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

Mike Patterson

with input by Judah Cohen and Xiangdong Zhang

Background and Context

Purpose and Scope

Key Findings and Recommendations

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Projects and Papers by the Numbers

Agency-funded projects (through 2014)

39 NSF Projects	16 NOAA	11 NASA	3 DOE	2 ONR
25 PLR/ARC				
12 AGS				

Journal papers

1973	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	1	1	1	8	5	3	1	5	6	12	9	21	21	33

Workshops

- Nov 2013 – IASC/CliC Workshop on the NH Polar Jet Stream and Links with Arctic Climate Change, Reykjavik, 33 participants from 8 countries
- Dec 2013 – NAS Workshop on Linkage between Arctic Warming and Mid-Latitude Weather Patterns, Washington, 57 participants
- May 2014 – NOAA Workshop on Predicting Arctic Weather and Climate and Related Impacts, Boulder, 86 participants
- Dec 2014 – WMO PPP Workshop on Polar–Lower Latitude Linkages, Barcelona, 80 participants from 20 countries

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US CLIVAR Working Group
Arctic Change & Possible Influence on Mid-latitude Climate & Weather

Judah Cohen, co-chair	Atmospheric and Environmental Research
Xiangdong Zhang, co-chair	University of Alaska, Fairbanks
Elizabeth Barnes	Colorado State University
Uma Bhatt	University of Alaska, Fairbanks
Dim Coumou	Potsdam Institute for Climate Impact Research
Clara Deser	National Center for Atmospheric Research
Steven Feldstein	Penn State University
Jennifer Francis	Rutgers University
Dorothy Hall	University of Maryland
Thomas Jung	Alfred-Wegener Institut
Arun Kumar	NOAA Climate Prediction Center
Ron Kwok	NASA Jet Propulsion Laboratory/Cal Tech
Gudrun Magnusdottir	University of California, Irvine
Wieslaw Maslowski	Naval Postgraduate School
James Overland	NOAA Pacific Marine Environmental Laboratory
Yannick Peings	University of California, Irvine
Ignatius Rigor	University of Washington
James Screen	University of Exeter
Julienne Stroeve	National Snow & Ice Data Center
Stephen Vavrus	University of Wisconsin-Madison
Timo Vihma	Finnish Meteorological Institute
Muyin Wang	University of Washington
Simon Wang	Utah State University

Objectives

- **Assess and synthesize existing knowledge** on the links between Arctic climate change and mid-latitude weather variability including weather extremes
- **Identify key questions and knowledge gaps**, with particular attention on physical processes and scale interactions
- **Propose or recommend targeted measurements** that will allow better understanding of Arctic climate variability and surface-atmosphere coupling
- **Assess the ability of current models** to reproduce the correct relationship between Arctic and mid-latitude weather and climate variability
- **Coordinate with other national and international programs** – SEARCH, CliC, and IASC; include their members in the WG
- **Inform funding agencies** through US CLIVAR Interagency Group and the IARPC (Interagency Arctic Research Policy Committee) of opportunities for advancing scientific understanding of Arctic influences on midlatitude climate

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Assembled 100 experts from atmosphere, ocean, and cryosphere sciences to:

- assess the rapidly evolving state of understanding
- identify consensus on knowledge and gaps in research
- develop specific actions to accelerate progress within the research community
  - –address observational constraints for evaluating links
  - –coordinate modeling experiments (MIP)

Sponsored by

- US CLIVAR Agency Programs – NASA, NOAA, NSF, DOE
- NSF Arctic Natural Science
- WMO PPP

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Workshop Findings

Focus:

- ❑ Seasonal and longer timescales and regional to global linkages
- ❑ Addressing source of inconsistency and uncertainties among studies
- ❑ Not including extreme event attribution

Challenges:

- ❑ Short observational records for the observed period of present-day Arctic Amplification
- ❑ Determining role of Arctic vs lower latitudes and internal variability
- ❑ Discrepancies and uncertainties exist in AGCM-alone and CGCM models and forcing data prescription
- ❑ Physical processes linking Arctic and midlatitude are not well understood
- ❑ Biases and uncertainties exist in metrics for quantitatively detecting Arctic - midlatitude linkages

