Deep Freezes: Will future warming paradoxically cause more extreme cold events?

By Zack Guido

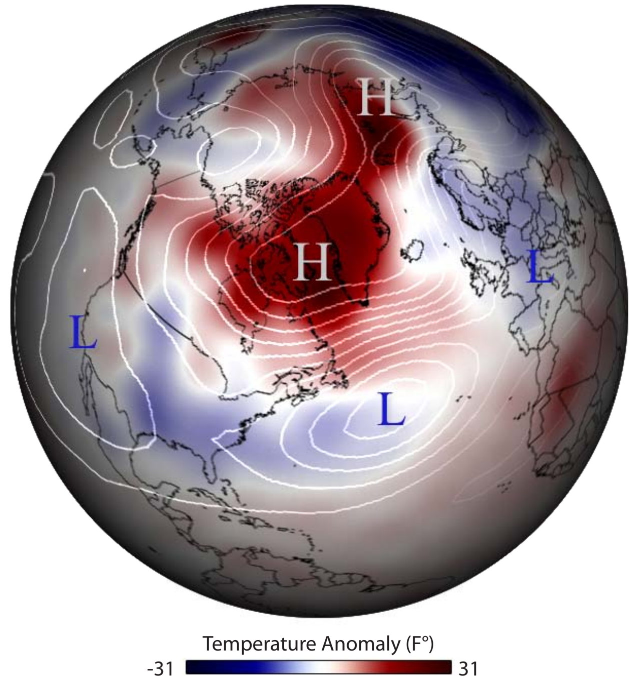

Figure 1. In February 2010, the Arctic Oscillation was strongly negative and Arctic air maintained higher pressure than lower latitude air masses. This allowed frigid air to spill south into mid-latitudes. This image shows surface temperatures for February 1-11, 2010, relative to the 1971–2000 average for the same dates. The Arctic was warmer than average (red colors), while most of the mid-latitude regions around the world were colder than average (blue colors). Image source: NOAA.

Prickly pear cacti slump like wilted flowers in Tucson and all around the Sonoran Desert, a reminder of the deep freeze that wreaked havoc across the region in early February.

For several nights, temperatures plummeted in Arizona and New Mexico, freezing vegetation, bursting water pipes, and driving up energy consumption, all courtesy of the jet stream, the swift air current that flows thousands of feet above the Earth's surface.

Early this month, the jet stream looped farther to the south than normal, blasting Arizona and New Mexico with Arctic air. While the jet stream always meanders and sometimes brings winter air from the north into the Southwest, far off changes in sea level pressure over the Arctic also appear to be blasting parts of the U.S. and Europe with extreme cold.

Several nascent hypothesizes suggest global warming, paradoxically, may partially be to blame.

The Arctic Oscillation Matters Too

The most well known—and perhaps most influential—climate pattern is the El Niño–Southern Oscillation (ENSO). ENSO is a natural seesaw in oceanic sea surface temperatures and surface air pressure between the eastern and western tropical Pacific Ocean that causes changes in climate and weather thousands of miles away. During La Niña events, winters in the Southwest are often drier than average, while El Niño events usually bring wetter-than-average conditions to the region.

The Southwest is vividly experiencing the heavy hand of La Niña this winter. La Niña events can also influence temperatures by redirecting the path of the jet stream.

"During La Niña events the jet stream can loop more than normal," bringing Arctic air into the region, said Mike Crimmins, a climate science extension specialist at the University of Arizona.

However, ENSO is just one of the climate puzzle pieces.

"Changes in sea surface temperatures and atmospheric pressures in the north Pacific and Atlantic oceans combine with ENSO to influence the climate and weather," said Jeremy Weiss, senior research specialist for the Environmental Studies Laboratory in the Department of Geosciences at the University of Arizona.

Outside of the tropics, the Arctic Oscillation (AO) is the most influential natural climate fluctuation to affect climate in the Northern Hemisphere. The AO, also known as the Northern Annular Mode (NAM), is characterized by differences in the atmospheric pressures over the Arctic and surrounding regions (Figure 1).

The pressure difference, in turn, influences the strength of the winds aloft and either prevents or allows cold air to spill south. When surface air pressures are lower over the polar region and higher over surrounding regions (described as a positive phase of the AO), the jet stream blows harder and more consistently from west to east, pinning the cold Arctic air to the polar region and driving winter storms farther north.

These changes in the atmospheric circulation contribute to drier conditions in the western U.S. Conversely, when pressures are high over the polar region (described as a negative phase of the AO), the winds slacken and the cold air can spill out into mid-latitudes. Positive and negative phases of the AO flip back and forth routinely, even over several weeks. However, one state of the AO usually predominates during a season.

