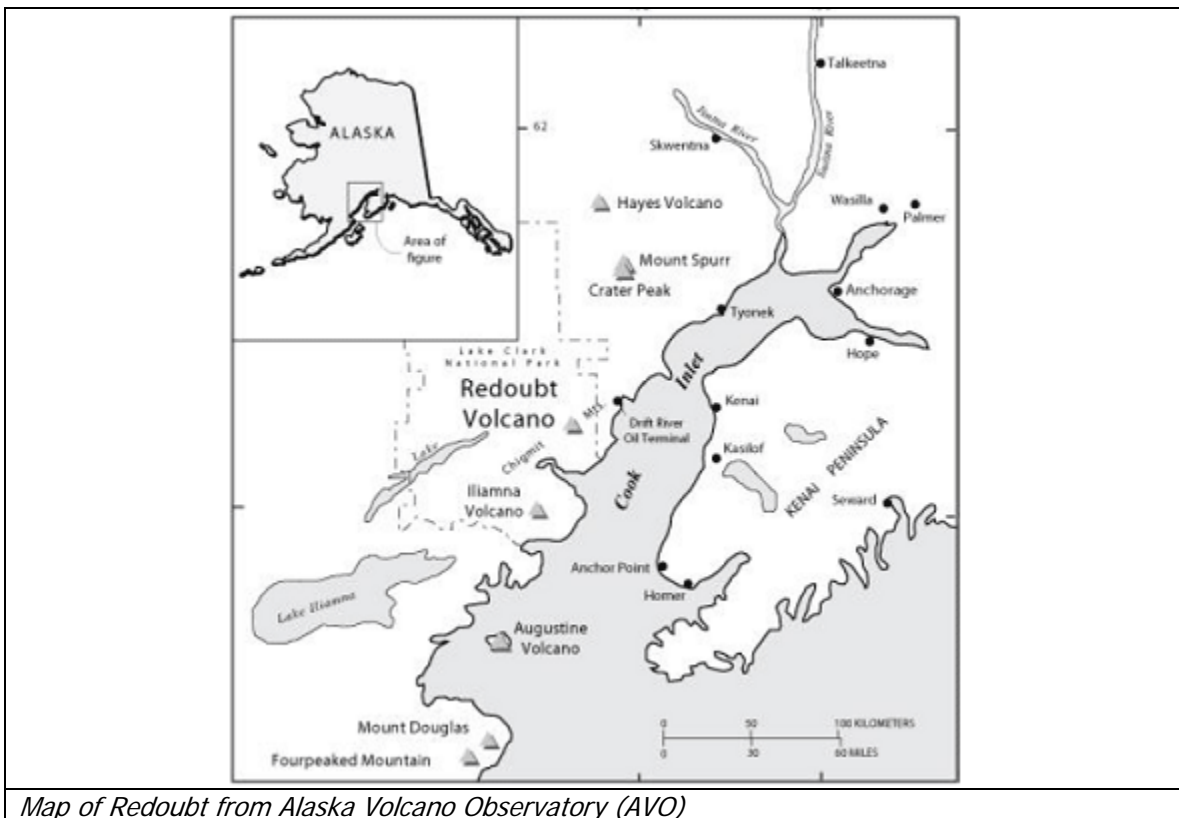


Winter One of the Coldest and Snowiest Where Most People Live- Follows a Cool Summer

By Joseph D'Aleo, CCM

It has been an interesting year and a winter for many to remember (or forget). There are lots of reasons why. The sun is just coming out of a very long slumber for one. Let's look at some of the other factors likely at play.

In [April 2009](#), Alaska's Mt Redoubt erupted (and later Russia's Sarychev) and the effect it might have on high latitude blocking and cooling summer and winter. Starting on March 22, a series of major eruptions have taken place from Mt. Redoubt in Alaska. The biggest exceeded 65,000 feet in height. More than a dozen eruptions as high as 60,000 have followed.



Map of Redoubt from Alaska Volcano Observatory (AVO)

Mt Redoubt Volcano



Image of April explosion of Redoubt. Alaska Volcano Observatory (AVO)

Climatologists may disagree on how much the recent global warming is natural or manmade but there is general agreement that volcanism constitutes a wildcard in climate, producing significant global scale cooling for at least a few years following a major eruption. However, there are some interesting seasonal and regional variations of the effects.

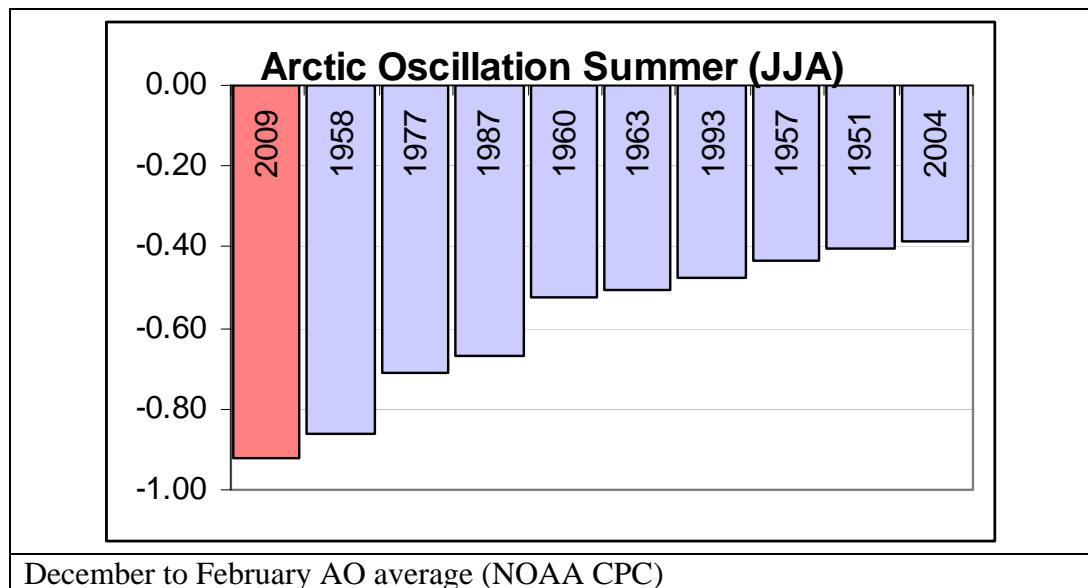
[Oman et al](#) (2005) and others have shown that though major volcanic eruptions seem to have their greatest cooling effect in the summer months, the location of the volcano determines whether the winters are colder or warmer over large parts of North America and Eurasia. According to their modeling, tropical region volcanoes like El Chichon and Pinatubo actually produce a warming in winter due to a tendency for a more positive North Atlantic Oscillation (NAO) and Arctic Oscillation (AO).

The North Atlantic Oscillation (NAO) Index first found by Walker in the 1920s, is the north south flip flop of pressures in the eastern and central North Atlantic. The difference of normalized MSLP anomalies between Lisbon, Portugal and Stykkisholmur, Iceland has become the widest used NAO index and extends back in time to 1864 (Hurrell, 1995), and to 1821 if Reykjavik is used instead of Stykkisholmur and Gibraltar instead of Lisbon (Jones et al., 1997).

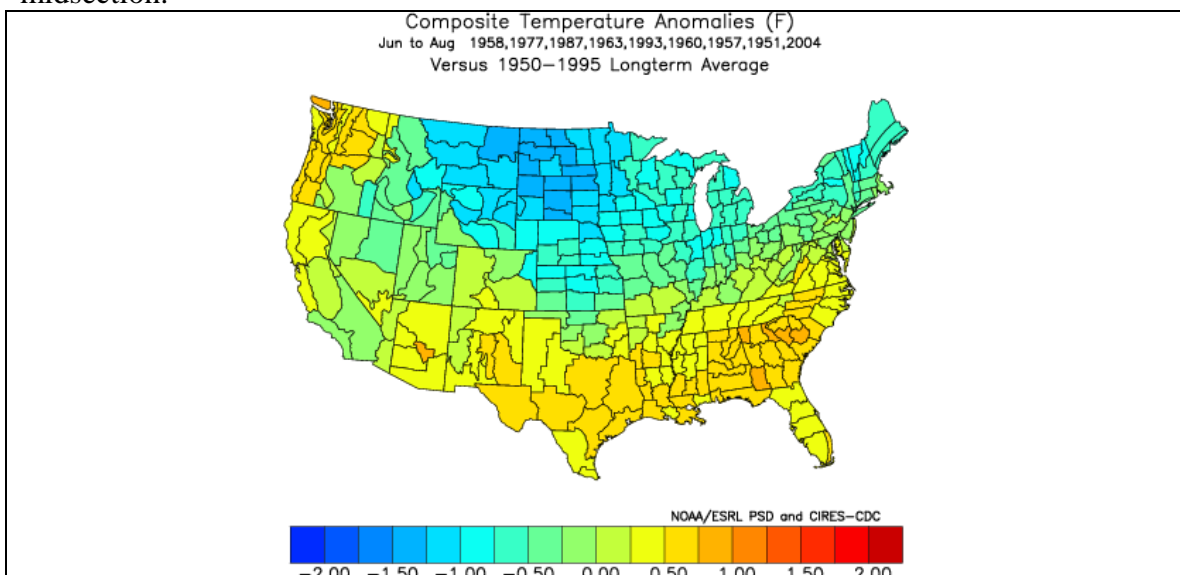
Arctic Oscillation (also known as the Northern Annular Mode (NAM) Index) is defined as the amplitude of the pattern defined by the leading empirical orthogonal function of winter monthly mean NH MSLP anomalies poleward of 20°N (Thompson and Wallace, 1998, 2000). The NAM /Arctic Oscillation (AO) is closely related to the NAO.

