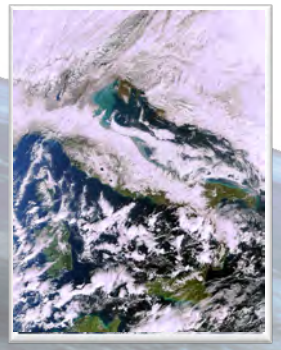
# Arctic Change and Possible Influence on Mid-latitude Climate and Weather

## *Workshop Summary*

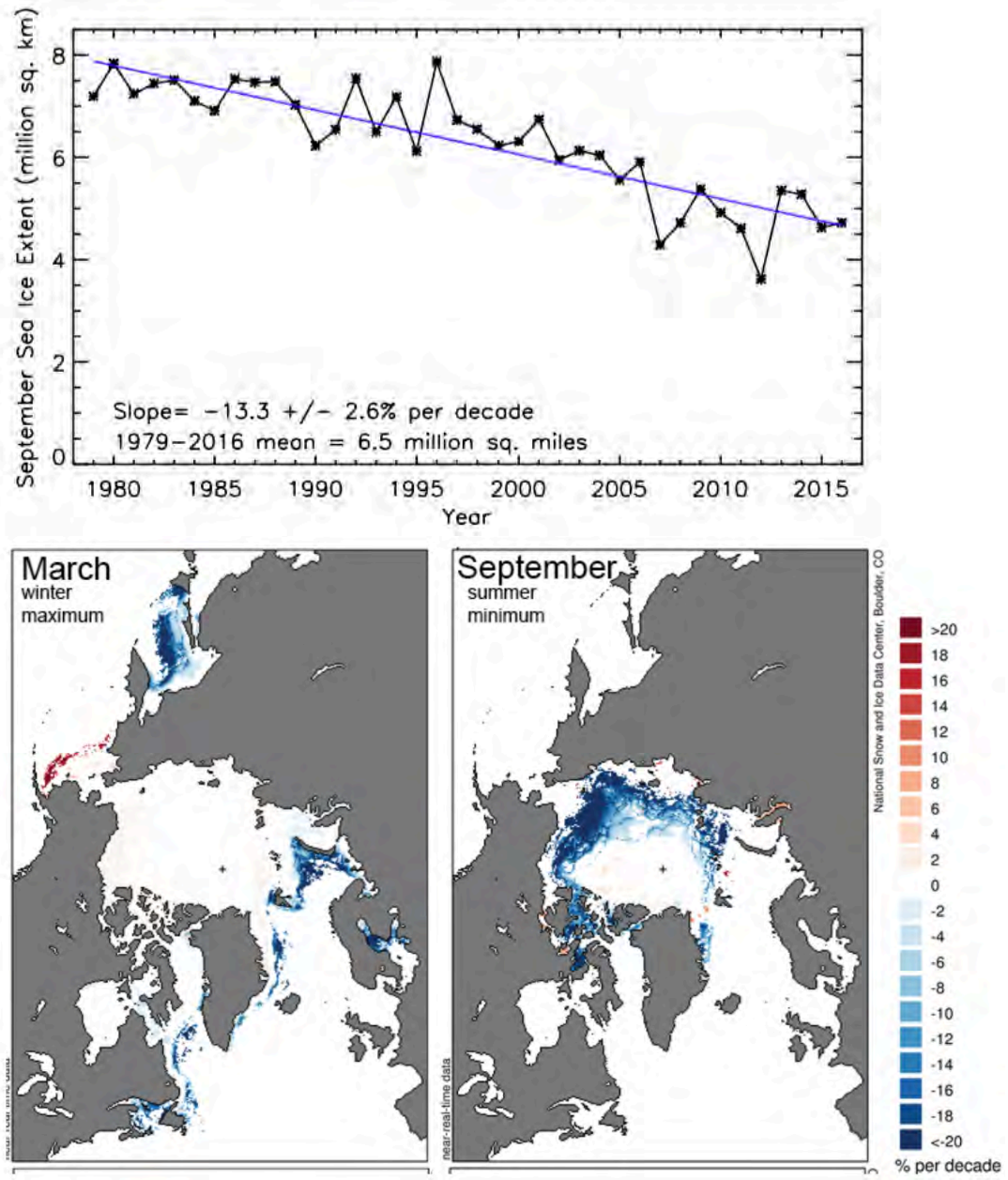
**J. Cohen, X. Zhang, J. Francis, T. Jung, R. Kwok and J. Overland**

