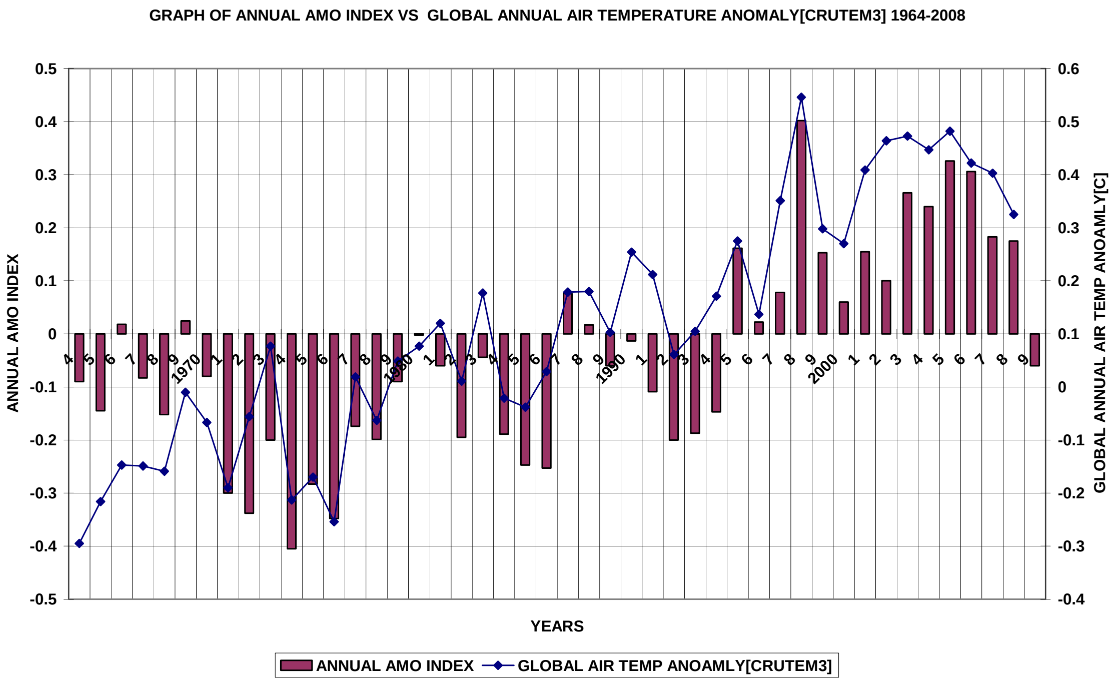
AMO, THE KEY GLOBAL CLIMATE INDICATOR

The AMO is an ongoing series of long-duration changes in the sea surface temperature of the North Atlantic Ocean, with cool and warm phases that may last for 20-40 years at a time and a difference of about 1°F between extremes. These changes are natural and have been occurring for at least the last 1,000 years. [per NOAA].

The AMO index is calculated at NOAAPSD by using the Kaplan SST data set [5x5], determining the area weighted average over the North Atlantic over 0-70N and then detrending this data.

The average AMO index or the Atlantic Multidecadal Oscillation index went negative or cool in January 2009 The average for the first 5 months this year is about [-0.06] . It has been cooling since 2003. In the past, the very cold seasons of North America and especially the East coast happened when the annual average AMO went cool [as low as -0 .405] in the 1970's. It seems that this level of cool AMO may be several years off as the AMO cooling rate appears to be still slow. Back in 1964 it took about 8 years before the AMO went to [- 0.3] by 1971.Review of other periods for similar rates of decline of the AMO show a spread of about 2-8 years. However the solar activity was much higher during 1964-1972 and things may cool down faster currently with extended solar minimum and anticipated low future solar cycles. If AMO does drop faster, then the cold weather like 1964-1979 may be the norm here much sooner and the East Coast will cool down as well as will the globe. The most sustained number of low AMO levels was during the cold spell of 1902 -1925 and again the 1970's.

The graph below shows how closely Annual Global Air Temperature Anomalies [Crutem3] follow the Atlantic Multidecadal Oscillation Index [AMO].