In the positive phase of these large scale pressure oscillations, low pressure and cold air is trapped in high latitudes and the resulting more westerly jet stream winds drives milder maritime air into the continents.

The summer of 2009 had the most negative AO since 1950. Which explains the cold summer (especially July).

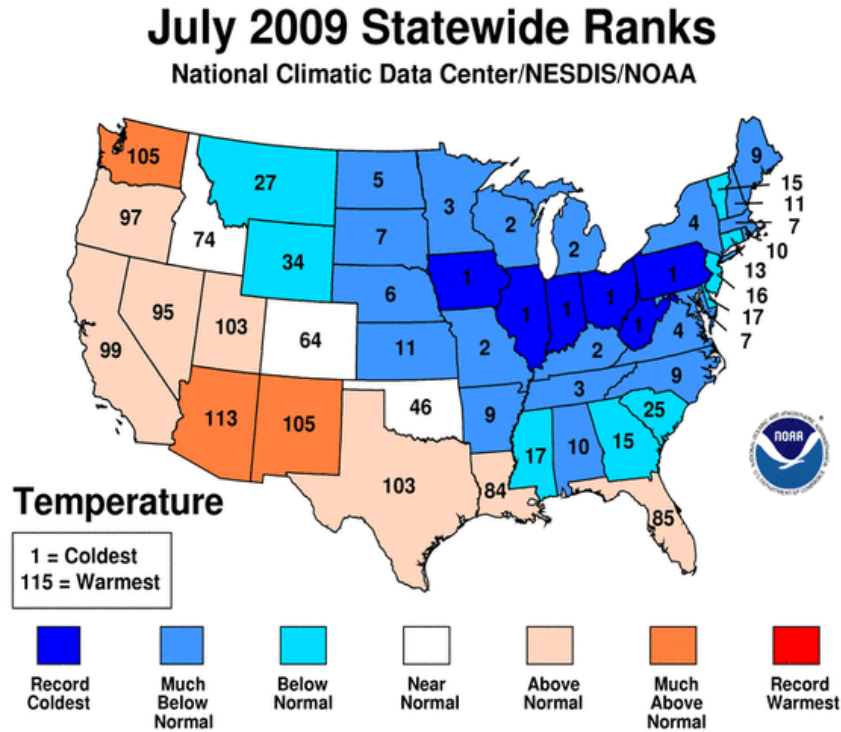


Summers with a very negative AO above have a cold anomaly centered in the nation's midsection.



Composite of all years with early year high latitude volcanos (sources Smithsonian GVC USGS and NOAA CDC reanalysis data)

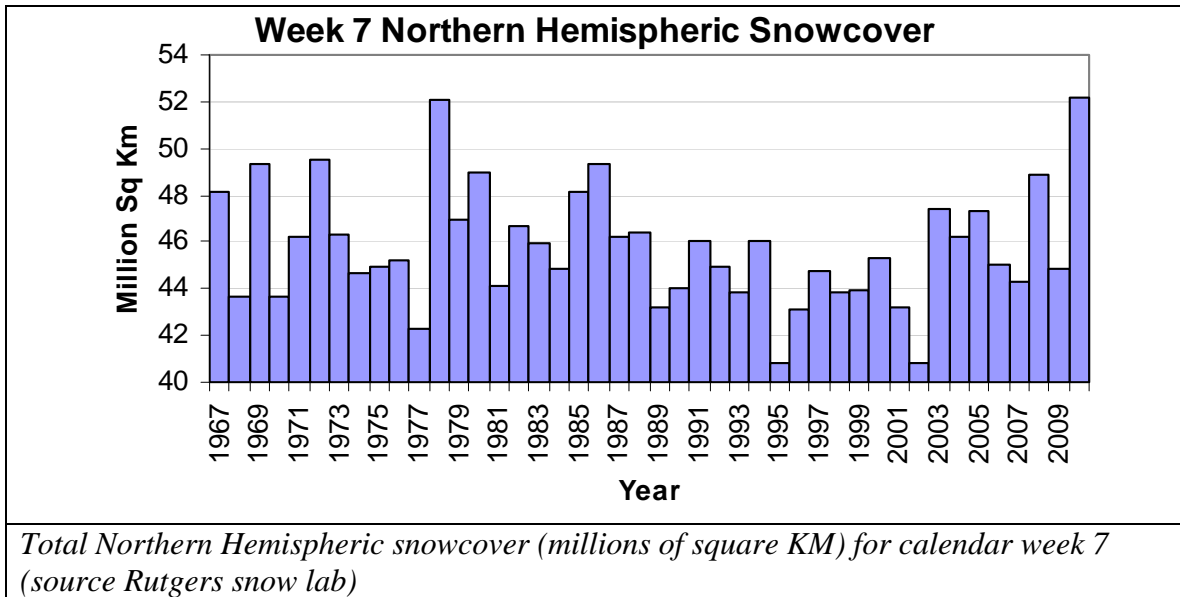
Last summer saw that pattern according to NOAA NCDC..



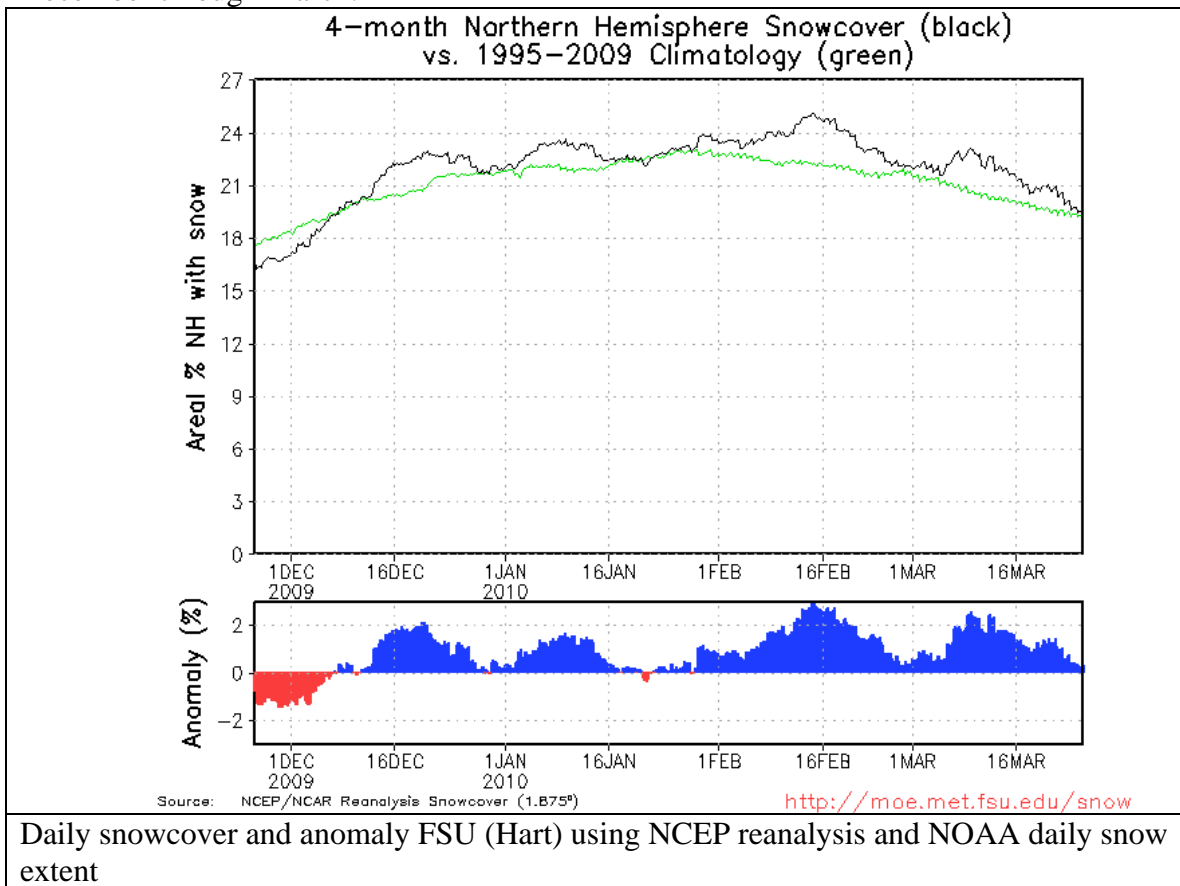
WINTER FOLLOWS SUIT MANY AREAS

The winter was a brutal one in the United States and across vast areas of Europe, Russia and northern China.