**July 20, 2017**

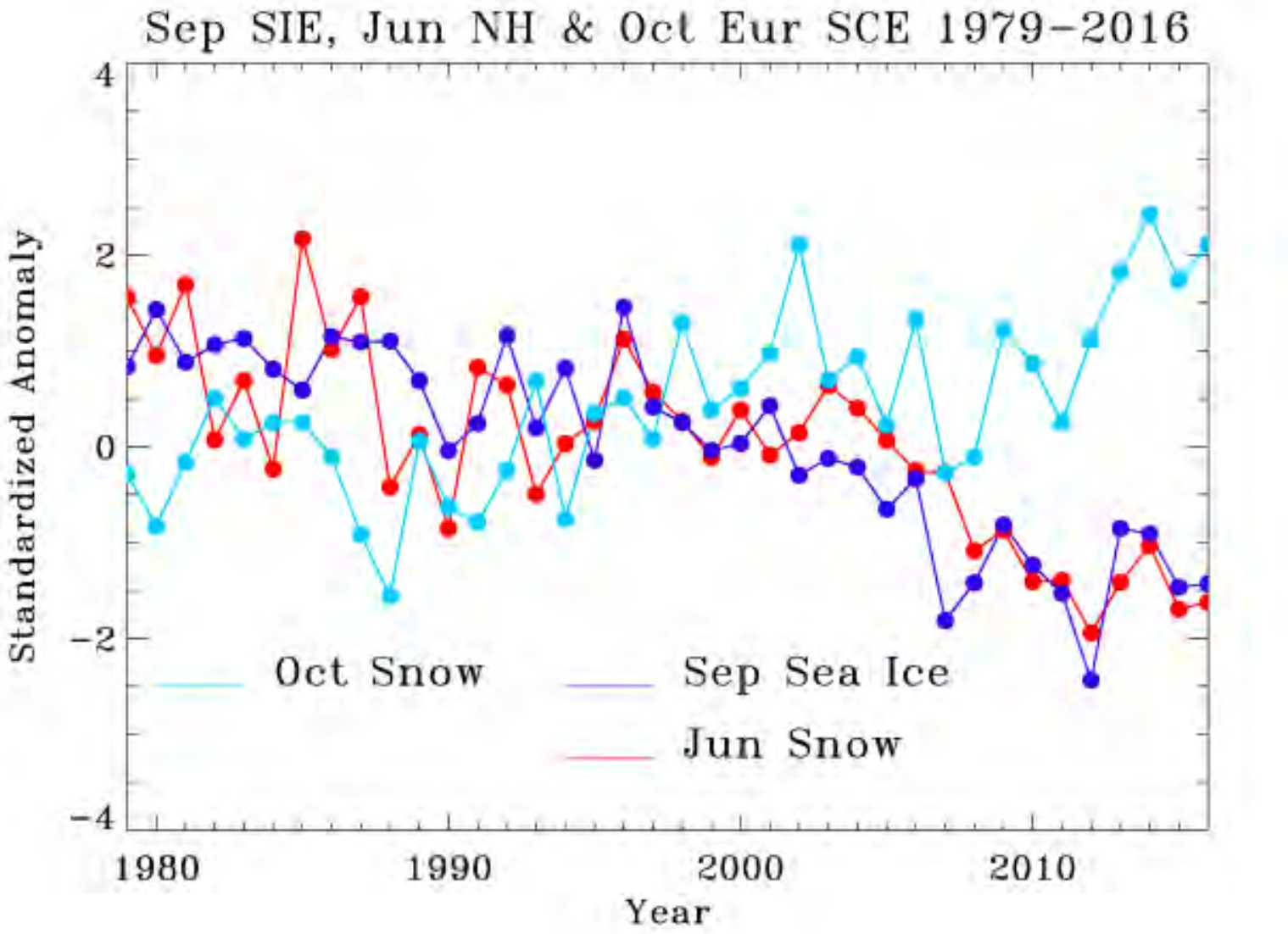


# ARCTIC AMPLIFICATION

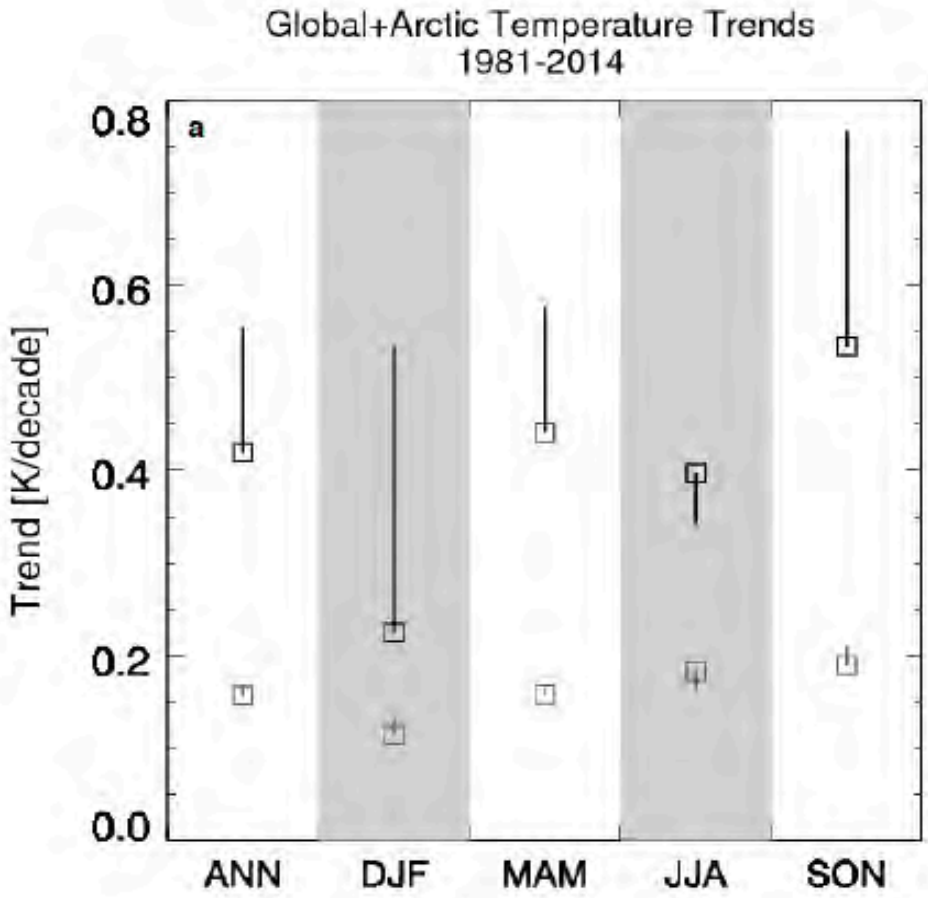
# Sea Ice Decline

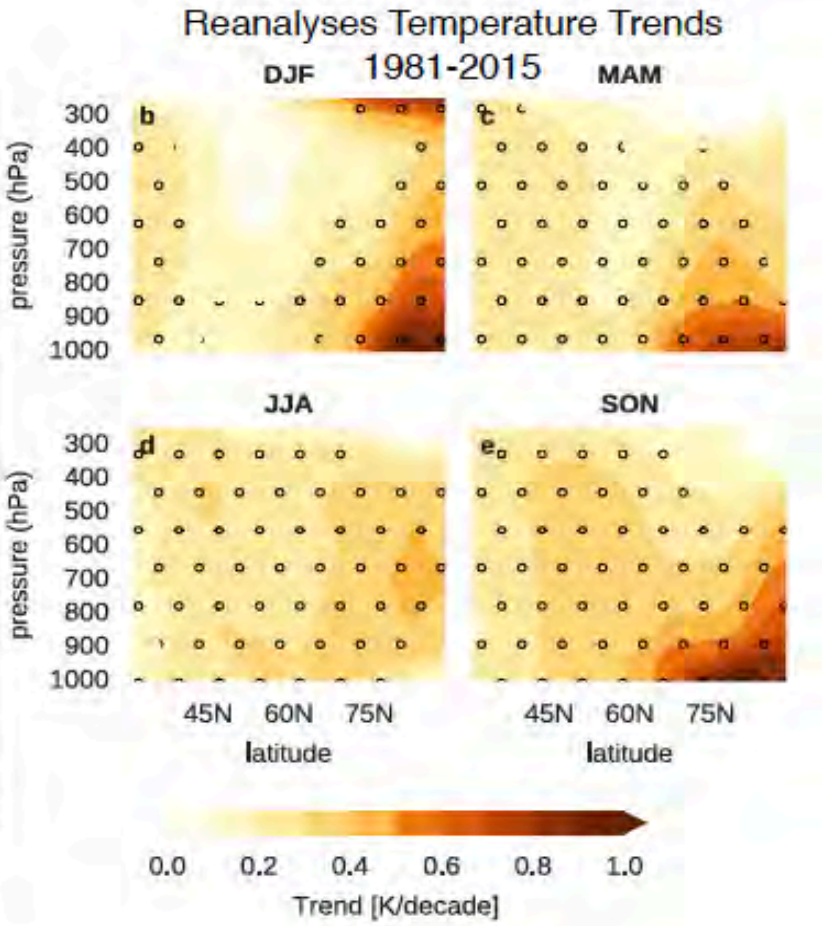


# Sea Ice and Snow Cover Decline



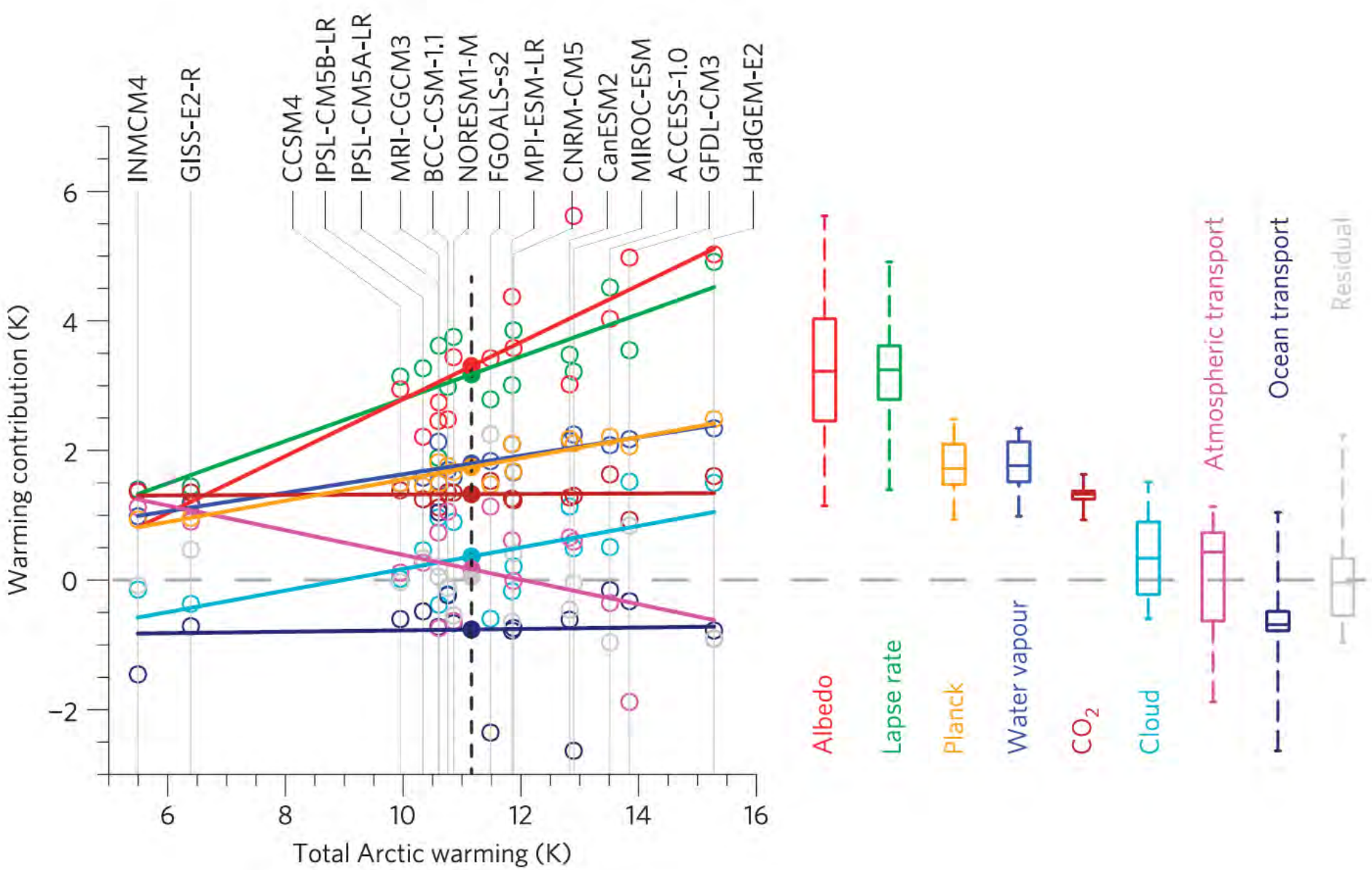
# Annual Cycle of Arctic Temperatures




Courtesy of Fred Laliberte/Lawrence Mudryk

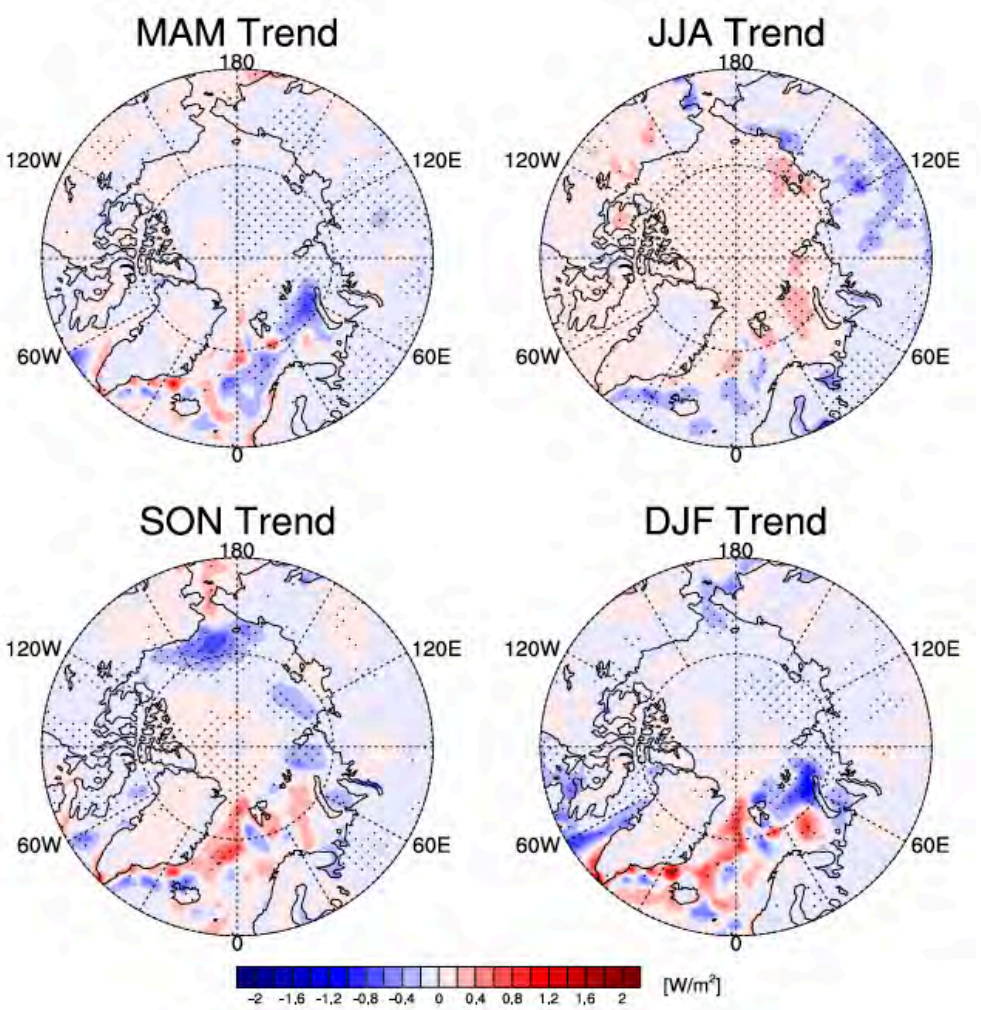
# Sea Ice loss and full AA

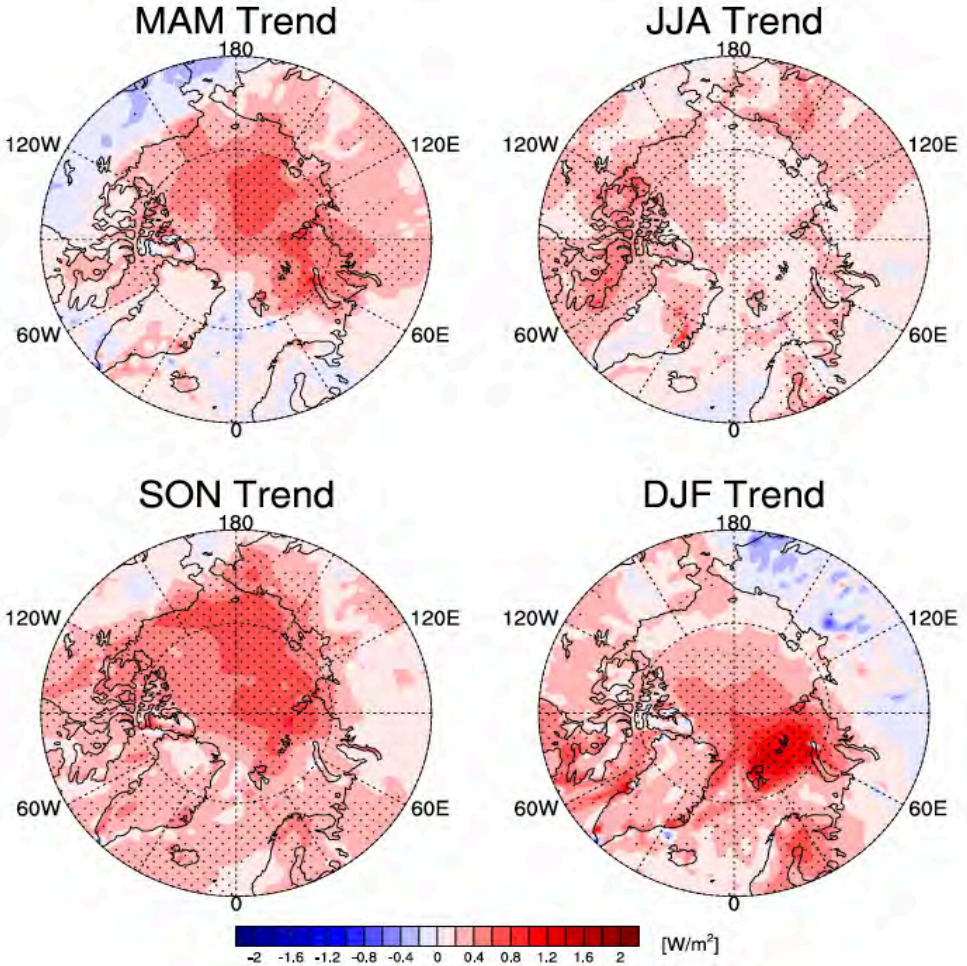



Sea ice loss is not the biggest contributor to AA

Pithan and Mauritsen (2014)