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Workshop Findings

❑ Arctic Rapid Change

While Arctic Amplification is evident in observations and simulated by GCMs, we have incomplete understanding of relative contributions of various radiative, thermodynamic, and dynamic processes including:

- sea ice and snow decline (best established)
- increased downwelling longwave radiation from greenhouse gases
- greater water vapor concentrations from local and remote sources
- increasing ocean heat content
- local and hemispheric atmospheric circulation changes
- increased poleward heat transport in the atmosphere and ocean
- poleward moisture transport
- cloud radiative forcing

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Workshop Findings

- Arctic mid-latitude linkages

Potential pathways, from high to low confidence

- low Barents-Kara Sea ice resulting in a northwestward expansion of the Siberian high leading to cold Eurasian winters
- increasing geopotential thickness over the polar cap
- weakening of the thermal wind
- modulating stratosphere-troposphere coupling
- exciting anomalous planetary waves or stationary Rossby waves in winter and transient synoptic waves in summer
- altering storm tracks and occurrence of blockings
- increasing frequency of occurrence of wave resonance

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Recommended Activities

- Expand observational datasets and analyses approaches of Arctic change and mid-latitude linkages
  - Synthesize new Arctic observations to provide the best high-resolution estimate of the atmospheric state for better understanding sea ice and ocean surface processes
  - Create physically-based sea ice/ocean surface forcing data sets available to investigate Arctic-midlatitude linkages
  - Systematically employ proven and new metrics to identify forced signals of atmospheric circulation from natural variability
  - Analyze paleoclimate data, new observational datasets, and reanalysis that span most of the past century
  - Utilize new observational analysis methods (e.g., fluctuation dissipation analysis, causal effect networks) that extend beyond correlative relationships to establish causal links between forcing and response

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Recommended Activities

- Establish Modeling Task Force to plan coordinated modeling experiments and analysis
  - Plan common protocols, forcing, and output parameters with multiple models
  - Collaborate with European Horizon 2020 projects (APPLICATE, Blue Action, and PRIMAVERA)
  - Multi-tiered set of runs, including Tier 1 with two "fast track" experiment sets

    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

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New development following the workshop

Proposal: Polar Amplification – Model Intercomparison Project (PA-MIP)

US Modeling Centers invited to participate. Contact Yannick Peings (ypeings@uci.edu)

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PA-MIP Experiments

No.	Experiment name	Description	Notes	Tier	Number of years	Minimum ensemble size
1. Atmosphere-only time slice experiments						
1.1	amip-control	AMIP simulations forced by climatological monthly mean sea surface temperature (SST) and sea ice concentration (SIC) for the present day		1	1	100
1.2	amip-piSST	Repeat 1.1 but with pre-industrial SST	Investigate the role of SSTs in polar amplification	1	1	100
1.3	amip-2degSST	Repeat 1.1 but with future SST representing 2 degree global warming		2	1	100
1.4	amip-piSIC-Arctic	Repeat 1.1 but with pre-industrial Arctic SIC	Investigate the impacts of present day and future Arctic sea ice, and the role of Arctic SIC in polar amplification	1	1	100
1.5	amip-2degSIC-Arctic	Repeat 1.1 but with future Arctic SIC		1	1	100
1.6	amip-piSIC-Antarctic	Repeat 1.1 but with pre-industrial Antarctic SIC	Investigate the impacts of present day and future Antarctic sea ice, and the role of Antarctic SIC in polar amplification	2	1	100
1.7	amip-2degSIC-Antarctic	Repeat 1.1 but with future Antarctic SIC		2	1	100