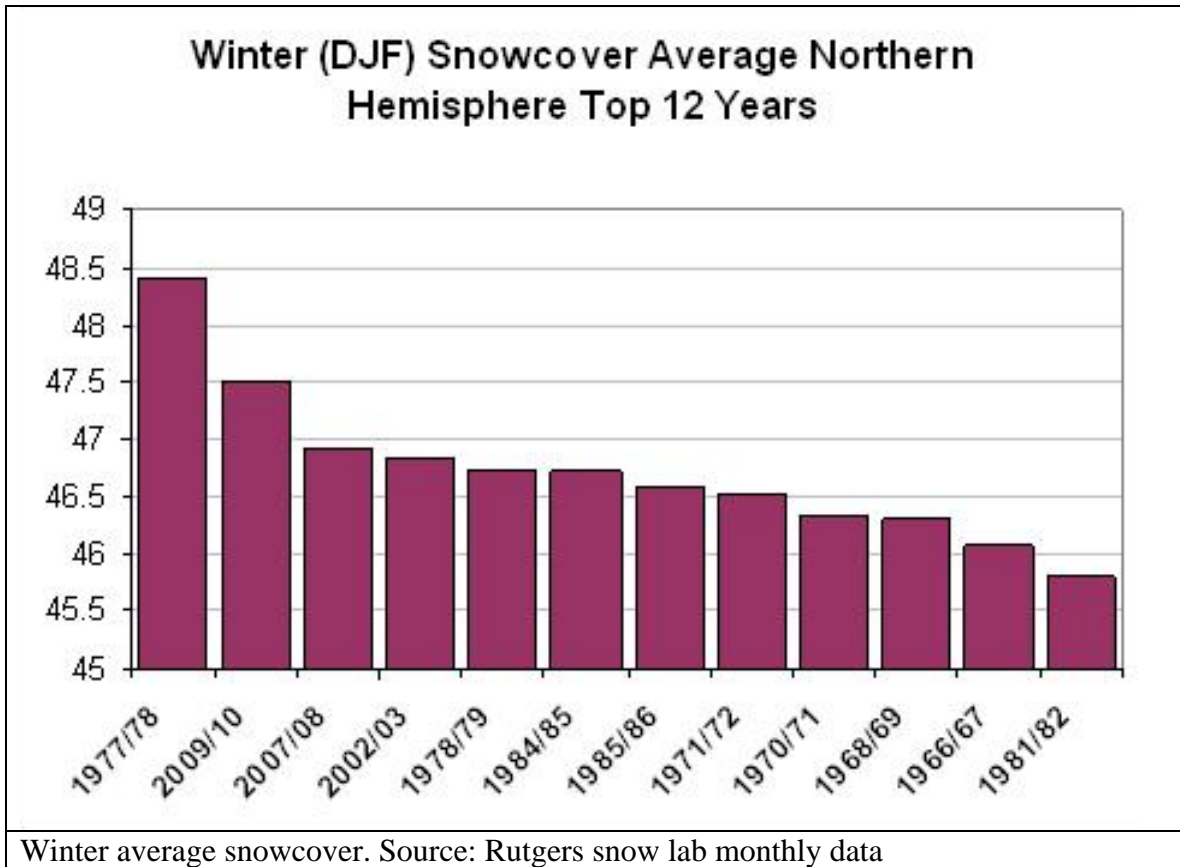
Near the end of meteorological winter, the northern hemispheric snowcover reached the highest level of the entire record, extending back to 1967, beating out the legendary 1978.



Notice how the snowcover for the hemisphere was persistently above normal from December through March.



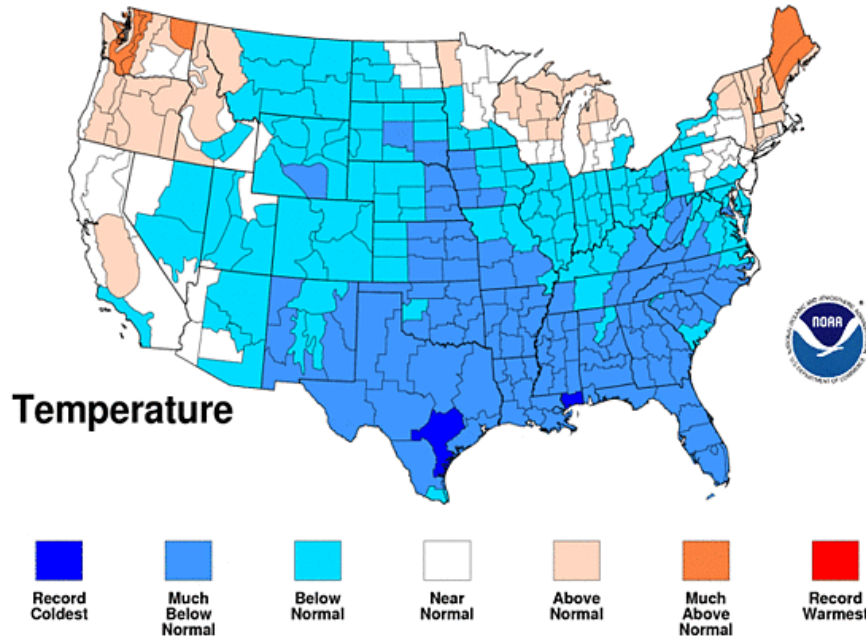
This is the top 12 winters for average Northern Hemisphere snowcover. 2009/10 trailed only 1977/78 and finished ahead of 2007/08 and 2002/03 (courtesy Rutgers's snowlab).



The winter (December through February) temperatures were well below normal in much of the United States.

Dec 2009 - Feb 2010 Divisional Ranks

National Climatic Data Center/NESDIS/NOAA



Departure from Normal of Temperature for December 2009 through February 2010 (Degrees C). Source NOAA NCDC.

It was coldest from the plains to the southeast. In Nashville TN, it was the coldest winter since 1977/78 with below normal temperatures in every month. The worst freeze hit the Florida citrus since 1989 and records for duration of cold were wet in many places in Florida and the southeast. January ties as 5th coldest January in Key West and January 7 through 13 ties coldest week where records have been kept since 1873.

For Florida, it was the coldest winter since 1981, including the coldest 12 day period since at least 1940 ([PDF](#)).

Snowflakes were seen in Miami (for the first time since 1978) and Naples (first time ever). It was the coldest in three decades in Key West with the second lowest temperature ever recorded.

Top 10 Coldest Recorded Temperatures (F) in Key West (International Airport), Florida

Date	Low Temperature (F)
1/13/1981	41
1/11/2010	42
12/27/1985	44

12/24/1989	44
12/26/1983	45
1/10/1996	45
2/5/1996	45
2/18/1996	45
1/24/2003	45
1/3/2008	45

New seasonal snow records were set in Philadelphia, Baltimore and Washington, DC and surrounding cities (Source NOAA).

City	Snowfall (in)	Previous Record (Year)
Baltimore	79.9	62.5" (1995-1996)
Washington (Dulles International Airport)	72.8	61.9" (1995-1996)
Washington (Regan National Airport)	55.9	54.4" (1898-1899)
Wilmington, Del.	66.7	55.9" (1995-1996)
Philadelphia	71.6	65.5" (1995-1996)
Atlantic City, N.J.	49.9	46.9" (1966-1967)

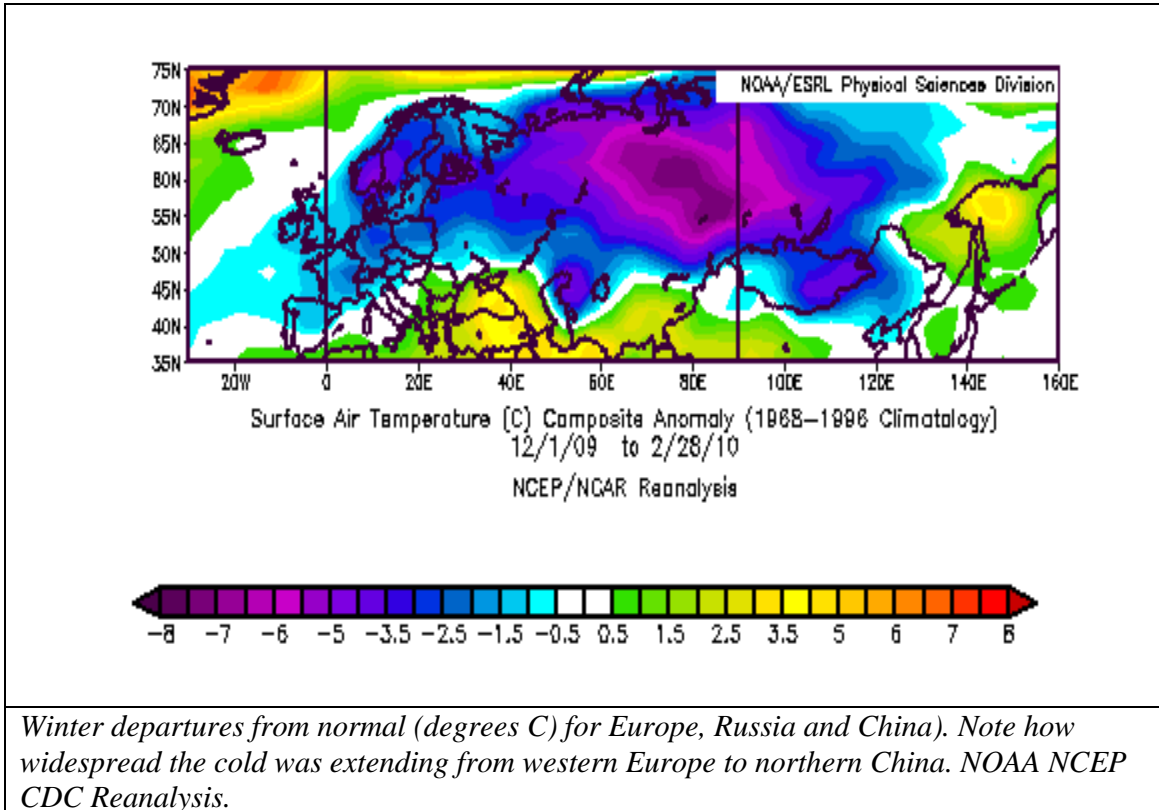


This season's snowfall in Washington, D.C., toppled a record that had stood since the winter of 1898-99. Manuel Balce Ceneta, AP

Dallas came within one half an inch of their seasonal record set in 1977/78. Des Moines Iowa as of March 26 had 69 inches to data for the season, within reach of the 72 inch all-time record of 1911-12 with a late snow always possible there.