# Sensible heat flux and downwelling longwave radiation

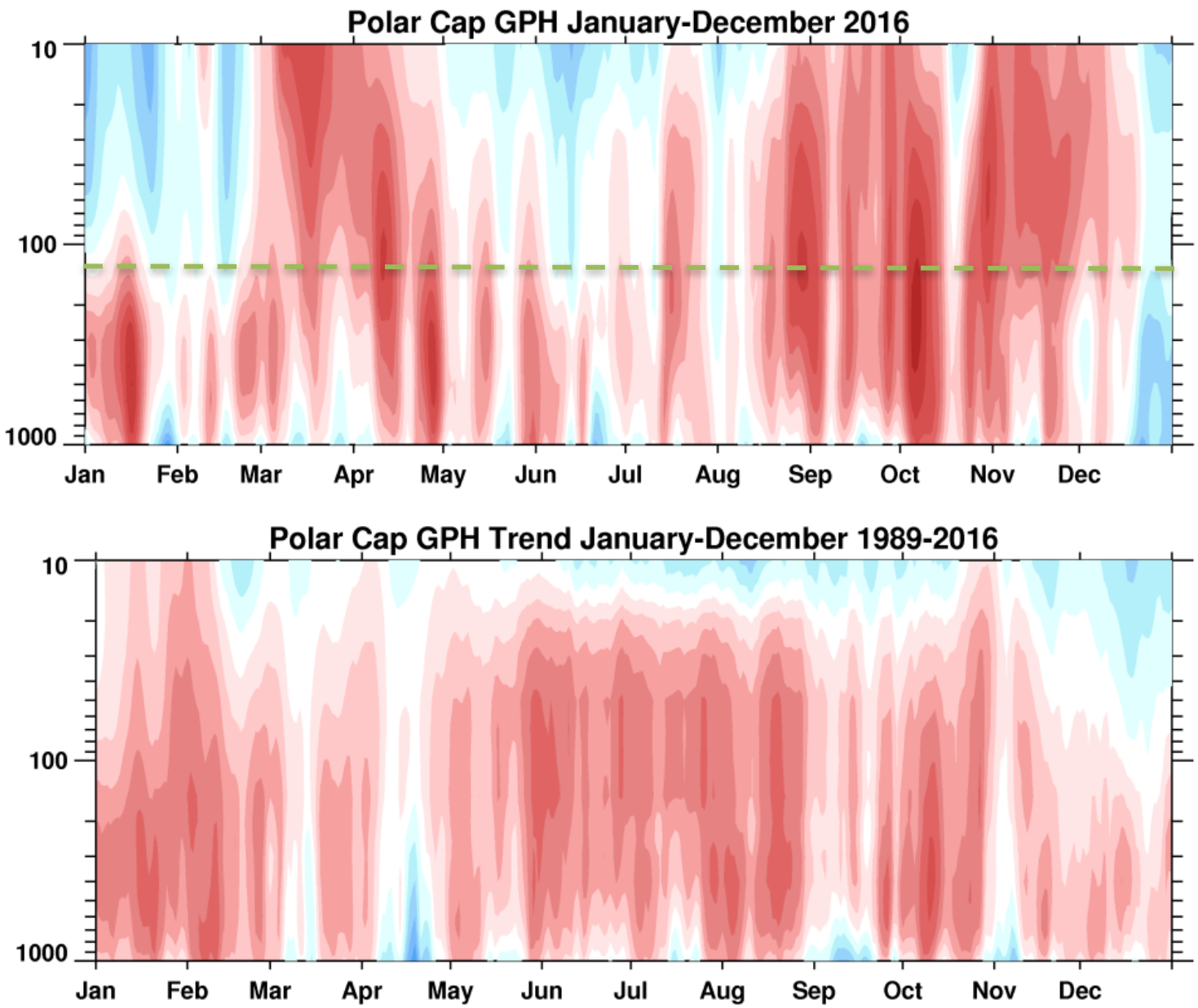


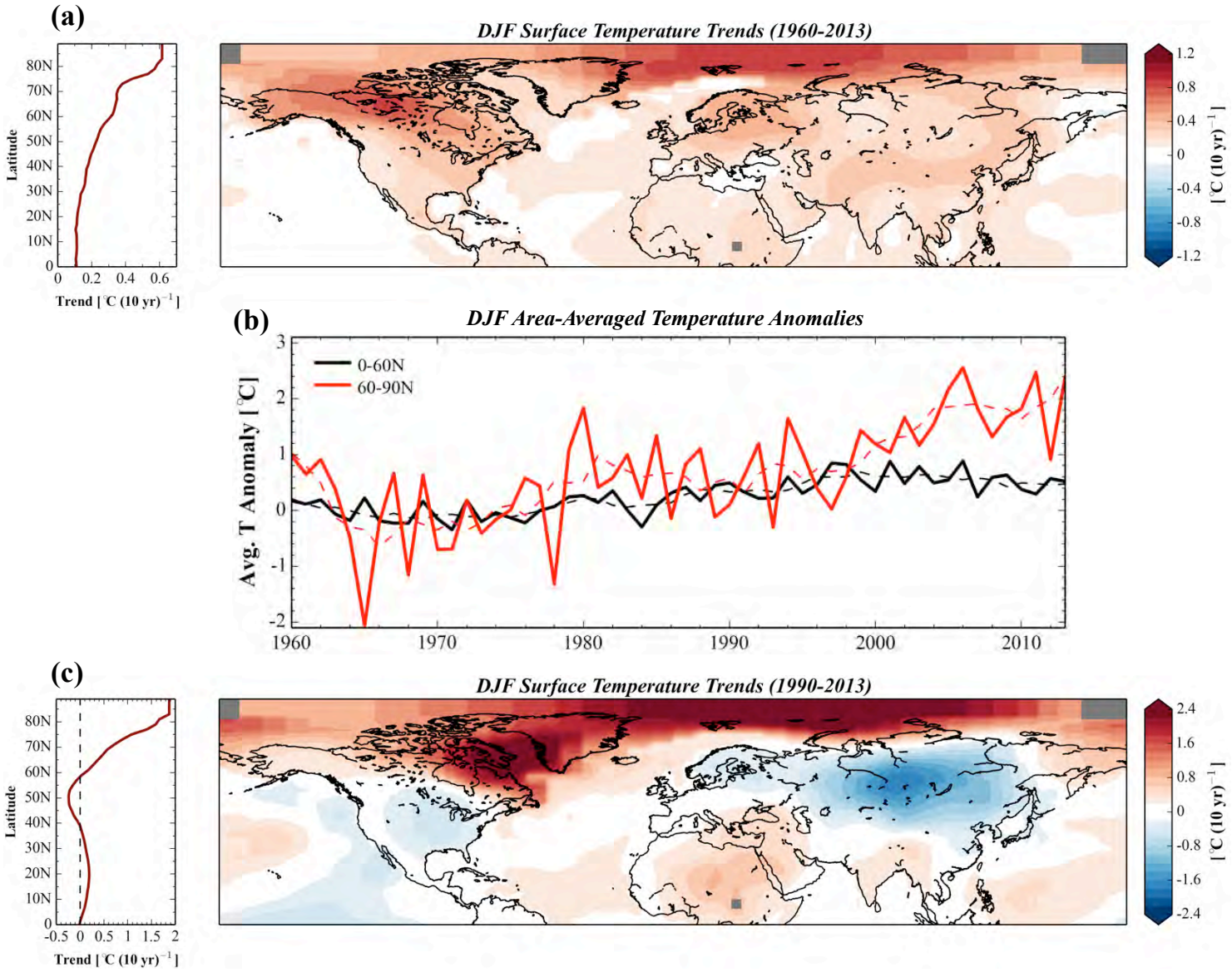

Courtesy of Tingting Gong (Units: W $m^{-2}$ $yr^{-1}$)

# WARM ARCTIC-COLD CONTINENTS/EURASIA

# Arctic Warmth reaches to the Stratosphere



# Arctic Amplification



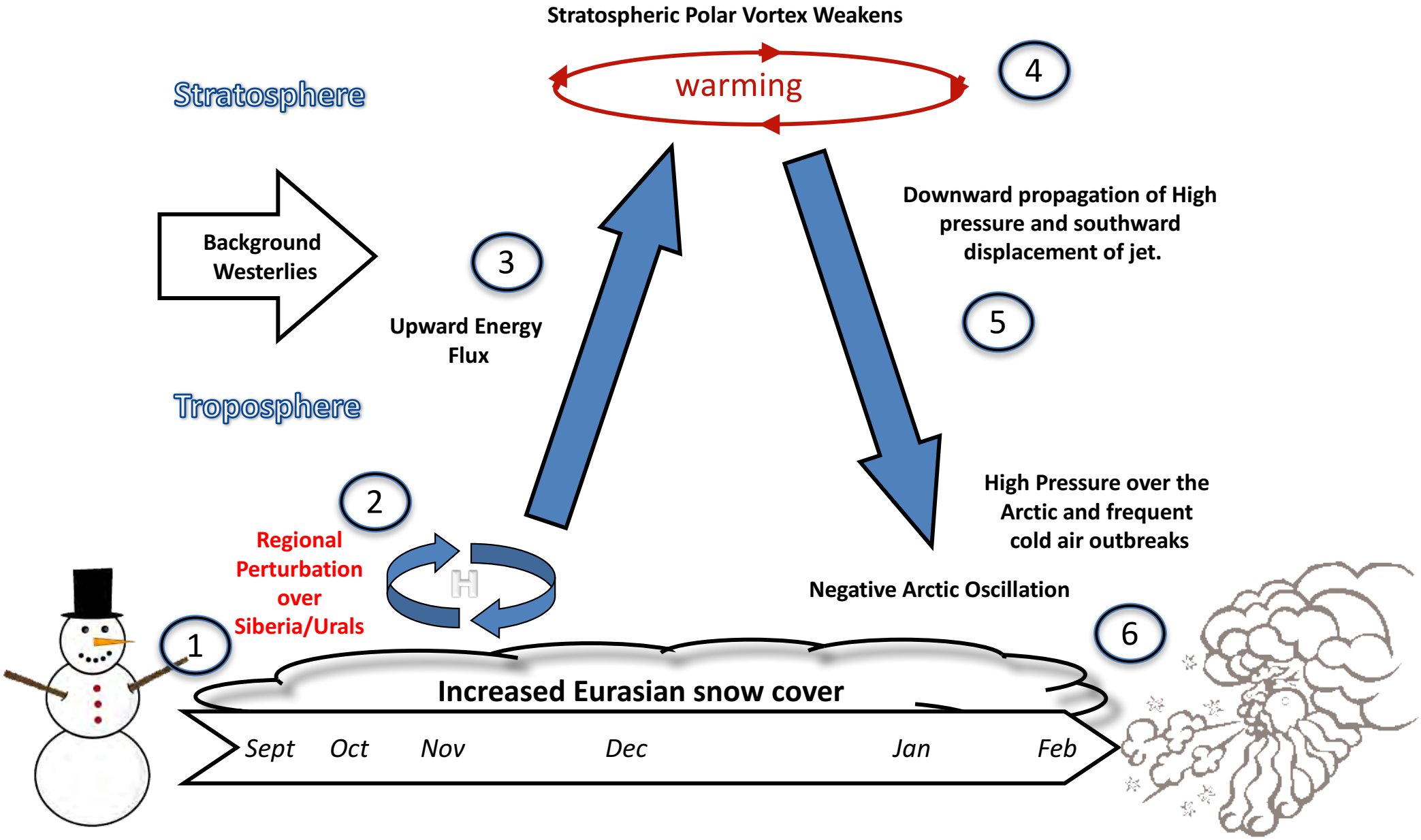

Cohen et al. 2014 Review paper

# Arctic Amplification - Jet Stream

**Figure 3:**
*Schematic of a typical jet stream trajectory (solid line) over North America and the expected elongation of ridge peaks northward (dashed line) in response to Arctic Amplification.*

