# Multidecadal Ocean Cycles and Greenland and the Arctic

***By Joe D'Aleo***
Monday, May 12, 2008

The last two weeks we showed how the natural multidecadal cycles in the Pacific (called the Pacific Decadal Oscillation or PDO) and Atlantic (called the Atlantic Multidecadal Oscillation or AMO) affected the frequency of El Ninos and La Ninas and combined to correlate strongly with temperatures over the United States.

In early May, a paper appeared in Nature that created quite stir in the media by showing how by including long term ocean cycles in models the recent global cooling or at least lack of warming may continue to 2020.  The same week, a story by NASA's Earth Observatory reported on the flip of the Pacific Decadal Oscillation to its cool mode. “This multi-year Pacific Decadal Oscillation ‘cool’ trend can intensify La Niña or diminish El Niño impacts around the Pacific basin,” said Bill Patzert, an oceanographer and climatologist at NASA's Jet Propulsion Laboratory, Pasadena, Calif. “The persistence of this large-scale pattern tells us there is much more than an isolated La Niña occurring in the Pacific Ocean.”

You heard these first here on Intellicast (in fact even in the prior incarnation of Dr. Dewpoint, we often talked about the importance of these ocean cycles in climate cycles). This week we will talk about temperatures and ice in Greenland and the Arctic, topics sure to dominate the news this summer. Already recent media stories have some scientists predicting another big melt this summer. We will show how that is not at all unprecedented (happens predictably every 60 years or so) and is in fact entirely natural.

***GREENLAND***

Many recent studies have addressed Greenland ice mass balance. They yield a broad picture of slight inland thickening and strong near-coastal thinning, primarily in the south along fast-moving outlet glaciers.