Meanwhile over the Great Lakes the suppressed storm track meant a dry winter. See [this story](#) from Gaylord, Michigan.

In Europe and Asia, the winter was harsh and for the most part unrelenting.



Russia's top weatherman announced that the winter now drawing to a close in Siberia may turn out to be the coldest on record. 'The winter of 2009-10 was one of the most severe in European part of Russia for more than 30 years, and in Siberia it was perhaps the record breaking coldest ever,' said Dr Alexander Frolov, head of state meteorological service Rosgidromet.

Statistics are still being analyzed in detail, but it is known that in western Siberia the mean temperature was minus 23.2C, with more colder days than in previous years. Russia's top weatherman today announced that the winter now drawing to a close in Siberia may turn out to be the coldest on record. Some 63 days were colder than minus 25C and 39 days below minus 30C.

The cold which began last June in Germany continued through the winter.

'Sheep's Chill' cold snap hits Germany 6/3/2009
<http://www.thelocal.de/national/20090603-19671.html>

All-time October low recorded in Bavaria 10/20/2009

Meteorologists on Tuesday morning recorded the lowest ever October temperature in Germany, as the mercury dipped to a chilly -24.3 degrees Celsius

<http://www.thelocal.de/society/20091020-22693.html>

Cold Snap Causes Christmas Chaos in Europe 12/21/2009

Generally Germany is well geared for colder weather. But nobody anticipated that this weekend would bring the year's coldest. Temperatures sank as low as minus 30 degrees Celsius <http://www.spiegel.de/international/germany/0,1518,668320,00.html>

Germany gripped by third day of record cold 1/8/2009

<http://globalfreeze.wordpress.com/2009/01/10/germany-gripped-by-third-day-of-record-cold/>

Berlin – Germany experienced its coldest night in 22 years as temperatures plummeted to more than 20 degrees below zero,

<http://www.earthtimes.org/articles/show/249133,germany-in-grip-of-arctic-weather.html>

Cold weather leaves 6 dead in Germany 02/01/2010

<http://english.cctv.com/program/worldwidewatch/20100201/101728.shtml>

Germany: Freezing weather holds Germany in its biting grip as all travel is disrupted across Europe. 2/18/2010

http://pressexposure.com/Extended_Cold_Weather_Conditions-115076.html

Many died in Eastern Europe and western Russia from the extreme cold. In China, the coldest weather since 1971 damaged crops and in Mongolia heavy snows and the extreme cold killed up to 20 million livestock according to Sky News.

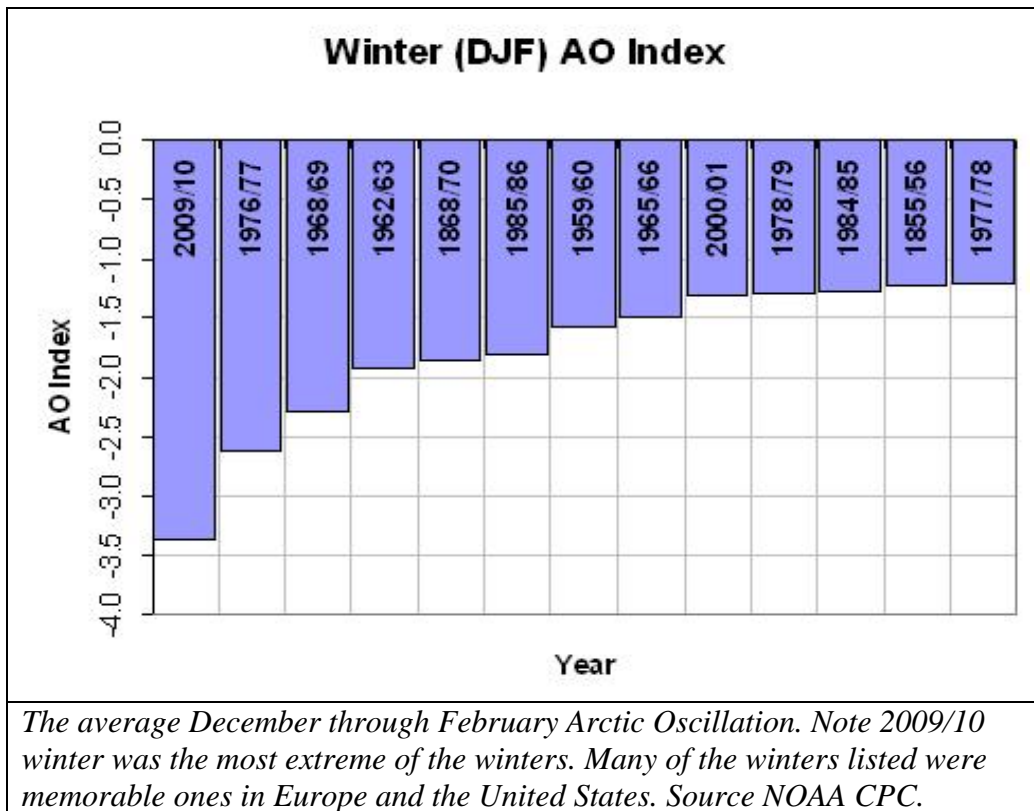


Photo of livestock and Herdsmen in Mongolia from Sky News

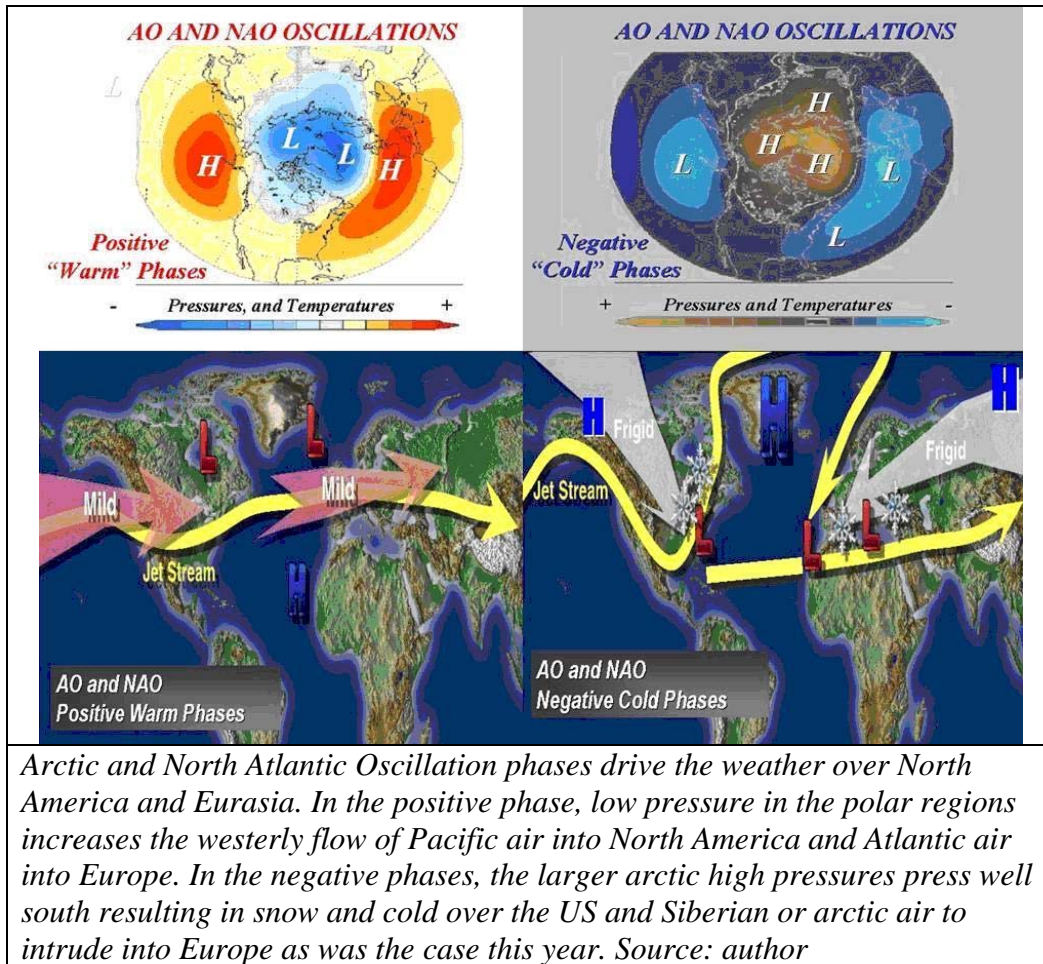
England has turned back the clock to the early 1800s with cold and snow. In parts of Scotland it was the coldest December and January and for the second year in a row, England got significant snow. In the UK the winter was said to be the coldest since 1977/78 while in Scotland and northern Ireland, it was the coldest since 1962/63. Many other nations reported similar “coldest winter in decades”. See [here](#) how worst snow on March 8 since 1962/63 brought Barcelona to a complete collapse.

This is part due to the similarity with regards to the ultra-long solar minimum to that of the late 1700s and early 1800s, the so-called Dalton Minimum. See more [here](#).

Again the Arctic Oscillation set a new record for extreme negativity for the winter after having established a similar record last summer probably related to the long solar minimum but especially to the high latitude volcanoes in Alaska (Redoubt) and Russia (Sarychev).