Extreme AMO levels both cool and warm have clearly affected each of the following warm and cool global periods to account for the extreme global temperature anomalies Note that all AMO levels shown are **annual average** figures.

RECORD AMO LEVELS DURING RECENT EXTREME WARM AND COLD PERIODS

1900-1926 COOL PERIODS [AMO NEGATIVE]
Lowest global temperature anomalies ever especially 1902-1913

1904 -0.345[4th lowest ever
1913 -0 .386[2ND lowest ever]
1920 -0.330[6th lowest ever

1926-1944 WARM PERIOD [AMO POSITIVE]
[Last global warming period prior to the 1994-2008 warming, the period of the 1930's drought & dust bowl]

1944 0.360 2nd warmest]
1937 0.304 6th warmest ever]

1964-1976 COOL PERIOD [AMO NEGATIVE]
[Latest cool phase post early 1900's especially 1964-1976]

1974- 0.405[lowest ever]
1976-0.349 [3rd lowest ever]
1972 –0.338[5th lowest]

1994 -2008 WARM PERIOD [AMO POSITIVE]
[Latest global warming period]

1998 0.402[highest ever]
2005 0.326[3rd highest]
2006 0.306[4th highest
2003 0.266[8th highest]
2004 0.240[10th highest

YEARS WITH THE WARMEST SINGLE MONTH AMO

1878	0.636	
1937	0.622	
1998	0.562	WARMEST YEAR EVER
2003	0 .504	YEAR OF EUROPEAN HEAT SPELL
2005	0.503	SECOND WARMEST YEAR

YEARS WITH THE COLDEST SINGLE MONTH AMO

1913	-0.563	10 Th COLDEST YEAR GLOBAL
1974	-0.495	2ND COLDEST YEAR IN LAST 30 YEARS
1904	-0.474	4TH COLDEST YEAR GLOBAL
1976	-0.464	COLDEST YEAR IN LAST 30 YEARS
1972	-0..460	COLDEST YEAR IN CANADA 1948-2008

GLOBAL WARMING EXPLAINED

IPCC said that “Eleven of the last twelve years [1995-2006] rank among the twelve warmest years in the instrumental record of global surface temperature [since 1850]” However, 13 OF THE WARMEST GLOBAL AIR TEMPERATURES happened during the 14 year period JAN 1995- DEC 2008 when **PDO and AMO were essentially both warm or positive** * and accounts for the global warming and the temperature records . Five of the 10 highest ANNUAL AMO levels occurred during this recent global warming period

The numbers below show how the 3 highest monthly global temperature records were accompanied by 3 of the 5 highest single AMO index readings ever .Only1878 and 1937 had the higher monthly AMO levels. The single PDO readings were also high [around 2.0] during these peak periods.

1998 Highest Temperature anomaly [0.546C] AMO [0.562 3rd highest]

2005 Second Highest Temperature anomaly [0 .482C] AMO [0.503 5TH highest]

2003 Third Highest Temperature anomaly [0.473C] AMO [0.504 4th Highest]

As one can see there was a similar warming period in 1926-1944.
So global warming existed well before manmade green house gases started to rise after the 1940's

