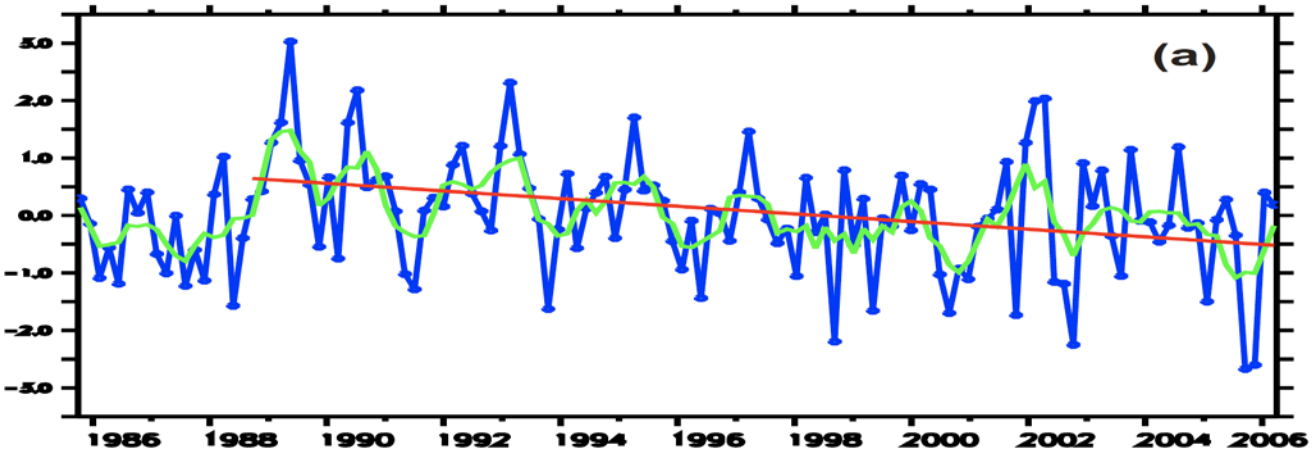


Zhang et al. 2008

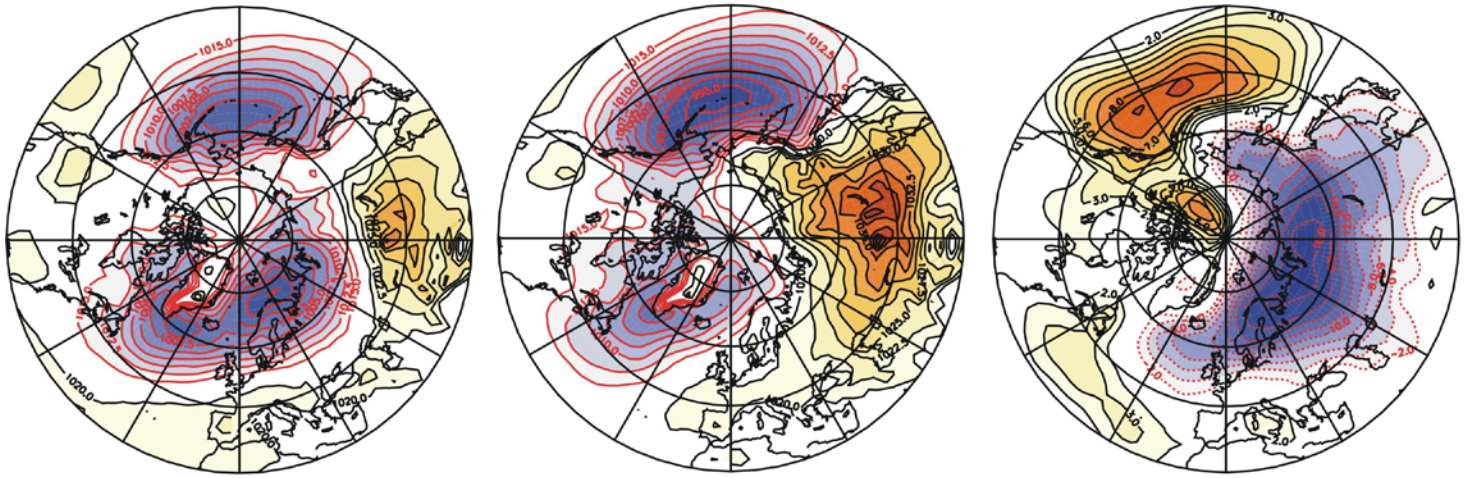
In the mid-1990s



What physics or dynamics does ARP represent?



