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

Workshop Summary

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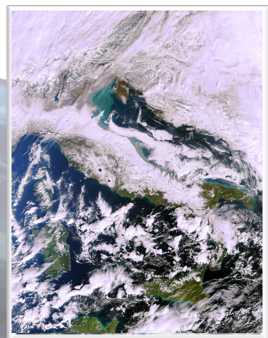
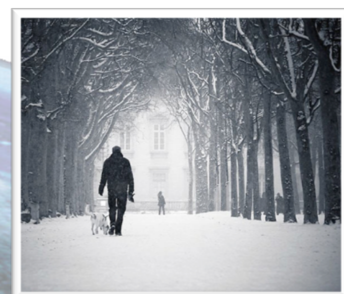
J. Francis, T. Jung, R. Kwok and J. Overland – workshop organizers

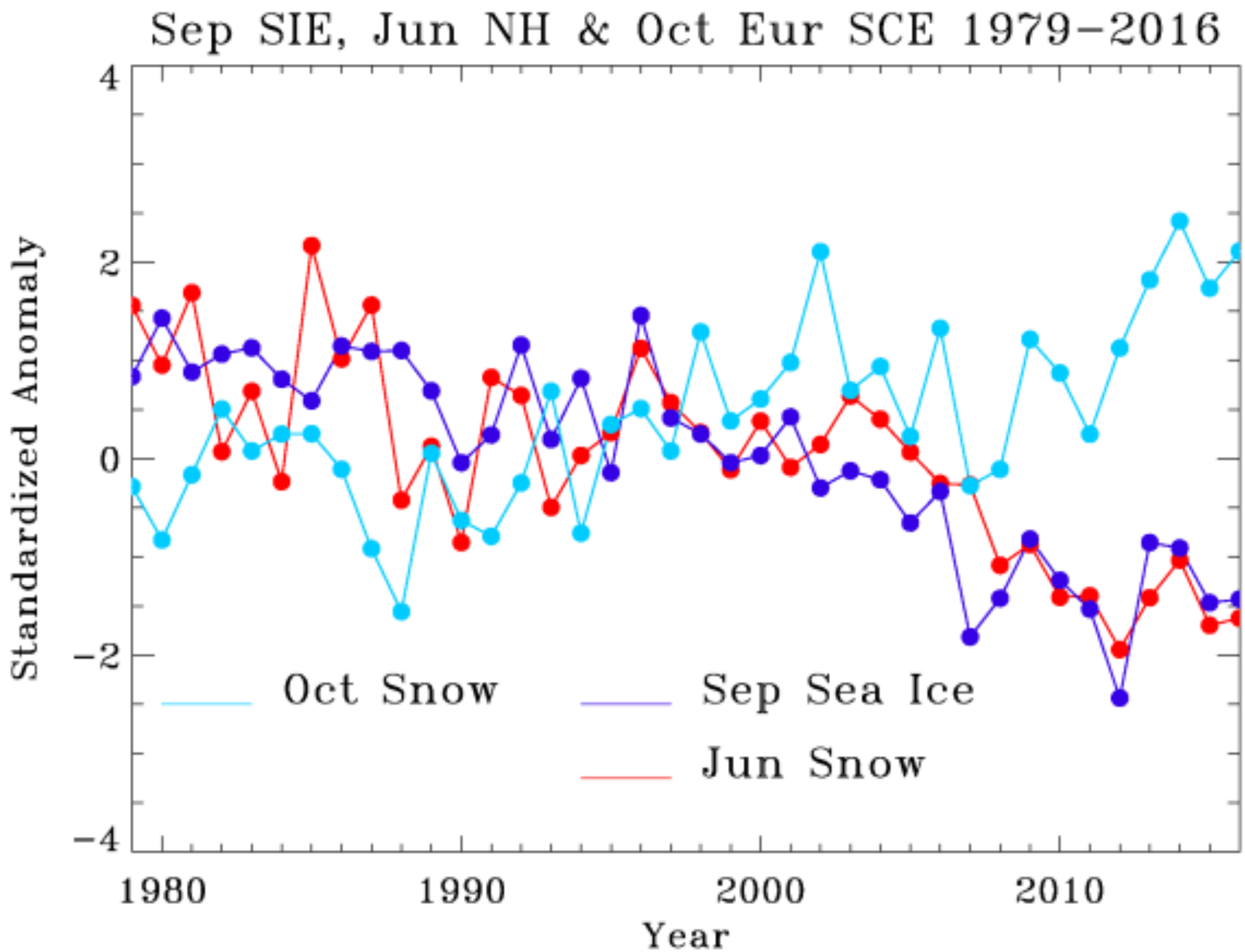
August 8, 2017



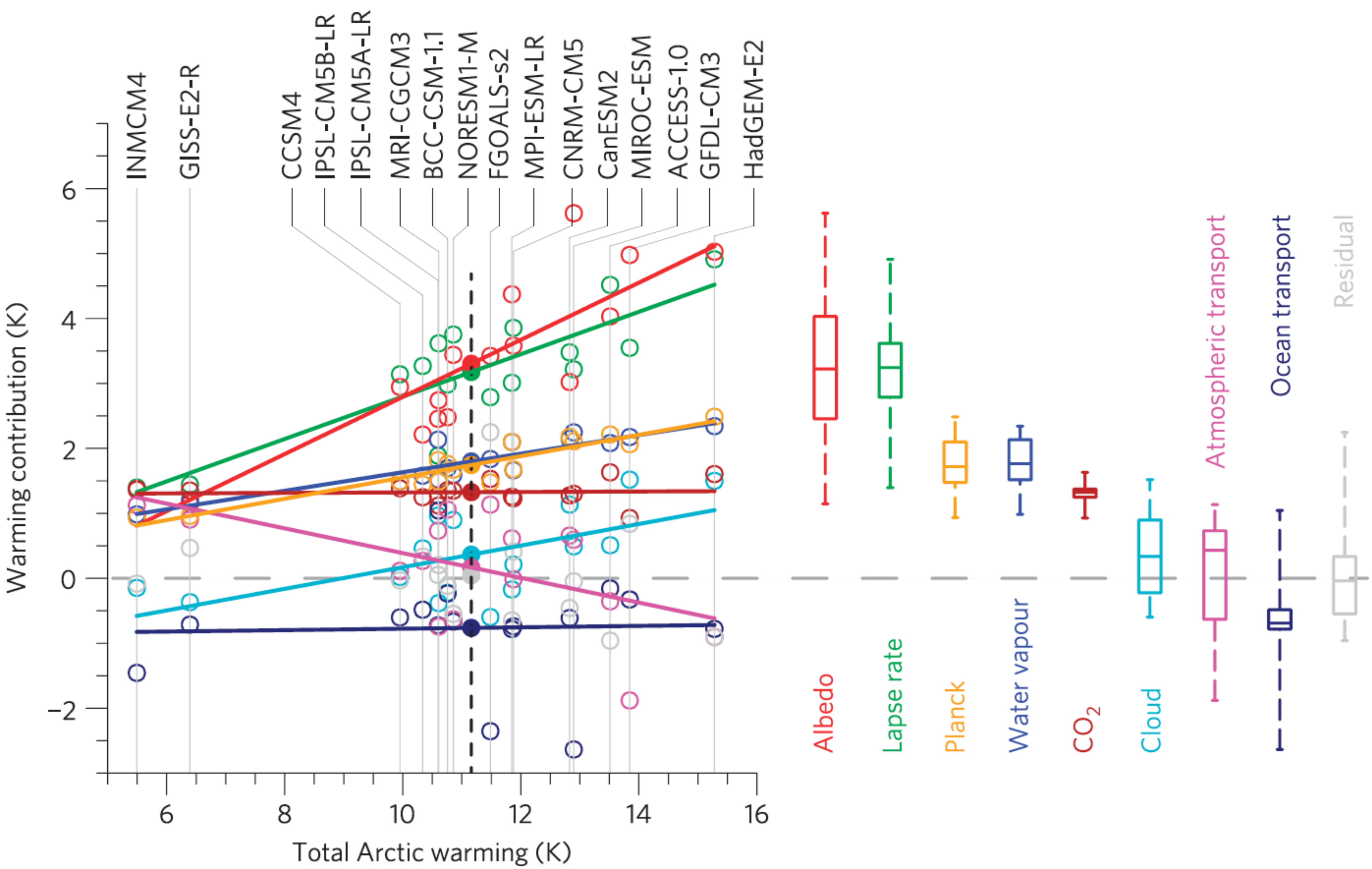


ARCTIC AMPLIFICATION

Sea Ice and Snow Cover Decline



Sea Ice loss and full AA

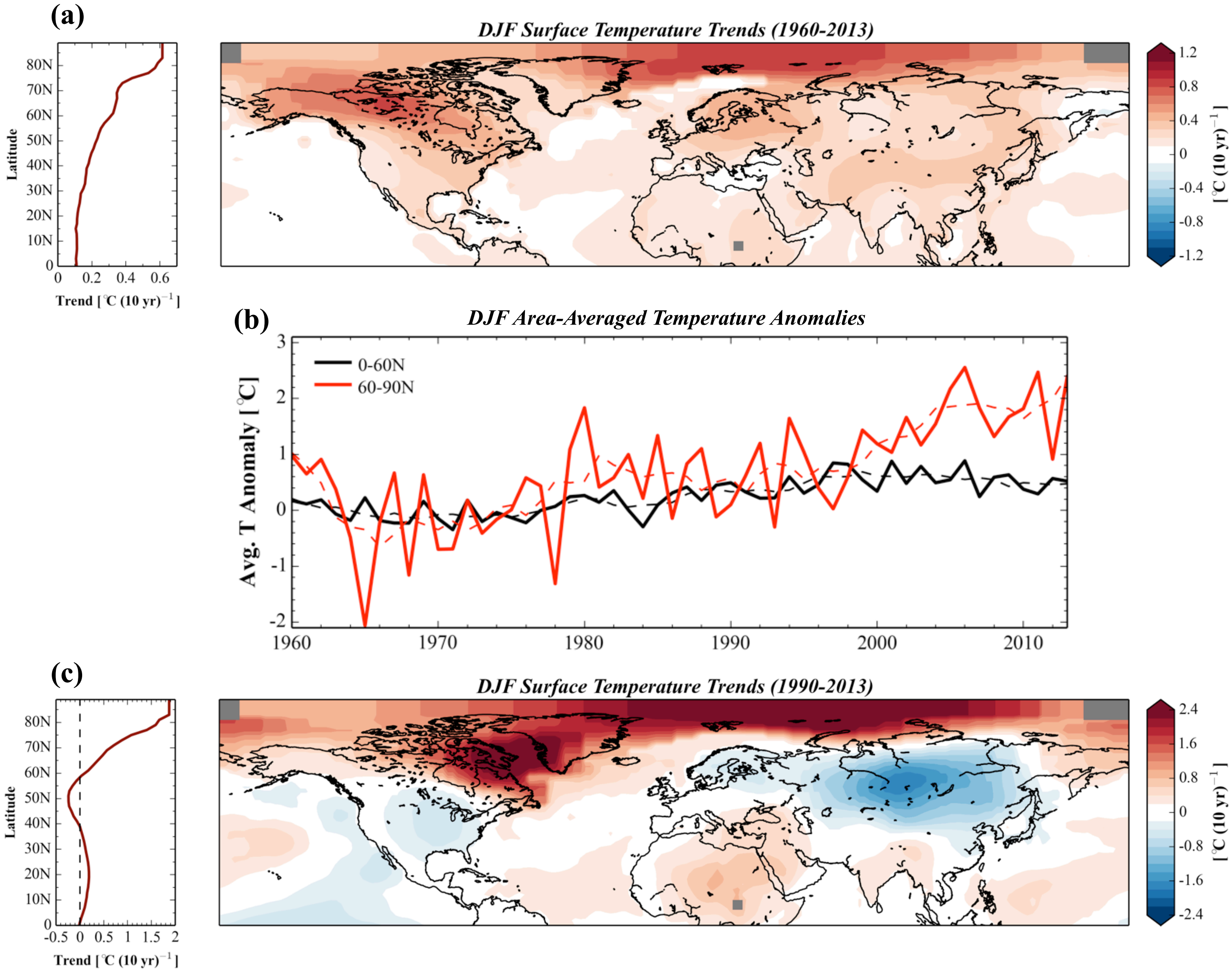


Sea ice loss is not the biggest contributor to AA

Pithan and Mauritsen (2014)

