This Week in Weather

The Relationship of the PDO to El Nino and La Nina Frequency

By Joe D'Aleo
Monday, April 28, 2008
EL NINO DOMINANCE SINCE THE LATE 1970S EXPLAINED

John McLean in a paper here reported Australia's CSIRO and Bureau of Meteorology (Power and Smith 2007) wrote about a period of unprecedented El Niño dominance the last 30 years, which they blamed on human activity. Vecchi (2006, 2007) speculated there was a just 1% probability that this was due to natural events.

McLean's paper and the following discussion will show how the change had precious little to do with anthropogenic factors but was the result of a natural large scale cyclical climate flip-flop known now as the Pacific Decadal Oscillation.

The first hint of a basin wide cycle was a recognition of a major regime change in the Pacific in 1977 among climatologists that became known as the Great Pacific Climate Shift. Later on this shift was shown to be part of a cyclical regime change given the name Pacific Decadal Oscillation by Mantua (1997). This followed research first showing decadal like ENSO variability by Zhang in 1993.

Mantua found the Pacific Ocean temperature regime and overlying pressure patterns tended to persist in one mode (in terms of ocean temperature anomalies and overlying pressure and wind patterns) for two or three decades and then flip to very nearly the opposite mode for a similar period.

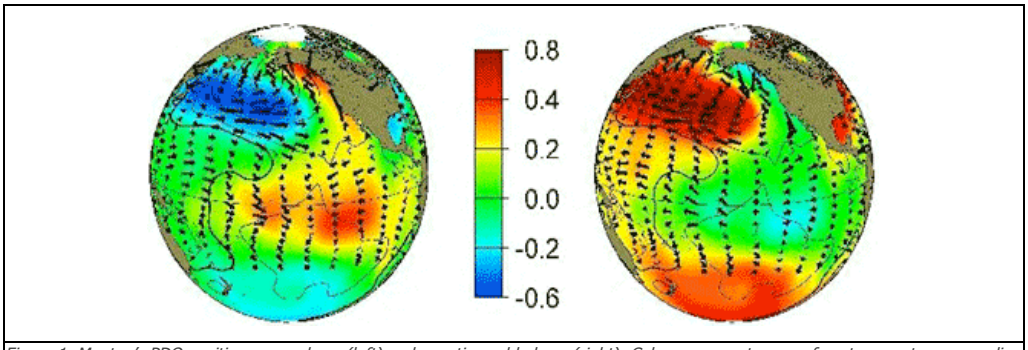

Figure 1: Mantua's PDO positive warm phase (left) and negative cold phase (right). Colors represent sea surface temperature anomalies (reds are warmer than normal, blues colder than normal)

They discovered that in the 20th century, the PDO tended to be predominantly positive from 1922 to 1947 and negative from 1947 to 1977 and then positive most of the time since 1977.

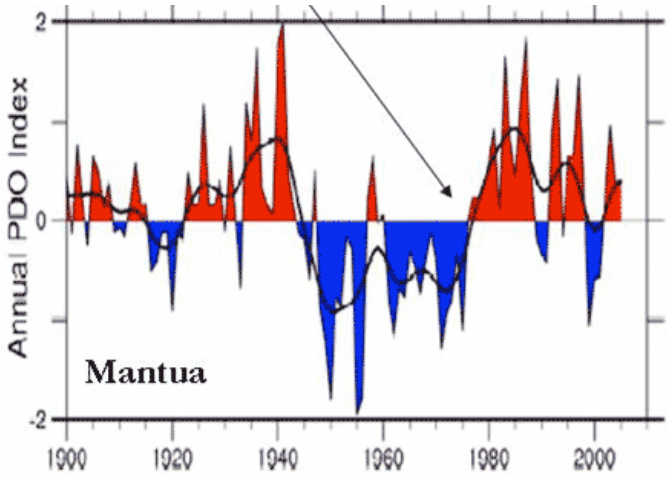

Figure 2: The PDO since 1900. Note the dominant warm regime from 1922 to 1947, cold from 1947 to 1977 and then mainly warm from 1997 to 2006. The arrow points to the Great Pacific Climate Shift around 1977.

