Recent freeze events: Natural variability or weird weather?

by Melanie Lenart

Recent freezing events highlight how challenging it remains to forecast some aspects of climate with enough accuracy that Southwest farmers, gardeners, and other growers can take steps to respond to it more than a week or two in advance.

Blasts of Arctic air this winter in Yuma, Ariz., for instance, posed challenges to a variety of growers, from those running citrus orchards to farmers cultivating cotton, broccoli, or leafy greens for Yuma's booming winter lettuce industry. These events led to rising food prices.

The southern sweeps of Arctic air raise the question of whether this is just another example of natural climate variability—a plausible prospect—or whether they might relate in a complex and little understood way to the ongoing summertime melting of Arctic sea ice. Either way, it's clear that the distant Arctic can bring a windy chill to southwestern winters even in a world that's generally warming.

When nighttime temperatures drop below 32 degrees F, the outer lettuce leaves may freeze, making them inedible. Photo: Kurt Nolte

Arctic chill

In mid-January, temperatures in Yuma plunged below freezing for several days in a row, putting it among the top six freezing events registered by the Arizona Meteorological Network (AZMET; *Table 1*), a system of high-tech weather stations that help farmers manage their crops.

Other cold sweeps followed, including a late February cold front that brought a dusting of snow and hail to major metropolitan regions in Arizona and New Mexico before winds carried it northeast into the Midwest and eventually New England. These events had one thing in common: they resulted from a shift of Arctic air southward thanks to a climatic pattern called the Arctic Oscillation (AO). It's also known as the North Atlantic Oscillation and Northern Annular Mode, with the names describing different aspects of the climate signal that were later traced back to the Arctic.

Like the El Niño-Southern Oscillation (ENSO), the AO comes with a signature climate, with a pattern based on its averages across the years. Based on an average of 1,945 days, a negative AO typically means slightly cooler-than-average January-March temperatures in southern Arizona and most of New Mexico, with more significant cooling closer to the Arctic.

During a negative AO signal, the Arctic acts like a refrigerator with an open door, allowing cold air to escape to the south, said Michael Crimmins, a University of Arizona Cooperative Extension climate specialist. That cold front can collide with a warm front, lifting moister warm air to heights that promote rain and snow. A positive AO describes winds tightly circling the Arctic, keeping its frigid air contained close to the North Pole.

Shifts into negative AO—with their potential for releasing cold air southward—can occur suddenly, so scientists continue to debate the exact mechanisms that set the AO changes into motion. So far, Crimmins said, prediction skills remain low until about a week in advance.

"Our understanding of the Arctic Oscillation is really poor," he explained. "We don't get it, we can't predict it. There's still argument about how it actually works."

Frozen food

The AO was negative in January when below-freezing Arctic air swept into the Southwest, including Yuma, glazing ripening lettuce heads with frost. Lettuce prices skyrocketed from $8 to

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Rank	Dates	Days <45 (°F)	Ave. Temp. (°F)	Min. Temp. (°F)
1	Dec. 22-26, 1990	5	41.2	29.5
2	Dec. 27-31, 1988	5	42.6	27.3
3	Dec. 25-28, 1987	4	41.4	26.4
4	Jan. 12-15, 2013	4	43.8	30.6
5	Jan. 13-15, 2007	3	40.8	22.3*
6	Feb. 2-4, 2011	3	42.2	26.4

*Record low for the station

Table 1. The top six freezing events for Yuma as registered by the Arizona Meteorological Network (AZMET, http://ag.arizona.edu/azmet/index.html) are shown here. Data compiled by Paul Brown and used with permission.

$38 a carton in a matter of days, said Yuma Extension agent Kurt Nolte. The price jump reflected added labor needed to peel off frozen outer leaves and the shortage of quality lettuce from farms struck by the freeze. This affected grocery stores and consumers throughout the U.S., and restaurants in Mexico, Canada, and even Europe.

"It's not like a farmers' market," Nolte said. "It's a very huge industry here." Yuma supplies about 95 percent of the national lettuce market from November through March. During peak periods, Nolte said, as many as 1,000 trucks a day transport greens from Yuma.

Broccoli, cauliflower, and the popular baby green salad varieties also were damaged in the freeze, he said. Meanwhile, Yuma's 18,000 acres of citrus, which largely produce big lemons for the winter market, generally did fine.

Yuma orchard growers weren't so lucky in 2007, when temperatures dropped below 28 degrees Fahrenheit for several consecutive nights—the kind of cold spell that takes a toll on citrus. Yuma lost some 40 percent of its lemon crop, although most of the trees survived to bloom the next season.

Cotton farmers also keep a close eye on winter temperatures. Yuma's growers had to wait until mid-March to plant cotton this year, when soils had warmed up enough from the earlier cold spells to reach the 60 degrees F temperatures needed to avoid damaging cotton sprouts, said Paul Brown, a UA Cooperative Extension specialist in biometeorology who has run AZMET since he launched it in 1987. Cotton farmers have to weigh the risks of another blast of cold against having the monsoon arrive before plants have matured, which creates its own set of problems.

Cold events in a warming world

The blasts of Arctic winds certainly weren't unprecedented for southern Arizona, Brown said. The negative AO pattern, with its cooler winter temperatures, generally indicates that the jet stream has taken on a wavy, meandering form that allows the transport of winds down from Alaska, Canada, and other parts of the Arctic.

In 1987, the first year that Brown began collecting AZMET measurements, freezing temperatures hit the area in late December (*Table 1*). Based on its duration, he ranked it as the third coldest event in the record, although he noted that temperatures actually reached cooler lows in the shorter cold snap of 2007.