WARM ARCTIC-COLD CONTINENTS/EURASIA

Arctic Amplification



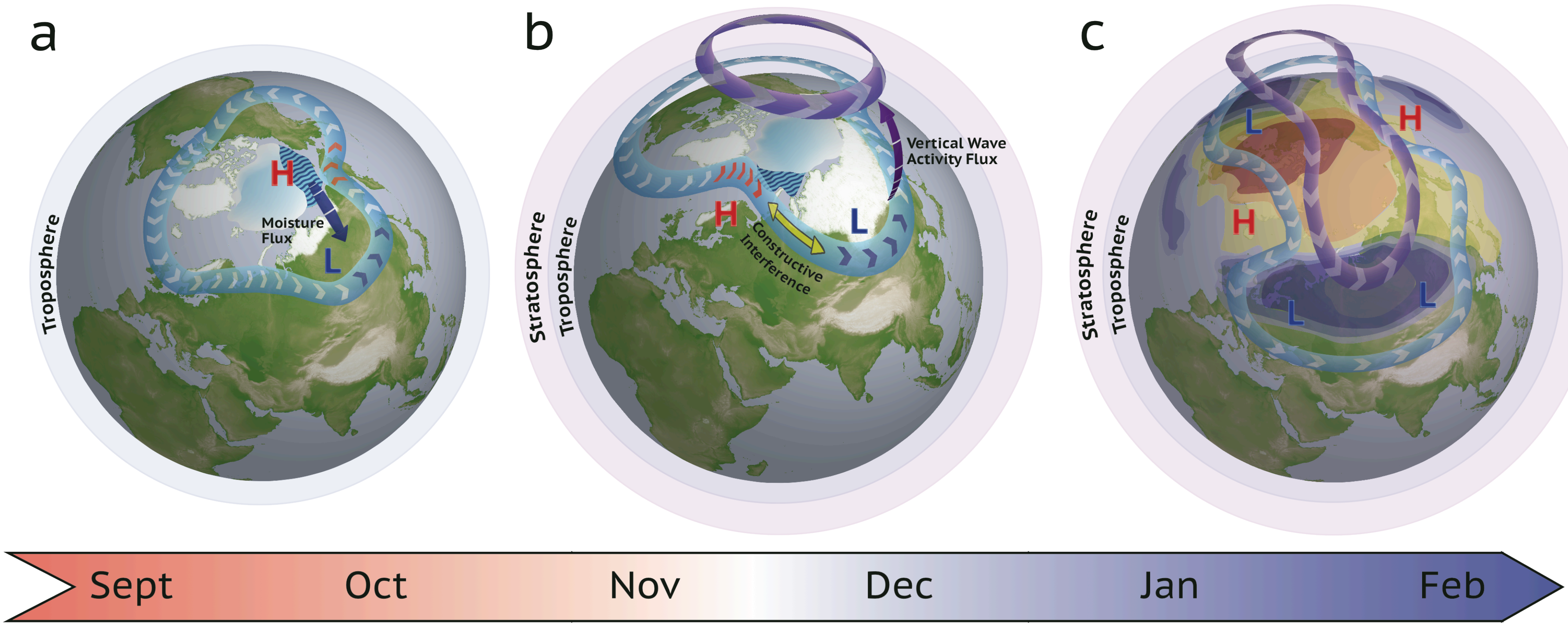
Cohen et al. 2014 Review paper

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

Synthesis of Sea Ice and Snow Cover

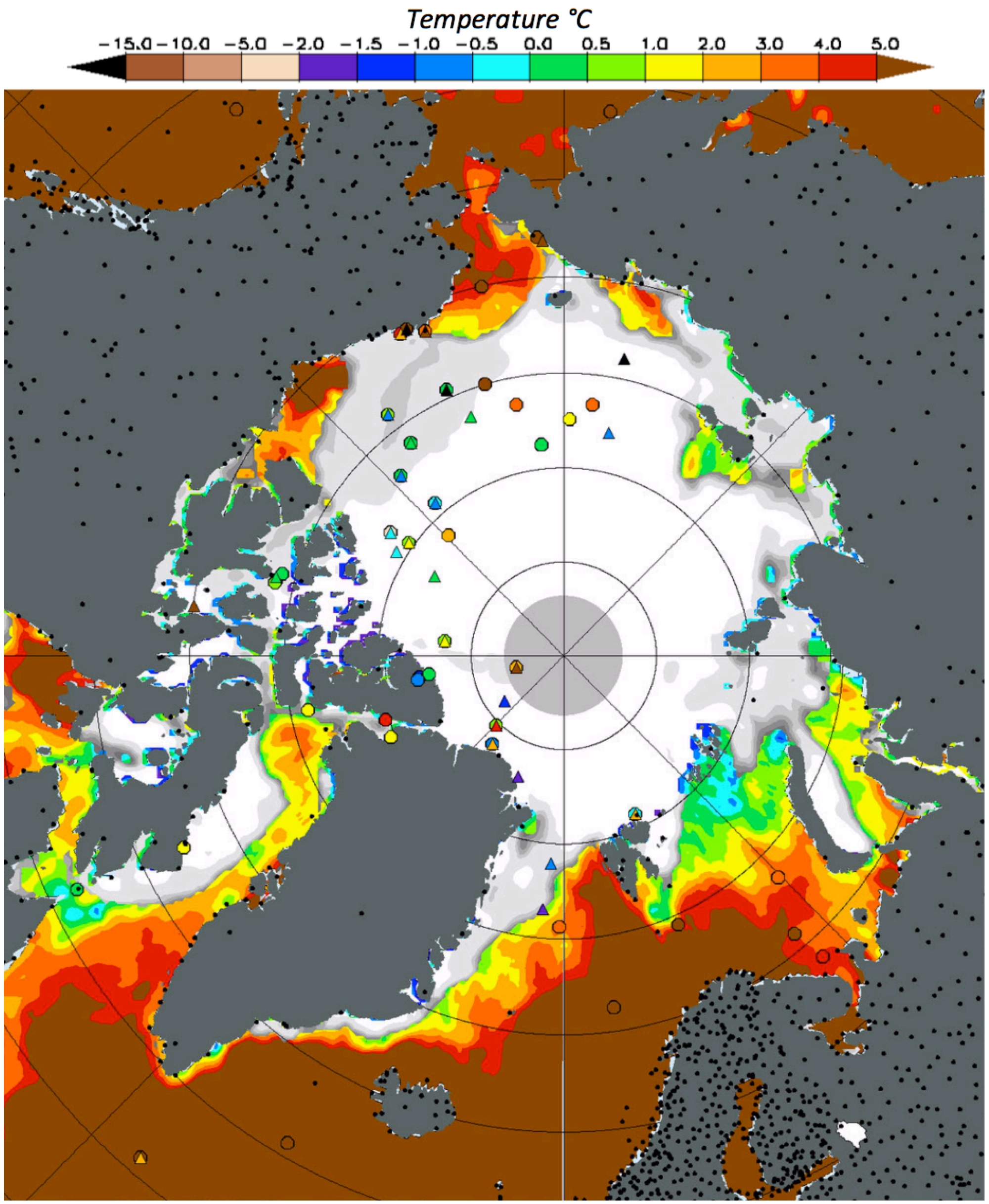


Cohen et al. 2014 Review paper

Challenges with Data and Models

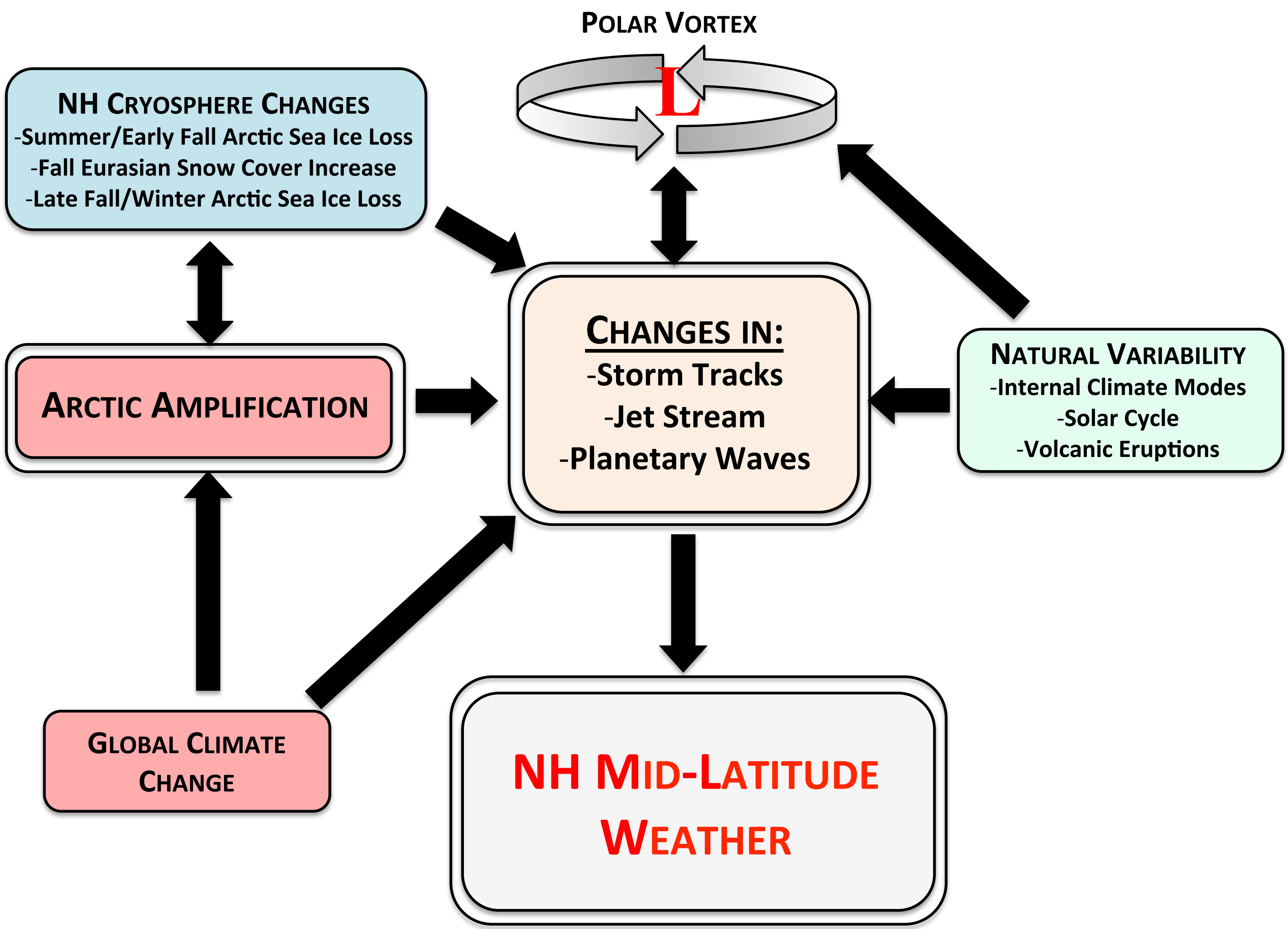
- Scarcity of observations in the Arctic
- Short time series in observations since AA
- Model deficiencies
- Uncoordinated modeling studies
- Biases and uncertainties in metrics for quantitative analysis
- The climate system is complicated

