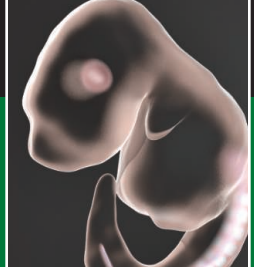
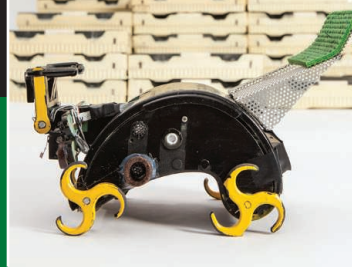




LETTERS

edited by Jennifer Sills

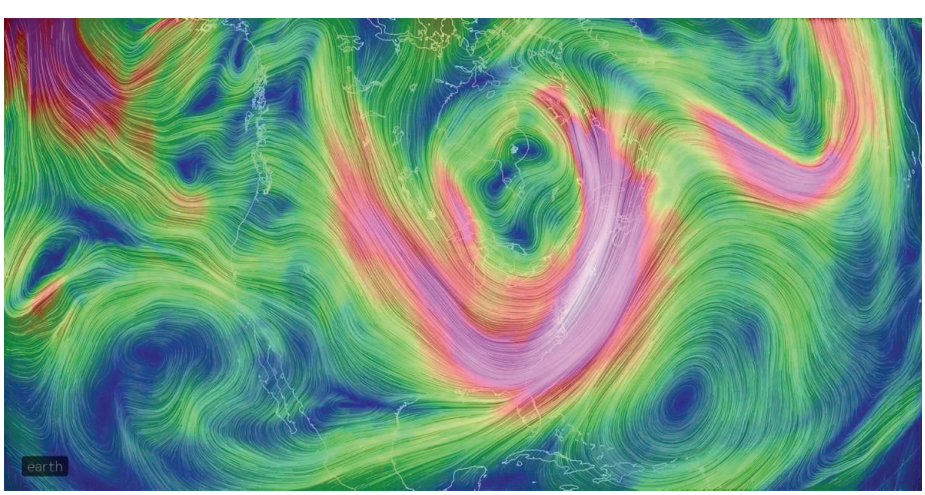
Global Warming and Winter Weather

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 (–8°C), 6 January], at Central Park in New York [4°F (–15.6°C), 7 January], and at many other stations (*1*). 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.

In contrast to the above examples, the notion that the demise of Arctic sea ice during summer should lead to colder winter weather over the United States seems counterintuitive. But that is exactly what an influential study has suggested (*2*). The authors hypothesize that global warming could perturb the polar vortex in a manner that renders the flow around it more wavy, leading to an increased incidence of both extreme warmth and extreme cold in temperate latitudes. It's an interesting idea, but alternative observational analyses and simulations with climate models have not confirmed the hypothesis, and we do not view the theoretical arguments underlying it as compelling [see (*3*–*6*)].



CREDIT: FIGURE GENERATED BY CAMERON BECCARIO (EARTH.NULLSCHOOL.NET); RESULTS SOURCED FROM THE NCEP/NOAA GLOBAL FORECAST SYSTEM

Icy blast. Arctic winds flowed down to North America in January, causing record-breaking cold temperatures. Image shows streamlines of wind at the 500 mbar level at 1:00 a.m. Eastern Standard Time on 7 January 2014. Red indicates faster speeds.

Other studies have suggested that the loss of Arctic sea ice may influence the atmospheric circulation in mid-latitudes during summer [e.g., (*7*)]. Sea-ice losses during late summer may indeed lead to regional changes in Arctic climate [e.g., (*5*, *8*)]. 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 (*6*). 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 (*2*) 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 [e.g., (*9*)]. 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 (*10*). 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

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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.

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The Big Picture for Big Data: Visualization

TO CONVERT INFORMATION FROM MASSIVE data sets into insights, data centers will need to support the humans who are trying to make sense of it all. Fortunately, innovations in information visualization are demonstrating that a good user interface is worth a thousand petabytes (2013 Visualization Challenge, News, 7 February, p. 600).

