

Board on Atmospheric Sciences and Climate, and Polar Research Board  
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## Linkages between Arctic Warming and Mid-Latitude Weather Patterns: Summary of a Workshop

**THE NATIONAL RESEARCH COUNCIL** convened a workshop on September 12–13, 2013, to review current understanding of proposed linkages between a warming Arctic and mid-latitude weather and to discuss research needed to advance understanding.

**The Arctic has been undergoing** significant changes in recent years. Surface temperatures are rising twice as fast as the global mean. The extent and thickness of sea ice is rapidly declining. Such changes may have an impact on atmospheric conditions outside the region. Of particular concern is emerging research that may indicate that Arctic warming can have dramatic impacts upon weather patterns across the heavily populated northern mid-latitudes, and that such impacts could increase as ice cover continues to retreat and the Arctic continues to warm.

The National Research Council held a workshop to review the connections between Arctic warming and mid-latitude weather patterns, to discuss gaps in understanding, and to explore future research needs ([learn more about the workshop](#)). Presenters and participants at the workshop included many leading researchers in this realm with a diverse array of perspectives ([see list of participants](#)).

### RESEARCH IS STILL YOUNG

Several hypotheses for how Arctic warming may be influencing mid-latitude weather patterns have been proposed ([look at a list of hypotheses](#)). For example, Arctic amplified warming could lead to a weakened jet stream, resulting in more persistent weather patterns in the mid-latitudes. These linkages are the subject of active research. However, many workshop participants noted that research on the Arctic influence on mid-latitude weather is still young, making it difficult



Bronx, New York, snow storm in 2014.

Credit: eddtoro / Shutterstock.com

to draw conclusions regarding the existence of such linkages or their mechanisms.

Understanding those potential linkages is difficult. Workshop presentations ([available online](#)) highlighted the complex mechanisms and feedbacks that are involved, including links among the tropics, poles, and mid-latitudes, which can be bidirectional and are not necessarily direct (e.g., the upper atmosphere and ocean may act as intermediaries). Apart from the connections to mid-latitude weather, even understanding why the Arctic is warming and losing sea ice so rapidly is an active area of research. Furthermore, many of the proposed linkages are composed of multistep hypotheses, and inconsistent evidence from observations and modeling studies complicates our understanding of several of those steps.

## OBSERVATIONAL EVIDENCE OF TRENDS

One goal of the workshop was to discuss observational evidence of possible Arctic linkages. Observational evidence discussed at the workshop included:

- Arctic warming faster than the Northern Hemisphere
- Decrease in the temperature gradient between the Arctic and the mid-latitudes
- Slowing of upper-level zonal winds (west-to-east winds)
- Upper-level flow becoming more meridional (north-south)
- Increase in the amplitude of large-scale waves (in the jet stream)
- Increase in blocking events (stagnant weather episodes)
- Large-scale waves (jet stream) progress more slowly eastward
- Increase in extreme events
- Weakening of the polar vortex (the circle of winds in the polar region)

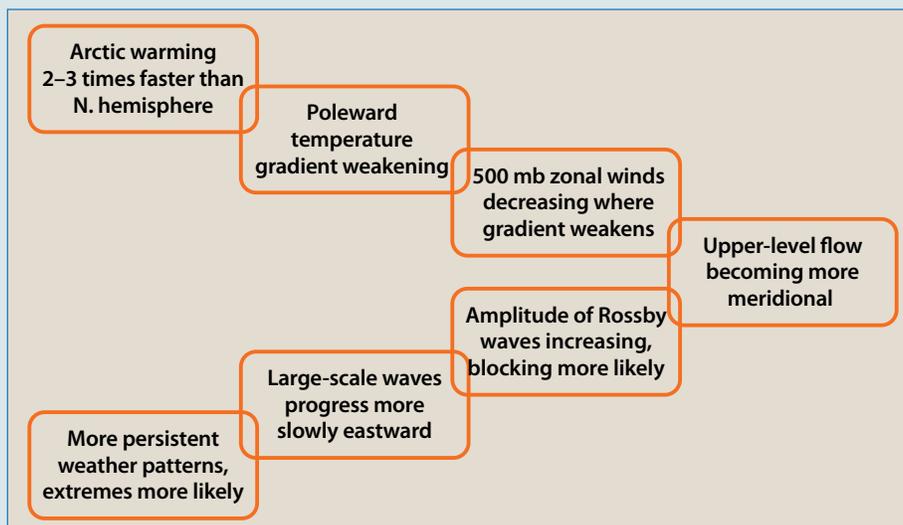
Some of the observational evidence presented supports hypotheses for linking Arctic amplification and mid-latitude weather patterns. Others do not. Observations can help decipher whether there is a trend, but participants noted the following challenges with observations:

- There may be several mechanisms behind any observed trend.
- The time series for observations is too short to detect statistically significant trends.
- How a variable is measured and defined can impact whether you observe a trend.

