# MEDIEVAL WARM PERIOD AND THE WORLD'S OCEANS

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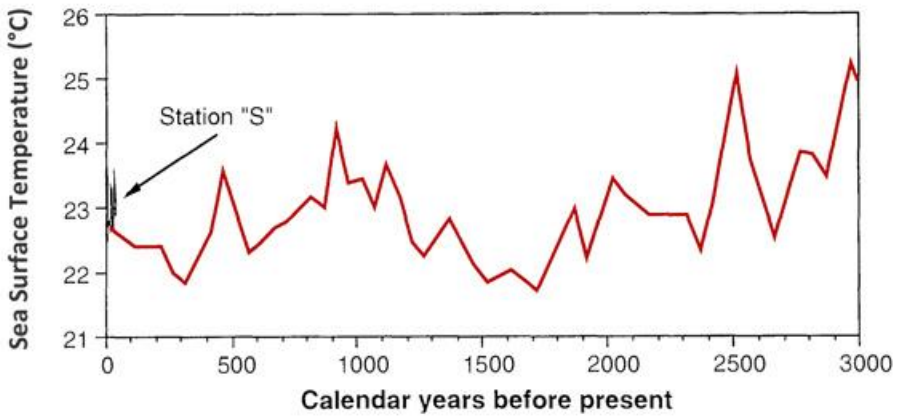
Keigwin (1996)[1] introduced his classic paleoclimatic study of the northern Sargasso Sea by stating that "it is important to document natural climate variability in order to understand the effects of anthropogenic forcing." And, therefore, working with two subcores of a sediment box core retrieved from 33°41.6'N, 57°36.7'W of the undulating plateau of the northeast Bermuda Rise, he measured the oxygen isotope ratios ($\delta^{18}O$) of the white variety of the planktonic foraminifera *Globigerinoides ruber*, which lives year-round in the upper 25 meters of the northern Sargasso Sea and has a relatively constant annual mass flux and shell flux to the sediments. Calibrating these data against temperature and salinity data obtained at Ocean Station "S" (32°N, 62°30'W) over the prior 42 years, he first determined that "temperature accounts for about two-thirds of the isotopic signal, whereas salinity accounts for one-third." And based on these results, he calculated *sea surface temperatures* (SSTs) of the prior three millennia, after which he "stacked the temperature proxy data from the two subcores by averaging results in 50-year bins," obtaining the results below.




*Fifty-year averages of mean annual sea surface temperature calculated from the $\delta^{18}O$ data of the two Bermuda Rise sediment subcores, together with the mean annual SSTs measured at Ocean Station "S" over the period 1954-1996. Adapted from Keigwin (1996).*

As can be seen from this figure, and as Keigwin stated, the northern Sargasso Sea SST "was ~1°C cooler than today ~400 years ago (the Little Ice Age) and 1700 years ago [the Dark Ages Cold Period], and ~1°C warmer than today 1000 years ago (the Medieval Warm Period)." And with respect to his reason for conducting the study, which was *to document natural climate variability in order to understand the effects of anthropogenic forcing*, Keigwin stated that "over the course of three millennia, the range of SST variability in the Sargasso Sea is on the order of twice that measured over recent decades," and, therefore, he concluded that "at least some of

[1] http://www.co2science.org/articles/V13/N50/C3.php.

the warming since the Little Ice Age appears to be part of a natural oscillation." In addition, he said that "because the changes described here for surface waters over the Bermuda Rise are probably typical of a large part of the western Sargasso Sea, they most likely reflect climate change on the basin or hemispheric scale." Thus, one can have a high degree of confidence that the Medieval Warm Period in this particular part of the world - and maybe a much wider region as well - was significantly warmer than what it is there today, and at a time when there was *way* less $CO_2$ in the air than there is currently (about 285 vs. 400 ppm).

At the dawning of the new millennium some four years later, Andren *et al*. (2000)[2] conducted an extensive analysis of changes over time in siliceous microfossil assemblages and chemical characteristics of various materials found in a well-dated sediment core obtained from the Bornholm Basin in the southwestern Baltic Sea; and the data they obtained from that core revealed the existence of a period of high primary production at approximately AD 1050. In addition, the diatoms they identified were warm water species such as *Pseudosolenia calcar-avis*, which they described as "a common tropical and subtropical marine planktonic species" that "cannot be found in the present Baltic Sea." They also noted that what they called the Recent Baltic Sea Stage, which began about AD 1200, started at a point when there was "a major decrease in warm water taxa in the diatom assemblage and an increase in cold water taxa, indicating a shift towards a colder climate," which they associated with the Little Ice Age.