OUTLOOK FOR THE FUTURE

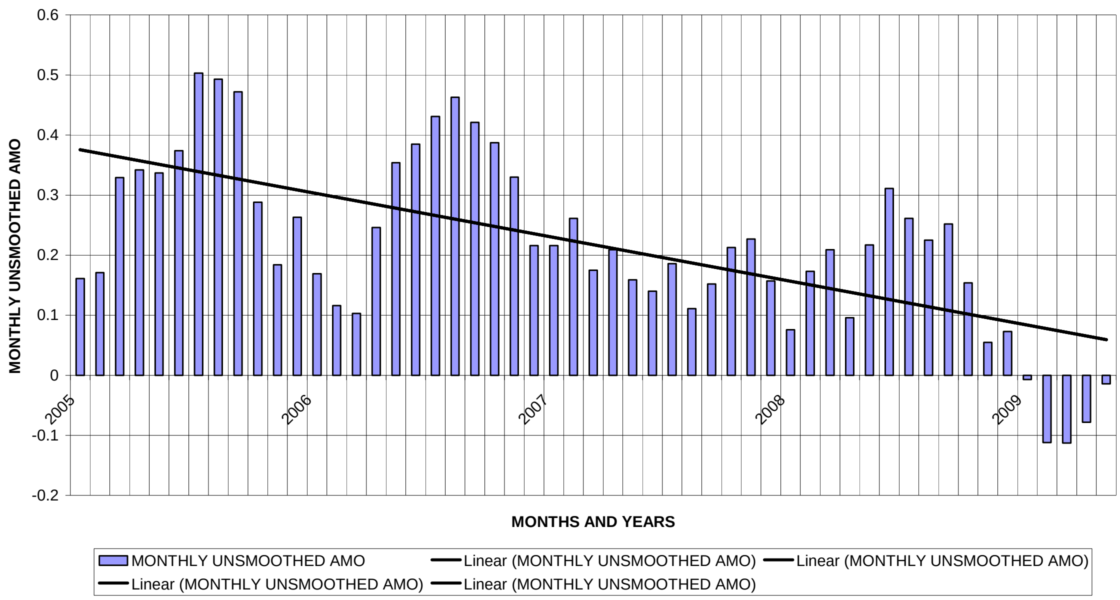
Unlike the PDO, numerical models have been unable to predict AMO cycles with any accuracy. There are only about 130-150 years of data based on instrument data which are too few samples for conventional statistical approaches. With aid of multi –century proxy reconstruction, a longer period of 424 years was used by Enfield and Cid –Serrano to develop an approach as described in their paper called, *The Probabilistic Projection of Climate Risk*. [See reference below.] Their histogram of zero crossing intervals from a set of five re-sampled and smoothed version of Gray et al(2004) index together with the maximum-likelihood [MLE] gamma distribution fit to the histogram, showed that the largest frequency of regime interval was around 10 –20 year. The cumulative probability for all intervals 20 years or less was about 70 % .

The last interval change was 1994 or about 15 years ago and according to their work, the probability that AMO will switch to cool in 15 years is about 80 % .

Based on this analysis , there is a high probability that the current cooling phase of AMO which started in 2009 is real and likely sustainable for the next 20 years at least.

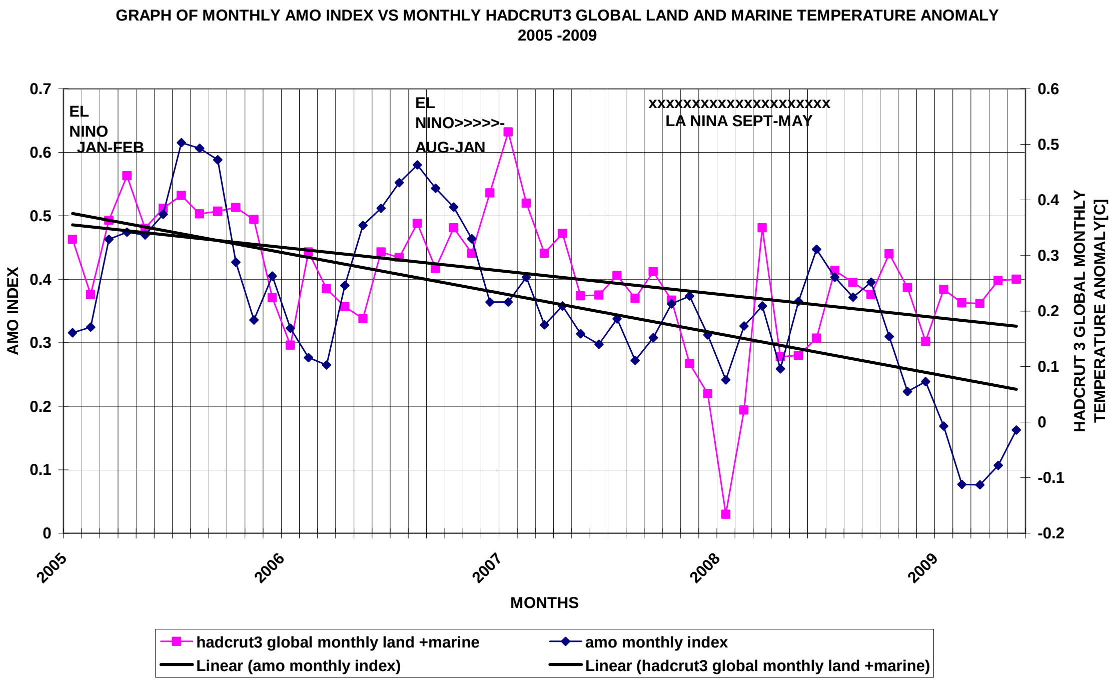
The graph below shows the decline of the AMO index from warm to cool between 2005 and 2009

