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Global Warming, Winter Weather and the Olympics – Leading Climate Scientists Weigh In

By ANDREW C. REVKIN

Updated below | There's a noteworthy letter in today's edition of the journal Science, titled "Global Warming and This Winter's Cold Weather," that aims to cut through the flood of overwrought assertions about recent Northern Hemisphere winter weather in the context of global warming.

It's written by five leading climate scientists, all of whom have long been reliable guides to a complicated and consequential body of science — John M. Wallace at the University of Washington, Isaac M. Held at the Geophysical Fluid Dynamics Laboratory, David W. J. Thompson at Colorado State University, Kevin E. Trenberth at the National Center for Atmospheric Research, and John E. Walsh at the University of Alaska, Fairbanks.

The letter is behind the journal's subscription wall, so I'm providing excerpts here:

> In mid-January, a lobe of the polar vortex sagged southward over the central and eastern United States. All-time low temperature records for the calendar date were set at O'Hare Airport in Chicago [–16°F (–27°C), 6 January], at Central Park in New York (4°F (–15.6°C), 7 January], and at

many other stations. Since that event, several substantial snow storms have blanketed the East Coast. Some have been touting such stretches of extreme cold as evidence that global warming is a hoax, while others have been citing them as evidence that global warming is causing a "global weirding" of the weather. In our view it is neither.

As climate scientists, we share the prevailing view in our community that human-induced global warming is happening and that, without mitigating measures, the Earth will continue to warm over the next century with serious consequences. But we consider it unlikely that those consequences will include more frigid winters.

Distinguishing between different kinds of extreme weather events is important because the risks of different kinds of events are affected by climate change in different ways. For example, a rise in global mean temperature will almost certainly lead to an increase in the incidence of record high temperatures. Global warming also leads to increases in atmospheric water vapor, which increases the likelihood of heavier rainfall events that may cause flooding. Rising temperatures over land lead to increased evaporation, which renders crops more susceptible to drought. As the atmosphere and oceans warm, sea water expands and glaciers and ice sheets melt. In response, global sea level rises, increasing the threat of coastal inundation during storms.

There is a section on recent research pointing to a connection between expanded open water on the Arctic Ocean in summers and extreme winter weather in the temperate zone of the Northern Hemisphere. The authors write:

Sea-ice losses during late summer may indeed lead to regional changes in Arctic climate. But tremendous natural variability occurs in the large-scale atmospheric circulation during all seasons, and even in summer the links between Arctic warming and mid-latitude weather are not supported by other observational studies. The lag between decreases in sea ice extent during late summer and changes in the mid-latitude atmospheric circulation during other seasons (when the recent loss of sea ice is much smaller) needs to be reconciled with theory.

Summertime sea ice extent in the Arctic has been remarkably low since 2007 and the ensuing years have been marked by some notable cold air outbreaks. It was this coincidence that prompted Francis and Vavrus [*paper*] to link the cold air outbreaks to global warming. But coincidence does not in itself constitute a strong case for causality. Cold air outbreaks even more severe than occurred this winter affected the United States in the early 1960s, the late 1970s (most notably 1977), and in 1983, back when the Arctic sea ice was thicker and more extensive than it is today. Over the longer time span of 50 to 100 years, it is well established that there has been a decrease in the rate at which low temperature records are being set relative to all-time high temperature records at stations across the United States. For the present at least, we believe that statistics based on the longer record are more indicative of what the future is likely to bring.

The research linking summertime Arctic sea ice with wintertime climate over temperate latitudes deserves a fair hearing. But to make it the centerpiece of the public discourse on global warming is inappropriate and a distraction. Even in a

> warming climate, we could experience an extraordinary run of cold winters, but harsher winters in future decades are not among the most likely nor the most serious consequences of global warming.

I asked the authors if they had similar concerns about a recent burst of assertions related to threats from global warming to the future of the Winter Olympics. Here's my query (I've cleaned up email shorthand here and in the replies):

> Do you have similar thoughts on talk of "the end of snow" by winter Olympians and others (including in an opinion piece in last Sunday's Sunday Review in The New York Times), who point to the spring snow trend but ignore the long-term trends in winter snow cover? [I included a link to Northern Hemisphere snow cover data compiled by the Rutgers University Global Snow Lab.]