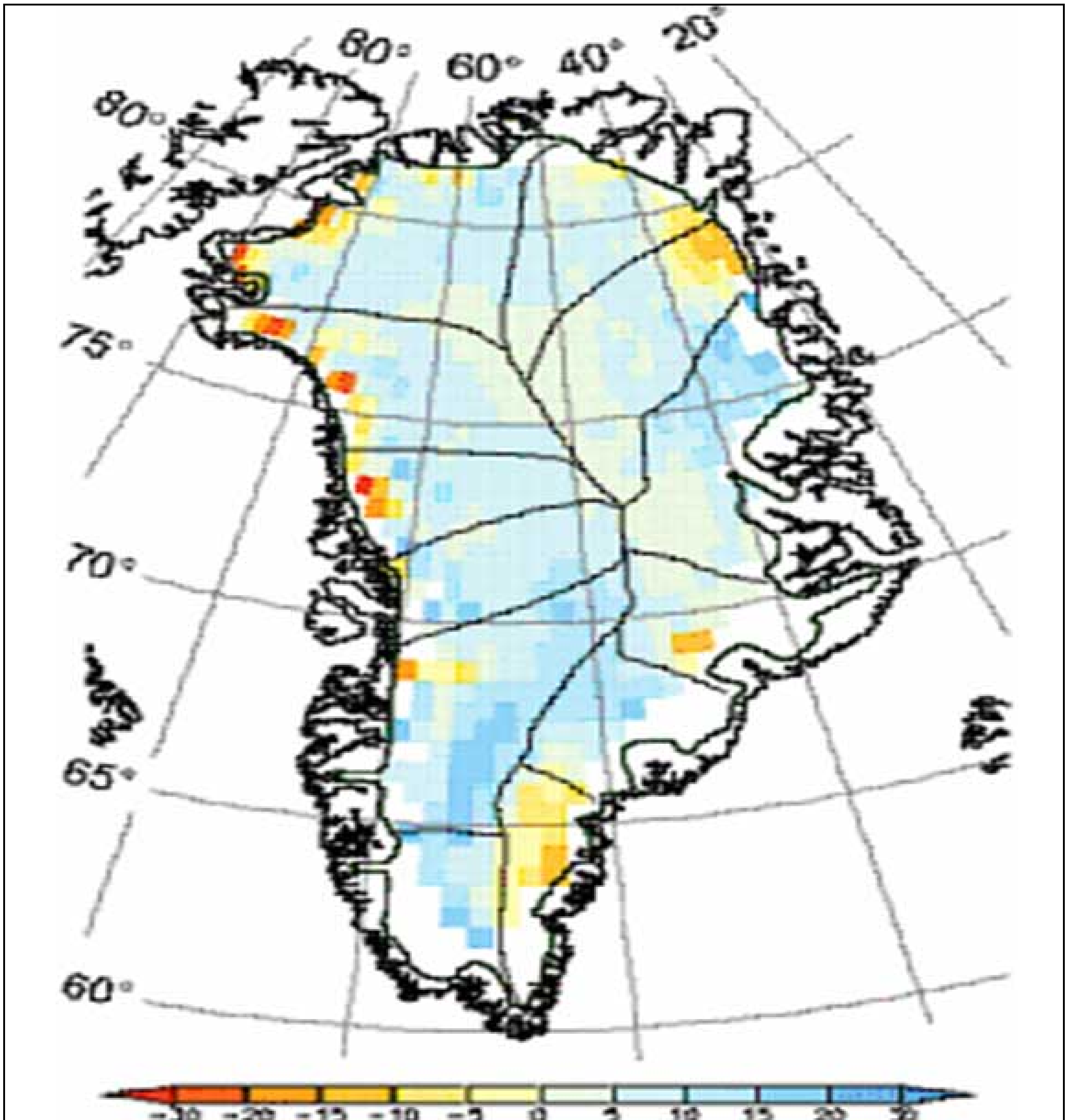

*Figure 1: Greenland ice thickness changes as determined from NASA satellites*

However, interannual variability is very large, driven mainly by variability in summer melting and sudden glacier accelerations. Consequently, the short time interval covered by instrumental data is of concern in separating fluctuations from trends. But in a paper published in Science in February 2007, Dr. Ian Howat of the University of Washington reports that two of the largest glaciers have suddenly slowed, bringing the rate of melting last year down to near the previous rate. At one glacier, Kangerdlugssuaq, "average thinning over the glacier during the summer of 2006 declined to near zero, with some apparent thickening in areas on the main trunk."

Dr. Howat in a follow-up interview with the New York Times went on to add

*"Greenland was about as warm or warmer in the 1930's and 40's, and many of the glaciers were smaller than they are now. This was a period of rapid glacier shrinkage world-wide, followed by at least partial re-expansion during a colder period from the 1950's to the 1980's. Of course, we don't know very much about how the glacier dynamics changed then because we didn't have*

*satellites to observe it. However, it does suggest that large variations in ice sheet dynamics can occur from natural climate variability."*

Thomas, et al. (2000) showed great variance in mass balance of the Greenland ice sheet with highly variable thickening and thinning depending on location. This February during a bitter cold winter, Denmark's Meteorological Institute stated that the ice between Canada and southwest Greenland reached its greatest extent in 15 years.

Temperatures were warmer in the 1930s and 1940s in Greenland. They cooled back to the levels of the 1880s by the 1980s and 1990s. In a GRL paper in 2003, Hanna and Cappelen showed a significant cooling trend for eight stations in coastal southern Greenland from 1958 to 2001 (-1.29ºC for the 44 years). The temperature trend represented a strong negative correlation with increasing CO2 levels.

Shown below in figure 2, see the temperature plot for Godthab Nuuk in southwest Greenland. Note how closely the temperatures track with the AMO (which is a measure of the Atlantic temperatures 0 to 70N). It shows that cooling from the late 1950s to the late 1990s even as greenhouse gases rose steadily, a negative correlation over almost 5 decades. The rise after the middle 1990s was due to the flip of the AMO into its warm phase. They have not yet reached the level of the 1930s and 1940s.