PLOT OF UNSMOOTHED MONTHLY AMO PER KAPLAN SST V2[NOAA/ESRL/PSD1] YEARS 2005-2009



The main climate indicator in my opinion in the near term] is likely going to be the cool AMO, cool PDO. ENSO events and the changing polar jet stream which swings more often now north before coming south or heading east, bringing cold air to most of North America, and specially the western half and subsequently east, as the our climate moves from west to east.

The graph below shows the relationship between AMO and GLOBAL [land and marine] TEMPERATURE ANOAMLIES [Hadcrut 3]. AMO appears to be like a thermostat or predictor of global temperatures. ENSO events if moderate or strong seem to modify, amplify or over-ride the AMO effects.



This pattern will continue to bring cool yearly temperatures and colder and snowy winters like 2008 and 2009. My best guess is that the climate of the 1960'and 1970's will be our climate for the next several decades [2-3] at least, and inter-dispersed with periodic warm years. PDO and AMO readings are of limited value for short term use but quite useful and accurate for decadal forecasts .Currently 2009 looks something like 1971 [cool PDO, low cool/ near neutral AMO] and the rest of this decade looks like the 1970's if you had pick one decade from the past . The 1960's and the 1950 are also close behind .I also see that during the next few years, the AMO may go down to - 0.4 to -0.5 and PDO's down to -2 to -2.5. La Nina's may return and more often than El Nino's [like in 1970-1976]. If this happens, then the polar jet stream often splits into two parts with the lower branch bringing more rain, snow and cooler weather to the US North west and the upper or north branch which still goes north to Alaska and Yukon and then south, bringing cold air to the western half Canada and the US.

POSSIBILTY OF AN EL NINO 2009-2010

There has been an El Nino within about 12 months after each of the last four solar minimums. The same pattern seems to be developing again now.

If an El Nino does develop later this year or early 2010, it may be a moderate or weak and short lived [about a year].It may have a minor effect on global temperatures , like in the period 1965-1966 when US temperatures continued to drop despite the El Nino.

This latest period of cooler weather is not the start of some modern ice age or new grand cold minimum but just another cool cycle of the planet that happens about after every 20-30 years more recently when AMO and PDO are both in the cool mode simultaneously. The coldest last such cycle 1902-1925 when AMO hit a single month low of -0.563 and PDO went down to -1.72 and global air temperature anomalies plummeted to -0.581 C [crutem3] in 1911. Other such cool periods occurred 1964-1976 and also much earlier during the Dalton and Maunder Minimums.

BACKGROUNDER ON AMO

FREQUENTLY ASKED QUESTIONS ABOUT THE ATLANTIC MULTIDECADAL OSCILLATION [AMO] PARTIALLY REPRODUCED HERE PER NOAA WEBPAGE

*The AMO is an ongoing series of **long-duration changes in the sea surface temperature** of the North Atlantic Ocean, with cool and warm phases that may last for 20-40 years at a time and a difference of about 1°F between extremes. These changes are natural and have been occurring for at least the last 1,000 years.*

How much of the Atlantic are we talking about?

Most of the Atlantic between the equator and Greenland changes in unison. Some area of the North Pacific also seem to be affected.

What phase are we in right now?

Since the mid-1990s we have been in a warm phase.

What are the impacts of the AMO?

*The AMO has affected air temperatures and rainfall over much of the Northern Hemisphere, in particular, **North America and Europe**. It is associated with changes in the frequency of North American droughts and is reflected in the frequency of severe Atlantic hurricanes. It alternately **obscures and exaggerates** the global increase in temperatures due to human-induced global warming.*

How does the AMO affect rainfall and droughts?