Brown indicated that the recent cold events seem to fit in a longer-term record, even if they seem a bit unusual to those who become "normalized" to a warmer climate. For instance, he said, cold events during the early 1960s led to "phenomenal" frost damage to citrus. Freezing temperatures also had an impact in the late 1980s early 1990s.

"Then all of a sudden those winters disappeared for about 15 years. And now they're back," Brown said, referring to potentially damaging freezes. "This has happened three times in the last six years where we've had these pretty serious cold outbreaks."

These freezes may seem unusual in the context of a climate that is warming overall, but they're likely just part of natural climate variability, agreed Martin Hoerling, a National Oceanic and Atmospheric (NOAA) research meteorologist specializing in climate dynamics. The average temperatures for the three-month winter period starting in December in the climate division that includes Yuma and many other areas in the Southwest show a general warming trend.

"The cold spells haven't been eradicated from our climate record," Hoerling said, noting that climate has always varied considerably. Just because temperature is registering an upward trend doesn't mean variability will end, he indicated, adding, "This year is an outlier relative to the longer-term trend."

Despite this trend in many areas of the country, growers must be cautious about planting warmer weather varieties, said Christopher Daly, a climatologist who headed the 2012 revision of the U.S. Department of Agriculture's Plant Hardiness Zone Maps, which are designed to guide those planting perennials such as trees. A plant's survival depends more on the outliers, or extremes, that fall outside of the norm rather than the average temperatures.

"My message has been, as far as plant hardiness goes, is that while the averages have gotten warmer, you can still get that cold snap. All it takes is one

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cold snap to kill your plant," Daly said. "People shouldn't be lulled into a false sense of security that we're not going to see cold snaps any more."

Arctic winds remain a wild card

Daly also pointed out that Alaska and the Canadian Arctic will remain a potent source of cold air for Arctic blasts such as the ones witnessed this past winter, regardless of warming temperatures. While average temperatures have been rising faster in Alaska and the rest of the Arctic than the global average, winter temperatures remain low. For instance, even daily highs in winter averaged below 0 degrees Fahrenheit in Barrow, Alaska, located within the Arctic Circle.

Even as scientists gain an understanding of the AO, the factors affecting it may well be shifting as the Arctic loses some of its sea ice. Several papers published since 2008 have suggested that the melting of Arctic sea ice, ironically, could push down winter lows in many parts of the continent. (For more on this, see the link below to the February 2011 *Southwest Climate Outlook*.)

The ice cover shields the atmosphere from the underlying warmer ocean and puts a cap on the evaporation of underlying water that, when airborne, can produce rain or snow. Also, ice tends to reflect sunshine, while water tends to absorb it, thus collecting heat that promotes a continued decrease in sea ice. Some researchers even suggest ice-related changes are helping shift the AO into its cold-exporting negative pattern.

Scientists generally agree that the shift in Arctic ice cover is likely to cause changes in circulation patterns, but debate rages over what those changes are and the possible mechanisms that drive them.

Meanwhile, the dramatic reductions in sea ice really started taking hold only in the last decade (see Figure 1). This short record puts researchers at a serious disadvantage. The longer a climate record, the greater the chances of discerning the complexities of a climate pattern enough to allow predictions and forecasts beyond a week or so.

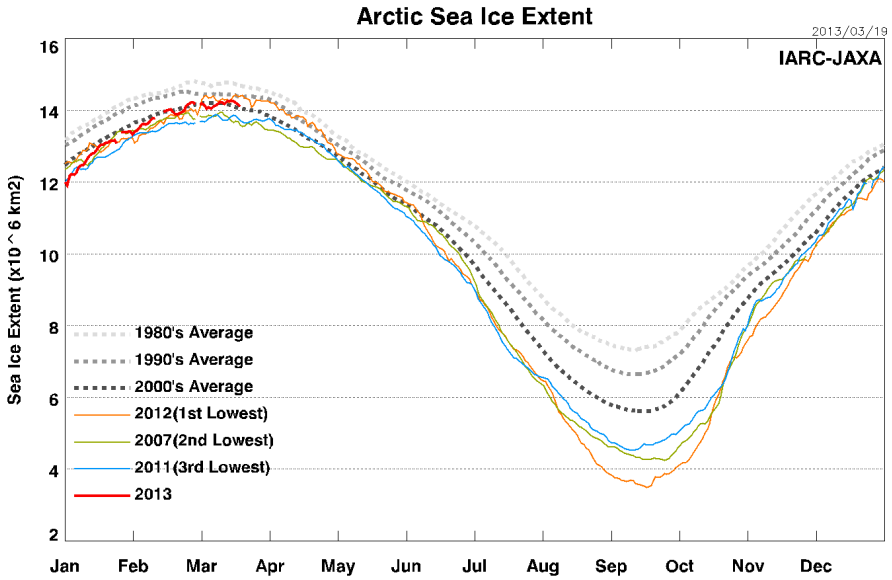

Figure 1. Arctic sea ice is declining, and the rate of its decrease has been picking up in recent years compared to earlier decades, as illustrated by this graphic from the International Arctic Research Center (IARC) in cooperation with the Japan Aerospace Exploration Agency (JAXA). Data available at http://www.ijis.iarc.uaf.edu/en/home/seaice_extent.htm.

If changes in sea ice in the Arctic are affecting the AO, researchers will almost certainly need a longer dataset than what is currently available to figure out what the signal means and how to predict the impacts from the associated changes.

What does this mean for farmers, gardeners, and other growers? They should stay alert for cold snaps even in a generally warming climate. This is likely what they planned to do anyway.

"I'm fairly confident the agricultural community will adapt to climate change as effectively as the environment will allow them in terms of water and extremes," Brown said. "They're a very adaptive group. That's just their nature. If they don't adapt, they don't stay in business very long."