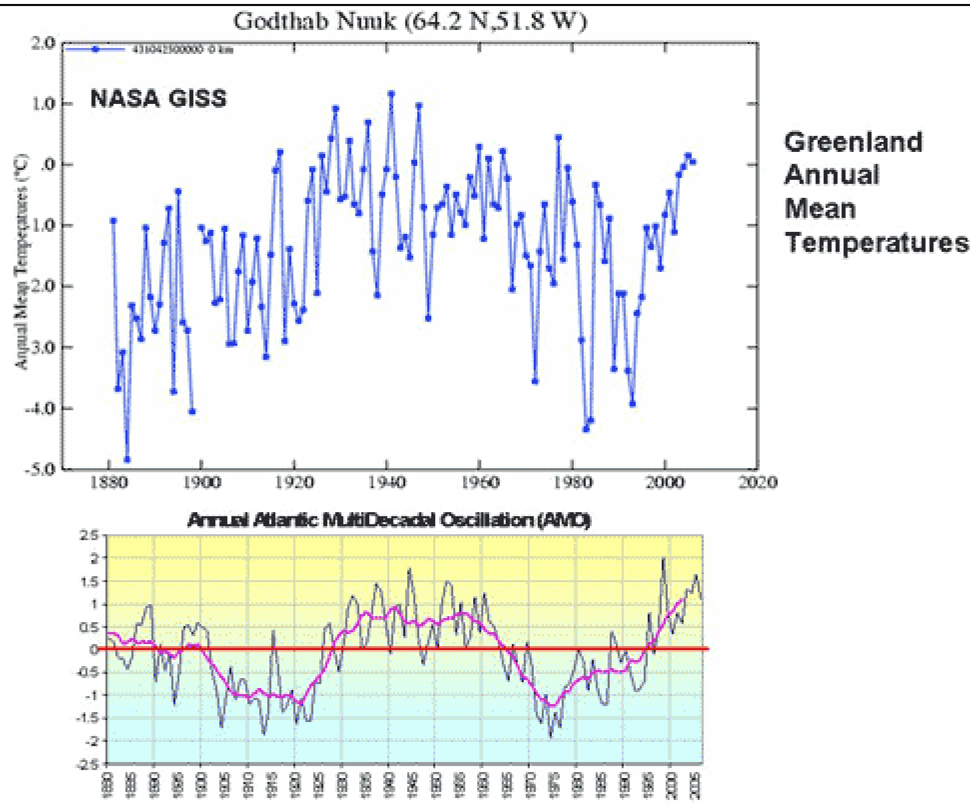


*Figure 2: Godthab Nuuk, Greenland annual mean temperatures (NASA GISS) top and the AMO bottom (annual dark blue and 5 year running mean purple) source CDC Climate Indices*

***A SIMILAR STORY IN THE ARCTIC***

Warming in the arctic is likewise shown to be cyclical in nature. This was acknowledged in the AR4 which mentioned the prior warming and ice reduction in the 1930s and 1940s. Warming results in part from the reduction of arctic ice extent because of flows of the warm water associated with the warm phases of the PDO and AMO into the arctic from the Pacific through the Bering Straits and the far North Atlantic and the Norwegian Current.

Polyakov et al (2002) created a temperature record using stations north of 62 degrees N. The late 1930s-early 1940s were clearly the warmest of the last century. In addition, the numbers of available observations in the late 1930s-early 1940s (slightly more than 50) is comparable to recent decades. The annual temperatures are plotted in figure 3.