When GE Healthcare researcher Nick Thomas studied a visualization of the critical RBP1 protein—a genomic carrier of vitamin A necessary for reproduction and vision—he was surprised by what he saw. Thomas scanned the mosaic grid of thousands of red and green dots, as well as the linked scattergram and color-coded plate view. He confirmed expected patterns, but one unexpected bright red dot revealed RBP1's marked influence in cellular development. This clue gave Thomas an insight that, with statistical confirmation, led to an important scientific contribution (*1*).

Like a growing number of researchers, policy-makers, and interested citizens, Thomas was exploring increasingly complex data sets by adjusting filters, changing color palettes, and choosing novel visualizations to search for relationships, clusters, gaps, and outliers. Powerful information visualization tools are realizing famed statistician John Tukey's 50-year-old prediction: "The graphical potentialities of the computer...are going to be the data analyst's greatest single resource" (*2*).

Some Big Data advocates seem to promise automatic results with little human participation [e.g., (*3*, *4*)]. A more effective approach will be to put human users in control, since they can often identify patterns that machines cannot. Statistically and algorithmically oriented researchers are increasingly recognizing that visual strategies for exploring complex data lead to more potent and meaningful insights. Automated analyses can work for well-understood data, but visualizations increase the efficacy of experts in frontier topics, where big breakthroughs happen.

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Innovation Goes Global

BY TAKING A U.S.-NATIONAL APPROACH TO innovative capabilities and comparing the present with the postwar period, W. B. Bonvillian ("Advanced manufacturing policies and paradigms for innovation," Policy Forum, 6 December 2013, p. 1173) ignores the truly transformational change that has occurred over the past several decades: the growth of the global science system. The critical knowledge needed to innovate into the next generation of production is increasingly distributed across the globe, and it is just as likely to be located in India or China as in Ohio. The Organization for Economic Co-Operation and Development reports that the growth in the number of triadic patents demonstrates the worldwide spread of innovative activities (*1*).

U.S. researchers are actively tapping this global resource by collaborating with researchers from many other countries. The global network of international links (drawn from coauthorships on publications) has tripled in density over the past 20 years (*2*), with many new members joining the global network from developing countries, particularly China. Chinese addresses now appear more frequently than any other country in publications coauthored with U.S. researchers.

Scientific globalization does not threaten an end to U.S. excellence in innovation; quite the opposite. The diffusion and rooting of scientific capacity to new places provides opportunity for greater efficiency in research activities, particularly by removing redundancy. Creative problem-solving can be enhanced by having new entrants grapple with technological challenges, as many U.S. companies are finding as they invest in foreign research.

Culturally tied knowledge is often important to market access in foreign countries. These goods require a deliberate policy shift on the part of U.S. agencies from pushing knowledge creation to fomenting knowledge scanning and integration. Scanning the globe for the best new knowledge and ensuring local uptake is the more promising approach to closing the gaps in U.S. know-how than building a U.S.-only R&D effort, as Bonvillian suggests.

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CORRECTIONS AND CLARIFICATIONS

Perspectives: "Hiding in plain view—An ancient dog in the modern world" by H. G. Parker and E. A. Ostrander (24 January, p. 376). In the figure, the red branch should have been labeled "CTVT." The HTML and PDF versions online have been corrected.

Reports: "Transmissible dog cancer genome reveals the origin and history of an ancient cell lineage" by E. P. Murchison *et al.* (24 January, p. 437). In the title, "Transmissable" should have been "Transmissible." The HTML and PDF versions online have been corrected.

Reports: "Identification of a plant receptor for extracellular ATP" by J. Choi *et al.* (17 January, p. 290). The doi should be 10.1126/science.343.6168.290. It is correct in the HTML and PDF versions online.

Research Article: "The hidden geometry of complex, network-driven contagion phenomena" by D. Brockmann and D. Helbing (13 December 2013, p. 1337). In Fig. 2D, the label "Zamonia" should have read "Latvia." The HTML and PDF versions online have been corrected.

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the past 3 months or matters of general interest. Letters are not acknowledged upon receipt. Whether published in full or in part, Letters are subject to editing for clarity and space. Letters submitted, published, or posted elsewhere, in print or online, will be disqualified. To submit a Letter, go to www.submit2science.org.