Temperatures during the positive warm mode tend to be above normal in the tropical Pacific and along the west coast of North America to Alaska but cooler than normal in the southeast United States. The opposite occurs in the negative cold mode.

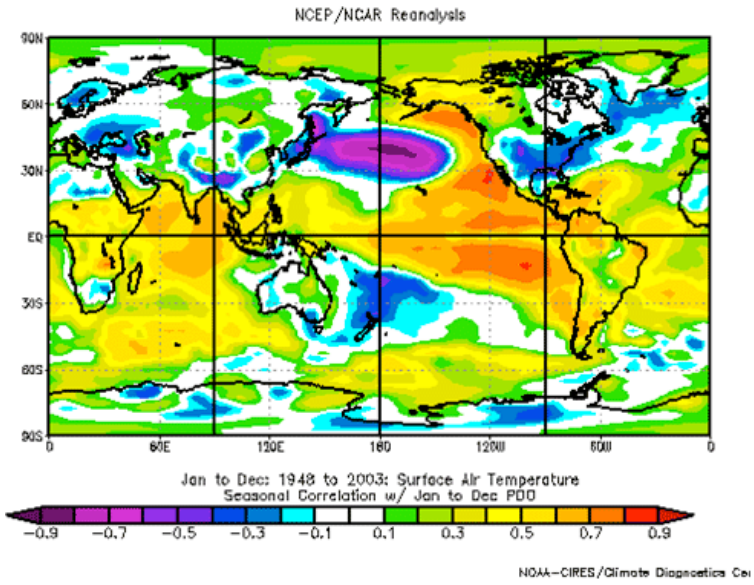

Figure 3: The global temperature regimes during the warm phase of the PDO as provided by NOAA CIRES CDC. Note the tendency for a warm tropical Pacific, warmth in Alaska but a cool southeast United States.

Global temperatures have followed this cycle very well. It warmed during the warm mode from 1922 to 1947, cooled during the cold mode after a few years till a few years after the Great Pacific Climate Shift in 1977, warmed after a few years into the warm PDO mode after 1980.

Actual average temperatures in the decades since the Great Pacific Climate Shift match this pattern very well.

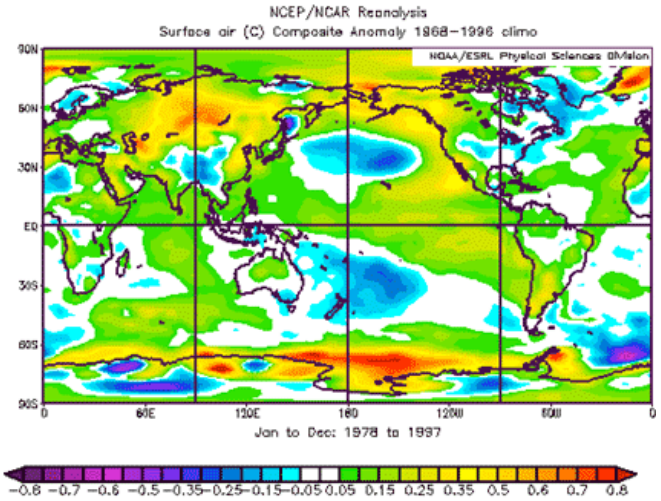

Figure 4: Actual annual global temperature anomalies after the Great Pacific Climate Shift in 1977 to 1997. Note the warm tropical Pacific and Alaska as well as the tendency for cooler than normal conditions in the southeast United States.

The IPCC in their latest report (2007) also showed how during the positive phase of the PDO, the sea surface temperature pattern suggested more warmth in the eastern tropical Pacific (thus more El Ninos).