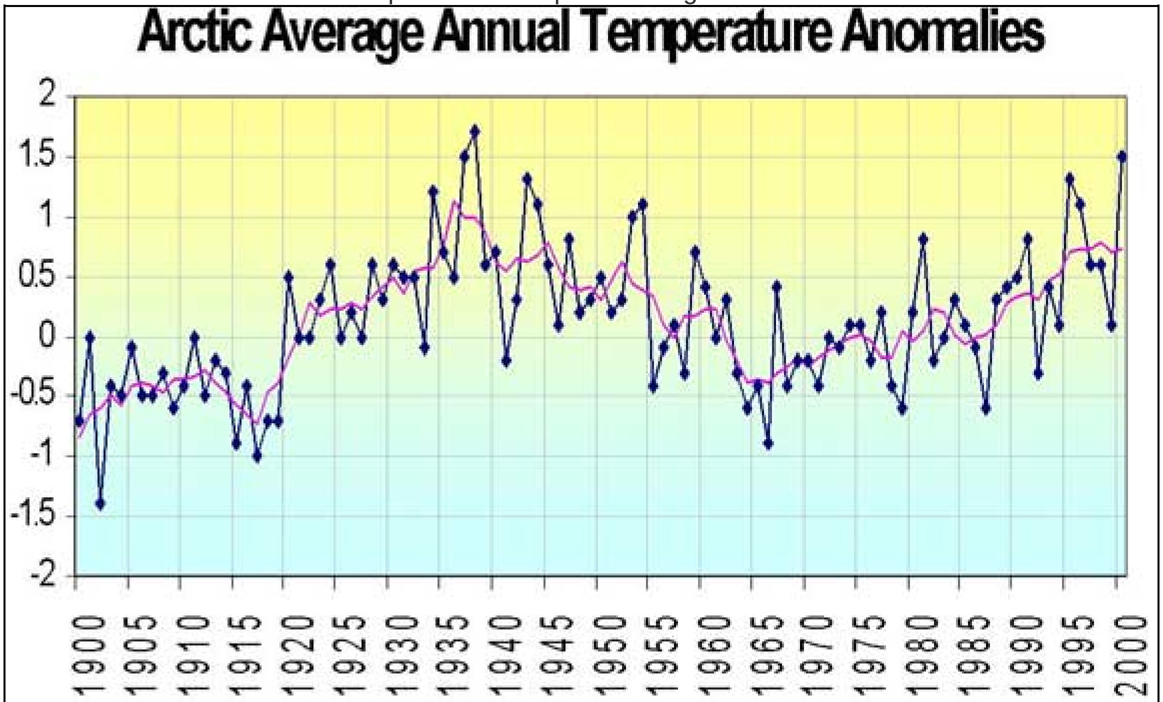


*Figure 3: Arctic Basin wide temperatures (Polyakov 2003)*

Pryzbylak (2000) says:

> *"There exists an agreement in estimating temperature tendencies prior to 1950. Practically all (old and new) of the papers which cover this time period concentrate on the analysis of the significant warming which occurred in the Arctic from 1920 to about 1940. Estimates of the areal average Arctic temperature trend in the second half of the 20th century are inconsistent.*
>
> *"The second phase of contemporary global warming in the Arctic [since 1970] is either very weakly marked or even not seen at all. For example, the mean rate of warming in the last 5-year period in the Arctic was 2–3 times lower than for the globe as a whole.*
>
> *"In the Arctic, the highest temperatures since the beginning of instrumental observation occurred clearly in the 1930s. Moreover, it has been shown that even in the 1950s the temperature was higher than in the last 10 years."*

Polyakov (2003) showed ice extent time series with a combination of decadal and multidecadal tendencies, with lower values prior to the 1920s, in the late 1930s to 1940s and in recent decades. They showed higher values in the 1920s to early 1930s and 1960s-1970s, similar to variability in temperature records. It is impossible to find a consistent long term trend in the data plots

The Japan Agency for Marine-Earth Science and Technology in Yokosuka, Kanagawa Prefecture observed in a story in Yahoo Asia News in 2005 an ice shrinkage in the western Arctic Ocean from 1997 to 1998 that they attributed to *"… by the flow to the area of warm water from the*

*Pacific Ocean, not by atmospheric impact as previously thought".* This was related to the super El Nino of 1997/98. JAMSTEC's Koji Shimada, the group's sub-leader, said the shrinkage was particularly severe in the Pacific side of the Arctic Ocean. The ocean's ratio of area covered with ice during the summer stood at about 60-80 percent from the 1980s to mid-1990s, but it went down to 15-30 percent after 1998, he said. Trenberth (1999) also has acknowledged this warming effect of El Nino on the arctic.

***THE IMPORTANCE OF THE ATLANTIC***

Of the two oceans, for the larger arctic basin, the Atlantic may be more important. Przybylak (2000) noted that

> *"For arctic temperature, the most important factor is a change in the atmospheric circulation over the North Atlantic" The influence of the atmospheric circulation changes over the Pacific (both in the northern end and in the tropical parts) is significantly lower"*

Rigor, et al (2002) suggest that the Arctic Oscillation (AO) affects surface air temperatures and sea ice thickness over the Arctic in a profound way. Ice thickness responds primarily to surface winds changes caused by the AO. Positive AO values (as have been observed in recent years) correspond to higher wind speeds (and generally thinner ice).

The North Atlantic Oscillation and the Arctic Oscillation (also referred to as the NAM) are related to the AMO as we reported on in the last post here.

As noted in the AR4, the relationship is a little more robust for the cold (negative AMO) phase than with the warm (positive) AMO. There tends to be considerable intraseasonal variability of these indices that relate to other factors (stratospheric warming and cooling events that are correlated with the Quasi-Biennial Oscillation or QBO for example).