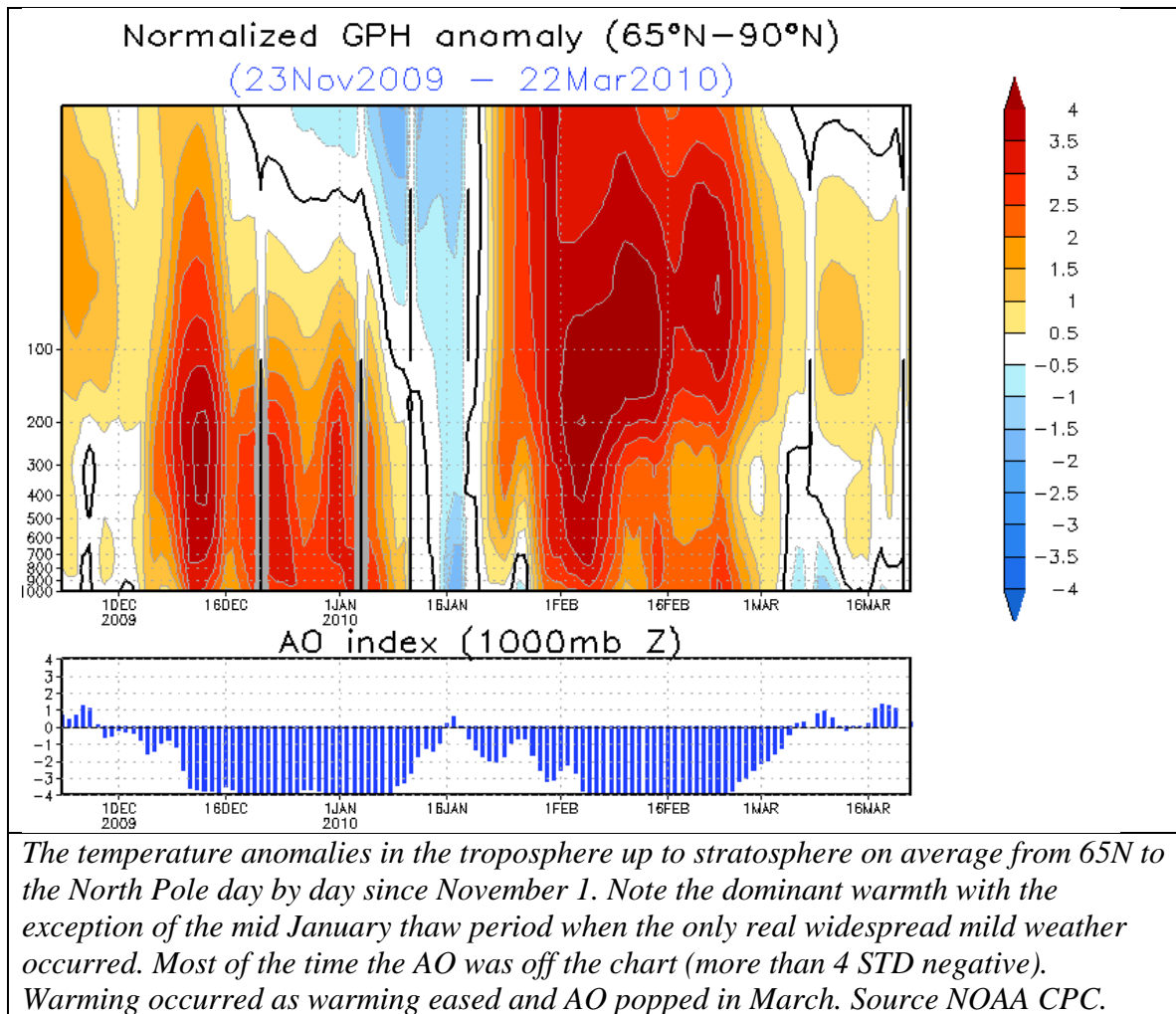


A negative arctic oscillation forces cold air into middle latitudes.



What drives the AO to be so negative? Often it is a phenomenon known as a stratospheric warming that causes high pressures to develop in Polar Regions and expand to middle latitudes pushing the boundary of the cold unusually far south (thus the rare cold winter in Florida). This year the stratospheric warming was dominant throughout the winter, characteristic of most of the most memorable winters of the 1960s and 1970s.

Stratospheric warmings often occur active solar years with a westerly Quasi-Biennial Oscillation (QBO) winds (over the equator in the tropical Pacific 10-12 months up, the wind oscillate from west to east about every 13 months or so) during active solar periods and easterly QBOs during quiet solar years. This year saw easterly QBO and solar activity was just emerging from solar minimum. Also high latitude volcanoes like we saw in April (Mt. Redoubt in Alaska) and June (Mt. Sarychev in Russia) often is accompanied by negative arctic Oscillations in summer (lowest on record last summer too) and the following winter. It was likely the combination of the two that made this winter so special.



Although the southeast and Midwest got the brunt, it was an unusually mild winter in the northeast.

THE NORTHEAST HAS A PACIFIC NORTHWEST LIKE WINTER

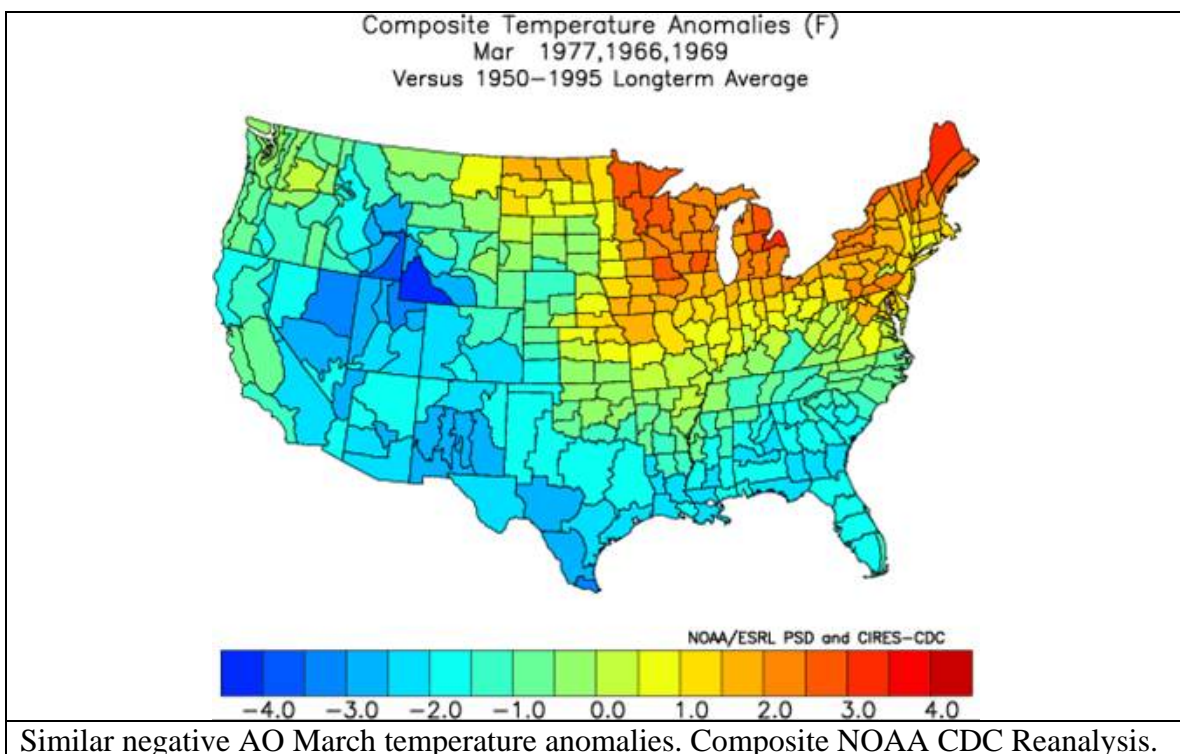
The northeast had several harsh winters in the row with seasonal snow records the last two La Nina years in parts of northern and central New England. This year was a very different story especially in the lower elevations. It was a mild winter in the northeast even as areas in the Mid Atlantic to Florida and northwest to the Northern Plains were hit hard with cold (many areas coldest since the 1960s or 1970s) and in places even all time record snowfall.

For 122 years, people have watched Lake Winnepesaukee to see when the ice clears and “Ice Out” can be declared, marking the coming of spring. This year, the day came so early it broke a record. Ice Out was declared Wednesday, March 24, beating the previous record, March 28, set in 1921, by four days.