Scarcity of Arctic Observation Stations



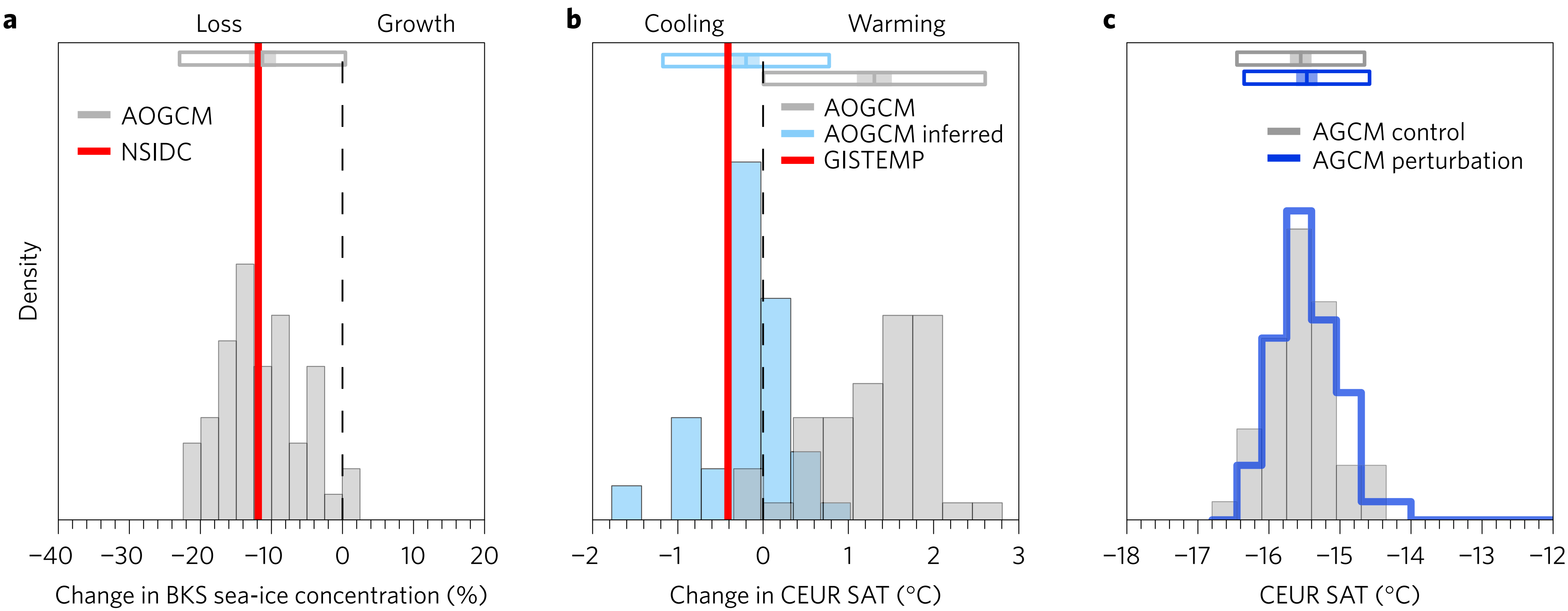
Courtesy of Wendy Ermold, University of Washington

Mid-latitude Weather is Complicated



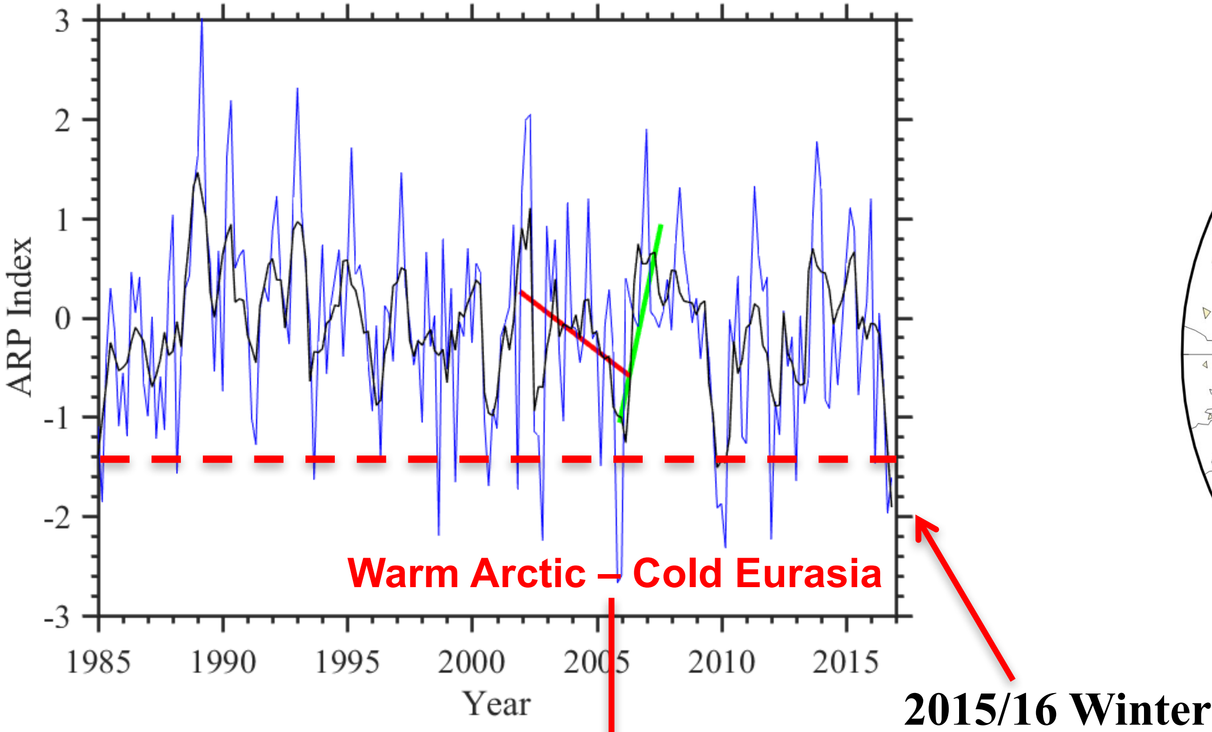
Cohen et al. 2014

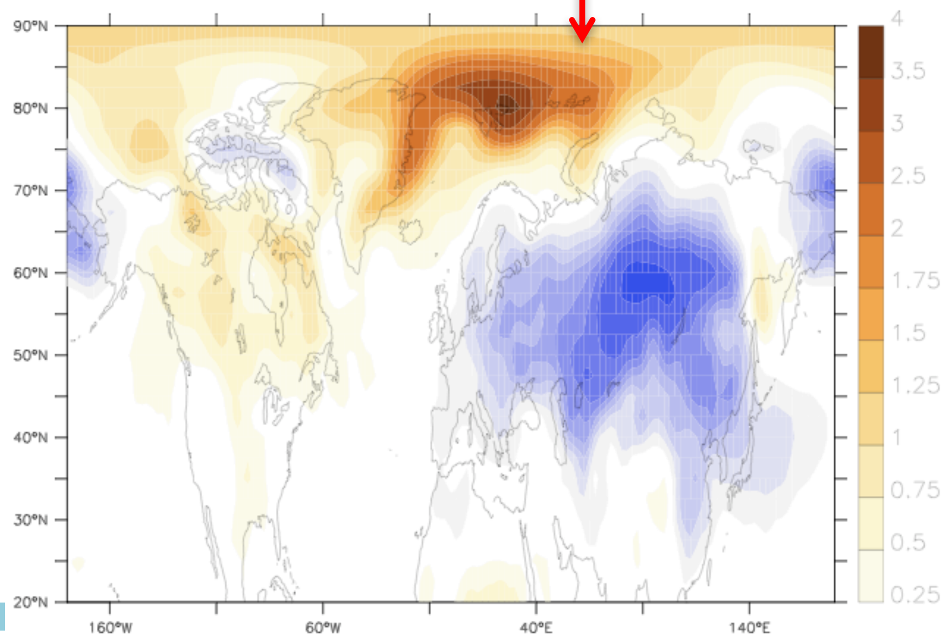
However, many model simulations show cold resulted from natural variability

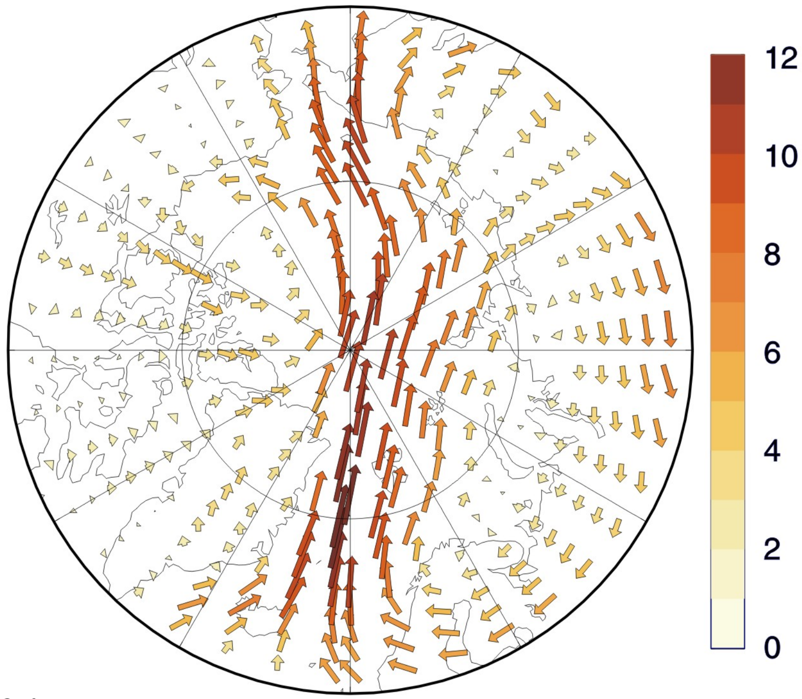


McCusker et al. 2016

An increase in frequency of occurrence of negative Arctic Rapid change Pattern (ARP) during recent years