Hass and Eicken (2001) and Proshutinsky and Johnson (1997) showed how arctic circulations vary from cyclonic to anticyclonic depending on strength and position of Icelandic low and Siberian highs. The latter paper noting the tendencies for the regimes to last 5-7 years and help explain the basin scale changes in arctic temperatures and the variability of ice conditions in the Arctic Ocean.  Vennegas and Mysak (2000) noted penetration of Atlantic waters into the arctic is affected by the North Atlantic Oscillation and multidecadal changes in the Norwegian Current.

As was the case for US temperatures, the combination of the PDO and AMO Indexes (PDO+AMO) again has considerable explanatory power for Arctic average temperature, yielding an r-squared of 0.73 (figure 4).

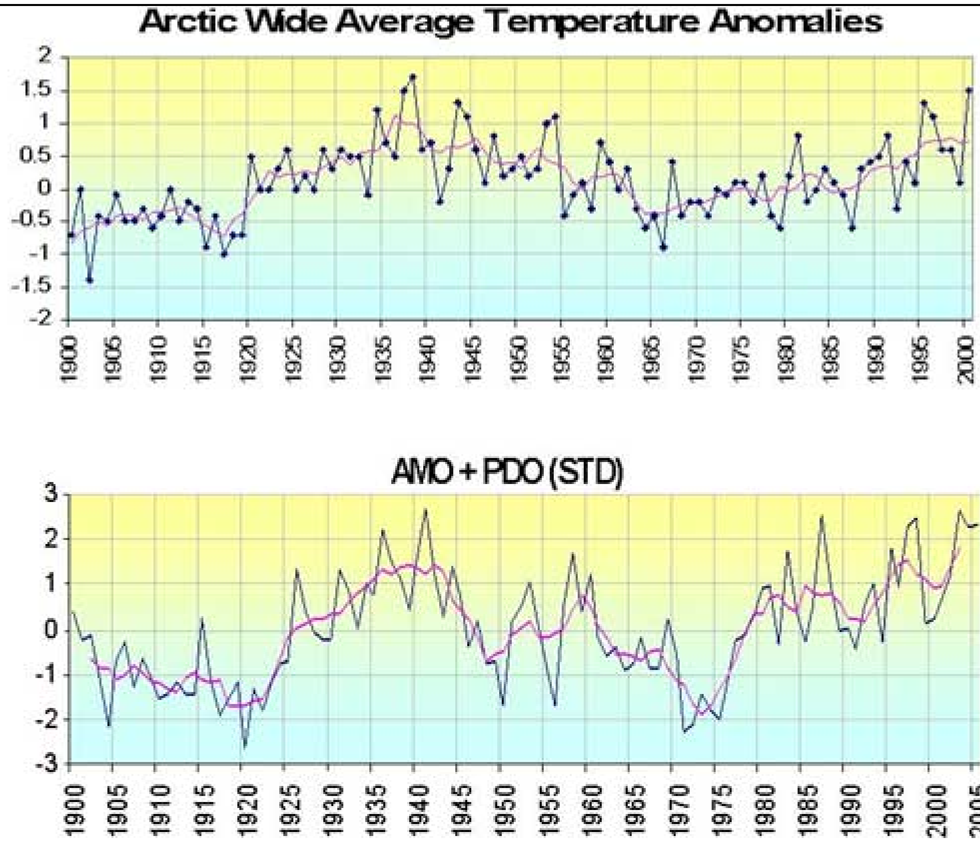


*Figure 4: Arctic basin wide temperatures from Polyakov (2003) versus PDO+AMO (STD). Dark blue is annual and purple 5 year running means.*

Karlen (2005) reported on historical temperatures in Svalbard (Lufthavn, at 78 deg N latitude), claiming that the area represents a large portion of the Arctic. It is reported that the “mean annual temperature increased rapidly from the 1910s to the late 1930s." Later, temperatures dropped, “and a minimum was reached around 1970." Once again, "Svalbard thereafter became warmer, but the mean temperature in the late 1990s was still slightly cooler than it was in the late 1930s."

Karlen goes on to say that similar trends (warm 1930s, cooling until about 1970, minor warming since) have occurred in Arctic areas of the North Atlantic, in northern Siberia, and in Alaska. At Stockholm, where records go back 250 years, "changes of the same magnitude as in the 1900s occurred between 1770 and 1800, and distinct but smaller fluctuations occurred around 1825."