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PA-MIP Experiments

No.	Experiment name	Description	Notes	Tier	Number of years	Minimum ensemble size
2. Coupled time slice experiments						
2.1	cpld-control	Coupled model simulation constrained by climatological monthly mean sea ice concentration for the present day		2	1	100
2.2	cpld-piSIC-Arctic	Repeat 2.1 but with pre-industrial Arctic SIC	As 1.4 and 1.5 but with coupled model	2	1	100
2.3	cpld-2degSIC-Arctic	Repeat 2.1 but with future Arctic SIC		2	1	100
2.4	cpld-piSIC-Antarctic	Repeat 2.1 but with pre-industrial Antarctic SIC	As 1.6 and 1.7 but with coupled model	3	1	100
2.5	cpld-2degSIC-Antarctic	Repeat 2.1 but with future Antarctic SIC		3	1	100

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PA-MIP Experiments

No.	Experiment name	Description	Notes	Tier	Number of years	Minimum ensemble size
3. Atmosphere-only time slice experiments to investigate regional forcing						
3.1	amip-2degSIC-Arctic-Pacific	Repeat 1.5 but with future Arctic SIC only in the Sea of Okhotsk	Investigate how the response depends on the pattern of Arctic sea ice forcing	3	1	100
3.2	amip-2degSIC-Arctic-Atlantic	Repeat 1.5 but with future Arctic SIC only in the Barents/Kara Seas		3	1	100
4. Atmosphere-only time slice experiments to investigate the role of the background state						
4.1	amip-control-cpldSST	Repeat 1.1 but with climatological SST from 2.1 rather than observations	Isolate the effects of the background state from the effects of coupling	3	1	100
4.2	amip-2degSIC - Arctic-cpldSST	Repeat 4.1 but with future Arctic SIC		3	1	100
5. Atmosphere-only transient experiments						
5.1	amip-climSST-transientSIC	Repeat CMIP6 AMIP (1979-2014) but with climatological monthly mean SST	Use CMIP6 AMIP as the control. Investigate transient response and individual years	3	36	3
5.2	amip-transientSST-climSIC	Repeat CMIP6 AMIP (1979-2014) but with climatological monthly mean SIC		3	36	3
6. Coupled transient experiments						
6.1	cpld-control-transient	Coupled model control simulation of present day sea ice	Experiments to investigate the decadal and longer impacts of Arctic sea ice on the ocean.	3	100	1
6.2	cpld-2degSIC-Arctic-transient	Coupled model simulation but with reduced Arctic sea ice		3	100	1

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Recommended Activities

- Synthesis by the Working Group and new researches following findings and recommendations by the workshop.
  - A white paper by the Working Group (under preparation)
  - Special collections:
    - Nature journals (6-8 invited articles)
    - AGU or AMS journals (open to community; include PA-MIP papers)