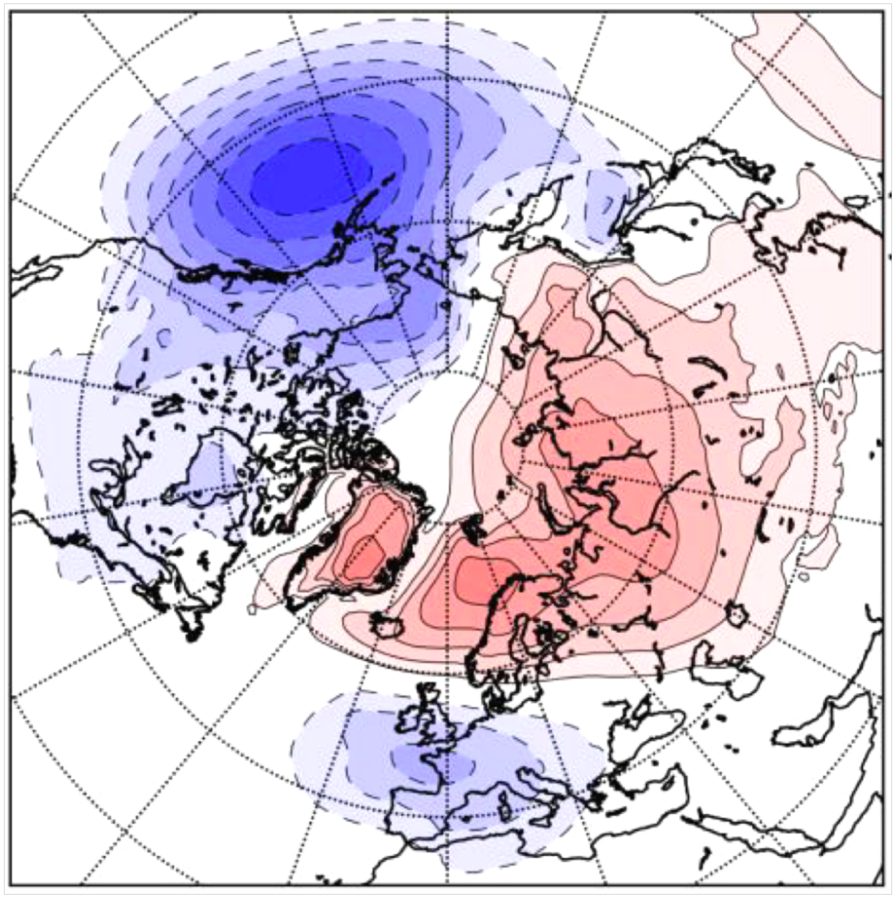


Heat transport regressed onto winter ARP index (surface - 850 hpa)

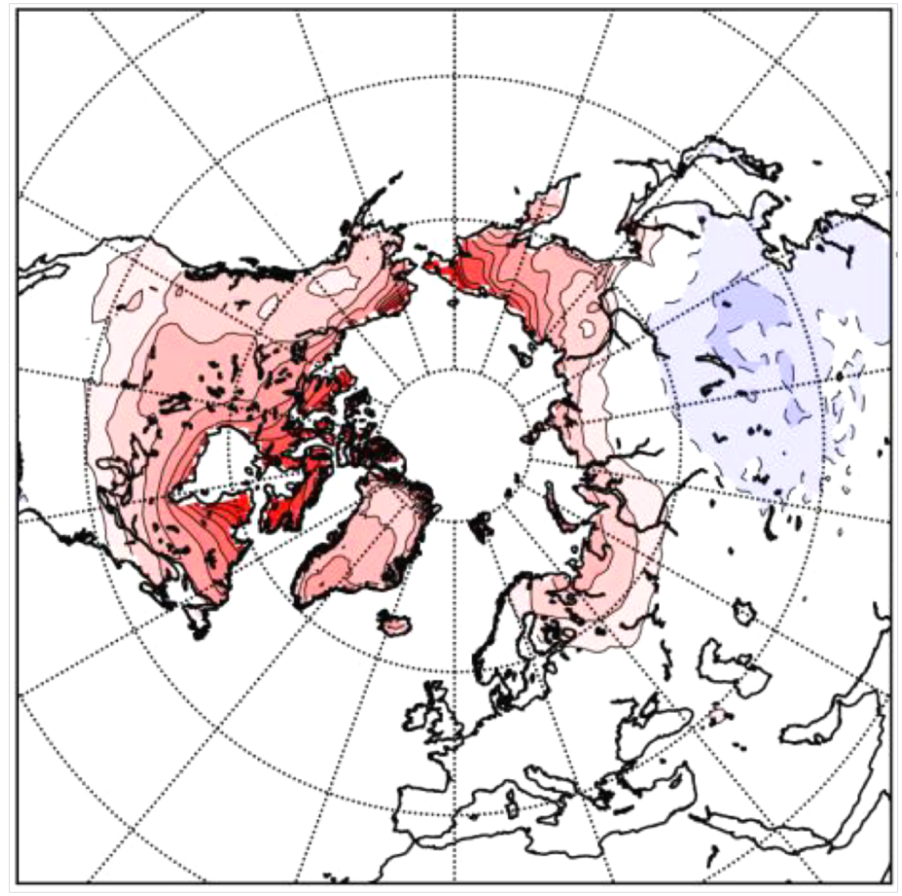
Enhanced transport of warm and moist air into the central Arctic Ocean and cold air to the Eurasian midlatitude in the extremely negative ARP phase.

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

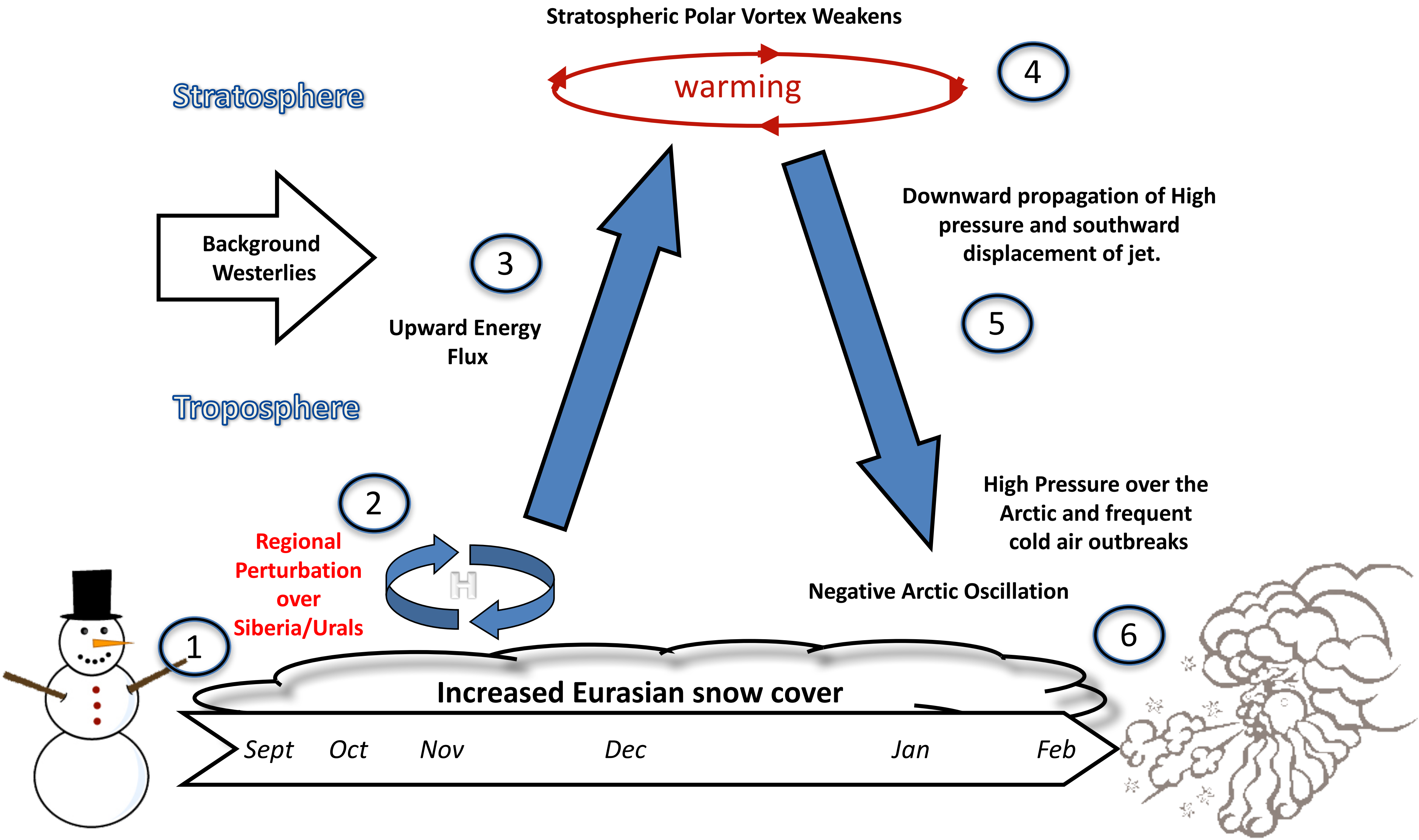
- No consensus has been reached among the modeling studies;
- Dynamic process linking Arctic and midlatitude has not been well understood, impacting selection of metrics to evaluate model performance;
- Uncertainties exist in defining and prescribing forcing in AGCM or CGCM simulations;
- Impacts of 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.