Composite Analaysis Based on ARP Index

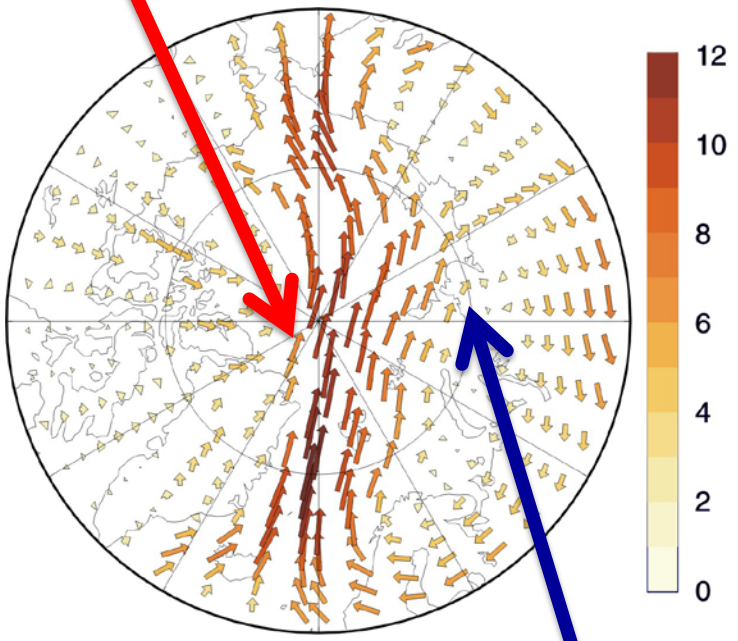


Positive ARP **Negative ARP** **Difference**

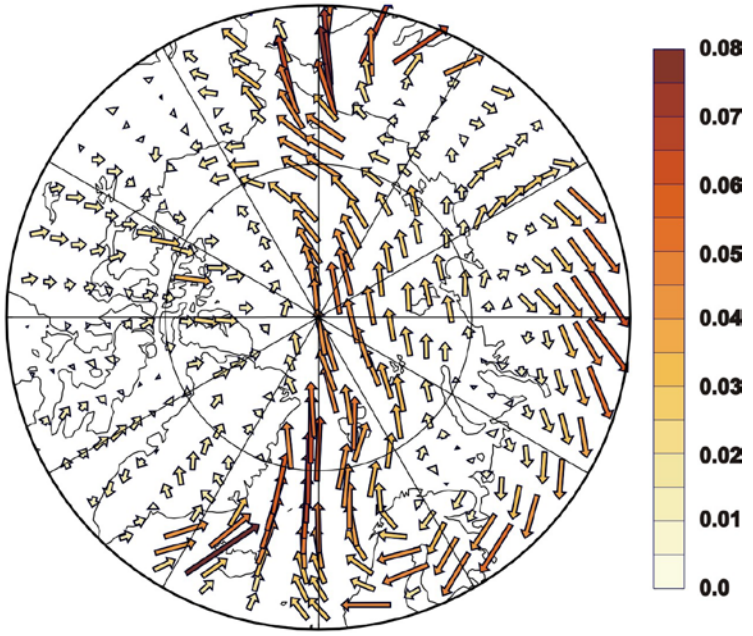
Zhang et al. 2008

ARP enhances Arctic-lower latitude interactions

provided a shortcut of atmosphere and ocean heat transport into the central Arctic from the midlatitude