Finally, in view of the fact that "during the 50 years in which the atmospheric concentration of CO2 has increased considerably, the temperature has decreased," Karlen concludes that "the Arctic temperature data do not support the models predicting that there will be a critical future warming of the climate because of an increased concentration of CO2 in the atmosphere."

Drinkwater (2006) concluded that "in the 1920s and 1930s, there was a dramatic warming of the air and ocean temperatures in the northern North Atlantic and the high Arctic, with the largest changes occurring north of 60°N," which "led to reduced ice cover in the Arctic and subarctic regions and higher sea temperatures." This was “the most significant regime shift experienced in the North Atlantic in the 20th century."

During the late 1920s, "average air temperatures began to rise rapidly and continued to do so through the 1930s." In this period, "mean annual air temperatures increased by approximately

0.5-1°C and the cumulative sums of anomalies varied from 1.5 to 6°C between 1920 and 1940 with the higher values occurring in West Greenland and Iceland." Later, "through the 1940s and 1950s air temperatures in the northernmost regions varied but generally remained relatively high." Temperatures declined in the late 1960s in the northwest Atlantic and somewhat earlier in the northeast Atlantic.

Hanna, et al (2006) estimated Sea Surface Temperatures (SSTs) near Iceland over a 119-year period based on measurements made at ten coastal stations located between latitudes 63°'N and 67°'N. They concluded that there had been “generally cold conditions during the late nineteenth and early twentieth centuries; strong warming in the 1920s, with peak SSTs typically being attained around 1940; and cooling thereafter until the 1970s, followed once again by warming - but not generally back up to the level of the 1930s/1940s warm period."

***THE EFFECT ON ICE COVER***

Both the Atlantic and Pacific play roles in arctic ice extent.

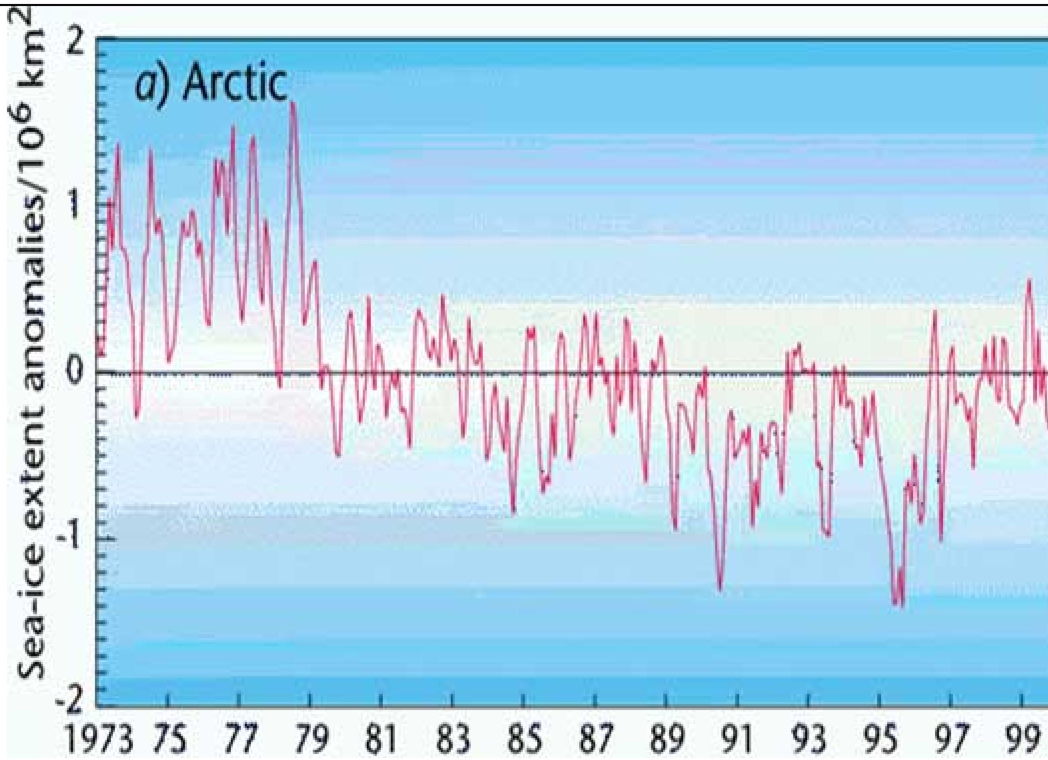


*Figure 5: USGCRP Arctic sea ice extent (2000)*

The sea ice extent diminished following the Great Pacific Climate Shift (flip of the PDO to positive) in the late 1970s (figure 5). It stayed relatively stable until the last few years when a more precipitous decline began (figure 6), related to a spike in North Atlantic warmth and a positive AO.