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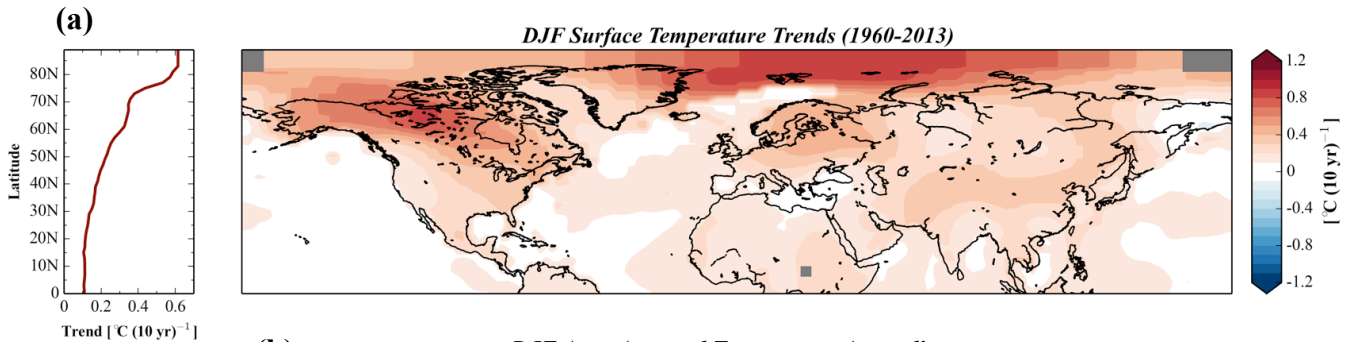
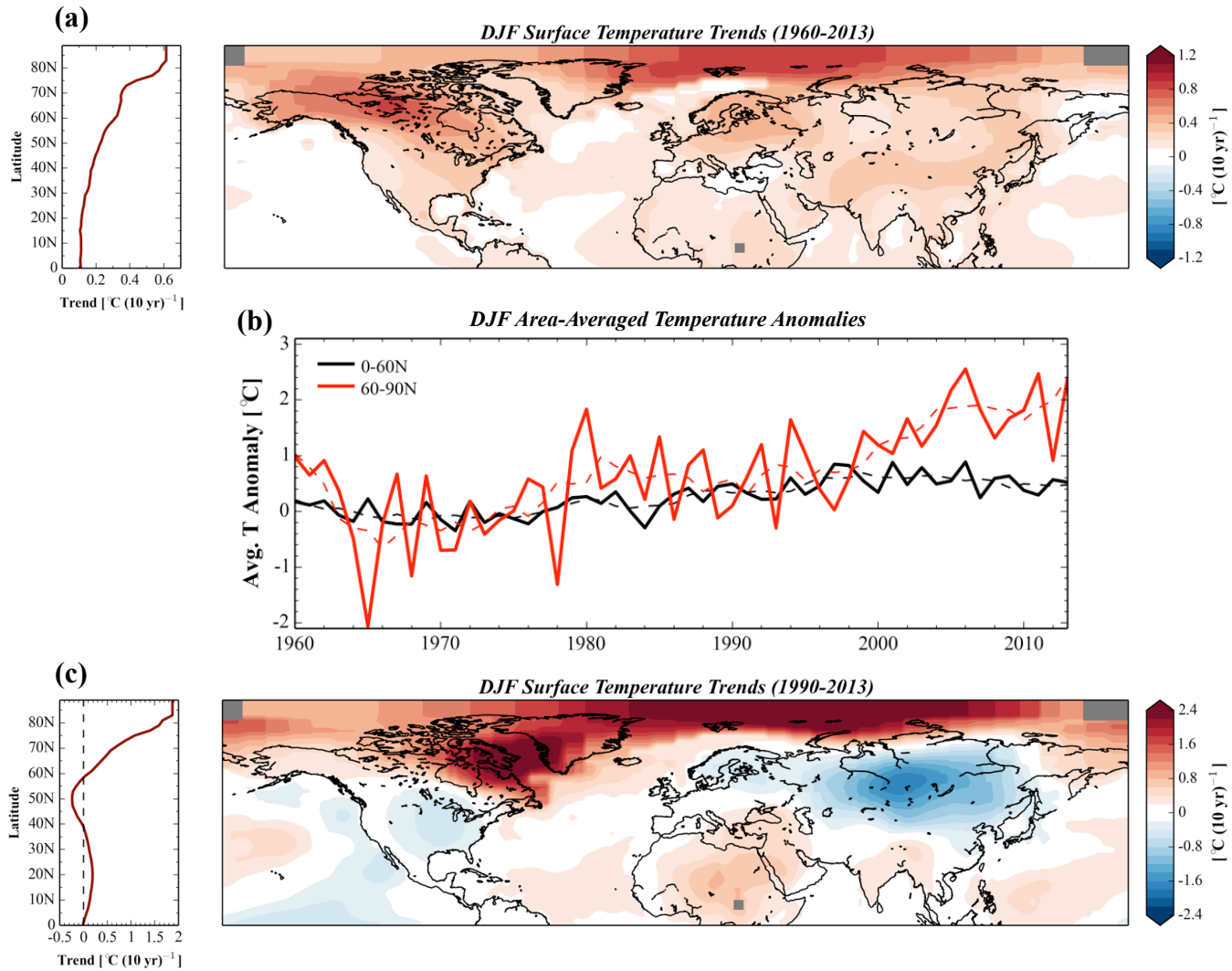
Arctic Amplification