Heat transport regressed onto winter ARP index (surface - 850 hpa)

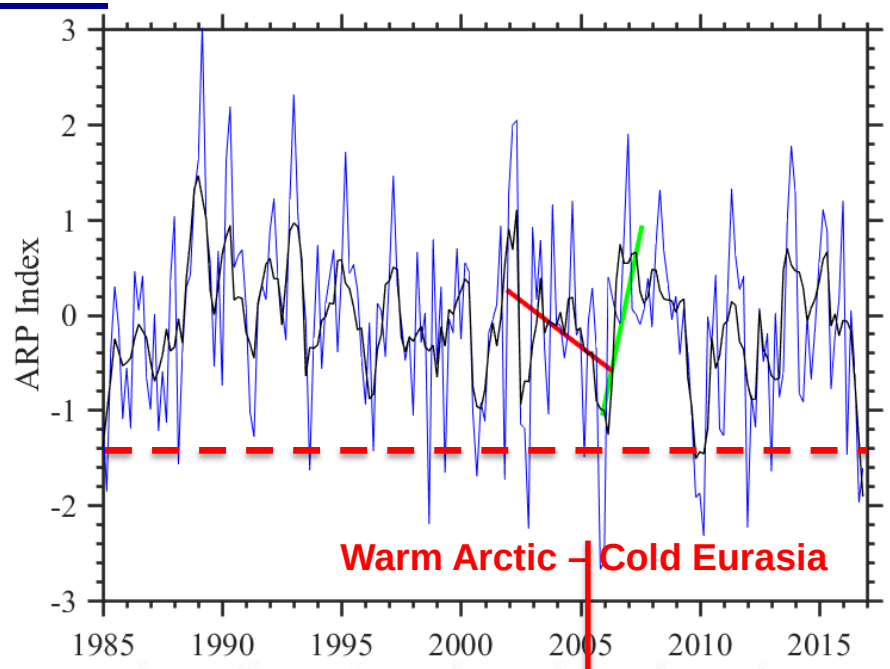


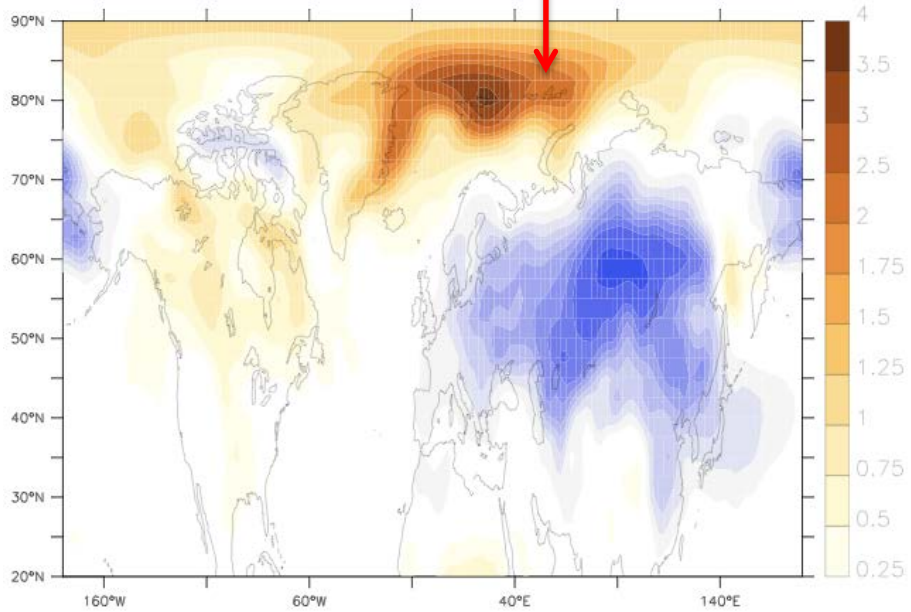
Surface wind stress regressed onto winter ARP index