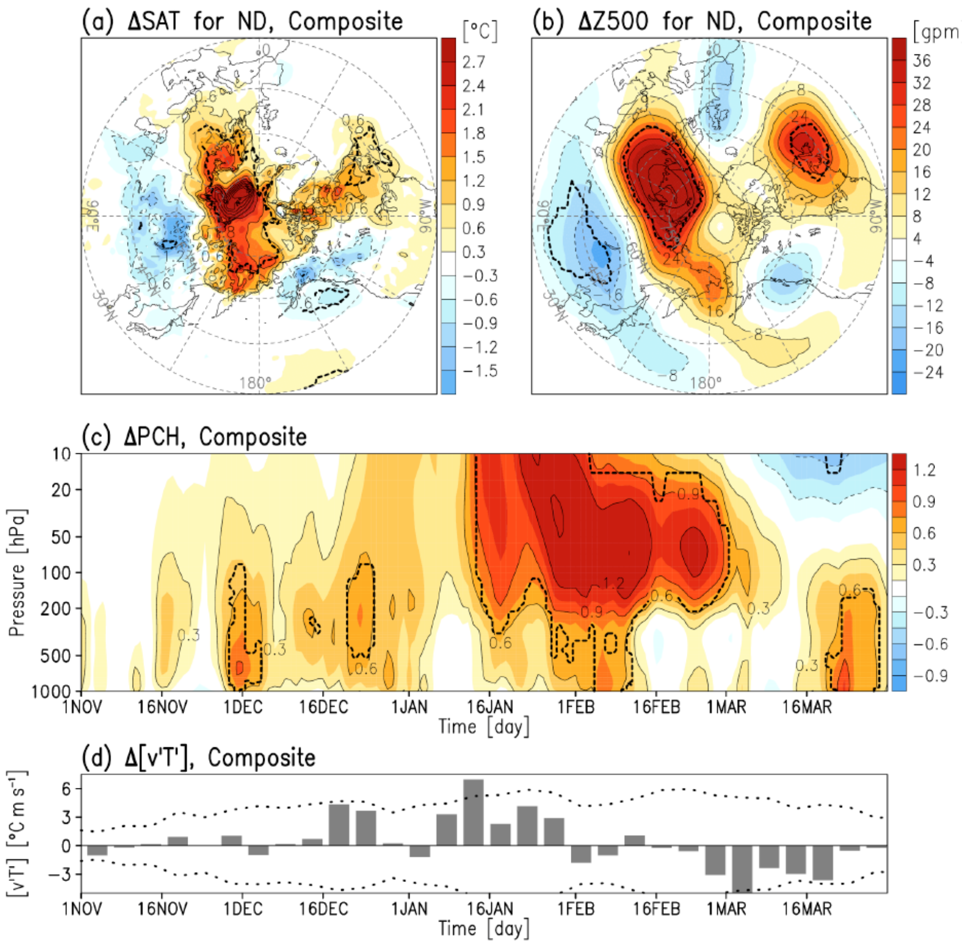
  - PA-MIP: A great component.