Cohen et al. 2014 Review paper

Arctic Amplification



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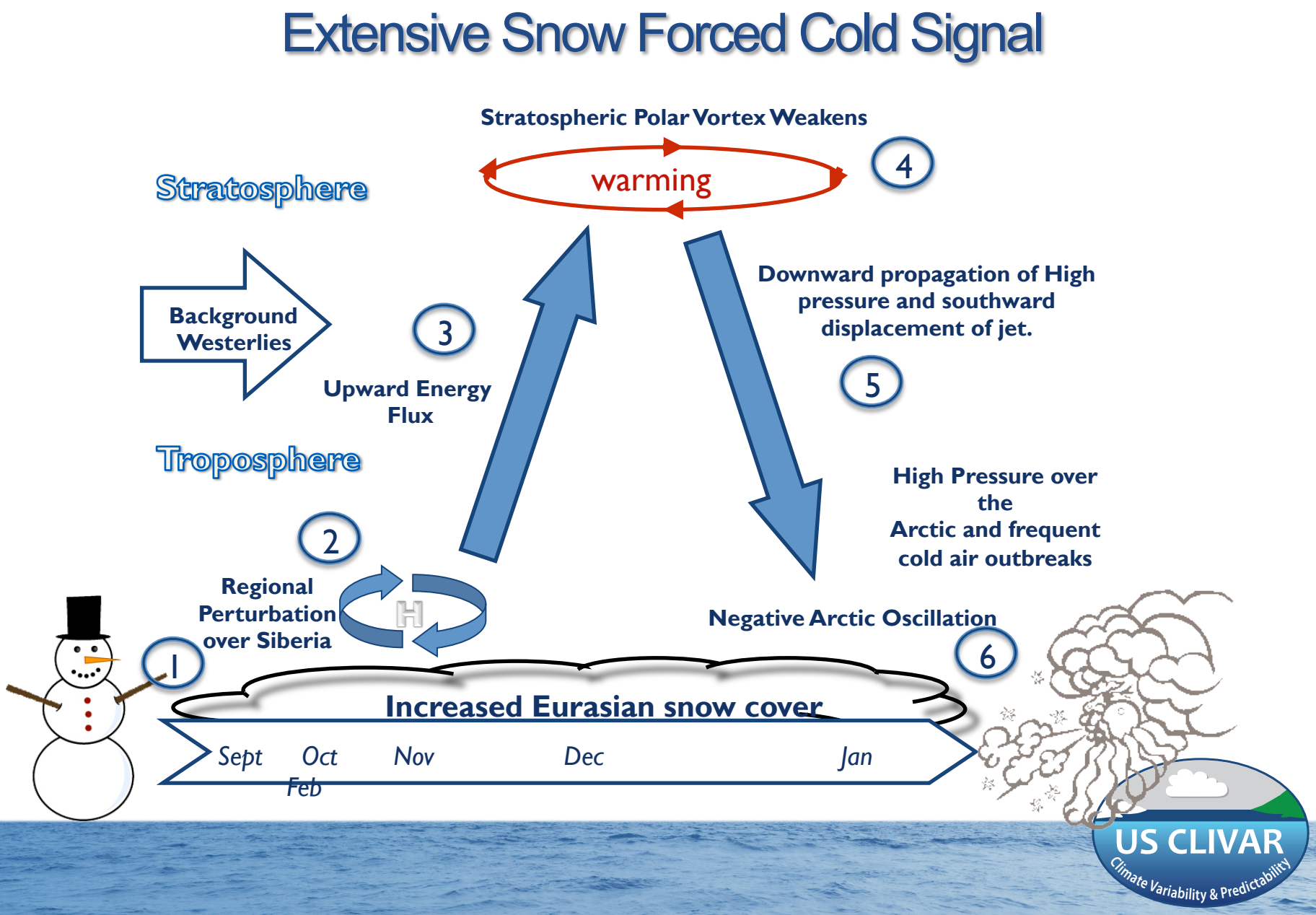
Pathways Linking Arctic and Midlatitude