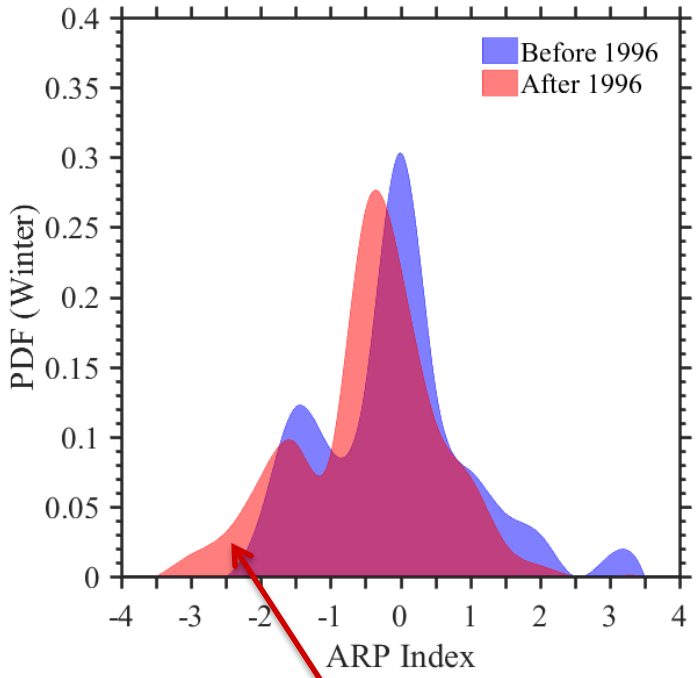
re-circulate cold polar air to the midlatitude from Arctic