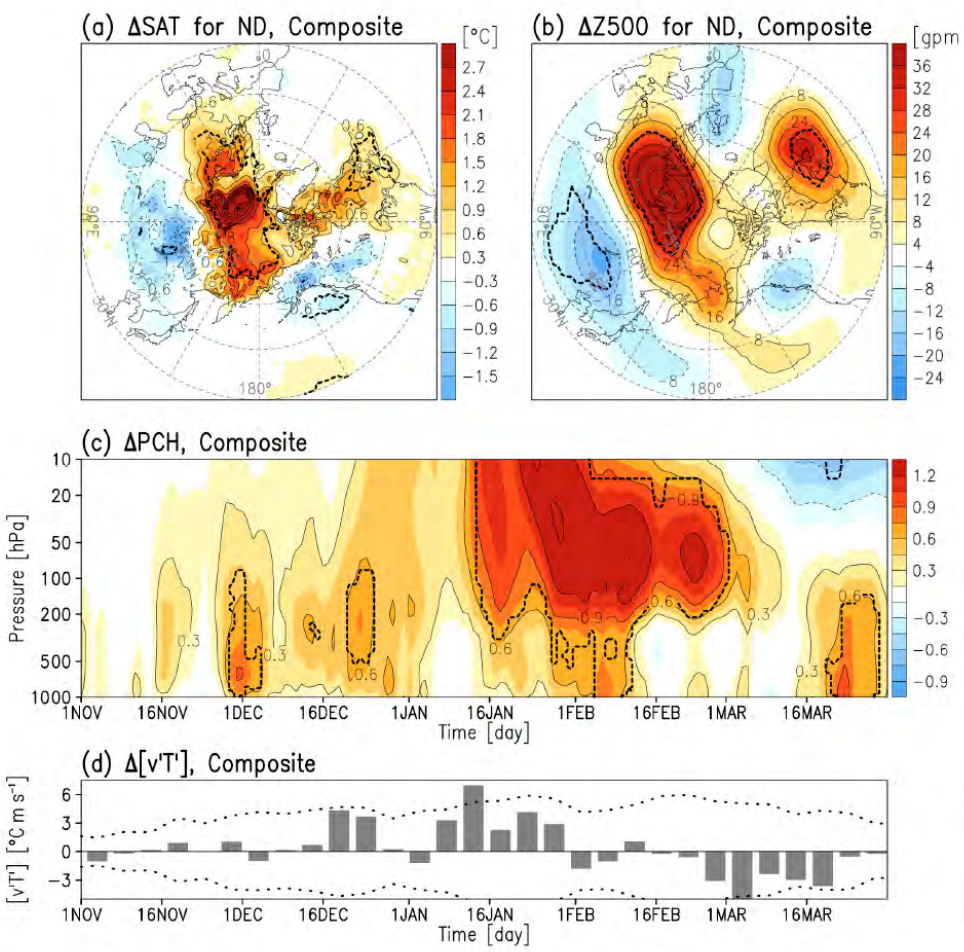
Francis and Vavrus 2012

# Extensive Snow Forced Cold Signal

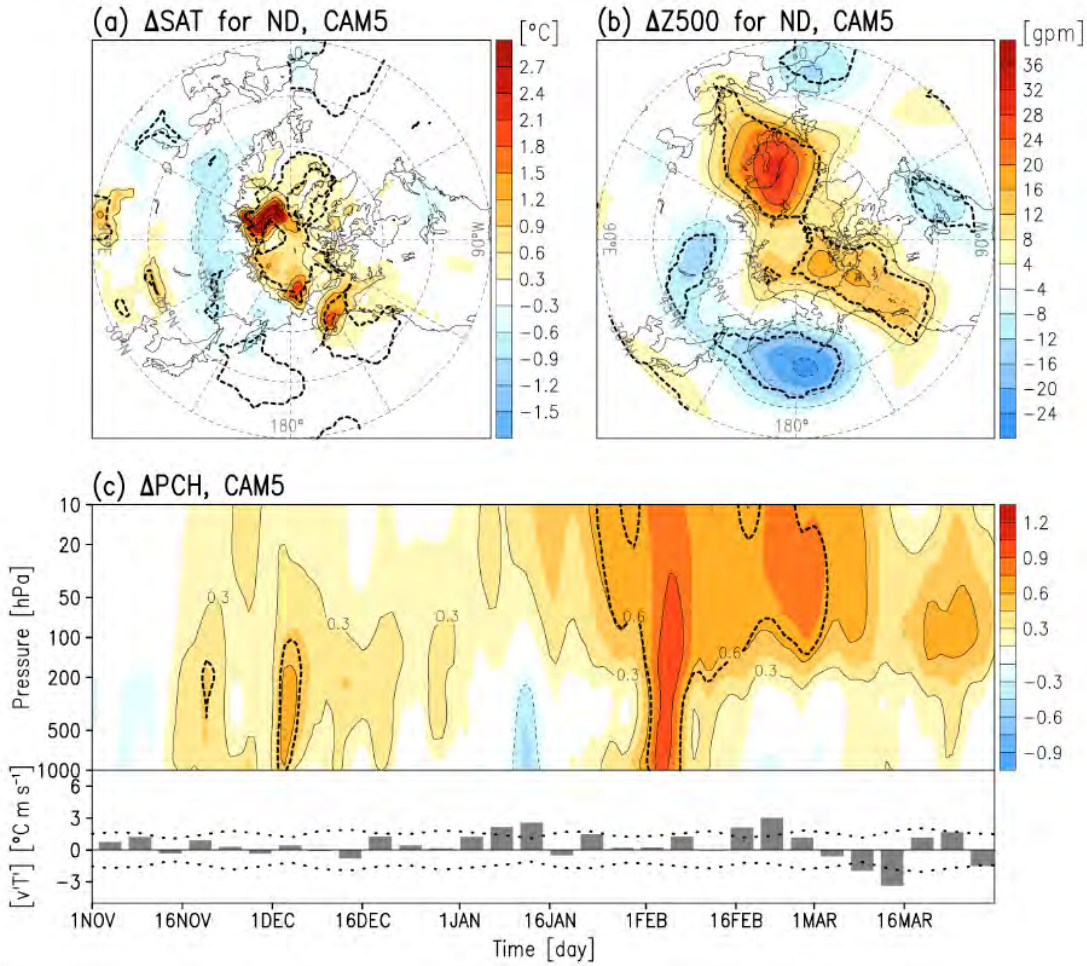


# Reduced Sea Ice Forced Cold Signal

observations



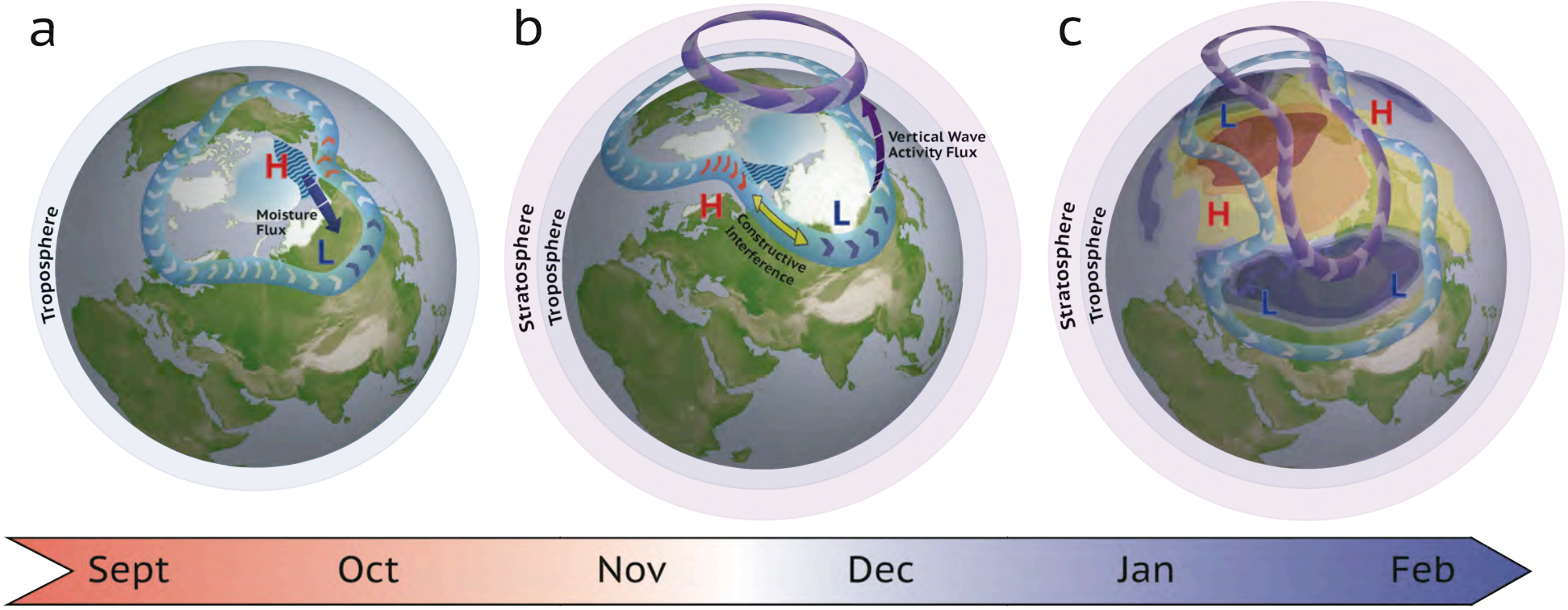

model




Some model runs forced with low sea ice have been able to simulate atmospheric response as observed.