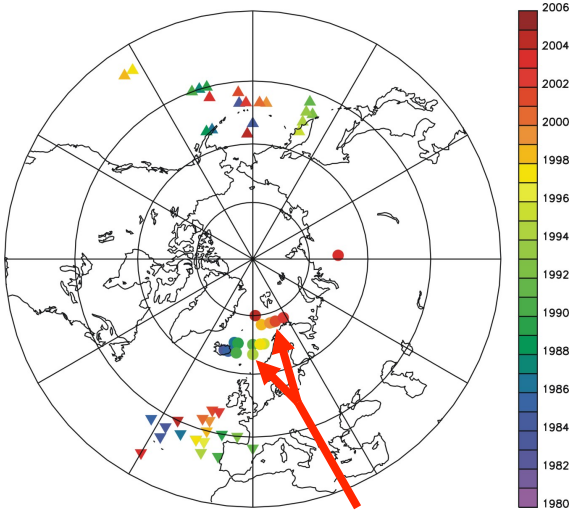


Challenges and Uncertainties in analysis metrics

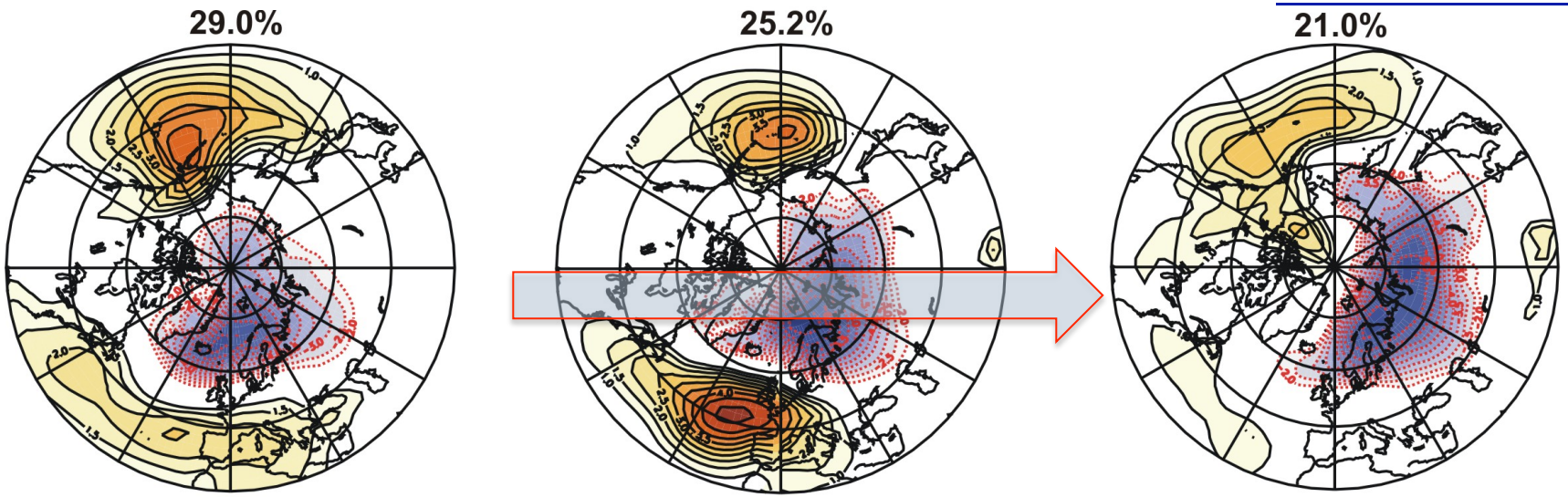
Does AO/NAO link Arctic and midlatitude ?

Since Arctic Amplification occurred from the mid-1990s, the atmospheric circulation pattern has experienced a radical spatial shift

Zhang et al. 2008



In the mid-1990s



1986/87-1990/91

1998/99-2002/03

2001/02-2005/06

Arctic Oscillation (AO)

Arctic Rapid change Pattern (ARP)

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