Zhang et al. 2008

An increase in frequency of occurrence of negative ARP during recent years

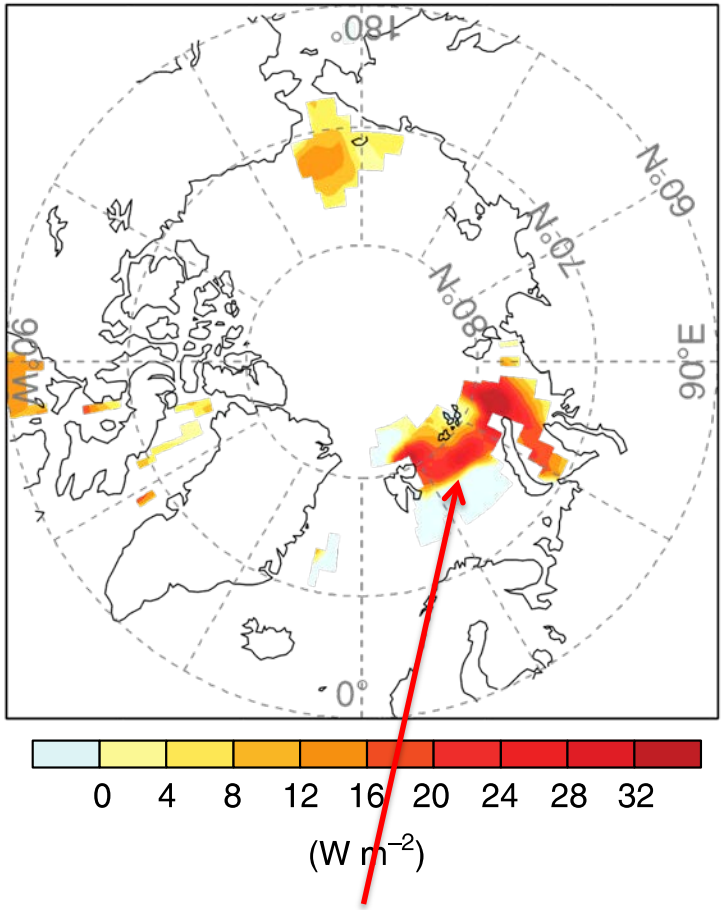




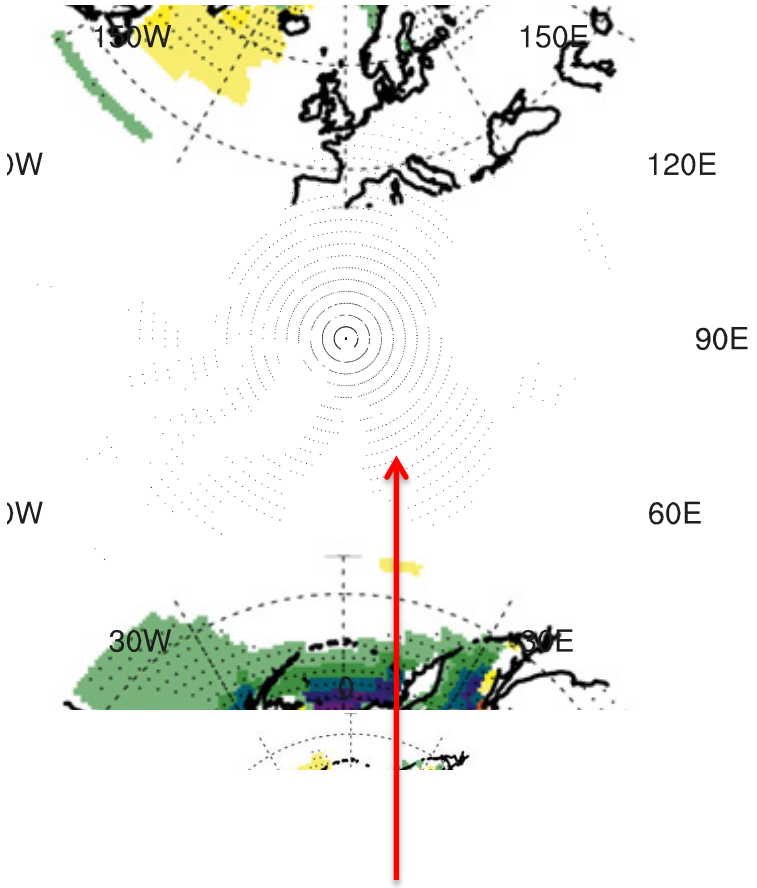


Increased frequency of the extremely negative ARP phase.

Uncertainties from prescribed forcing



Atmosphere gains heat energy



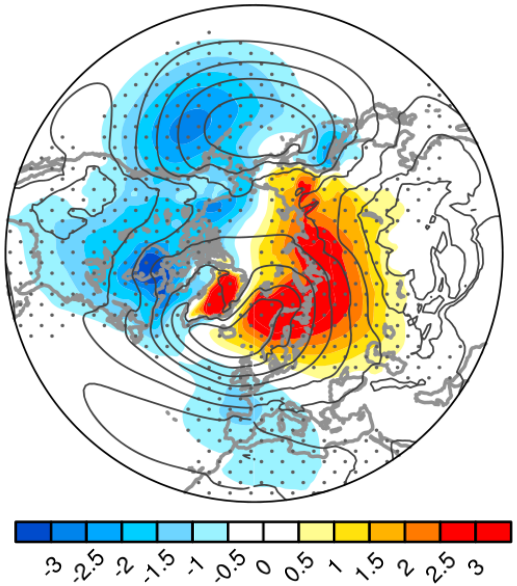
Atmosphere loses heat energy

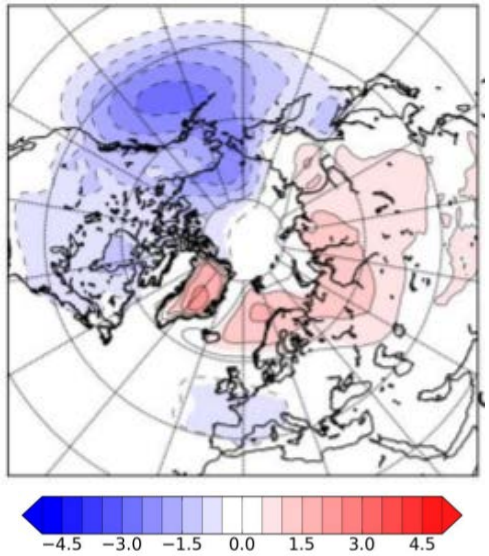
Kim et al. 2014

Peings and Magnusdottir 2014

Uncertainties from prescribed forcing (Doug Smith et al.)