Kim et al. 2014

# Synthesis of Sea Ice and Snow Cover

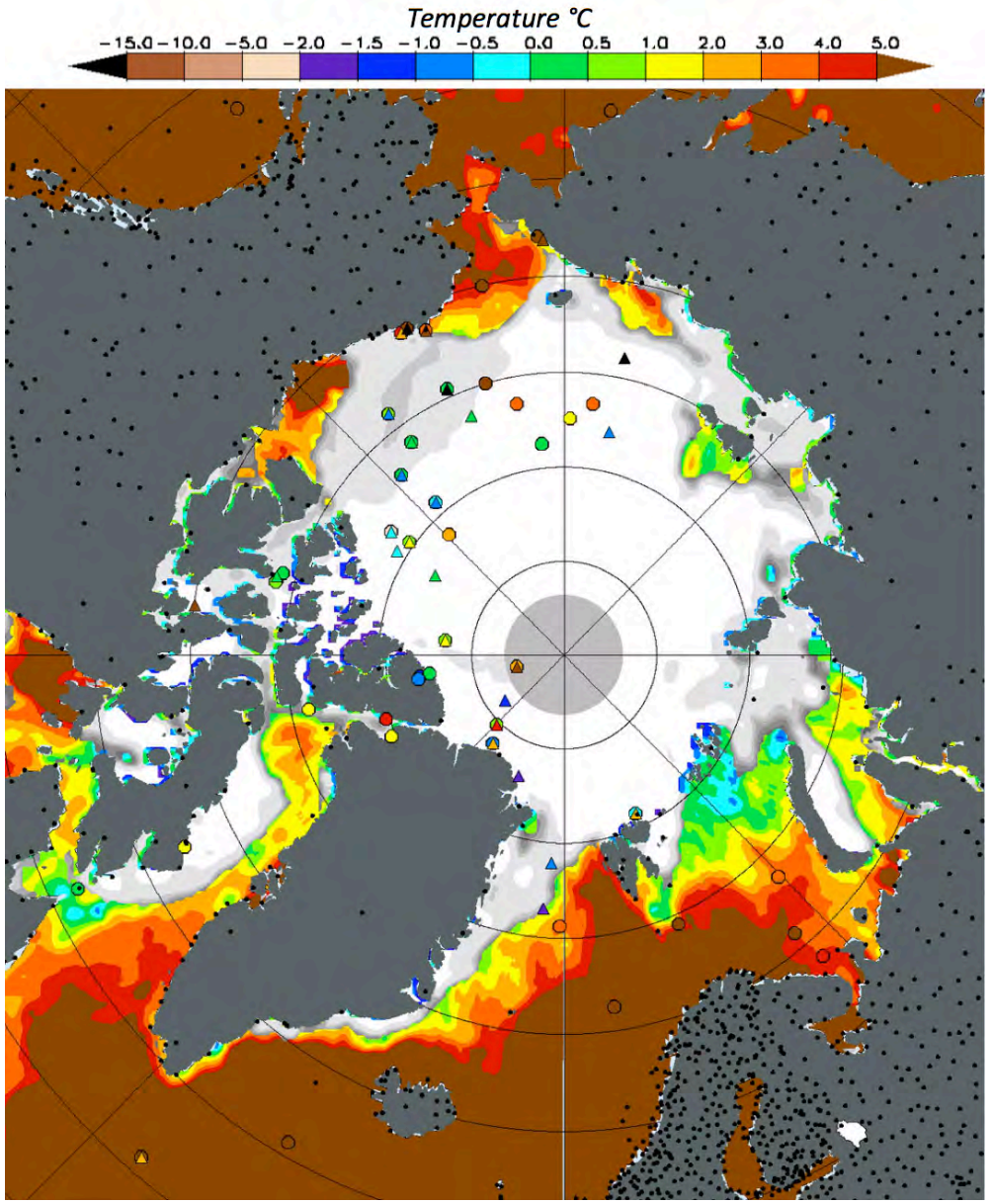



Cohen et al. 2014 Review paper

# Challenges with Data and Models

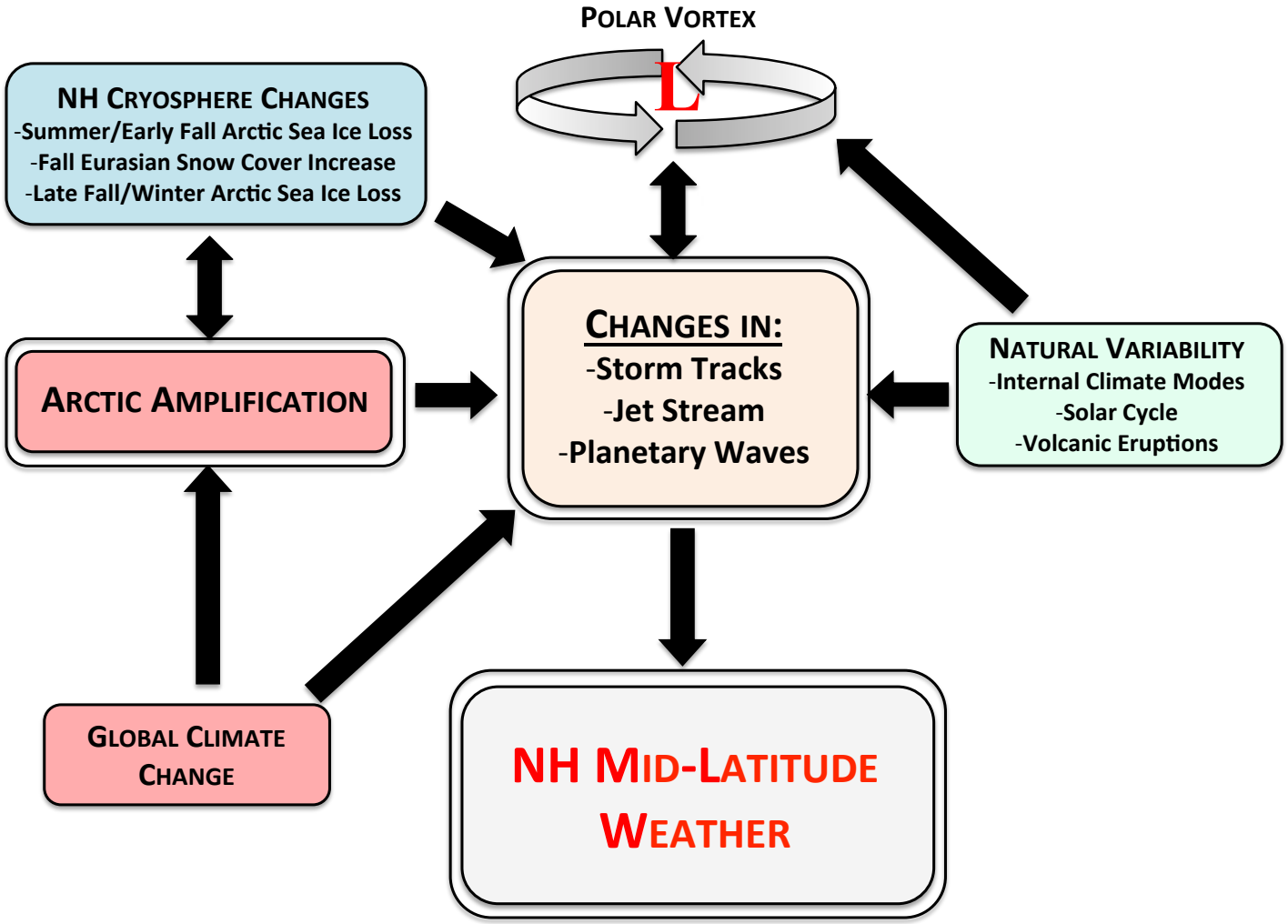
- Scarcity of observations in the Arctic
- Short time series in observations since AA
- Model deficiencies
- Uncoordinated modeling studies
- Biases and uncertainties in metrics for quantitative analysis
- The climate system is complicated

# Scarcity of Arctic Observation Stations

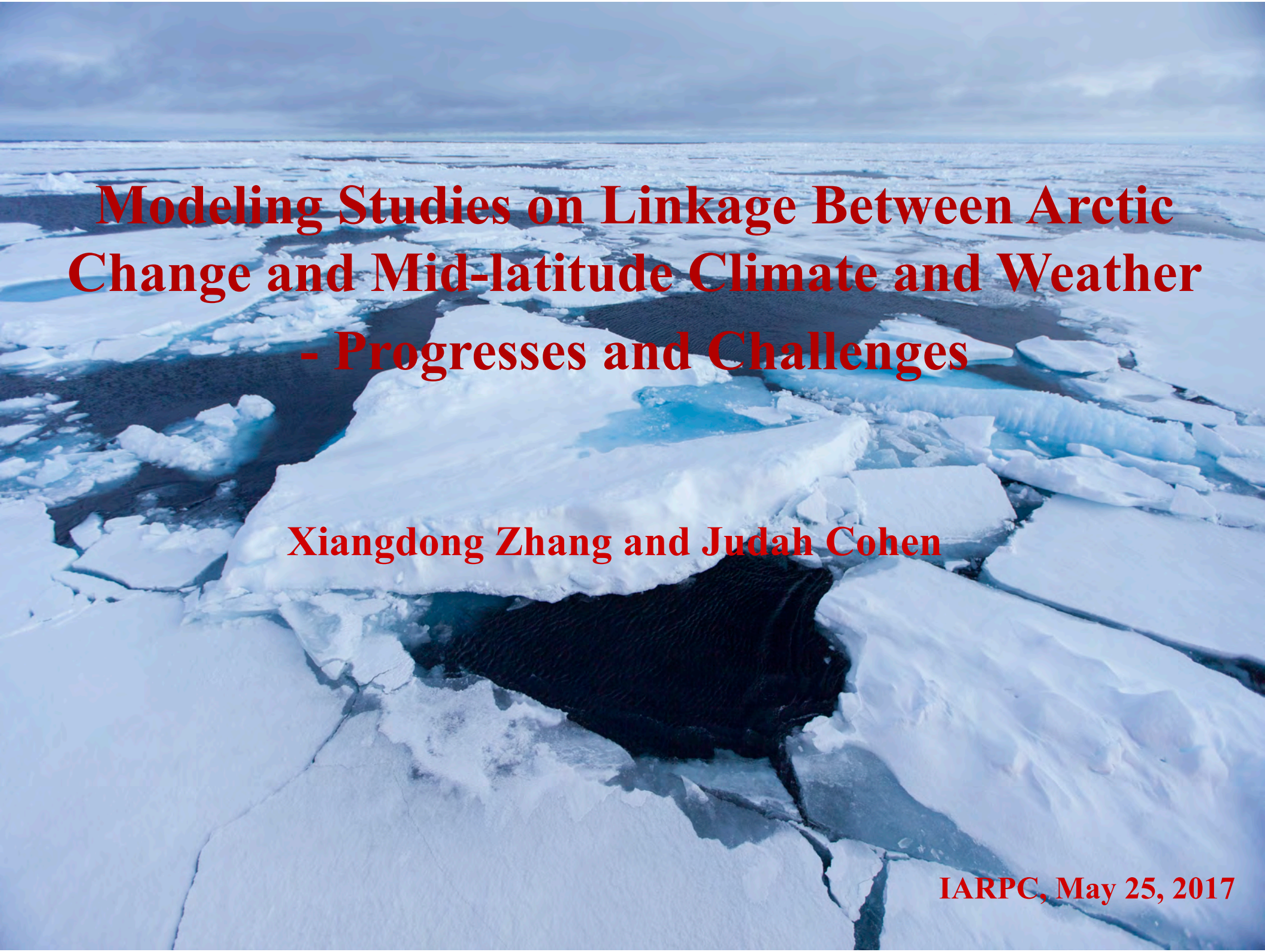



Courtesy of Wendy Ermold, University of Washington

# Mid-latitude Weather is Complicated




Cohen et al. 2014

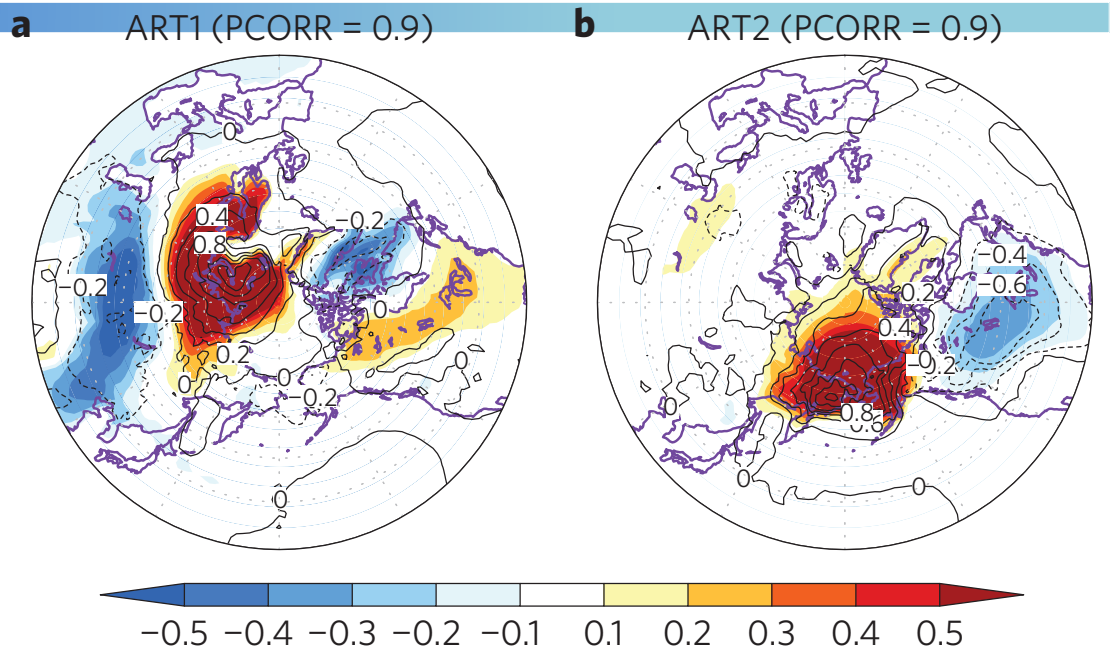


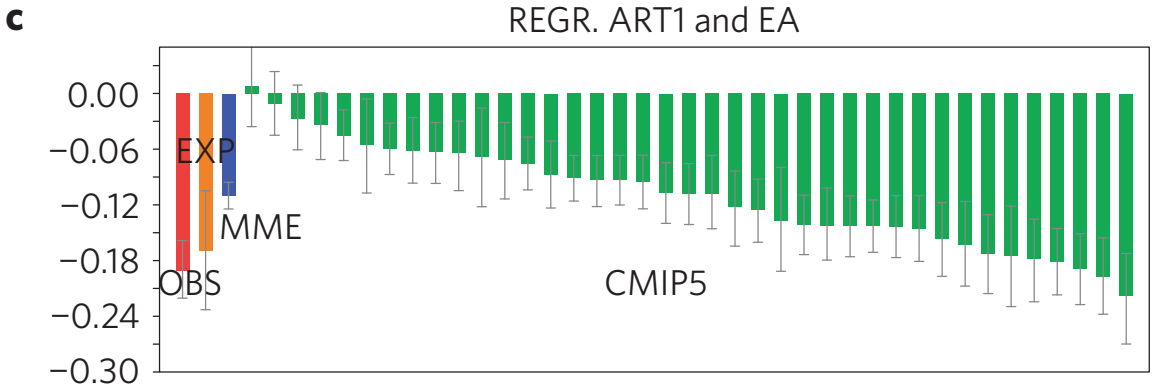
# Modeling Studies on Linkage Between Arctic Change and Mid-latitude Climate and Weather - Progresses and Challenges