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These data clearly indicated there was a period of time in the early part of the past millennium when the climate in the area of the southwestern Baltic Sea was significantly warmer than it is today, as the sediment record of that time and location contained several warm water species of diatoms, some of which can no longer be found there. This period of higher temperatures, in the words of the three researchers, fell within "a period of early Medieval warmth dated to AD 1000-1100," which they made a point of noting "corresponds to the time when the Vikings succeeded in colonizing Iceland and Greenland." And it should also be noted that this period was one of strikingly high oceanic primary productivity, demonstrating what seems to be the case with both ecosystems and human societies, i.e., that *warmer is better*.

Contemporaneously, Keigwin and Boyle (2000)[3] discussed the evidence for a climate oscillation with a return period on the order of 1,500 to 2,000 years that is evident in proxy climate data

[2] http://www.co2science.org/articles/V4/N3/C2.php.
[3] http://www.co2science.org/articles/V4/N5/C2.php.

pertaining to the last deglaciation and which has continued (with reduced amplitude) through the Holocene, along with its association with contemporaneous changes - demonstrable for the last deglaciation but tenuous for the Holocene - in the thermohaline circulation of the North Atlantic Ocean.

The *Little Ice Age* (LIA) was the most recent cold phase of this persistent climatic phenomenon that may be induced by variations in the production rate of North Atlantic Deep Water. And as the two researchers reported, "mounting evidence indicates that the LIA was a global event, and that its onset was synchronous within a few years in both Greenland and Antarctica." In the Northern Hemisphere, for example, they stated that it was expressed as a 1°C cooling between approximately 1500 and 1900 AD, with a cooling of approximately 1.7°C in Greenland.

Although the immediate cause or causes of the phenomenon have yet to be definitively identified, there is little question but that earth's climate oscillates globally on a millennial time-scale independent of the activities of man, and that the most recent cold phase of that natural oscillation was what we call the Little Ice Age, which was centered on approximately AD 1700 and lasted until about AD 1900. Hence, it was only to be expected that temperatures would have risen over the last century or so, as they indeed have, and that they may continue to rise even further until a warm epoch analogous to the Medieval Warm Period is reached. And to thus say, as climate alarmists often do, that the majority of any warming that may currently be occurring is due to anthropogenic $CO_2$ emissions is even *less* than ill-advised. The same also goes for their infamous "hockey stick history" of earth's temperature variation over the past millennium, which does not even depict the *existence* of either the Medieval Warm Period or the Little Ice Age.

One year later, Doose-Rolinski *et al*. (2001)[4] analyzed a complete and annually-laminated sediment core extracted from the bed of the northeastern Arabian Sea just south southeast of Karachi, Pakistan, using oxygen isotopes of planktonic foraminifera and measurements of long-chain alkenones to derive a detailed sea surface temperature and evaporation history of the area. This work revealed that the greatest temperature fluctuations of the 5,000-year record occurred between 4600 and 3300 years ago and between 500 and 200 years ago, which periods were also the coldest of the record. Of the latter interval, they noted that "in northern and central Europe this period is known as the 'Little Ice Age'," and they stated that their results confirmed the "global effects" of this unique climatic excursion. Also apparent in their temperature history was a period of sustained warmth that prevailed between about 1250 and 950 years ago, which corresponded nicely with the Medieval Warm Period of northern and central Europe.