Kevin Trenberth replied:

> With respect to snow, one expects that the snow season gets shorter at both ends (more rain), but that snow amounts could be larger in mid winter. In continents in winter, the freeze drying of air is a big factor ("it's too cold to snow" or to snow much) because the atmosphere can't hold much moisture. So it is not a surprise to me to see more snow in winter, but the global warming signal should be in the snow pack in late spring.

John Walsh added this:

> Kevin's snow scenario is exactly what the global climate models show: a shorter snow season everywhere, but increases in maximum snow water equivalent in the northern continental areas (with decreases in maximum snow water equivalent in the

more southerly regions, where rain-to-snow ratios increase). Some maps showing these projections are in the Arctic Monitoring and Assessment Program's recent synthesis report, "Snow, Water, Ice and Permafrost in the Arctic."

Addendum, Feb. 14, 12:23 p.m. | Jennifer Francis, a climate scientist at Rutgers whose work is cited above, sent the following note by email:

I received a copy of the letter a few days ago, and wrote this response to the co-authors:

I agree with most of the statements in this letter. The media certainly had a field day with the "attack of the polar vortex" in early January, and in their hyping of the story, some misquoted me (and others) by saying that climate change caused the unusual cold spell. Of course this sort of event has happened before, and this one wasn't unprecedented.

I also agree that greenhouse-gas induced warming will reduce, not increase, the likelihood of breaking cold temperature records — the data already show this. Not only will this occur via general global warming but also because enhanced Arctic warming will make any future southward excursions of Arctic airmasses warmer on average, reducing the contrast between them and mid-latitude airmasses. So when a deep trough like the one this winter happens in the future, the southward surge of cold air won't be as extreme.

The Screen and Simmonds (2013) paper cited in the letter actually shows some evidence of this effect, as they find a decrease in vertical wave amplitudes (Az in the paper) while the meridional (north-south) waves (Am) are increasing, albeit not statistically significantly.

Here's where I don't agree with statements in the letter: It states that our study (Francis and Vavrus, 2012) suggests that, "…the demise of Arctic sea ice during summer should lead to colder winter weather over the United States." This is incorrect. Nowhere in our paper do we say this. What we *do* suggest is that the weakened poleward temperature gradient owing to the rapidly warming Arctic relative to mid-latitudes (Arctic amplification) should increase the north-south component of the upper-level flow, making highly wavy jet-stream patterns (like the one this winter) more likely. These patterns favor persistent weather patterns, not necessarily more record-breaking cold or warm temperature extremes. Again, the amazing persistence of this winter's highly amplified pattern is an example of this behavior, but of course it can't be blamed on any one factor. Even though the cold in the U.S. has not been unprecedented, the public perception is "extreme" because the cold in the central/eastern/southeastern U.S., drought in California, and the heat/heavy precipitation in Alaska has been so prolonged. This is exactly the type of "extreme" we refer to in our paper, not the record-breaking-temperature sort.

Further, the new Barnes et al paper is cited to support the statement: "…even in summer the links between Arctic warming and mid-latitude weather are not supported by other observational studies." That study looks at trends in blocking-high patterns only, finding that various block-detection methods give different results. Blocking highs are only one part of the story — many extreme events caused by prolonged weather patterns are not associated with blocking highs, but rather very wavy jet patterns and/or cut-off lows (like blocking highs but in the opposite flow direction). Moreover, sea-ice loss is also only part of the story. Several recent studies, including

> this new one in Nature Geoscience [*link*] show that the sea-ice-albedo feedback is *not* the most important contributor to Arctic amplification. Most past modeling experiments that investigated the atmospheric response to Arctic change only considered the loss of sea ice, which of course misses much of the effect of Arctic amplification. The other challenge we readily acknowledge is that Arctic amplification has only emerged from the noise of natural variability within the last decade or so (strongest in fall and winter, weakest in summer), thus finding a statistically robust atmospheric response in the real world is not easy. Obviously many other factors (ENSO, PDO, PNA, stratospheric change, etc.) contribute to changes in jet stream patterns, as well.
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> Finally, the Arctic/mid-latitude linkage hypothesis proposed our paper is clearly in only in the early stages of research. Carefully designed modeling experiments and additional years of real-world data are needed to confirm it or not. To me, the ample discussion this idea has generated is not a "distraction," but rather a trigger of a great deal of new research and healthy scientific discussion.