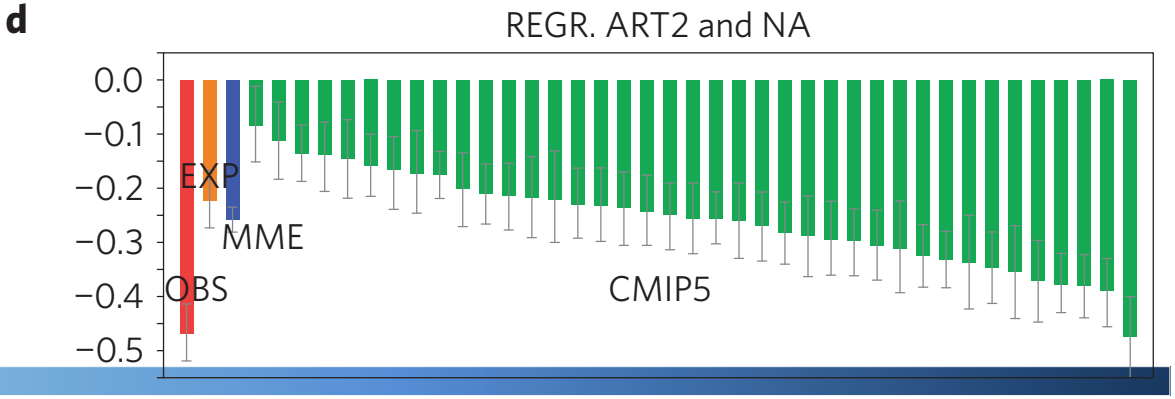
Xiangdong Zhang and Judah Cohen

IARPC, May 25, 2017

# Arctic warming forced changes in SAT

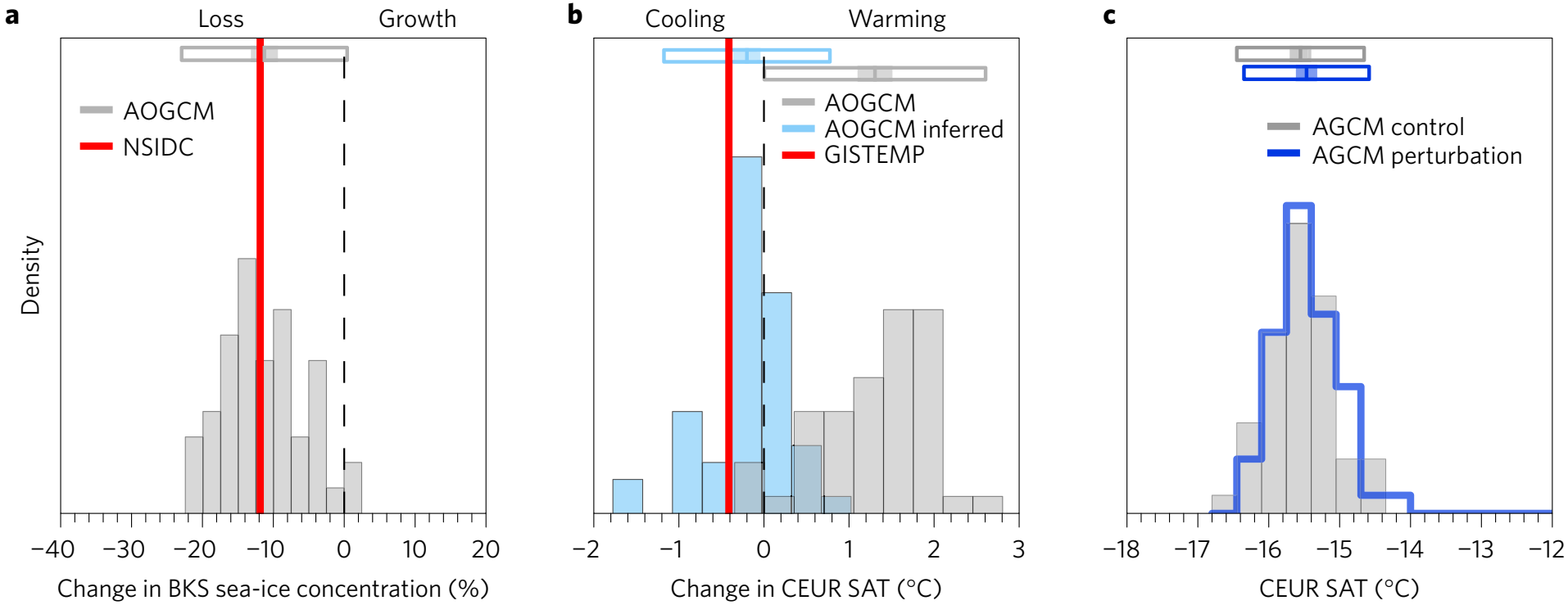


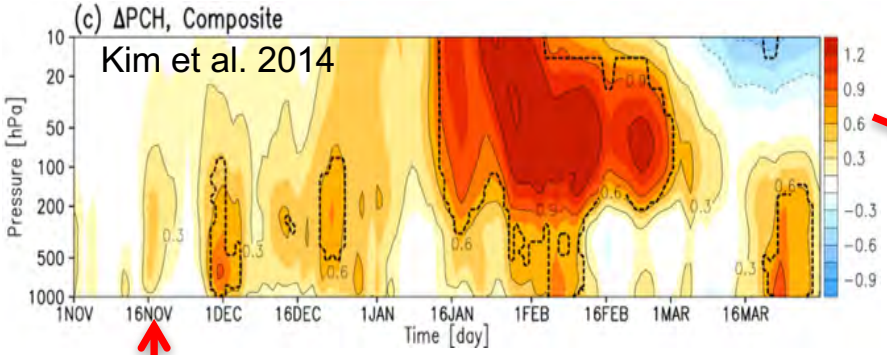

*Kug et al. 2015*

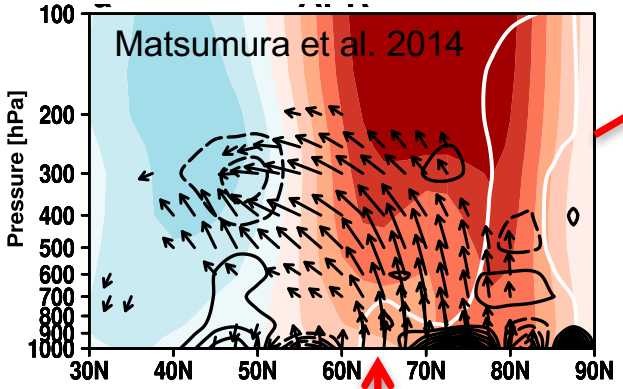
# However, other model simulations show diversified results