Three years further down the road, Roncaglia (2004)[5] analyzed variations in organic matter deposition from approximately 6350 cal yr BC to AD 1430 in a sediment core extracted from the Skalafjord, southern Eysturoy, Faroe Islands in an attempt to assess climatic conditions in that part of the North Atlantic from the mid- to late-Holocene. In doing so, she discovered an increase in structured brown phytoclasts, plant tissue and sporomorphs in sediments dating to

[4] http://www.co2science.org/articles/V4/N40/C1.php.
[5] http://www.co2science.org/articles/V7/N37/C2.php.

ca. AD 830-1090, which she considered indicative of "increased terrestrial influx and inland vegetation supporting the idea of improved climatic conditions." In addition, she reported that high "total dinoflagellate cyst concentration and increased absolute amount of loricae of tintinnid and planktonic crustacean eggs occurred at ca. AD 830-1090," concluding that these observations "may suggest increased primary productivity in the waters of the fjord," citing Lewis *et al*. (1990) and Sangiorgi *et al*. (2002). And she thus concluded that the "amelioration of climate conditions" that promoted the enhanced productivity of both land and sea at this time, "may encompass the Medieval Warm Period in the Faroe region," as indeed it does; for the data of Esper *et al*. (2002) show, in *their* words, that the warmest portion of the Medieval Warm Period "covers the interval 950-1045, with the peak occurring around 990."

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In a contemporaneously published paper, Lund and Curry (2004)[6] wrote that "while the Florida Current-Gulf Stream system is arguably one of the most studied features in modern oceanography, almost nothing is known about its behavior on centennial to millennial timescales." To rectify this situation, therefore, the two researchers analyzed planktonic foraminiferal $\delta^{18}O$ time series obtained from three well-dated sediment cores retrieved from the seabed near the Florida Keys (24.4°N, 83.3°W) that covered the past 5200 years. And as they went on to describe it, the isotopic data from the three cores indicated that "the surface Florida Current was denser (colder, saltier or both) during the Little Ice Age than either the Medieval Warm Period or today," and that "when considered with other published results (Keigwin, 1996; deMenocal *et al*., 2000), it is possible that the entire subtropical gyre of the North Atlantic cooled during the Little Ice Age ... perhaps consistent with the simulated effects of reduced solar irradiance (Rind and Overpeck, 1993; Shindell *et al*., 2001)." In addition, they noted that "the coherence and phasing of atmospheric $^{14}C$ production and Florida Current $\delta^{18}O$ during the Late Holocene implies that solar variability may influence Florida Current surface density at frequencies between 1/300 and 1/100 years." Once again, therefore, we have a situation where both centennial- and millennial-scale climatic variability is explained by similar-scale variability in solar activity, much as Bond *et al*. (2001) found for ice-rafting variability in the subpolar North Atlantic, which suggests there is no need to invoke the historical increase in the air's $CO_2$ content to explain the increase in temperature that represents earth's transition from the Little Ice Age to the Current Warm Period.

With the passage of two more years, and working with a sediment core collected at 5°12.07'S, 117°29.20'E in the Indo-Pacific Warm Pool (one of the warmest regions in the modern oceans),

[6] http://www.co2science.org/articles/V8/N45/C3.php.

Newton *et al*. (2006)[7] analyzed planktonic foraminiferal (*Globigerinoides ruber*) Mg/Ca and $\delta^{18}O$ data to derive high-resolution summer sea surface temperature (SST) and salinity histories extending back in time about a thousand years. This work revealed, in their words, that "the warmest temperatures and highest salinities occurred during the Medieval Warm Period," which lasted from about AD 1020 to1260. Over this period, summer SSTs averaged about 29.7°C, as best as can be determined from their graph of the data, with a peak of about 30.9°C in the vicinity of AD 1080, which values are to be compared with the region's average *modern* summer SST of 29.0°C, which is significantly lower than that of the Medieval Warm Period. Likewise, they found that "the coolest temperatures and lowest salinities occurred during the Little Ice Age," the lowest temperatures of which occurred "around AD 1700, during the period of reduced solar intensity known as the Maunder Minimum," when summer SSTs "were 1.0-1.5°C cooler than present," presumably due to the lower solar activity of that period. And in clear contradiction of the climate-alarmist claim that the Medieval Warm Period and Little Ice Age were merely *regional* phenomena confined to countries surrounding the North Atlantic Ocean, Newton *et al*. stated that their data from the Makassar Strait of Indonesia clearly indicated that "climate changes during the Medieval Warm Period and Little Ice Age were *not* confined to the high latitudes" nor to countries bordering the North Atlantic Ocean.