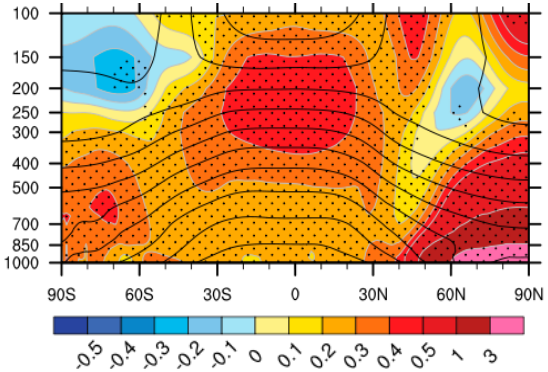
Sea level pressure

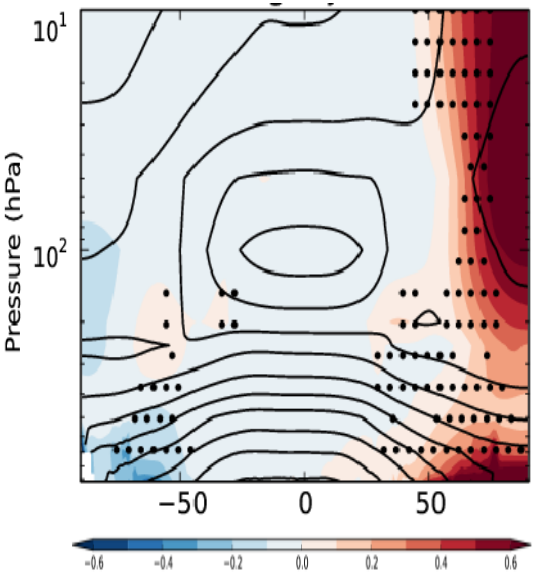




- Longwave flux (left, Deser et al 2015)
- Albedo (right, Blackport and Kushner 2017)
- Same model
- Similar sea level pressure response…

Zonal mean temp



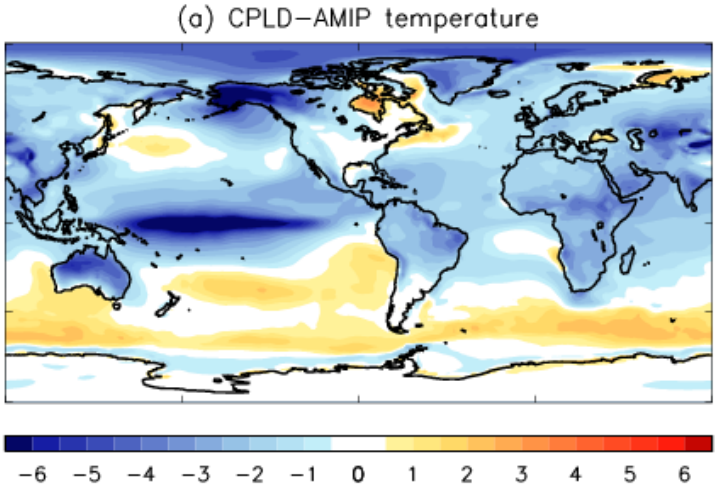


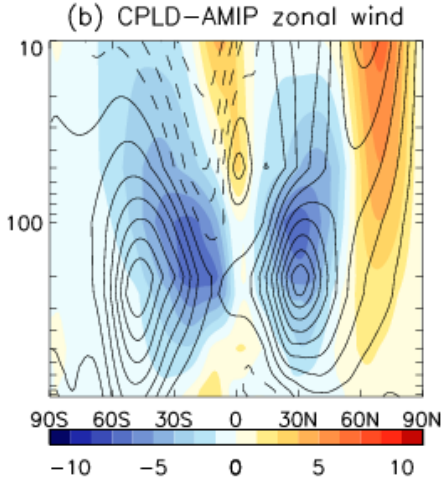
- Low latitude warming simulated in response to longwave forcing (left, Deser et al 2015)
- …but not in study using relaxation to impose sea ice (right, Smith et al submitted)