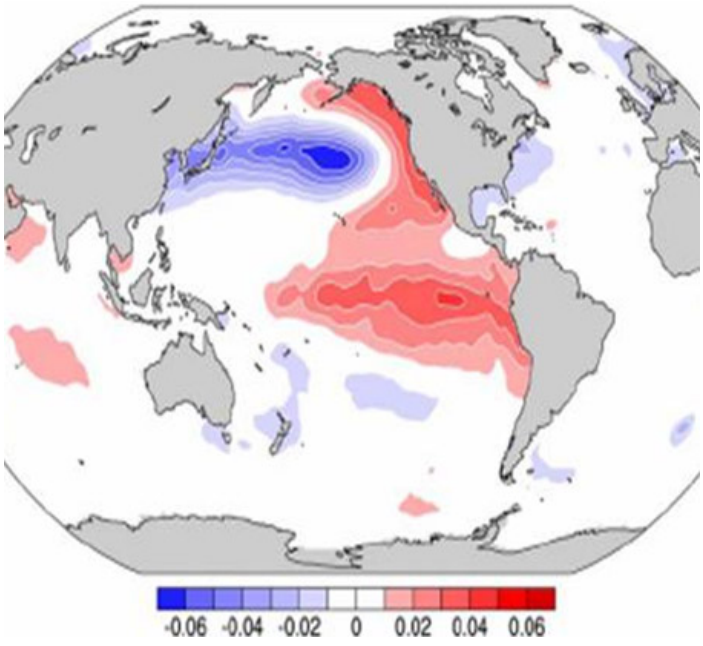

Figure 5: IPCC AR4 analysis of sea surface temperature anomalies during the warm phase of the PDO. Note the tendency for warmth in the eastern tropical Pacific, implying more El Ninos.

Wolter's Multivariate ENSO Index indeed shows a greater frequency of El Ninos (positive MEI values in red) during the warm phase and the opposite, more La Ninas in the cold phase (negative MEI values in blue), when the reverse of the sea surface anomaly pattern above dominates.

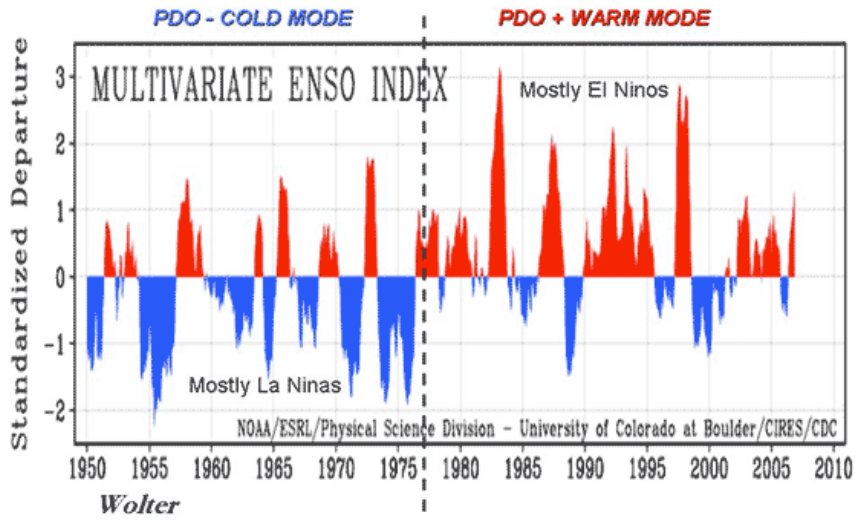

Figure 6: Wolter's Multivariate ENSO Index (MEI) plotted since 1950. Cold phase of the PDO lasted until 1976 followed by the warm phase. The more significant positive spikes (red) are El Ninos and negative (blue) La Nina

This shows about twice as many El Ninos as La Ninas during the positive PDO and nearly three times as many strong El Ninos and La Ninas. The opposite occurred during the prior cold PDO regime.

It is well know that El Ninos with their large expanse of warm tropical waters leads to global warmth and La Ninas global cooling. This can be seen in the Spence and Christy's MSU satellite derived temperature plot (available only during the warm mode since 1979). The two prolonged cold spells in the early 1980s and 1990s were related to major volcanic activity (Mt. St. Helens/El Chichon in early 1980s and Pinatubo/Cerro Hudson in early 1990s).