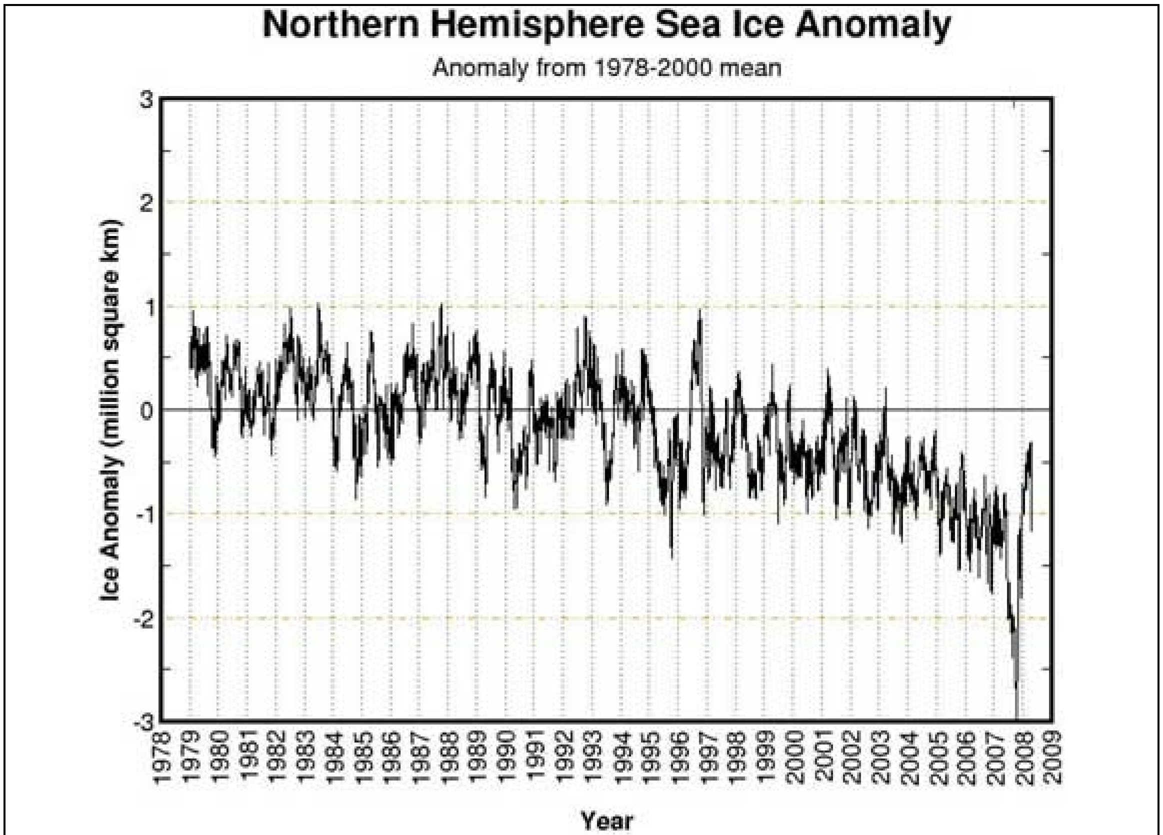

*Figure 6: Northern Hemispheric Sea Ice Anomaly (UIUC Cryosphere)*

Dmitrenko and Polyokov (2003) observed that warm Atlantic water in the early 2000s from the warm AMO that developed in the middle 1990s had made its way under the ice to off of the arctic coast of Siberia where it thinned the ice by 30% much as it did when it happened in the last warm AMO period from the 1880s to 1930s. Polyakov had previously concluded (2002)

> *"Arctic and northern hemispheric air-temperature trends during the 20th century (when multi-decadal variability had little net effect on computed trends) are similar, and do not support the predicted polar amplification of global warming. The possible moderating role of sea ice cannot be conclusively identified with existing data. If long-term trends are accepted as a valid measure of climate change, then the SAT and ice data do not support the proposed polar amplification of global warming."*

Rutger's Jennifer Frances (GRL) in 2007 showed how the warming in the arctic and the enhanced ice melting was in part the result of warm water (+3C) in the Barents Sea in the far North Atlantic moving into the Siberian arctic. The positive feedback of changed "albedo" or reflectivity due to open water then acts to enhance the warming.