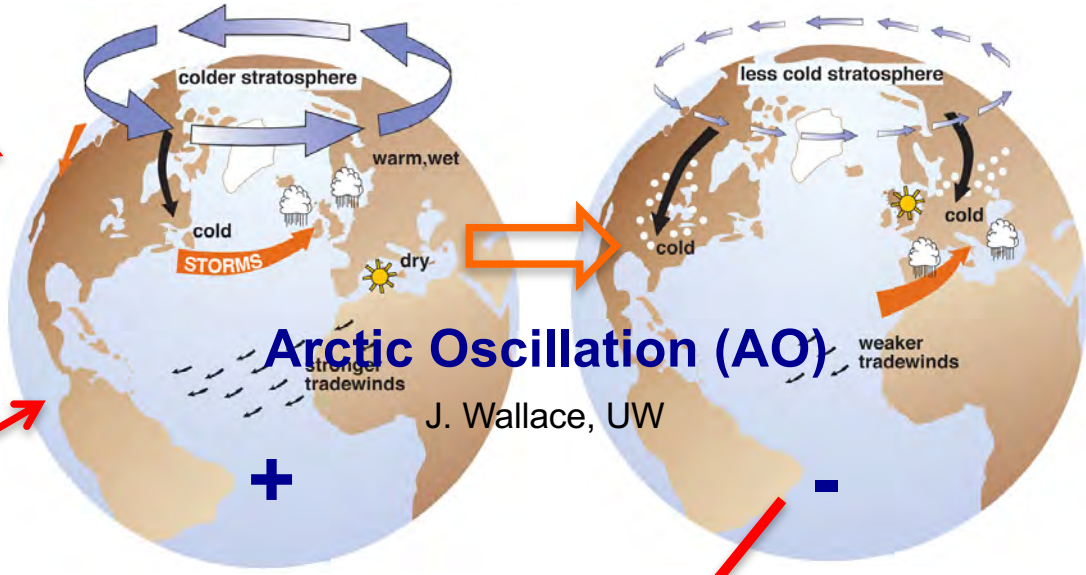


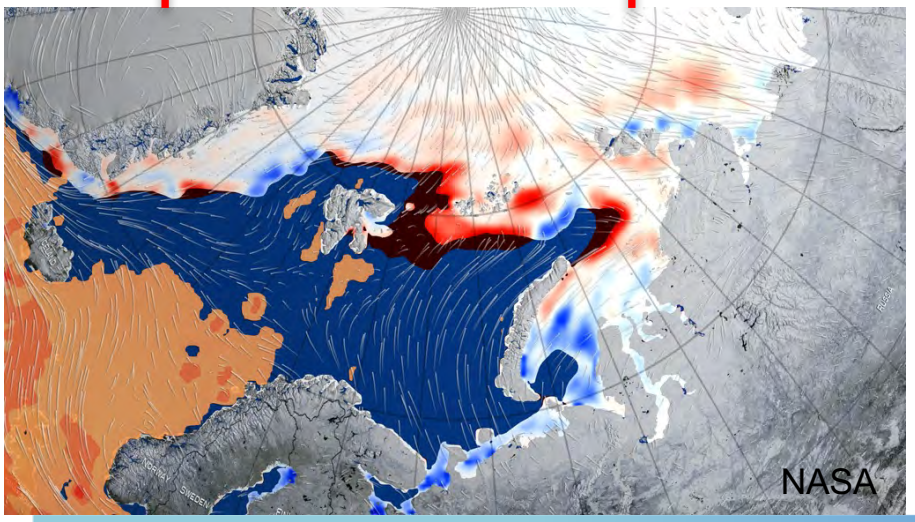

*McCusker et al. 2016*

# Atmospheric dynamics linking Arctic sea ice retreat/warming to midlatitude climate and weather



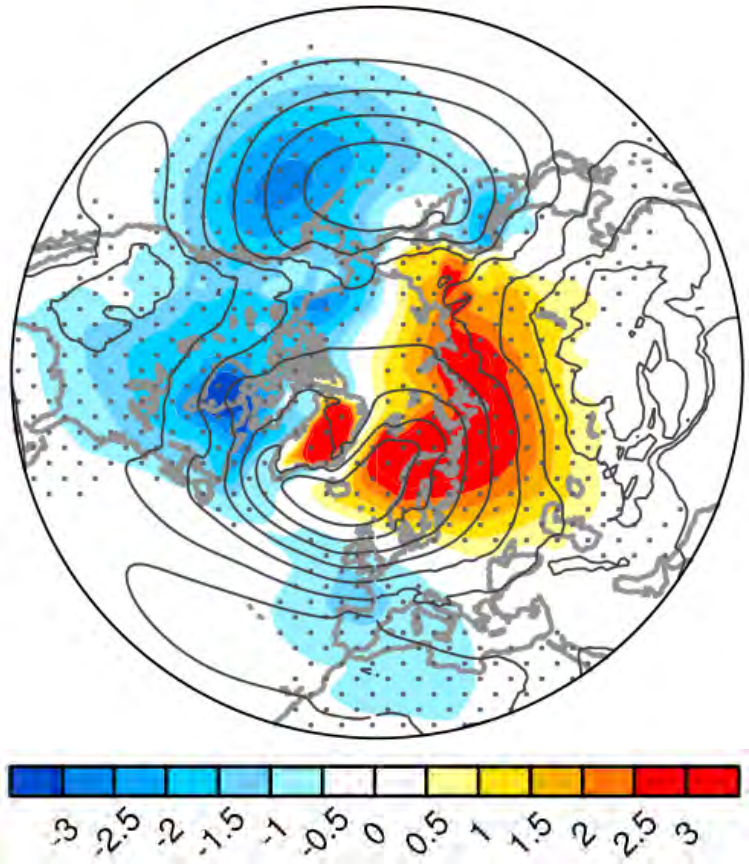



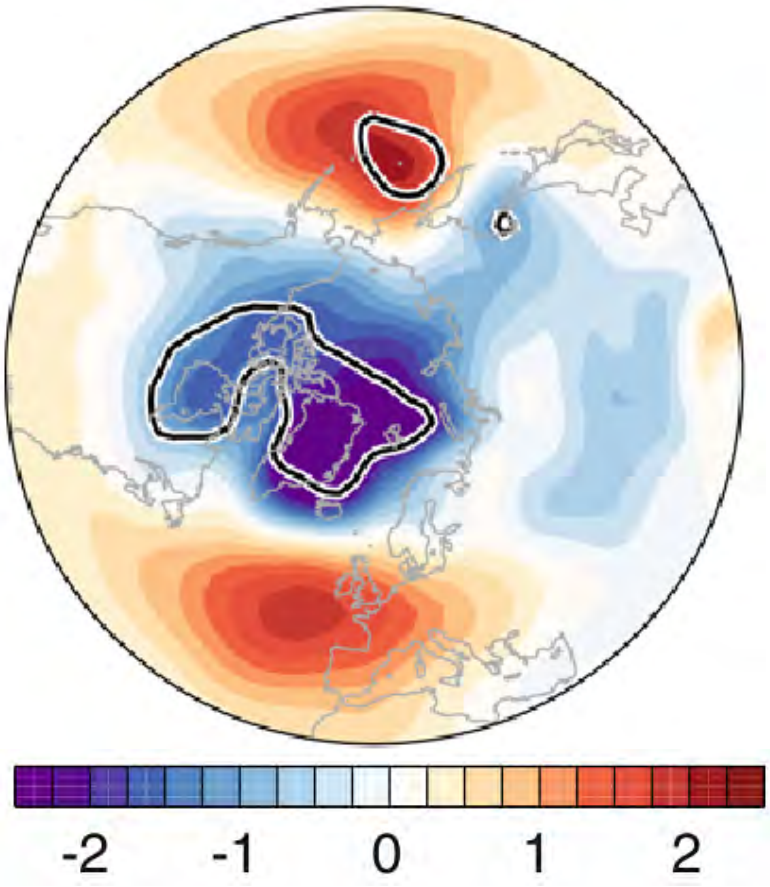




**Eurasian cold winter**

# Non-robust AO/NAO responses (Doug Smith et al., US CLIVAR Workshop)




• **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**

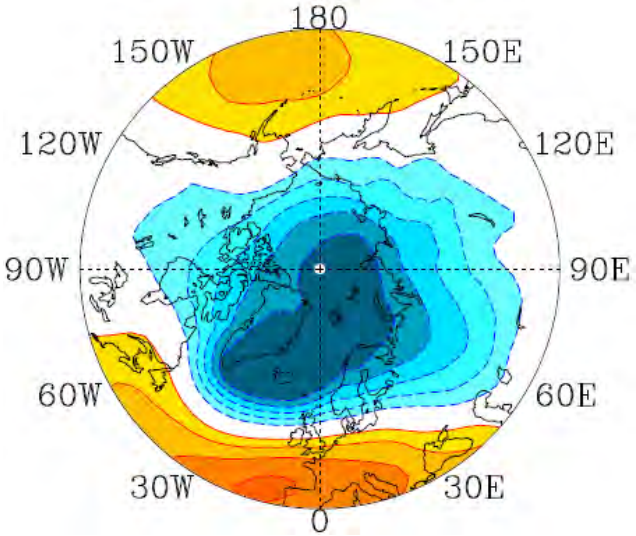
• Screen et al. 2013; Petrie et al 2015; Blackport and Kushner 2016 …

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

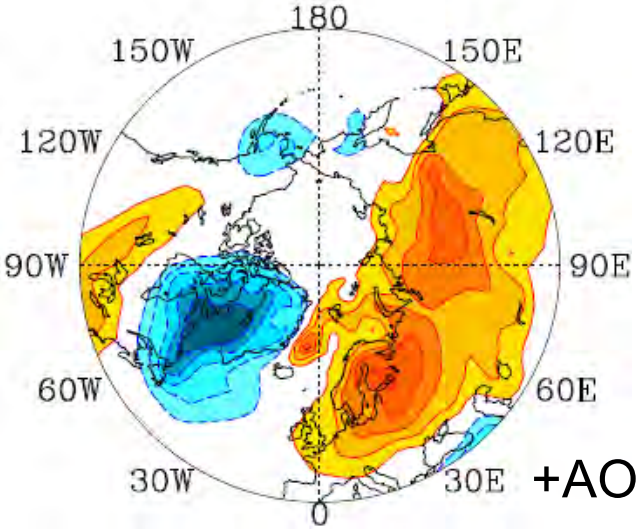
• Alexander et al 2004; Petoukhov and Semenov 2010; Sun et al. 2015; Pedersen et al 2016; Chen et al 2016 ...

# Does AO/NAO really play a role in linking Arctic and midlatitudes?

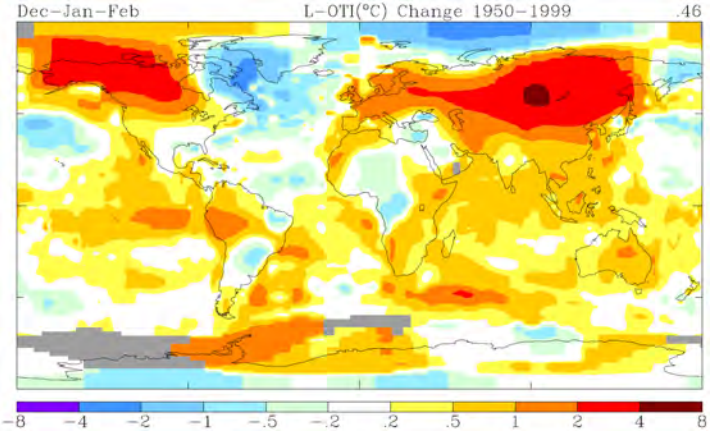
SLP (1958-1996)



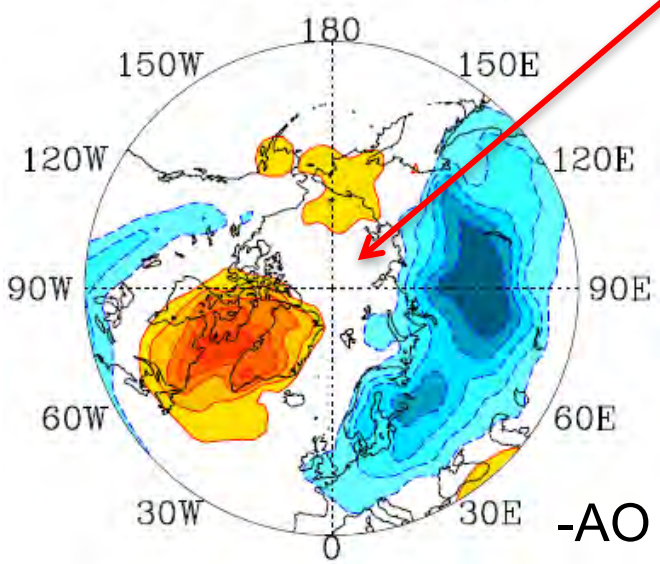

SAT(1958-1996)




+AO

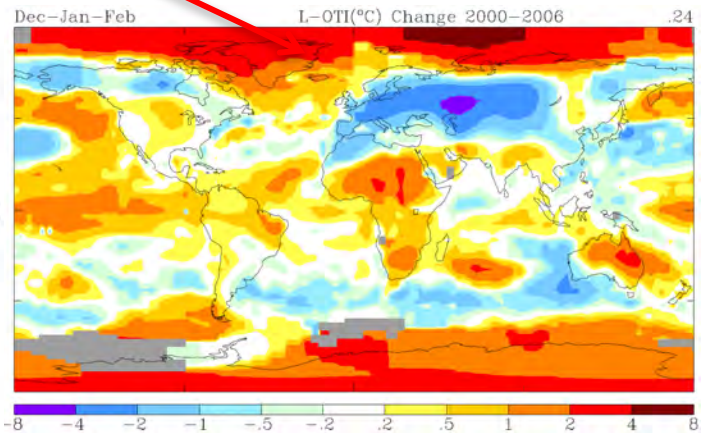



SAT(1997-2016)




-AO

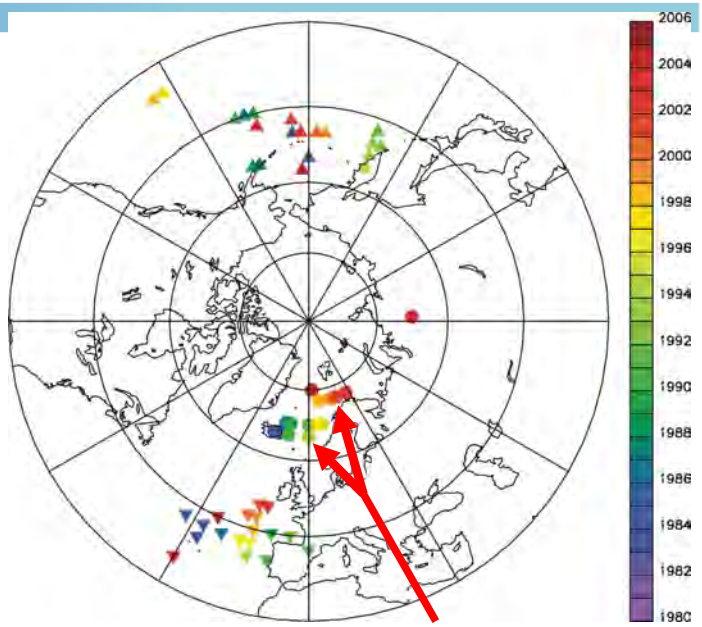
No Amplified Arctic Warming




**AO-driven temperature changes do not capture the Arctic amplification, or warm Arctic-cold Eurasia.**

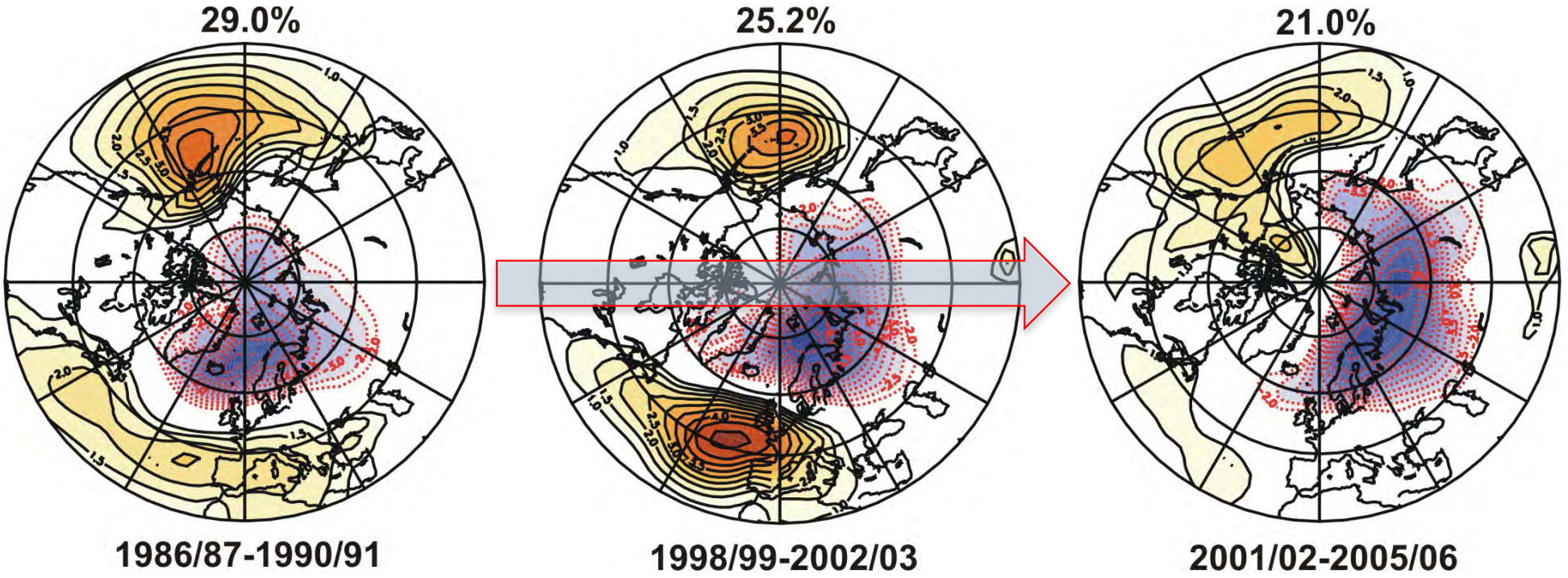
# Atmospheric circulation dynamics: A spatial pattern shift and the Arctic Rapid change Pattern (ARP)