- Longwave/albedo forcing artificially perturbs the energy balance?
- Relaxation does not allow feedbacks from the tropics to the Arctic (e.g. low lat warming, maybe also from rainfall, Baggett et al 2016)
- Which is “best”?

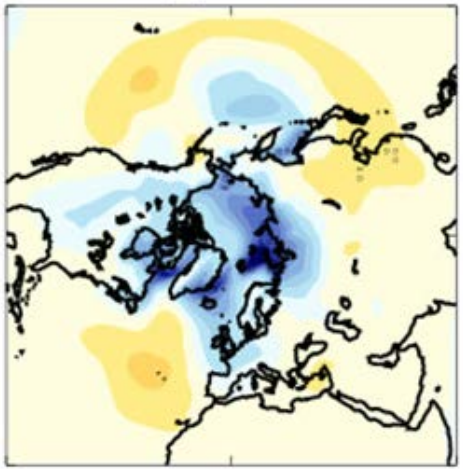
Dependence on background state (Doug Smith et al.)

Coupled model biases

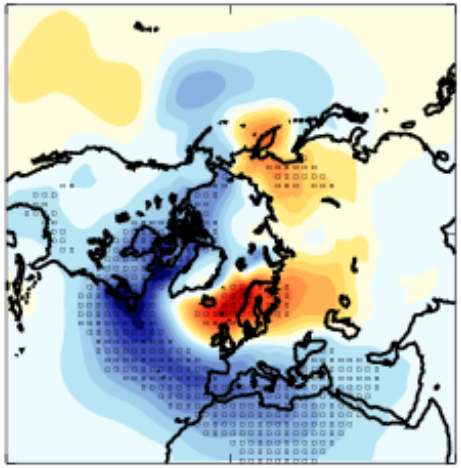




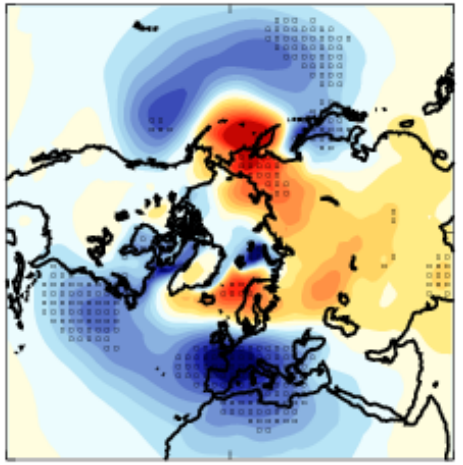
Atmosphere model



Coupled model



AMIP_CPLD



- **Different response could be caused by coupling or background state (model bias)**
- **Test by repeating atmosphere model but imposing COUPLED SST bias → AMIP_CPLD**
- **Reproduces COUPLED response → background state is key**

Smith et al submitted

Summary

- No consensus has been reached among the modeling studies;
- Dynamic process linking Arctic and midlatitude has not been well understood, impacting selection of metrics to evaluate model performance;
- Uncertainties exist in defining and prescribing forcing in AGCM-along or CGCM simulations;
- Impacts of model systematic biases have not been well investigated;
- Influence or modulation by tropical and midlatitude forcing remains unclear.

Proposed effort

- Coordinated modeling experiments and analysis – same design, forcing, and analysis metrics but different models.

  - Fast Track #1: Using CMIP6 AMIP as control + Sensitivity (Clim SIC and SST)

  - Fast Track #2: AMIP-like control (Clim SIC/SST) + Time Slices Simulations