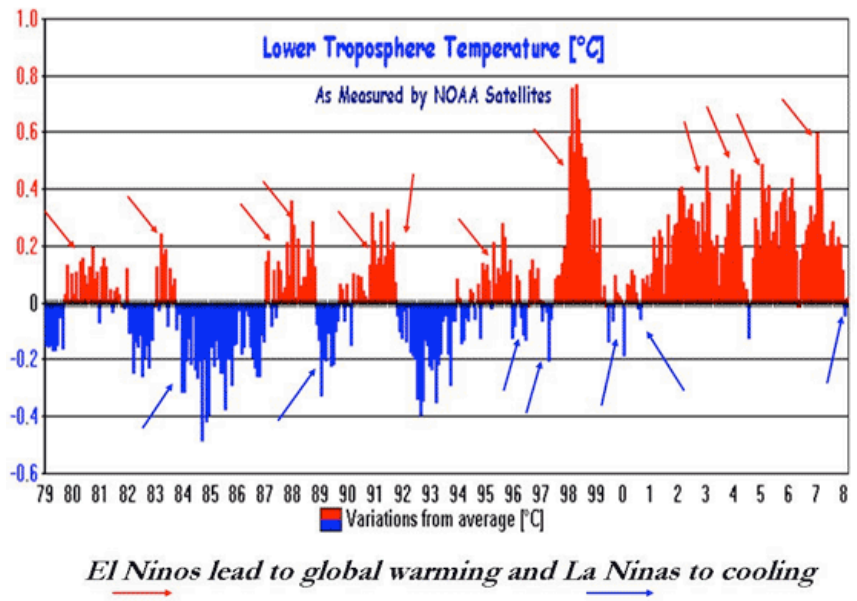

Figure 7: University of Alabama MSU satellite derived lower tropospheric temperatures variations from average. El Ninos are marked with red arrows, La Nina with blue arrows.

HAVE WE EXPERIENCED GREAT PACIFIC CLIMATE SHIFT II – A REGIME CHANGE IN PDO?

The PDO appears to have changed back to the cold mode in 1998 following the Super El Nino of 1997/98. Three straight years of La Nina followed. PDO bounced some during the early 2000s but this year dropped off dramatically again this past year as a strong La Nina developed. Since it is 30 years since the last climate shift, it appears likely this negative mode should continue.