We can see in figure 7 how the Atlantic warmth peaked in 2004 and 2005 several years ahead of the major decline. Cooling since suggests the ice may slowly recover year to year.

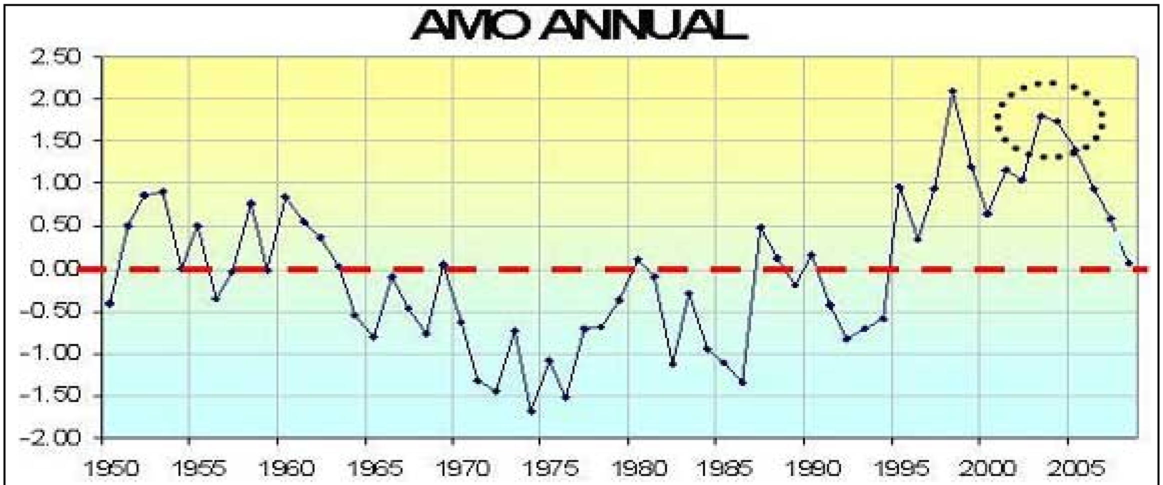


*Figure 7: Annual Average AMO*

The University of Colorado's National Snow and Ice Data Center (NSIDC) summarized the role of the ocean cycles very well in October 2007 in this way:

> *"One prominent researcher, Igor Polyakov at the University of Fairbanks, Alaska, points out that pulses of unusually warm water have been entering the Arctic Ocean from the Atlantic, which several years later are seen in the ocean north of Siberia. These pulses of water are helping to heat the upper Arctic Ocean, contributing to summer ice melt and helping to reduce winter ice growth.*
>
> *Another scientist, Koji Shimada of the Japan Agency for Marine–Earth Science and Technology, reports evidence of changes in ocean circulation in the Pacific side of the Arctic Ocean. Through a complex interaction with declining sea ice, warm water entering the Arctic Ocean through Bering Strait in summer is being shunted from the Alaskan coast into the Arctic Ocean, where it fosters further ice loss.*
>
> *Many questions still remain to be answered, but these changes in ocean circulation may be important keys for understanding the observed loss of Arctic sea ice."*

*Figure 8: What Me Worry?*

**SUMMARY**

Multidecadal Oscillations in the Pacific and the Atlantic are acknowledged to be the result of natural processes. We have shown the warm phase of the PDO leads to more El Ninos and general warmth and the cold phase to more La Ninas and widespread coolness. The warm mode of the AMO also produces general warmth across much of the Northern Hemisphere including Greenland and the Arctic. When you combine the two cycles, you can explain much of the temperature variances of the past 110 years for the United States, Greenland and the Arctic.

Warm waters from both ocean basins during the ocean's warm modes contribute to periodic summer ice decreases approximately every 60 years going back two hundred years.

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