Recent research suggests that the AMO is related to the past occurrence of major droughts in the Midwest and the Southwest. When the AMO is in its warm phase, these droughts tend to be more frequent and/or severe (prolonged?). Vice-versa for negative AMO. Two of the most severe droughts of the 20th century occurred during the positive AMO between 1925 and 1965: The Dustbowl of the 1930s and the 1950s drought. Florida and the Pacific Northwest tend to be the opposite - warm AMO, more rainfall.

How does the AMO affect Florida?

*The AMO has a strong effect on Florida rainfall. Rainfall in central and south Florida becomes more plentiful when the Atlantic is in its warm phase and droughts and wildfires are more frequent in the cool phase. As a result of these variations, the inflow to Lake Okeechobee - which regulates South Florida water - **changes by 40% between AMO extremes**. In northern Florida the relationship begins to reverse - less rainfall when the Atlantic is warm.*
http://www.aoml.noaa.gov/phod/amo_faq.php

AMO EFFECT ON THE 2003 EUROPEAN HEAT WAVE and NORTH AMERICAN CLIMATE

Quotes from paper called *Atlantic Ocean Forcing of North American and European Summer Climate* by

Rowan T. Sutton[*] and Daniel L. R. Hodson

..for the particular decadal change considered (1931 to 1960 compared with 1961 to 1990), the Atlantic Ocean was the dominant oceanic influence on summertime climate in the regions

Overall, our results provide strong evidence that during the 20th century the AMO had an important role in modulating boreal summer climate on multi-decadal time scales. We have focused here on time mean anomalies, but some of the most important impacts are likely to be associated with changes in the frequency of extreme events. There is evidence that the frequency of U.S. droughts and the frequency of European heat waves) are both sensitive to Atlantic SSTs.

Our results suggest, for example, that the change in phase of the AMO in the 1960s may have caused a cooling of U.S. and European summer climate; a further change in the AMO[AMO went warm in 1994] may have contributed to recent warming in these regions.
http://www.sciencemag.org/cgi/content/full/309/5731/115

EL NINO EFFECTS IN CANADA

During the winter of an El Nino event, the air temperature tends to be warm over most of Canada, with the greatest warming centered on Manitoba-western Ontario, where a temperature anomaly of up to +3 degrees Celsius (averaged over the last nine El Nino events) can be found (Hoerling et al., 1997; Shabbar and Khandekar, 1996). Southern Canada also tends to be drier during an El Nino winter (Shabbar et al., 1997). Southern British Columbia tends to receive less snow (Hsieh and Tang, 1999).

http://www.msc.ec.gc.ca/education/elnino/canadian/region/index_mean_e.cfm?region=southern_bc

THE PROBABALISTIC PROJECTION OF CLIMATE RISK
By David B. Enfield and Luis Cid-Serrano
http://www.usclivar.org/Newsletter/Variations_V3N3/Enfield.pdf
Quote fro opening paragraph
The last 15 years have seen much research on decadal to multidecadal (D2M) climate modes and their global and regional impacts. At least some of these D2M modes suggest compelling climatic and ecological impacts. Both the Pacific Decadal Oscillation (PDO) and the Atlantic Multidecadal Oscillation (AMO) are associated with alternating trans-decadal regimes in precipitation and drought frequency, which appear to be sensitive to small but persistent changes in the prevalent atmospheric circulation patterns over the continental regions adjacent to the oceans that mediate the oscillations. They have also been shown to modulate (render nonstationary) the rainfall signatures of El Niño-Southern Oscillation (ENSO) in the United States and they are reflected in the multidecadal changes in North Pacific fisheries. Of concern for climate applications is the fact that — unlike El Niño-Southern Oscillation (ENSO) —

numerical models have proven incapable of predicting future phase shifts of D2M climate modes in a deterministic manner.

The alternatives to such predictions are probability-based projections, but these are hampered because the instrumentally based time series are limited to the last 130-150 years,

Figure captions

Fig. 2*: histogram (vertical bars) of zero crossing intervals from a set of five resampled and smoothed versions of the Gray et al. (2004) index and the maximum likelihood (MLE) gamma probability distribution (solid curve) fit to the histogram.*