Participants identified some strategies for addressing observational challenges:

- Trends can be clarified by quantifying uncertainty in observational data.
- Observational records could be lengthened, for example, by extending the sea ice record back in time.
- Existing observational capabilities could be better utilized. For example, research aircraft surveys could be deployed in key seasons, and data that is already collected for other purposes could be harnessed for this research.

### Box 1. Proposed Linkage: A Weaker, More Meandering Jet Stream



Jennifer Francis of Rutgers University and Steve Vavrus of University of Wisconsin have proposed one of the more prominent hypotheses about a chain of events (shown above) that connects Arctic warming with changing weather patterns in the mid-latitude northern hemisphere. At the workshop, Francis said evidence is

strong for the first steps in the chain, but not as solid for the remaining steps in the chain. Francis and other participants noted that more research, using both new analysis techniques of observations/model output as well as targeted modeling experiments, is needed to either confirm or disprove the links.

## MODELING STUDIES

Another goal of the workshop was to explore modeling work to test the mechanisms of proposed linkages. Models are the best way to assess a large number of possible pathways to influence weather. Participants noted how model studies can offer clues to key mechanisms that link Arctic warming to mid-latitude weather and can identify contributions of other factors that can influence weather. Several additional modeling studies were briefly presented to highlight possible regional climate impacts when forced by a reduction in Arctic sea ice (see [Highlights of Other Modeling Studies](#)).

Participants noted that challenges with models include:

- Model results are divergent in ways that are not well understood.
- The use of different initial and/or boundary conditions make it difficult to compare model results in a useful way.
- Model limitations and biases need to be considered.

Participants noted some strategies to address challenges with modeling:

- Organizing some careful model intercomparisons and model sensitivity studies with similar boundary and/or initial conditions across the modeling community would allow for a more systematic review and comparison of the results.

### **Box 2. Proposed Linkage: The Weakening of the Polar Vortex**

Another linkage that was briefly discussed at the workshop was the hypothesis that Arctic sea ice loss leads to changes in regional heat and other energy fluxes, which results in a weak (or unstable) polar vortex. “Normal”, strong polar vortex winds, which circle the Arctic from west to east, isolate cold polar air from the mid-latitudes in winter. Thus, it is typically milder across the Eastern US, Europe and East Asia during winters when the polar vortex is strong. A weak or unstable polar vortex has more meridional flow (north-south). (Watch a [NASA animation to learn more](#).) This allows cold air from the Arctic to spill into the mid-latitudes and warm air from the subtropics to move into the Arctic. Thus, it is typically colder across the Eastern US, Europe and East Asia during winters when the polar vortex is weak.

- Model attribution studies could be used to improve understanding of the proportion of amplified Arctic warming due to processes outside of the Arctic.
- Higher resolution models that study the processes in the atmosphere nearer the Earth’s surface would be useful.



Dawlish, Devon, England, storm in 2014.

Credit: Wikimedia

## FUTURE NEEDS

It was clear from the discussion that research into potential linkages is still emerging and will continue in the future. Participant James Screen of the University of Exeter proposed using an “ACID test” as a framework for assessing confidence in proposed linkages, which has the following four characteristics: (1) studies that directly Attribute the linkage; (2) Corroboration by multiple lines of evidence; (3) Informed by an understanding of the mechanism of the linkage; and (4) Detectable in observation.

(See more about the ACID Test.) Screen believes that few, if any, of the proposed linkages pass the ACID test, and that more research is required to make more confident statements linking Arctic warming to recent weather trends.

Given the far-reaching societal impacts of changes in our climate system and the speed at which the Arctic sea ice cover is disappearing, many participants



Summer in the Arctic.

Credit: Wikimedia

thought it is imperative to advance understanding of Arctic linkages and what they could mean to the frequency, severity, and persistence of severe weather events. Many participants stressed that progress would require more observational work and modeling experiments to put Arctic linkages within a larger context of the other factors that also affect mid-latitude weather.

Participants expressed optimism that significant progress could be made due to several recent achievements and events: a) improvements in atmospheric, oceanic, and sea ice models; b) longer observational records of sea ice and atmospheric circulation; c) emergence of a reasonably strong sea ice forcing in recent years; and d) strong interest in the topic from policymakers, scientists, and the public.

**DISCLAIMER:** This summary was written by Katie Thomas, rapporteur, to present the various ideas and suggestions that arose in the workshop discussion and to synthesize the main discussion items. It does not include any conclusions or recommendations. The Summary was peer reviewed. Statements are those of the presenters and do not necessarily represent the view of all meeting participants, the planning committee, or the National Academies.

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For more information, contact the Polar Research Board at (202) 334-3479 or visit <http://dels.nas.edu/prb>. Copies of *Linkages between Arctic Warming and Mid-Latitude Weather Patterns: Summary of a Workshop* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; [www.nap.edu](http://www.nap.edu).

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