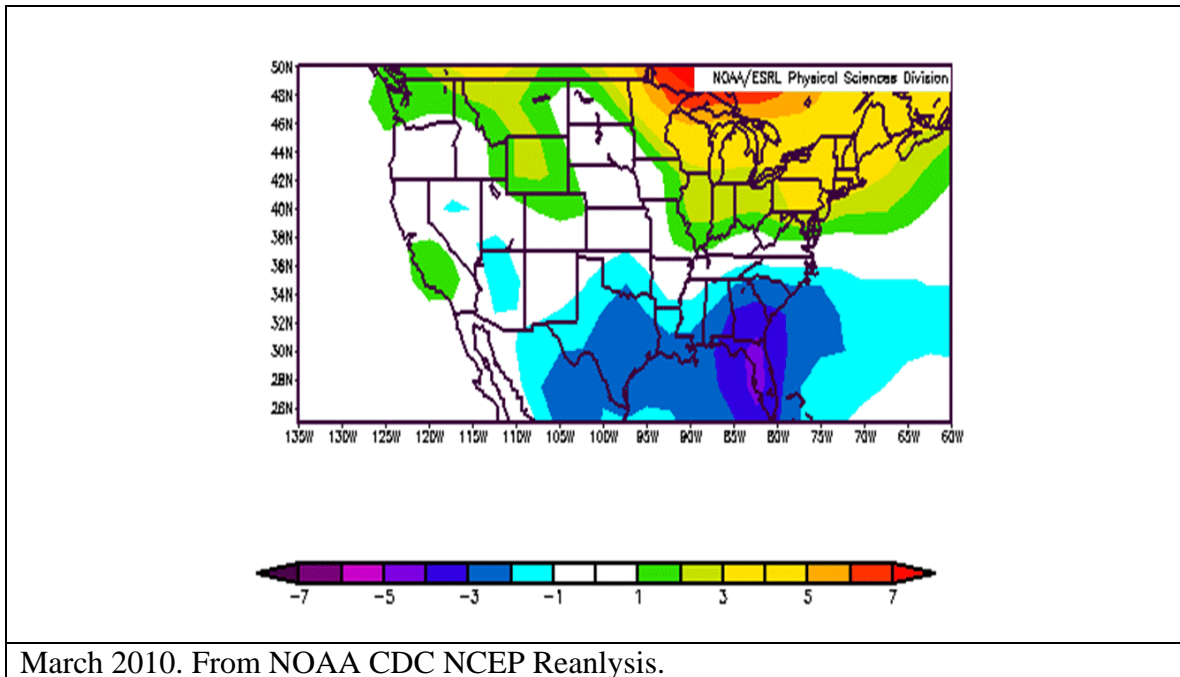
David Emerson, the official ice watcher, made the declaration at 2 p.m. Wednesday. Ice Out is a tradition dating back to 1888. The average Ice Out occurs in mid-April, Emerson said. But temperatures for January and February in the area have averaged three to five degrees warmer than normal, said. George Wiseman, a meteorologist with the National Weather Service in Grey, Maine. So far this month, the temperature in Concord has averaged 39.4 degrees, or about 7.4 degrees warmer than normal. And the high temperature has been above freezing every day this month, according to weather service records. Emerson said the lake didn't get a lot of snow this winter, and last week's unusually warm temperatures - the temperature rose into the 60s and one day to 70—and buckets of rain deteriorated the ice. "Then we had the big winds there yesterday," he said. "That finished it off."

With the strong negative AO and North Atlantic Oscillation (NAO), the high pressure in Canada drew in maritime air into the northeast and southeast Canada where normally there is a pool of cold air that storms on the southern El Nino storm track can draw on to produce major snows for inland and sometimes even coastal areas. The maritime air was cold enough to allow snow to fall in the higher elevations (it was a decent ski season) just as occurs in the Cascades in the Northwest each time the coastal storms romped up the coast but it was a cold rain down in lower elevations to the coast.

March 1977 was quite mild, in fact compositing the top 3 most negative AO winter Marchs we see:



This March has looked like those years thus far (though some arctic air invaded briefly today in the northeast). Notice also that it has remained cold in the southeast.



The snow stopped early in the [North Central](#). It looks like we'll finish out the month without snow," says FOX 9 meteorologist Erik Maitland. "This will be the third time that we've done that. But you have to go way back to 1860, 1878 for snowless Marches."

ENSO INFLUENCE

It also has been an El Nino year, the case in about half the top ten most negative AO years. All measures of ENSO have had it at least a moderate event. The Southern Oscillation Index (SOI) has peaked this month, the others in December. ENSO has different effects depending on other factors like the Quasi-biennial Oscillation (QBO) and the state of the Pacific Decadal Oscillation (now in its longer term cold mode again like the 1950s through much of the 1970s) and the location of the warmest waters in the tropics.

WALKER AND THE FIRST RECOGNITION OF LARGE SCALE OSCILLATIONS

Sir Gilbert Walker was generally recognized as the first to find large scale oscillations in atmospheric variables. As early as 1908, while on a mission to try and explain why the

Indian monsoon sometimes failed, he assembled global surface data and did a thorough correlation analysis.

On purely statistical grounds through careful interpretation, Walker was able to identify three pressure oscillations: a flip flop on a big scale between the Pacific Ocean and the Indian Ocean which he called the Southern Oscillation (SO); a second oscillation, on a much smaller scale, between the Azores and Iceland, which he named the North Atlantic Oscillation; and a third, between the areas of high and low pressure in the North Pacific, which Walker called the North Pacific Oscillation.

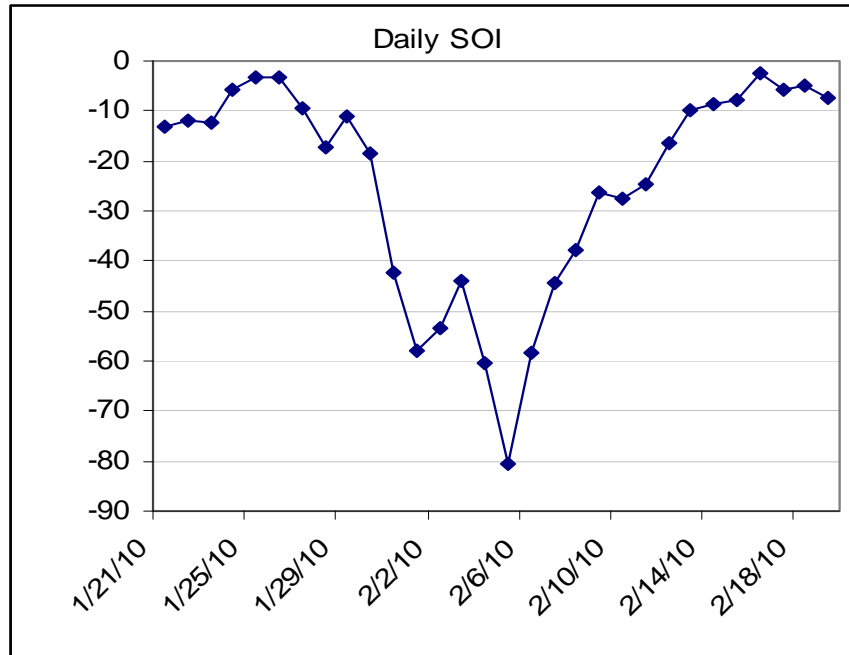
Walker further asserted that the SO is the predominant oscillation, and had a tendency to persist for at least one to two seasons. He went so far in 1924 as to suggest the SOI had global weather impacts and might be useful in predicting the world's weather. He was ridiculed by the scientific community at the time for these statements. Not until four decades later was the Southern Oscillation was recognized as a coupled atmosphere pressure and ocean temperature phenomena (Bjerknes 1969) and more than two decades further before it was shown to have statistically significant global impacts and could be used to predict global weather/climate at times many seasons in advance. Walker was clearly a man ahead of his time.

THE SOUTHERN OSCILLATION INDEX (SOI)

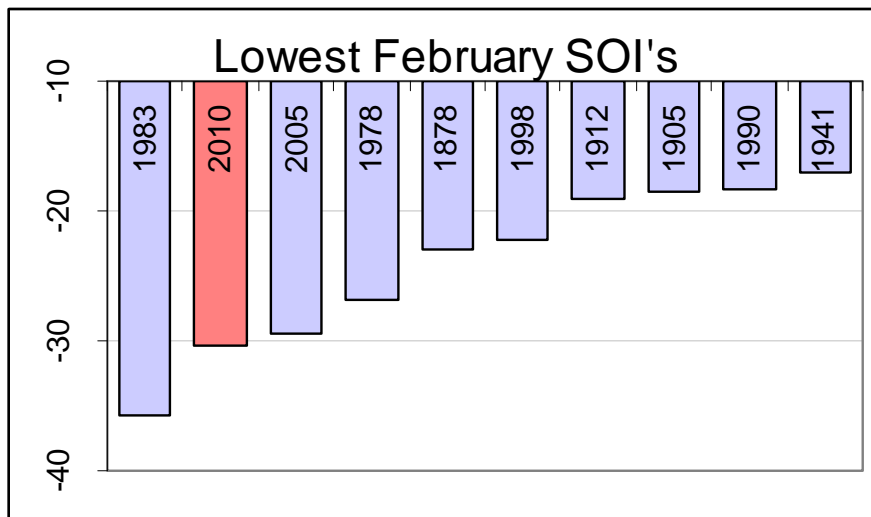
The Southern Oscillation Index (SOI) is the [oldest measure](#) of the large-scale fluctuations in air pressure occurring between the western and eastern tropical Pacific (i.e., the state of the Southern Oscillation) during El Niño and La Niña episodes (Walker et al.1932). Traditionally, this index has been calculated based on the differences in air pressure anomaly between Tahiti and Darwin, Australia. In general, smoothed time series of the SOI correspond very well with changes in ocean temperatures across the eastern tropical Pacific. The negative phase of the SOI represents below-normal air pressure at Tahiti and above-normal air pressure at Darwin. Prolonged periods of negative SOI values coincide with abnormally warm ocean waters across the eastern tropical Pacific typical of El Niño episodes. Prolonged periods of positive SOI values coincide with abnormally cold ocean waters across the eastern tropical Pacific typical of La Niña episodes.