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

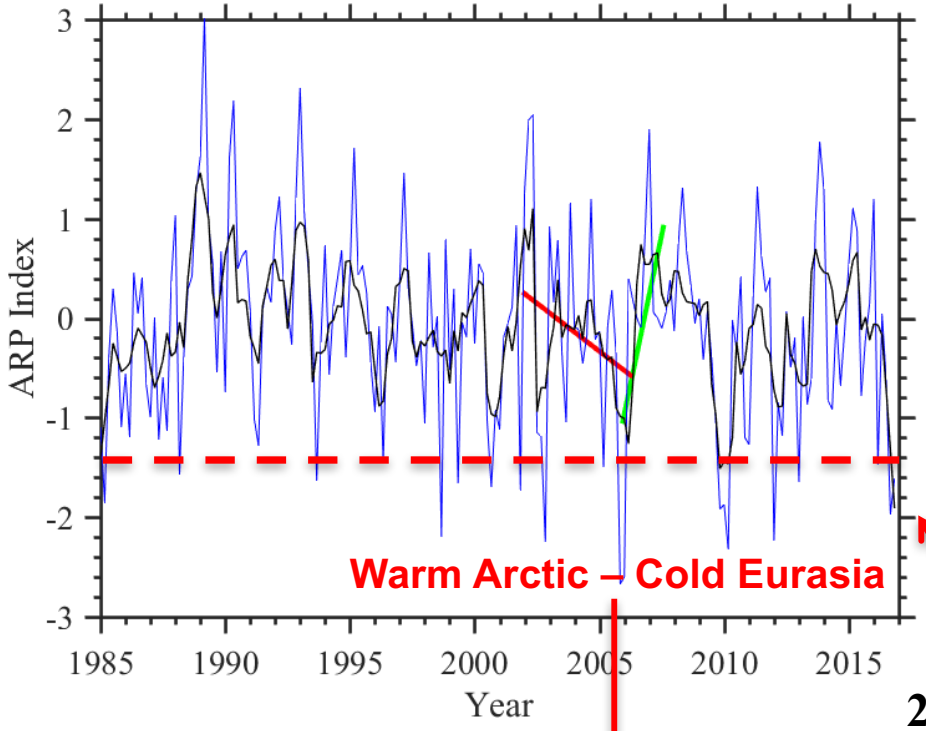


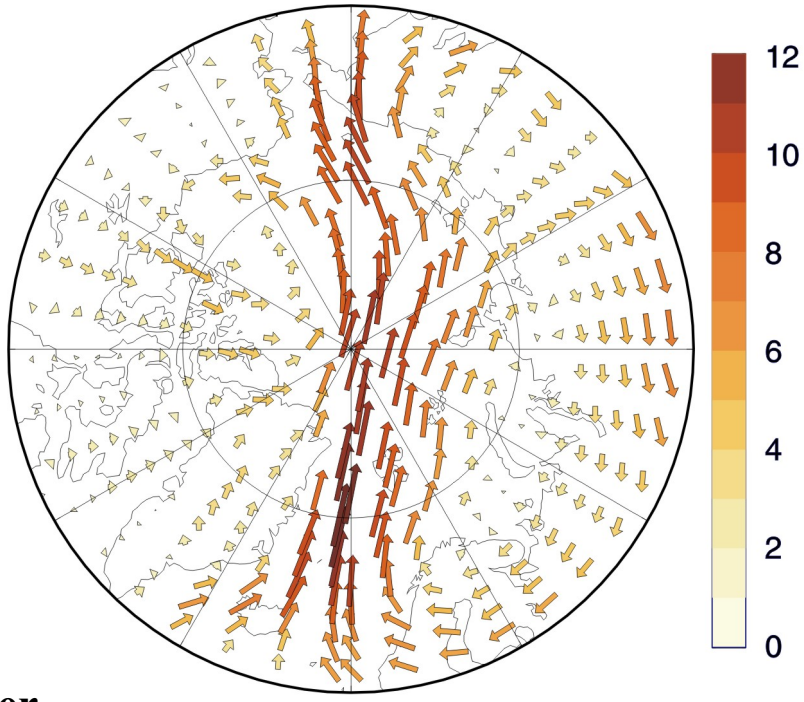

*Zhang et al. 2008*

**In the mid-1990s**

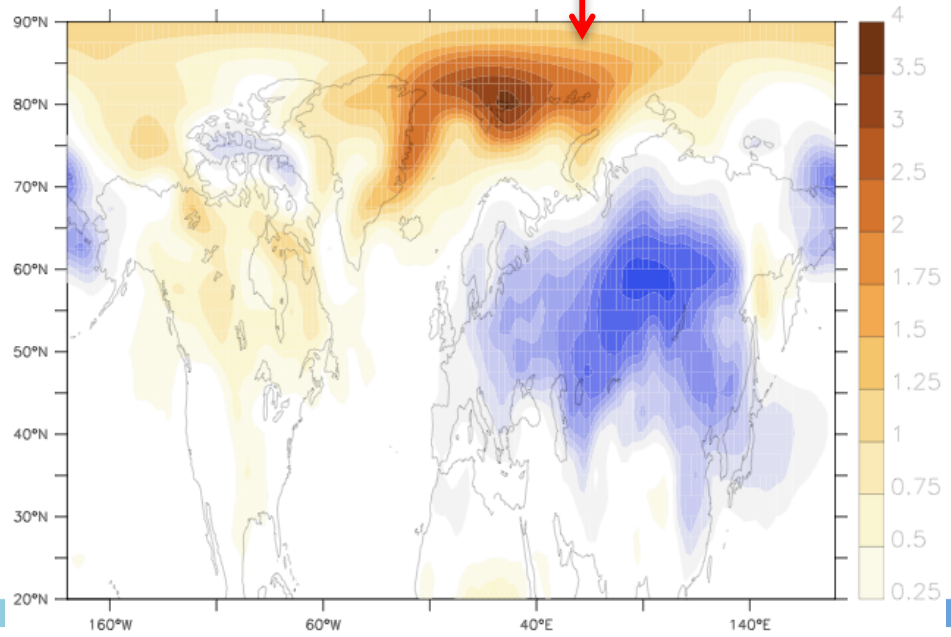


# An increase in frequency of occurrence of negative ARP during recent years




2015/16 Winter

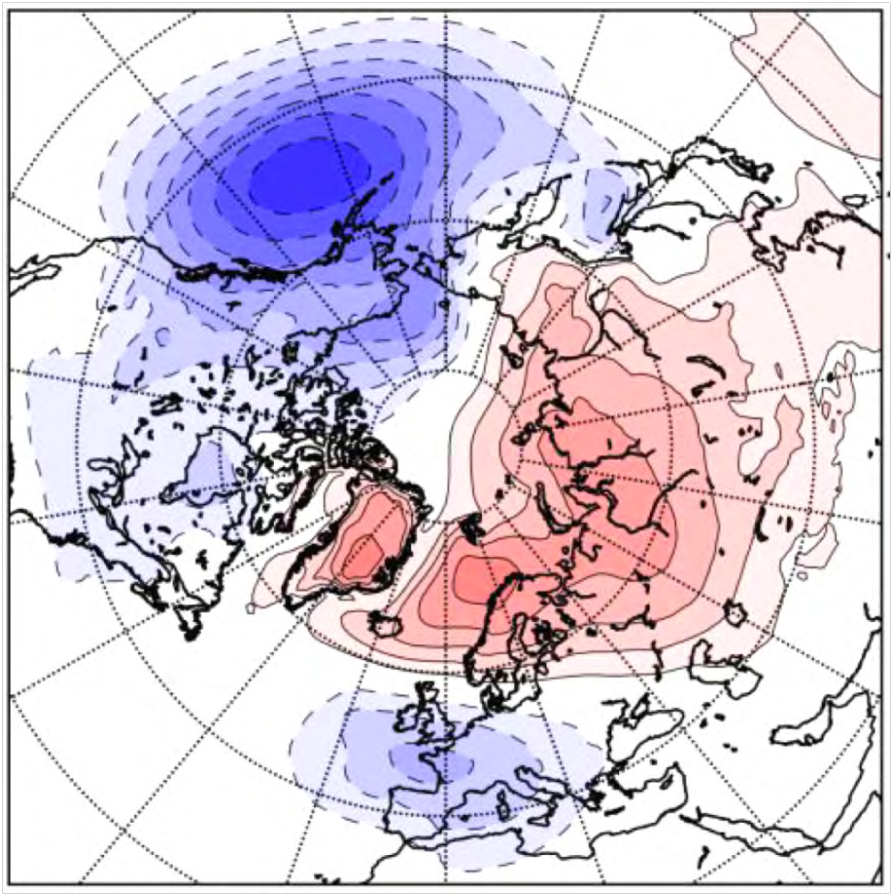



**Heat transport regressed onto winter ARP index (surface - 850 hpa)**

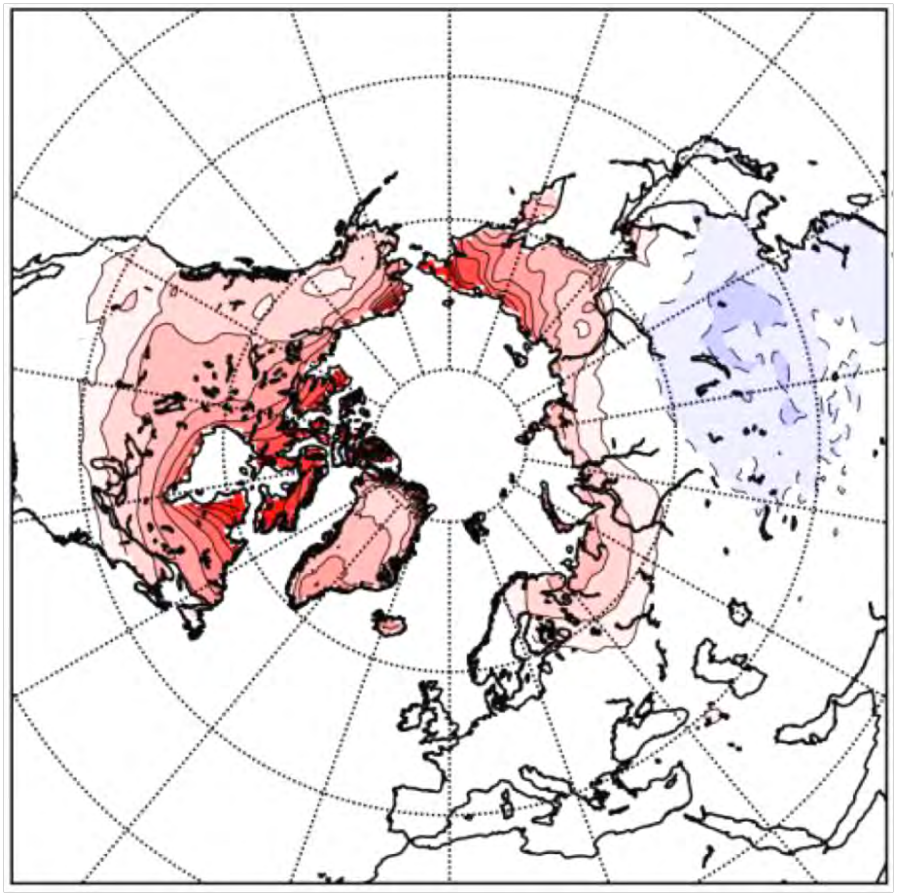
**Enhanced transport of warm and moist air into the central Arctic Ocean and cold air to the Eurasian midlatitude in the extremely negative ARP phase.**

# Emergence of the ARP pattern in the fully coupled model experiment: CESM1 RCP 8.5 forcing experiment

## Sea Ice Loss Related Responses



SLP



2 m Air Temperature

*Blackport and Kushner 2017*

**Polar Amplification – Multi-model Intercomparison Project (PA-MIP)**
**- D. Smith et al., partially supported by the H2020 APLICATE**

| Experiment – Time Slice | | | Forcing |
|---|---|---|---|
| 1. AMIP | Control | | Present-day Climatological SST and Sea Ice (SIC) |
| | SST | pi | Pre-industry SST |
| | | 2 degree | Future 2 degree warming SST |
| | Arctic SIC | pi | Pre-industry SIC |
| | | 2 degree | Future 2 degree warming SIC |
| | Antarctic SIC | pi | Pre-industry SIC |
| | | 2 degree | Future 2 degree warming SIC |
| 2. Coupled | Control | | Constrained by Present-day Climatological SIC |
| | Arctic SIC | pi | Constrained by Pre-industry SIC |
| | | 2 degree | Constrained by Future 2 degree warming SIC |
| | Antarctic SIC | pi | Constrained by Pre-industry SIC |
| | | 2 degree | Constrained by Future 2 degree warming SIC |

## 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 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.

  - PA-MIP: A great component.