Addendum, Feb. 16, 8:40 a.m. | Charles H. Green, a climate scientist at Cornell, sent this note by email referring to relevant research on Arctic snow and ice patterns and weather led by Judah Cohen, a commercial climate analyst whose work has been explored here before:

> I have very high regard for John Wallace, Isaac Held, David Thompson, Kevin Trenberth, and John Walsh. I also have a high regard for Jennifer Francis, who did a nice job correcting the other five on the misinterpretations of her work by them and others. There is one point that I would also like to add with regard to the following quote from Wallace and

colleagues:

> "The lag between decreases in sea ice extent during late summer and changes in the mid-latitude atmospheric circulation during other seasons (when the recent loss of sea ice is much smaller) needs to be reconciled with theory."

> Actually, the recent paper by Judah Cohen and colleagues (Cohen, J., J. Jones, J.C. Furtado, and E. Tziperman. 2013. Warm Arctic, cold continents: A common pattern related to Arctic sea ice melt, snow advance, and extreme winter weather. Oceanography26(4):150–160) provides key observations linking 1.) increased summertime sea ice melt to 2.) increased autumn Siberian snowfall to 3.) enhancement of negative Arctic Oscillation (AO) atmospheric circulation and 4.) associated mid-latitude extreme weather events during winter. The empirical relationships developed by Cohen and colleagues do a far superior job than current dynamical models in predicting recent wintertime weather. Therefore, I would recommend amending the above statement to the following:

> The lag between decreases in sea ice extent during late summer and changes in the mid-latitude atmospheric circulation during other seasons (like autumn and winter, when the recent loss of sea ice is much smaller) have been demonstrated empirically, but have not been captured by existing dynamical models. It is time for theory to be reconciled with the observations.

Addendum, Feb. 17, 11:35 p.m. | This reaction to Francis's comments was emailed by the five authors of the original Science letter:

> Our letter that appeared in the February 14th issue of Science Magazine was motivated by our concerns about the

widespread news reports, opinion pieces, and blog postings linking this winter's cold weather over the central and eastern U.S. to global warming. These largely unsubstantiated claims are polarizing the public discourse on climate change and drawing attention away from climate impacts that are more directly related to global warming and ultimately much more damaging to our planetary life support system.

Because of the limited length of our letter we were not able to present a comprehensive discussion of the scientific literature that is being cited in support of these linkages so we focused on just one of them: the paper by Francis and Vavrus, "Evidence Linking Arctic Amplification to Extreme Weather in Mid-Latitudes," in which it is argued that Arctic warming is linked to a range of extreme events in midlatitudes, including the kind of persistent cold that we have been experiencing this winter.

The purpose of our letter was not to pass judgment on the validity of the conclusions of the Francis and Vavrus paper. Rather, it was to draw a distinction between their provocative idea, which is presently being debated within a small segment of our community, and the broad scientific consensus on human-induced climate change, which is exemplified by the IPCC reports. We are concerned that the incorporation of unsubstantiated theories into what the public understands to be the "scientific consensus" on global warming is eroding public confidence in climate science.

To make it clear that we have accurately represented the conclusions of the Francis and Vavrus study in our letter, here are two brief excerpts from the final section of that paper:

"Can the persistent weather conditions associated with

recent severe events such as the snowy winters of 2009/2010 and 2010/2011 in the eastern U.S. and Europe, the historic drought and heat-wave in Texas during summer 2011, or record-breaking rains in the northeast U.S. of summer 2011 be attributed to enhanced high-latitude warming? Particular causes are difficult to implicate, but these sorts of occurrences are consistent with the analysis and mechanism presented in this study."

"As the Arctic sea-ice cover continues to disappear and the snow cover melts ever earlier over vast regions of Eurasia and North America, it is expected that large-scale circulation patterns throughout the northern hemisphere will become increasingly influenced by Arctic Amplification."

And from the abstract of another paper co-authored by the lead author of the Francis and Vavrus paper (but which was not cited in our letter due to length constraints; Tang, Zhang, Yang and Francis, ERL, 8, 014036, 2013):

"The results suggest that the winter atmospheric circulation at high northern latitudes associated with Arctic sea ice loss, especially in the winter, favors the occurrence of cold winter extremes at middle latitudes of the northern continents."