Extensive Snow Forced Cold Signal

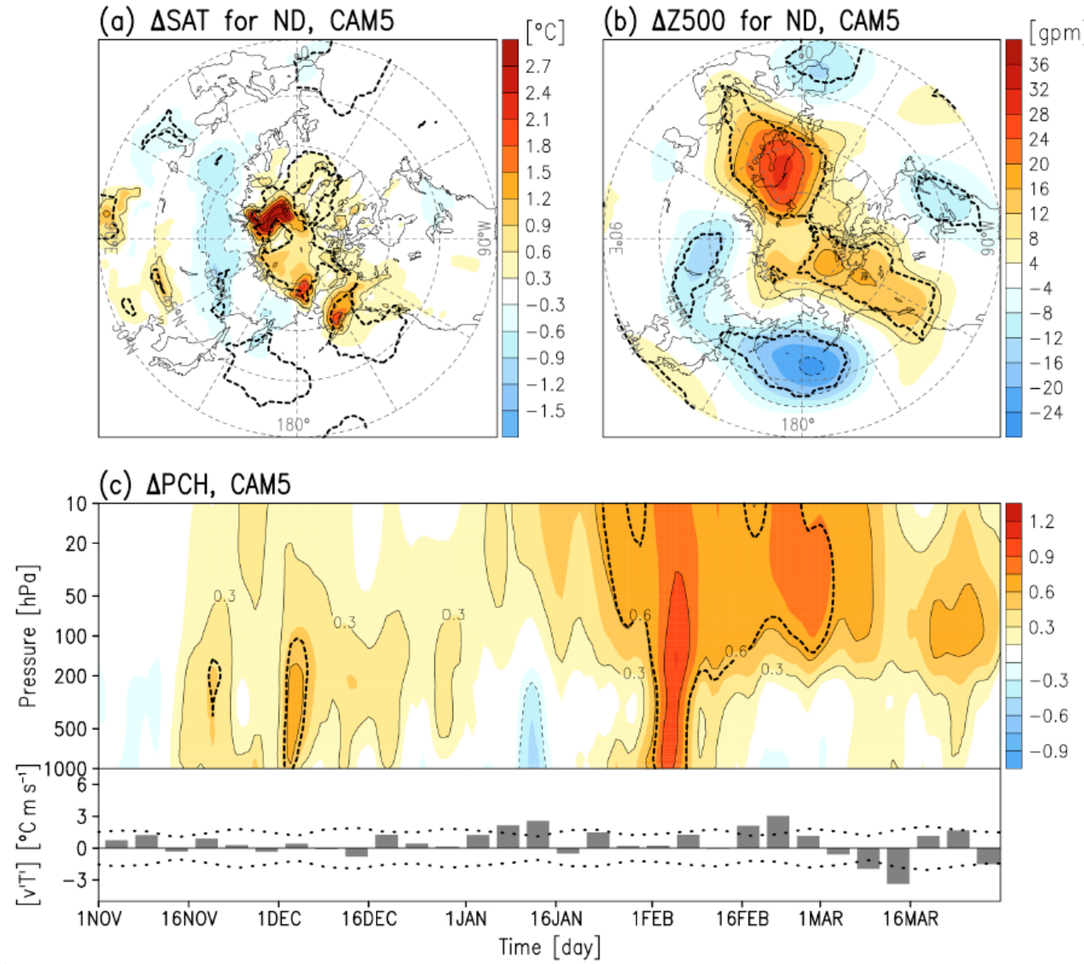


Reduced Sea Ice Forced Cold Signal

observations



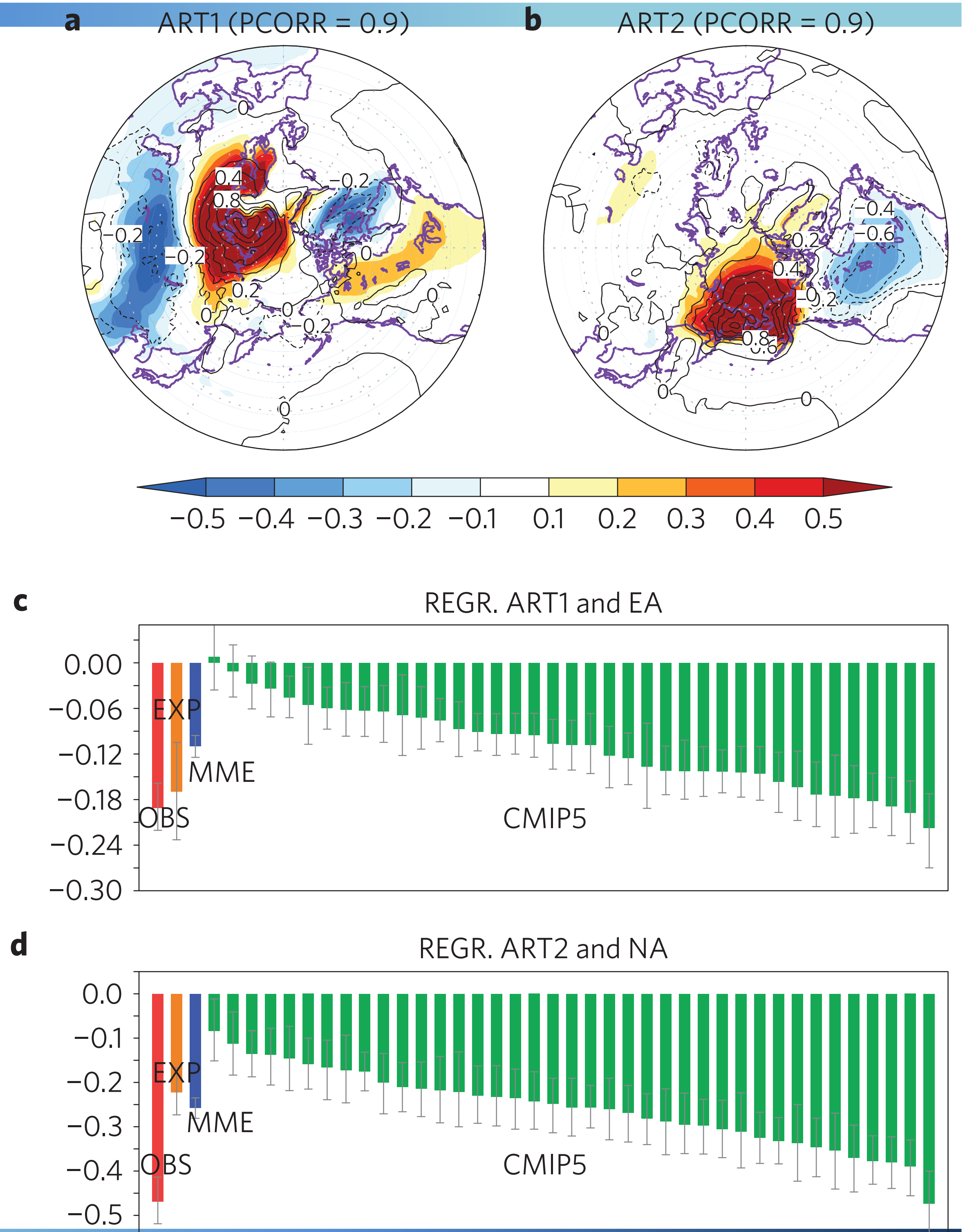
model



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

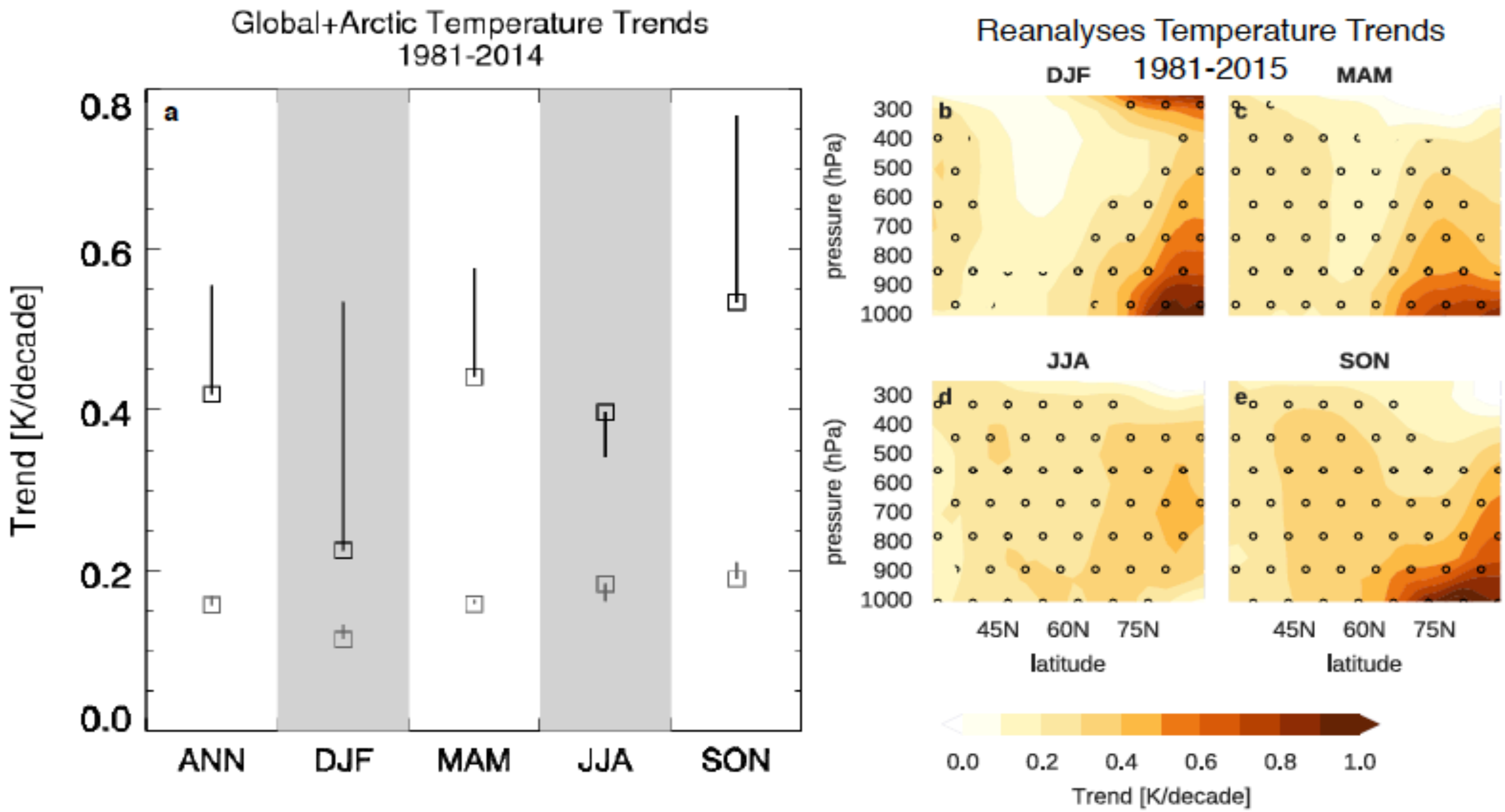
Kim et al. 2014

Arctic warming forced changes in SAT



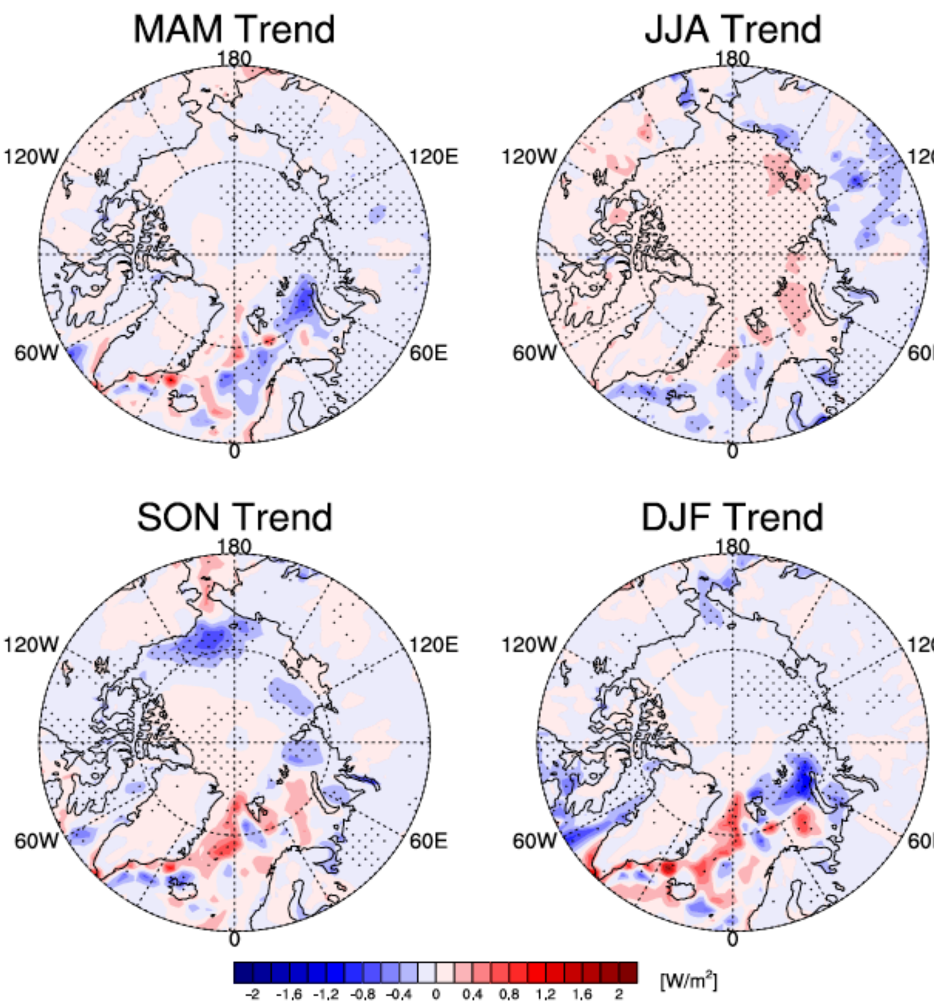
Kug et al. 2015

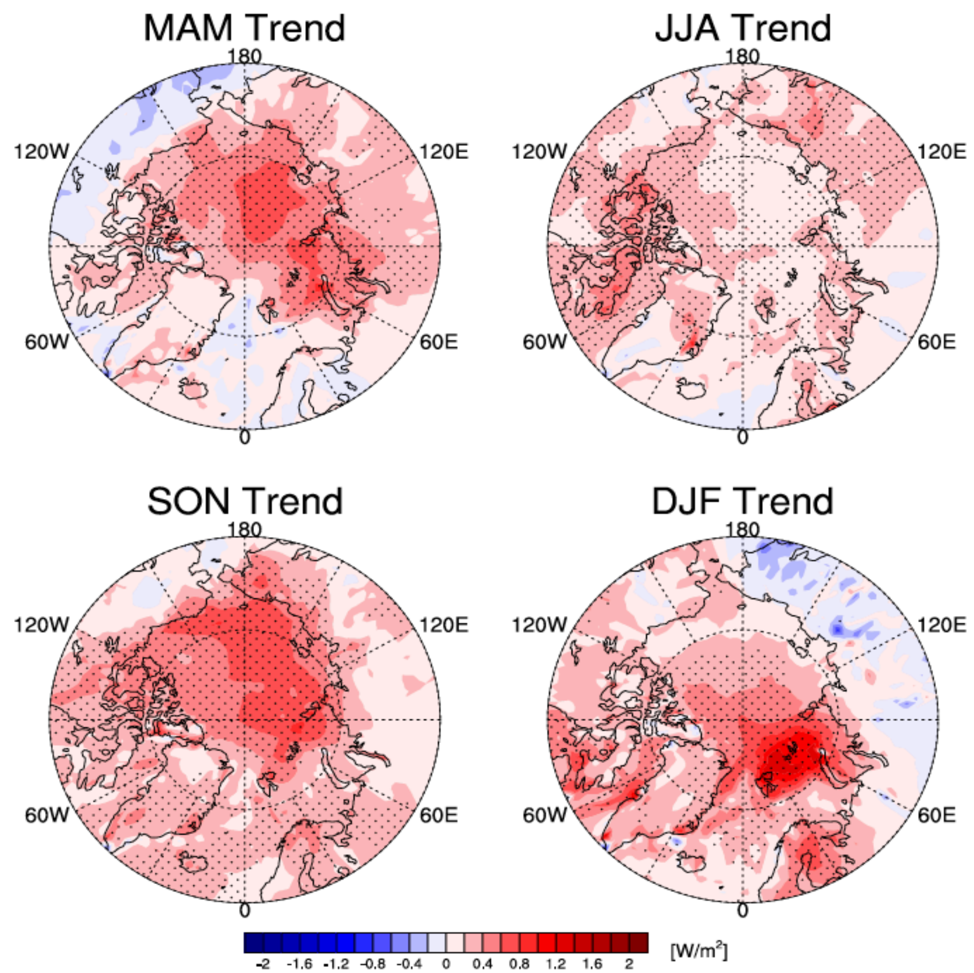
Annual Cycle of Arctic Temperatures



Courtesy of Fred Laliberte/Lawrence Mudryk

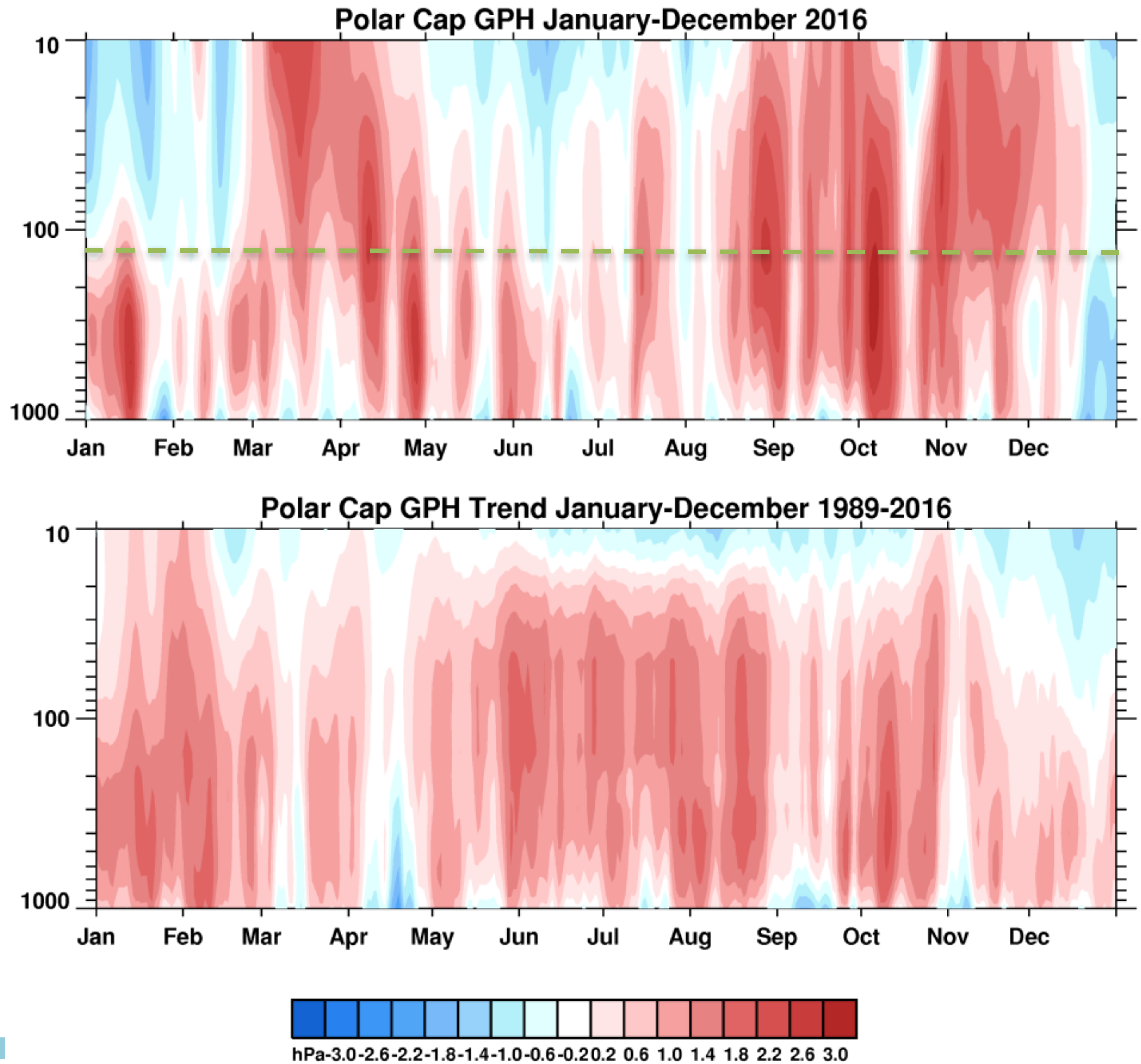
Sensible heat flux and downwelling longwave radiation