As an atmospheric observation-based measure, SOI is subject not only to underlying ocean temperature anomalies in the Pacific but also the intraseasonal oscillations like the Madden-Julian Oscillation (MJO). The SOI often shows month-to-month swings even if the ocean temperatures remain steady due to these atmospheric waves. This is especially true in weaker El Nino or La Nina events as well as La Nadas (neutral ENSO) conditions. Indeed, even the changes week-to-week can be significant. For that reason, other measures are often preferred.

The Southern Oscillation Index has dropped on a daily basis to an amazing 8 STD negative in early February. For the first 19 days, it has been second most negative February since 1870.

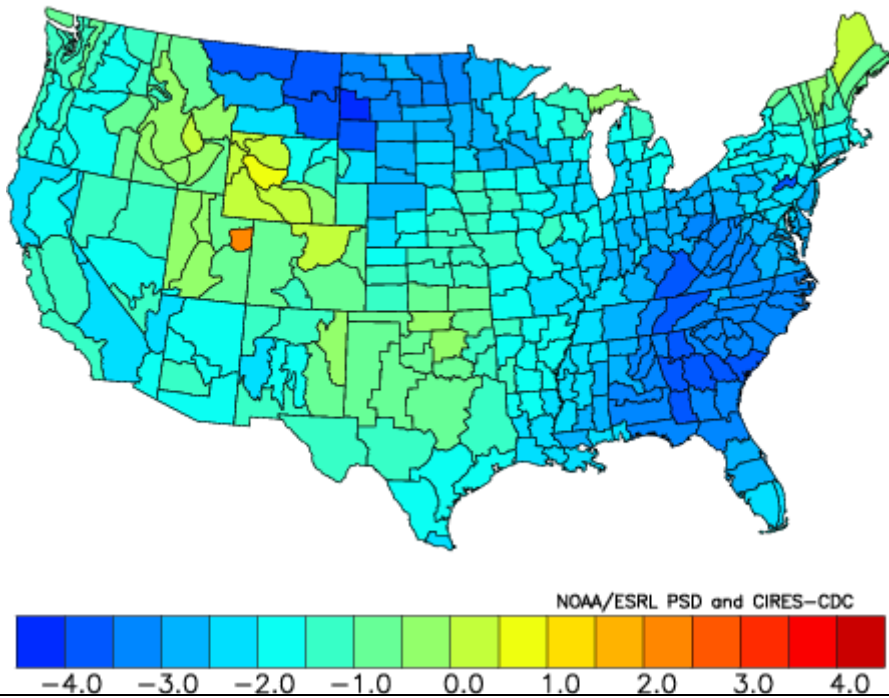


Daily SOI from the Queensland, Australia Long Paddock [site](#).



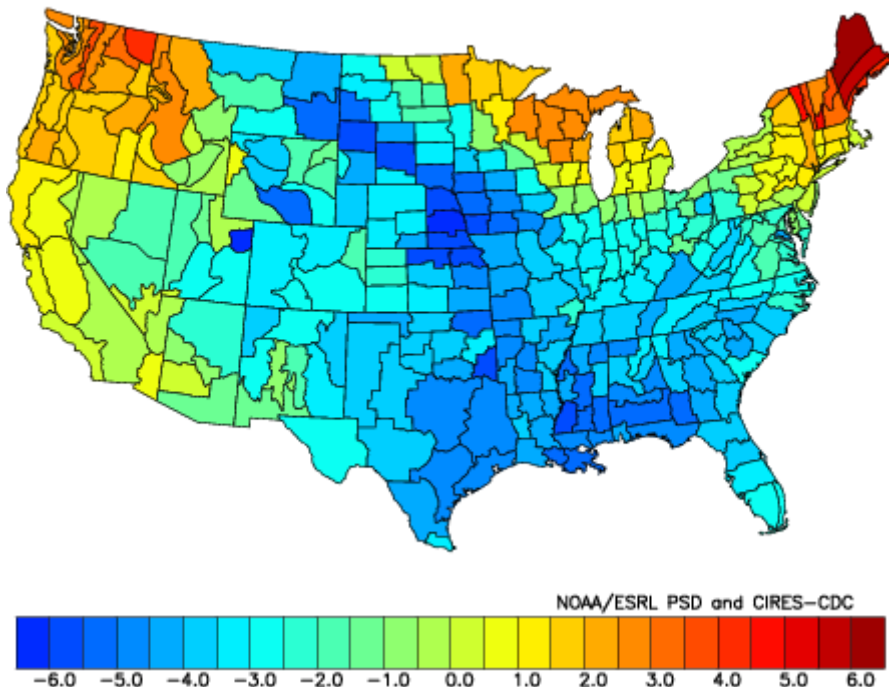
February SOIs from the Queensland, Australia Long Paddock [site](#).

Composite Temperature Anomalies (F)
Dec to Feb 1965–66, 1968–69, 1976–77
Versus 1950–1995 Longterm Average



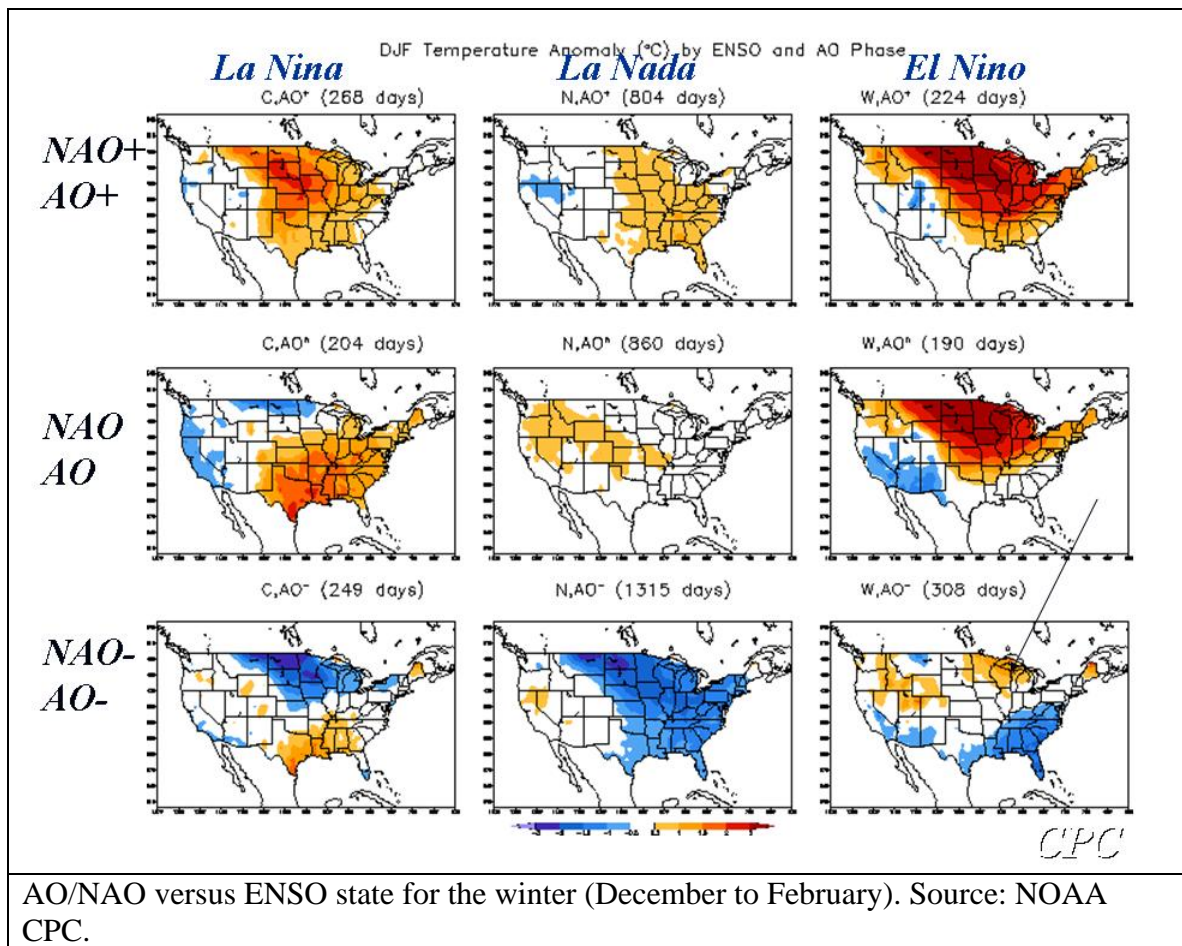
Composite winter anomaly for the analogs with the greatest similarity to 2009/10 winter.
Source: NOAA CDC NCEP Reanalysis.