During negative AO phases, temperatures in the U.S. during January–March and February–April tend to be below average (Figure 2). In many regions, the past two winters illustrated this; in both years the

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Deep Freezes, continued

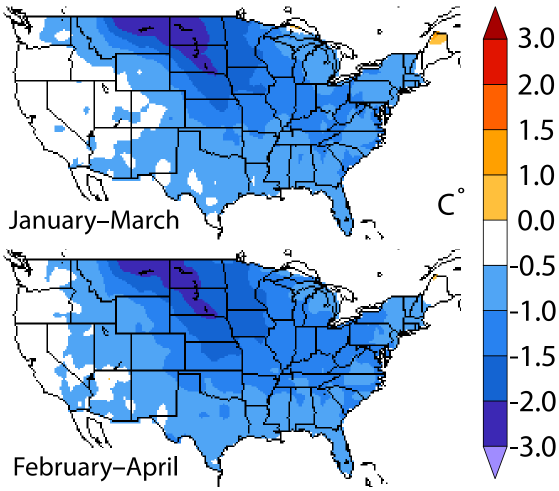

Figure 2. Average temperatures in degrees Celsius during the negative phase of the Arctic Oscillation between 1950 and 1999 and during the periods January–March (top) and February–April (bottom) have been below average in most of the U.S. 1 degree C is equal to about 1.6 degrees Fahrenheit. The maps and analysis were generated by the NOAA-Climate Prediction Center (CPC).

AO was very low. Between December 2009 and February 2010, when the AO hit its most negative reading since 1950, record-high snowfall blanketed Washington DC, Baltimore, and Philadelphia.

Will Global Warming Change the AO?
The average global temperature for 2010 tied 2005 for the warmest year on record since 1880, when widespread measurements began. The planet was 1.12 degrees Fahrenheit warmer than the 20th century average, according to the National Oceanic and Atmospheric Administration (NOAA).

The Arctic was even warmer, with temperatures soaring about 4 degrees F above average. In January, much of the Arctic experienced above-average temperatures of 4 to 11 degrees F, with some areas seeing even greater warming, according to the National Snow and Ice Data Center.

Temperatures have been much warmer in the Arctic in recent years, but it's not clear just yet what the impacts will be, Crimmins said.

Two different hypotheses both suggest that Arctic warming could alter the strength of the AO and alter the flow of air, which in turn could cause colder conditions in the U.S. and Europe.

One hypothesis states that as global temperatures have warmed and Arctic sea ice has melted during the past two and a half decades, more moisture has become available to fall as snow over the continents.

As a result, snow extent in Siberia, Russia—a region with a favorable geographic position to alter atmospheric circulation—has steadily increased over this period. Because the white landscape reflects solar rays back to space, the overlying atmosphere in this region has cooled, creating a barrier in the atmosphere that forces the jet stream to move north or south of Siberia. This then has sparked a chain-reaction, ultimately causing the AO to weaken and allowing Arctic air to move down into the U.S. and Europe. Analyses of observational data suggest that the increasing snow cover over Siberia during fall and early winter correlates to decreasing September Arctic sea ice over the Pacific sector.

The other hypothesis points to a causal chain that begins with melting ice and ends with slackening winds in polar regions and a lower AO. Around the North Pole, some of the world's coldest air currents normally bluster in a tight loop known as the polar vortex. Melting sea ice in recent years has left more of the Arctic Ocean free from ice in the winter. The relatively warm water has heated the atmosphere, increasing pressure in the polar region and causing the Polar Vortex to wane in strength. As a result of the weakened AO, cold air has been able to move south.

Both of these hypotheses suggest continued global, and therefore Arctic, warming would bring more cold winters. However, more research and time are needed to substantiate these theories.

"If there is a relationship with the Arctic and the recent cold winters, it is certainly not simple," said Klaus Wolter, research associate for the NOAA Earth System Research Laboratory in Boulder, Colorado. Sea ice has been low for the last four winters, but only two of those winters have been very cold.

In the Southwest, the current winter has been extremely chilly. Temperatures in Tucson dipped to 18 degrees F February 3—only one degree warmer than the coldest February temperature in the city's recorded history. The mercury in Albuquerque dipped to -7 degrees F, an all-time record for that date.

New Mexico declared a state of emergency after demand for gas and electric heat drained supplies and extreme temperatures forced suppliers to halt delivery citing safety precautions. A week later, another freeze clipped northeast New Mexico and areas to the east of the state.

During the first two weeks of February, temperatures averaged more than 6 degrees F below average in eastern Arizona and more than 12 degrees F below average in most of New Mexico.

Wolter thinks the recent freezing in the region has more to do with La Niña than the Arctic Oscillation. But the jury is still out on future cold events.

"The $64,000 question is will a warmer future bring more extreme cold temperatures," Wolter said.