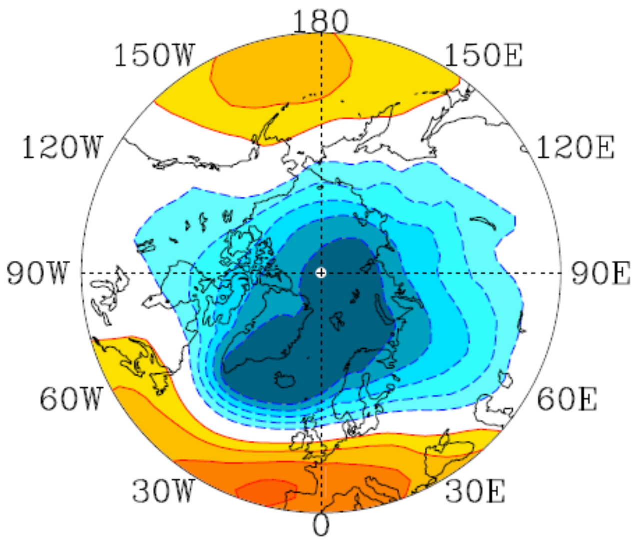
Courtesy of Tingting Gong (Units: W m^{-2} yr^{-1})

Arctic Warmth reaches to the Stratosphere

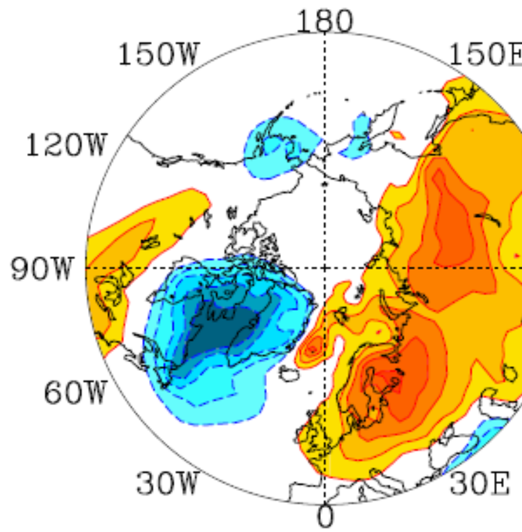


Does AO/NAO really play a role in linking Arctic and midlatitudes?

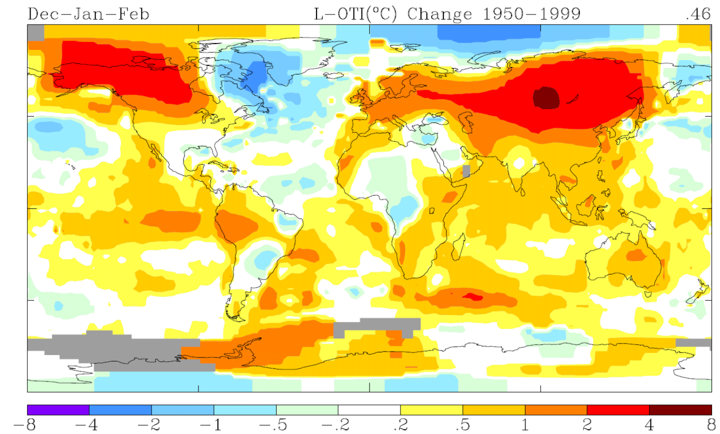
SLP (1958-1996)



SAT(1958-1996)

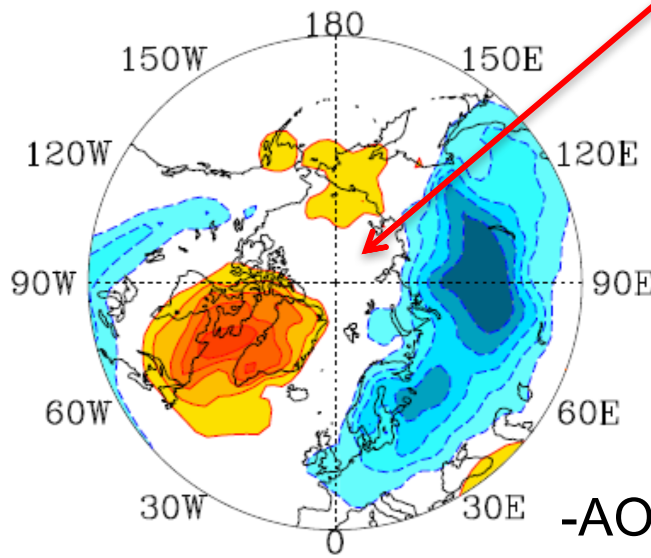


+AO

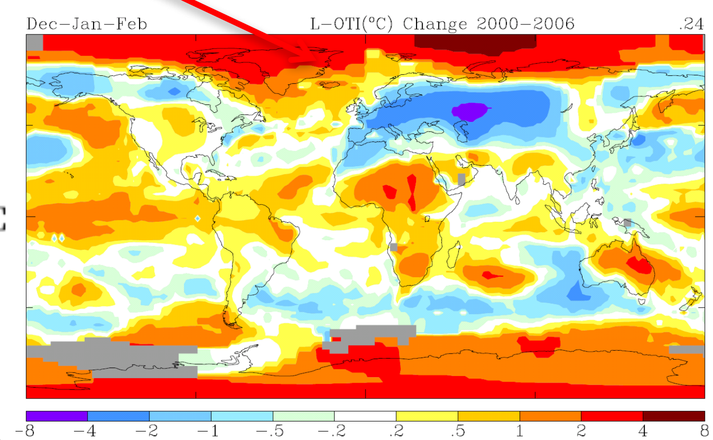


SAT(1997-2016)

No Amplified Arctic Warming



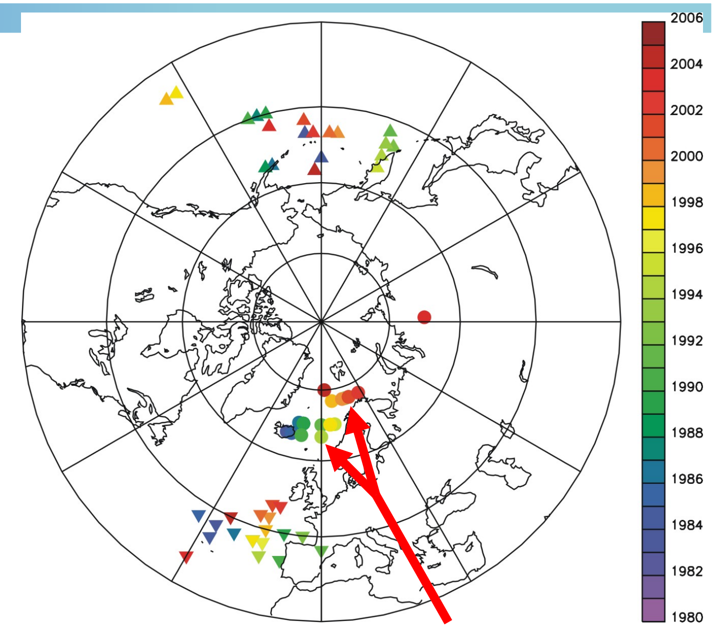
-AO



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

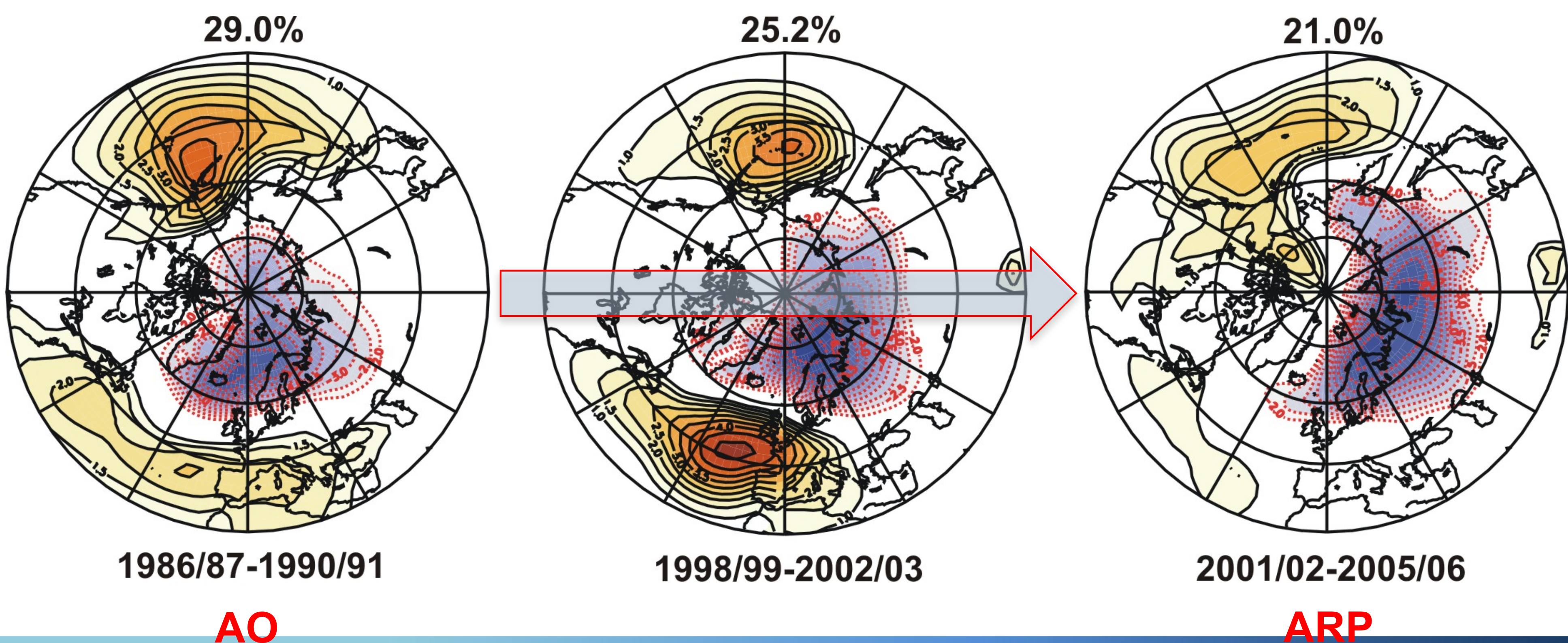
Atmospheric circulation dynamics: A spatial pattern shift and the Arctic Rapid change Pattern (ARP)