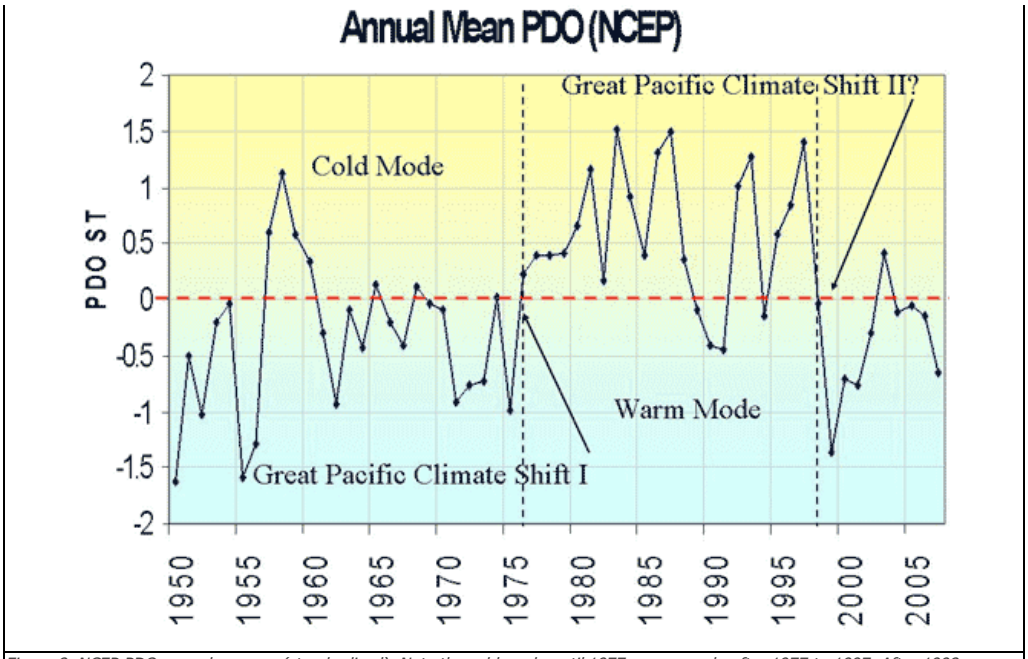

Figure 8: NCEP PDO annual average (standardized), Note the cold mode until 1977, warm mode after 1977 to 1997. After 1998, we have been mostly neutral to negative

If this regime change has indeed taken place, this would mean there would be more, stronger La Ninas and fewer, mainly weaker El Ninos in the next few decades. This would imply a cooling of global temperatures much as we saw in the last cool negative PDO phase from 1947 to 1977. Temperatures have not warmed since 1998 globally.

Note the similarity of the global temperature trends to this pattern with a spike in 1998 with the super El Nino, a big dip in the late 1990s to 2001 with a drop of PDO and moderately strong La Ninas, followed by a rise again with a PDO bounce and three El Ninos in the early 2000s until the La Nino and drop in PDO again this past year.

Notice also the lack of correlation of CO2 with the global temperatures (satellite derived lower tropospheric temperatures and Hadley land and ocean temperatures) the last decade. Even the head of the IPCC, Rajendra Pachauri noted this disconnect with carbon dioxide and suggested that we needed to see if some natural factors were offsetting greenhouse warming.

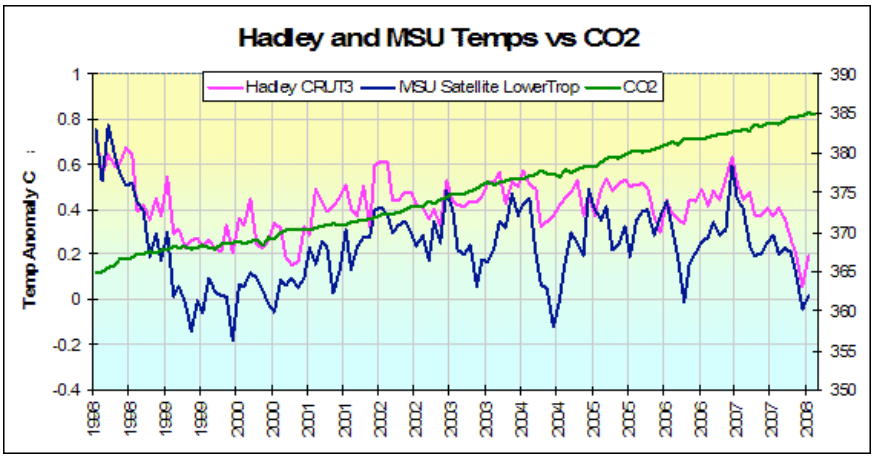

Figure 9: University of Alabama MSU satellite derived lower tropospheric temperatures variations from average. Hadley Center CRU land and ocean global temperature anomalies and Scripps seasonally adjusted CO2 .

The decadal correlation strengths (r-squared) of both the Hadley and MSU satellite with the corresponding CO2 is non-existent (r2=0.00). If you start in 2000 at the coldest point of the last decade, this does not significantly change (r2=0.01 for the Hadley and r2=0.08 for MSU). Co2 increased 5.5% during this decade and man-made emissions were said to be up 22%.

See how well the temperatures did correlate well with the El Ninos and La Ninas during that decade.