Temperature Anomalies (F)
Dec to Feb 2009–10
Versus 1950–1995 Longterm Average

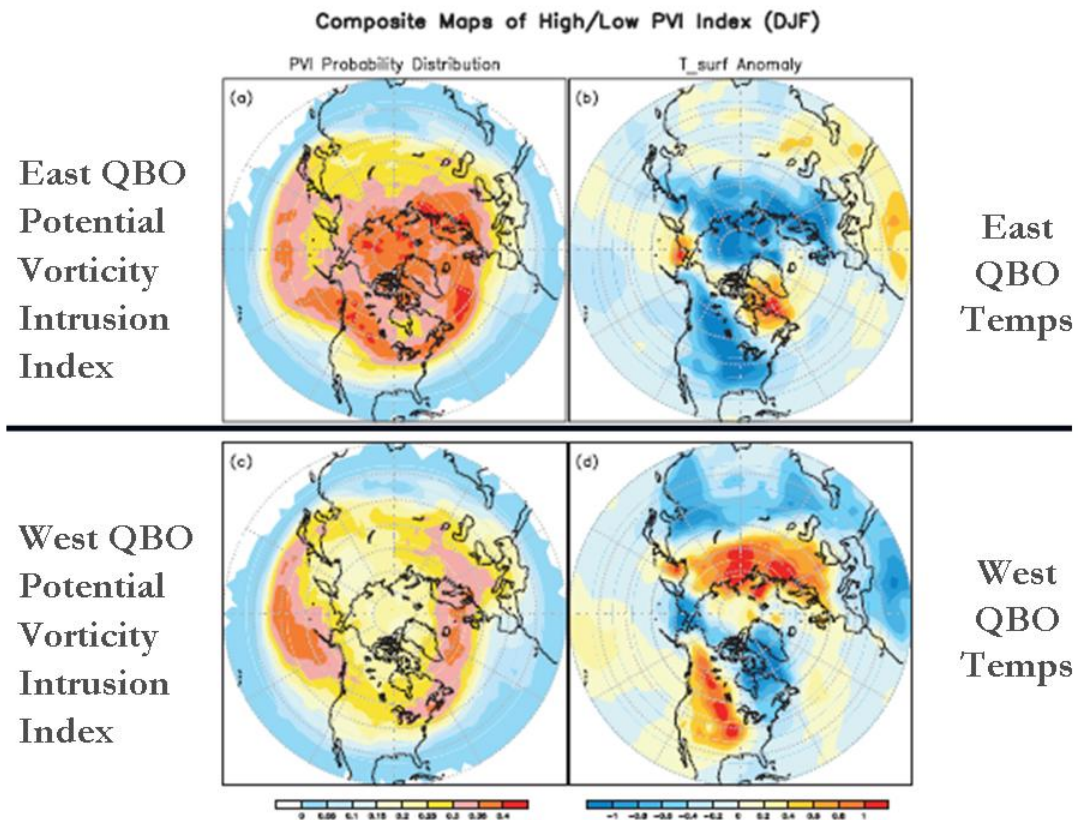


Winter of 2009/10. Source NOAA CDC NCEP Reanalysis.

This fits the combination of a negative AO El Nino very well (bottom right).



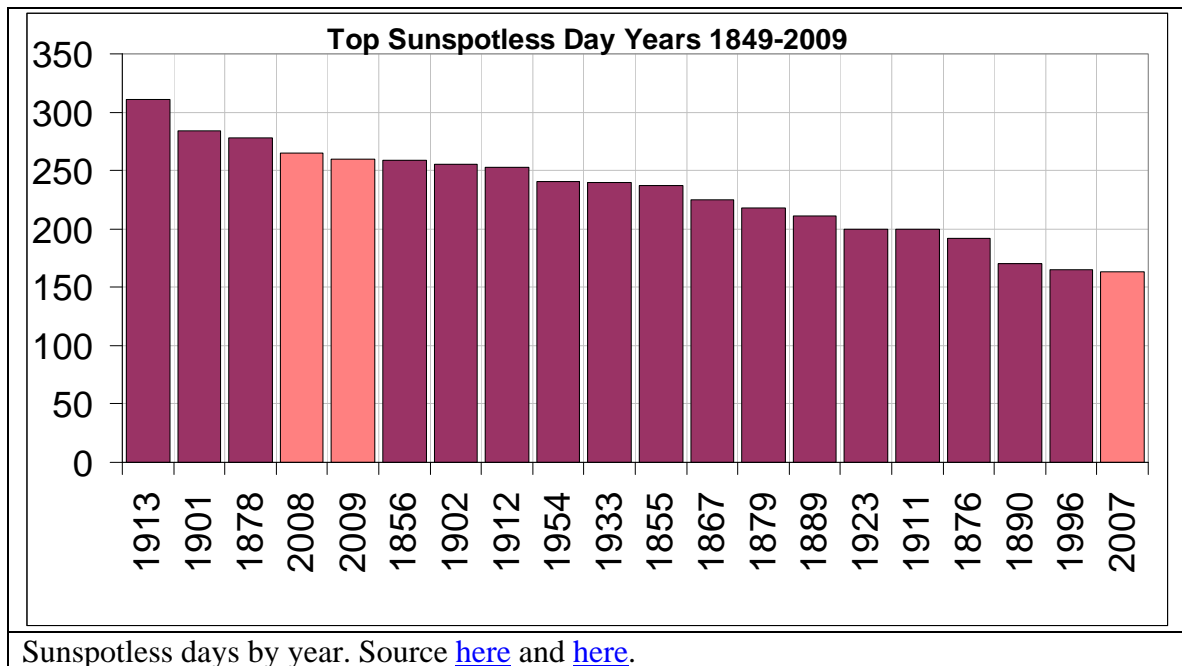
Easterly QBOs tend also to have more widespread snow in Eurasia and eastern and central North America (top right in graphic below).



Dr. Ming Cai analysis of upper level influences with QBO phase and corresponding surface temperatures ([link](#))

SOLAR ACTIVITY SLOWLY COMES OUT OF LONG SLUMBER

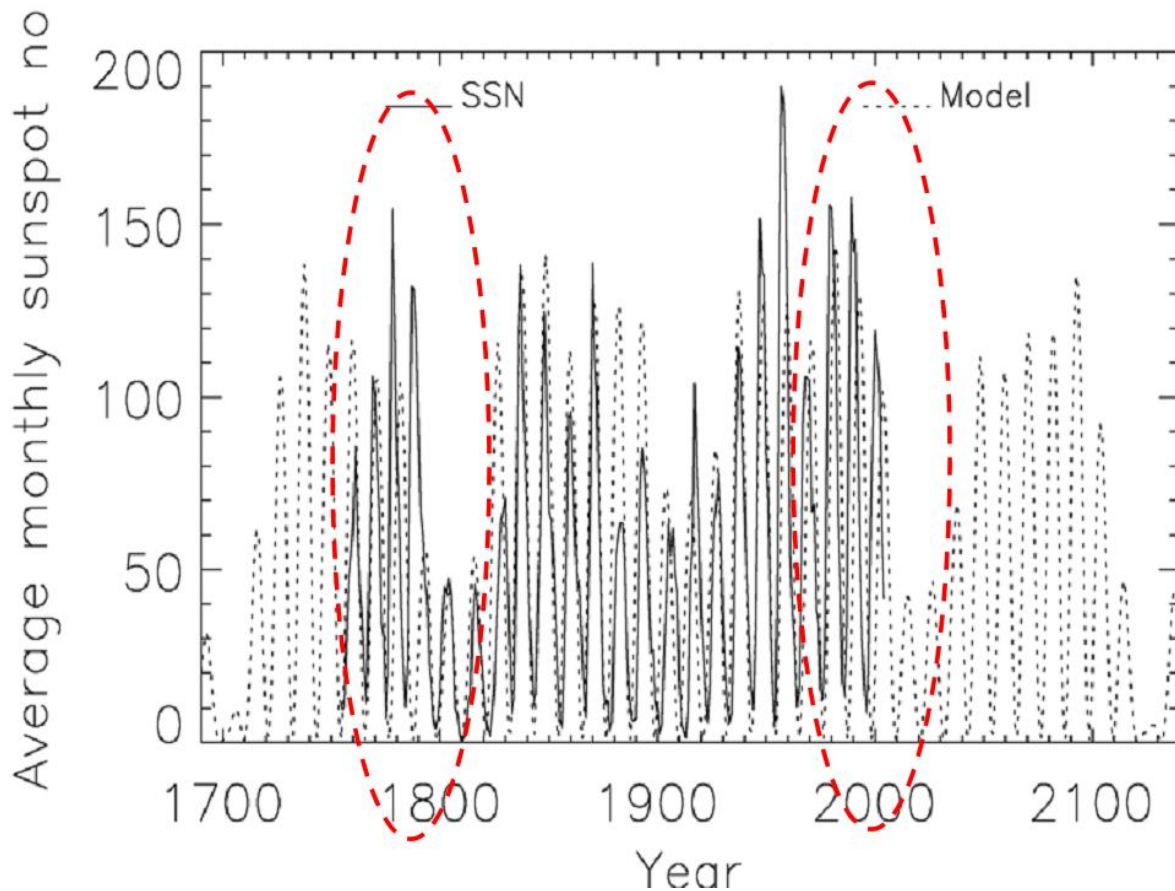
Solar cycle 23 lasted 12.7 years the longest since at least the middle 1800s. We had 776 spotless days. Both 2008 and 2009 were among the top 5 spotless years since 1849.



There is a similarity of the last 4 cycles and those in the late 1700s and early 1800s., the age of Dickens in what was called the Dalton Minimum. If you recall from the novels that was a period with snow common in London. Ironically the last several years has seen exactly that, with snow lasting for weeks.



There are a number of cycles besides the 11 year (9-13 year) cycle, including a 106 and 213 year cycle. The early 2000s should see the 213 and 106 cycle minima coincide so expect the next few cycles to also be long and weaker. The following is a statistical model based on a regression of past cycles by Clilverd et al 2007).



Sunspot cycle regression forecasts (Clilverd et al 2006) [here](#). Note how well the hindcasting performed and how the next two cycles are forecast like those of the early 1800s

If the sun indeed stays quieter, the El Nino give way back to La Nina, expect another snowy cold winter next year, although the heaviest snows will shift north again.

So as is almost always the case the seasonal patterns are the result of the combination of natural global oscillations called teleconnections. In this case, some combination of the AO/NAO, ENSO, QBO and solar and very likely the lingering effects of high latitude volcanism.