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

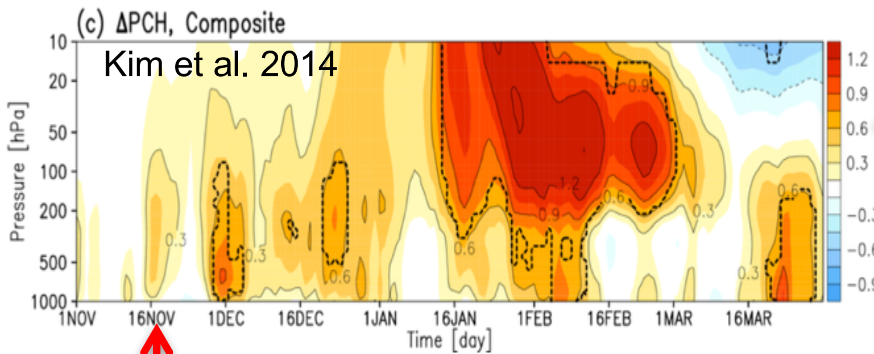


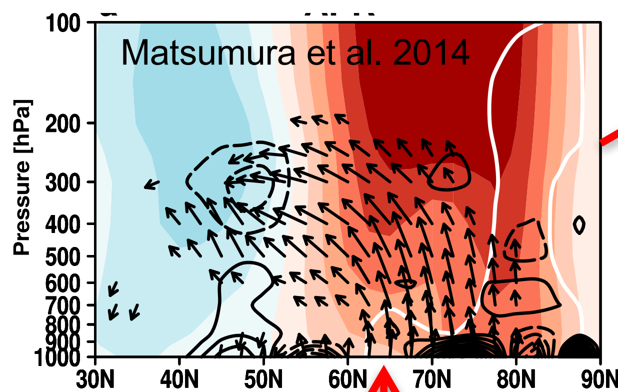
In the mid-1990s

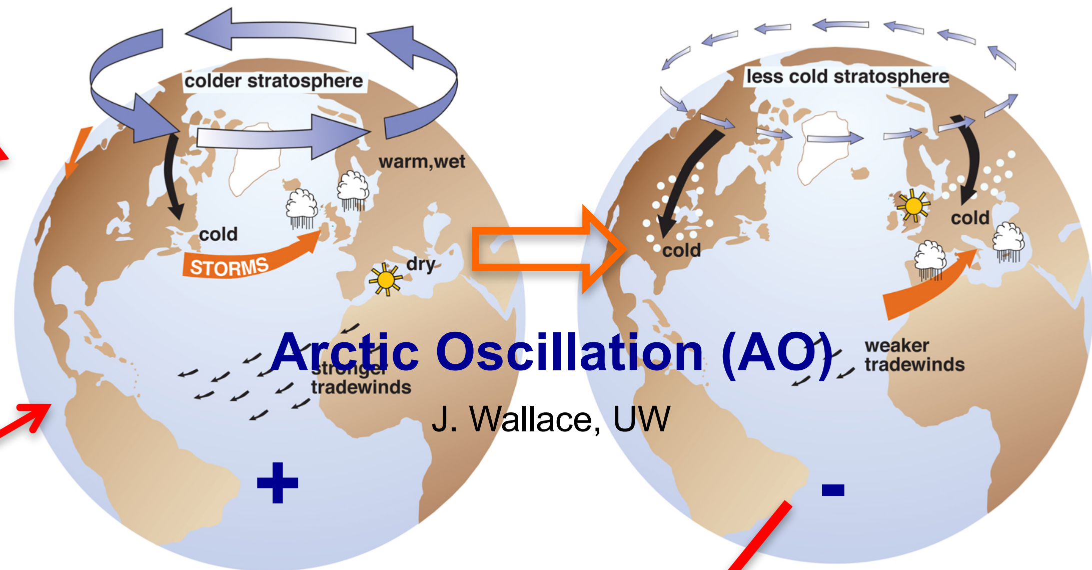
Zhang et al. 2008

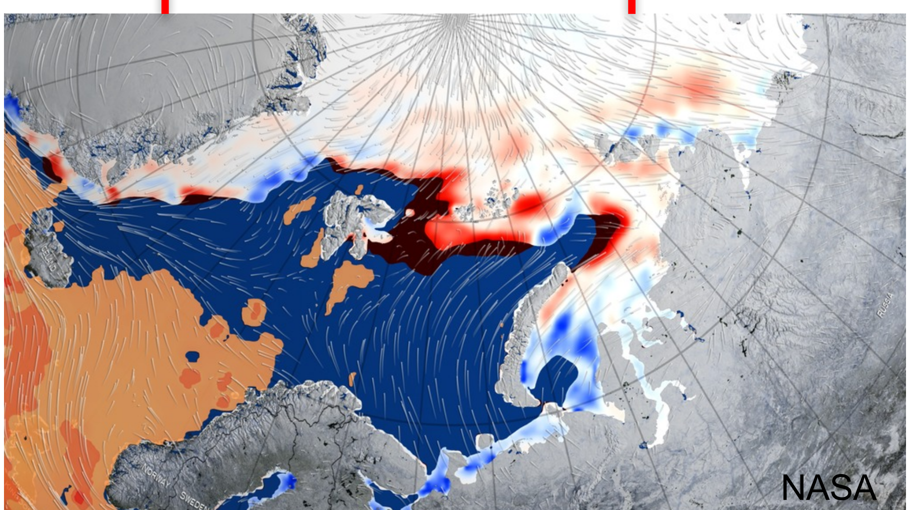


Atmospheric dynamics linking Arctic sea ice retreat/warming to midlatitude climate and weather



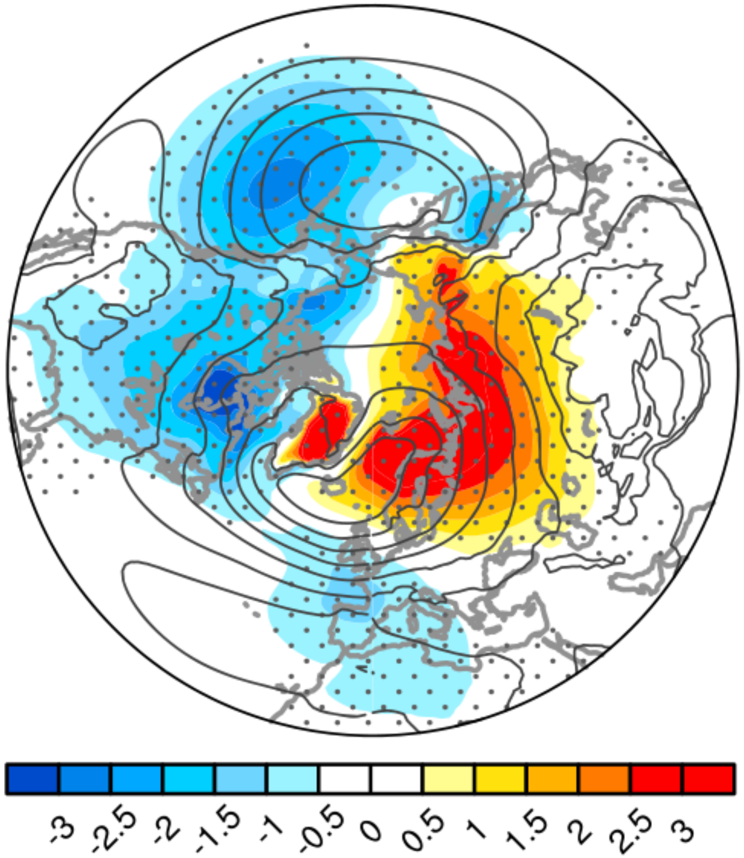


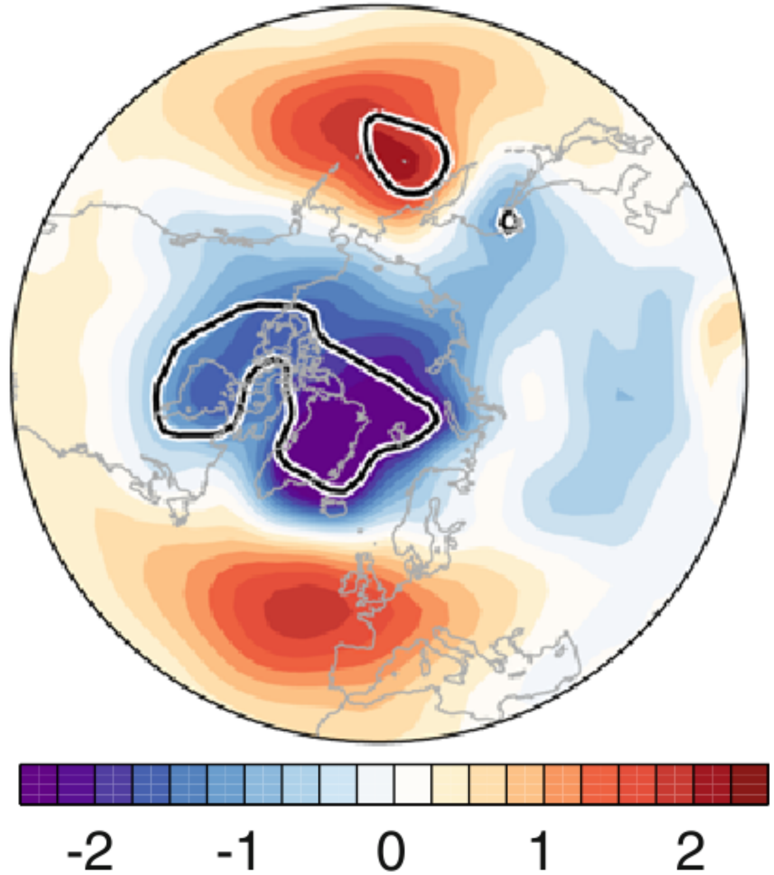




Eurasian cold winter

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 ...