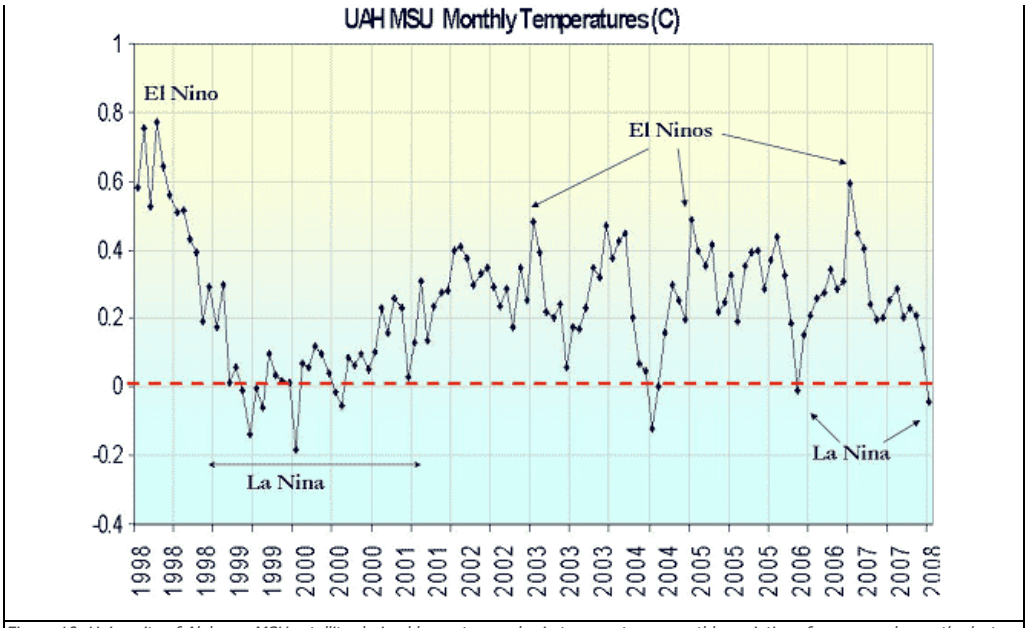

Figure 10: University of Alabama MSU satellite derived lower tropospheric temperatures monthly variations from normal over the last decade. Note how well the spikes line up with El Ninos and dips with La Ninas.

BUOYS AND GLOBAL TEMPERATURE COOLING SINCE 2003

Josh Willis of NOAA JPL recently reportedsome 3,000 scientific robots suggest that the oceans have not warmed up at all over the past four or five years (since deployment in 2003). "That could mean global warming has taken a breather." In actual fact the buoys are reporting a slight cooling. It is worth noting that Roger Pielke Sr. has advocated ocean heat content as a better measure of the global changes in temperatures than surface station based trends which are subject to contamination by urbanization, land use changes, poor siting or unaccounted for siting changes which not less than a half dozen peer-review papers in recent years suggest account for 30-50% of the measured warming the last century. Surface temperature trends from both Hadley and satellite (UAH MSU) agree with the buoy cooling the last 5 years.

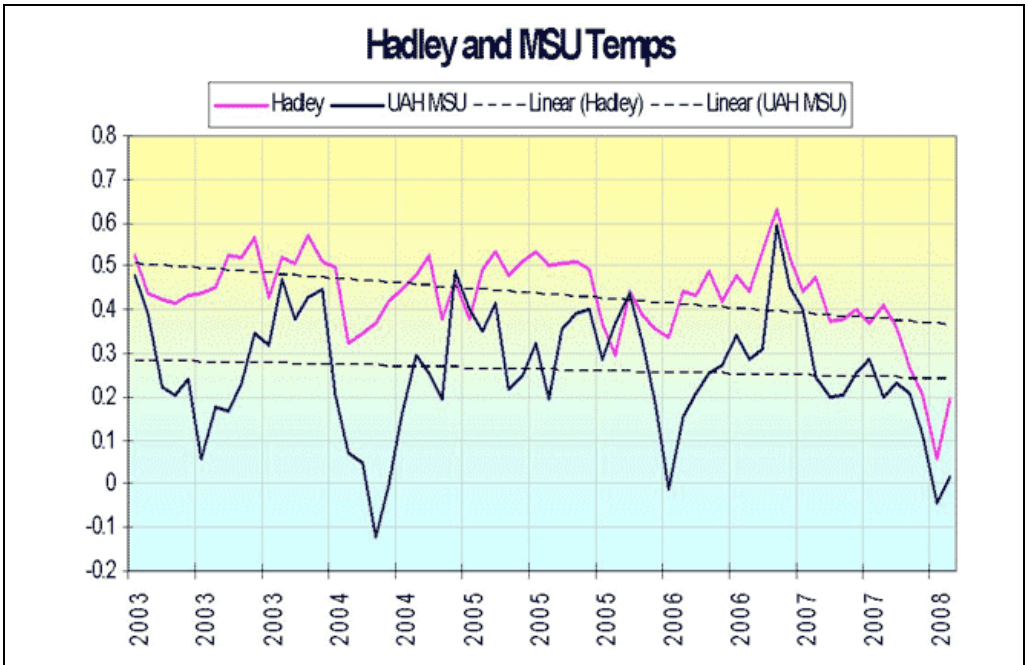

Figure 11: University of Alabama MSU satellite derived lower tropospheric temperatures monthly variations from normal and Hadley global temperature monthly anomalies since 2003. Linear trendlines support the buoy suggested cooling since 2003.

SUMMARY AND CONCLUSION

The Pacific Decadal Oscillation was shown to relate to the frequency of El Ninos and La Ninas and through them to global temperatures.

The big question for the climate and seasonal weather over the future (years and decades) depends in part on

whether the Pacific regime change first shown in 1998 and repeating now this time has legs. If it does, our climate will be characterized by more La Ninas and fewer El Ninos and further cooling. Those of you who were around before 1977 in the cold era with frequent La Ninas will have recognized the pattern this past winter and we will all get to see it more often than not in the years ahead.

Next week, will look at the Atlantic Multidecadal Oscillation. We will address how the PDO and AMO work together to influence hurricanes, global temperatures and arctic temperatures and sea ice.

References:

Mantua, N.J. and S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis,1997: Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society, 78, pp. 1069-1079.

McPhaden, M.J and D. Zhang (2002), "Slowdown of the meridional overturning circulation in the upper Pacific Ocean", Nature, 415(7), 603–608 (2002).

Miller, A.J., D.R. Cayan, T.P. Barnett, N.E. Graham and J.M. Oberhuber, 1994: The 1976-77 climate shift of the Pacific Ocean. Oceanography 7, 21-26.

Minobe, S. 1997: A 50-70 year climatic oscillation over the North Pacific and North America. Geophysical Research Letters, Vol 24, pp 683-686.

Power, S.B. and I.N. Smith (2007), "Weakening of the Walker Circulation and apparent dominance of El Niño both reach record levels, but has ENSO really changed?" Geophysical Research Letters, vol. 34, L18702, doi:10.1029/2007GL030854, 2007

Vecchi, G.A., B Soden, A.T. Wittenberg, I. M. Held, A. Leetmaa, and M. J. Harrison (2006), "Weakening of Tropical Pacific Atmospheric Circulation Due to Anthropogenic Forcing", Nature, 441, 73–76 (4 May 2006).

Vecchi, G.A. and B Soden (2007), "Global Warming and the Weakening of the Tropical Circulation", Journal of Climate, Vol. 20, (Sep 2007), pp 4316-4340

Wolter, K., and M.S. Timlin, 1993: Monitoring ENSO in COADS with a seasonally adjusted principal component index. Proc. of the 17th Climate Diagnostics Workshop, Norman, OK, NOAA/N MC/CAC, NSSL, Oklahoma Clim. Survey, CIMMS and the School of Meteor., Univ. of Oklahoma, 52-57.

Zhang, Y., J.M. Wallace, D.S. Battisti, 1997: ENSO-like interdecadal variability: 1900-93. Journal of Climate, 10, 1004-1020