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One year later - noting that the variability of the hemispheric temperature reconstructions of Mann and Jones (2003) over the past one to two thousand years were "subdued (<=0.5°C)," and that their low-amplitude reconstructions contrast "with several individual marine records that indicate that centennial-scale sea surface temperature (SST) oscillations of 2-3°C occurred during the past 1-2 k.y. (i.e., Keigwin, 1996; Watanabe *et al*., 2001; Lund and Curry, 2006; Newton *et al*., 2006)," just as they also contrast with "tree-ring and multiproxy reconstructions designed to capture multicentennial-scale variability (e.g., Esper *et al*., 2002; Moberg *et al*., 2005)," which further suggests that "the amplitude of natural climate variability over the past 1 k.y. is >0.5°C" - Richey *et al*. (2007)[8] went on to describe how they constructed a continuous decadal-scale-resolution record of climate variability over the past 1400 years in the northern Gulf of Mexico from a box core recovered in the Pigmy Basin,

[7] http://www.co2science.org/articles/V10/N6/C3.php.
[8] http://www.co2science.org/articles/V10/N44/C2.php.

northern Gulf of Mexico (27°11.61'N, 91°24.54'W), based on climate proxies derived from paired analyses of Mg/Ca and $\delta^{18}O$ in the white variety of the planktic foraminifer *Globigerinoides ruber* and relative abundance variations of *G. sacculifer* in the foraminifer assemblages.

Among the things they thereby learned, the four researchers reported that two multi-decadal intervals of sustained high Mg/Ca indicated that Gulf of Mexico sea surface temperatures (SSTs) were as warm as, or warmer than, near-modern conditions between 1000 and 1400 yr B.P. (during the MWP), while foraminiferal Mg/Ca during the coolest interval of the Little Ice Age (ca. 250 yr B.P.) indicated that SSTs were 2-2.5°C below modern SSTs. In addition, they found that the four minima in the Mg/Ca record between 900 and 250 yr. B.P. corresponded in time with the Maunder, Sporer, Wolf, and Oort sunspot minima.

Moving ahead another year, and using a well-established radiolarian-based transfer function, Fengming *et al*. (2008)[9] developed a mean annual *sea surface temperature* (SST) history of the last 10,500 years based on data derived from the top 390 cm of a gravity core recovered from the western slope of the northern Okinawa Trough (29°13.93'N, 128°53'E) of the East China Sea. This record revealed that early in the Holocene, between 10,500 and 8500 calendar years before present (cal. yr BP), mean annual SST gradually rose from ~23.5 to ~25.2°C, but then declined abruptly to ~24.0°C at about 8200 cal. yr BP. The middle portion of the Holocene that followed was relatively stable, with a mean SST of ~24.7°C, after which a dramatic cooling to ~23.6°C occurred at about 3100 cal. yr BP that lasted until about 2600 cal. yr BP, largely coincident with what is known as the "third Neoglaciation" of Europe.

This cold interval was followed by the Roman Warm Period (~2600-1700 cal. yr BP), when SSTs rose to ~24.8°C. Then came the Dark Ages Cold Period, when SSTs dropped to ~23.8°C, after which temperatures during the Medieval Warm Period (~1250-750 cal. yr BP) returned to ~24.8°C, only to decline to ~24.2°C during the Little Ice Age (~600-300 cal. yr BP). Thereafter, it began to warm once again; but the warming was short-lived, with the temperature actually reversing course and falling slightly *below* the Little Ice Age minimum value of ~24.2°C at about AD 1950, where the SST history terminates.

This SST record from the East China Sea clearly reveals the millennial-scale cycling of climate that has left its mark on numerous paleoclimatic proxies throughout the world; and it suggests that the near-identical peak SSTs of the East China Sea during both the Medieval and Roman Warm Periods were probably significantly greater than those of today, which have likely had insufficient time to once again reverse course and warm to such an elevated level from their lowest level of the past 1300 years.

Shortly thereafter, and in reference to the *claims* of Jansen *et al*. (2007) and Mann *et al*. (2008) that Northern Hemisphere surface temperature reconstructions indicate that "the late twentieth century was warmer than any other time during the past 500 years and possibly any time during the past 1,300 years," Oppo *et al*. (2009)[10] wrote that these temperature

[9] http://www.co2science.org/articles/V11/N39/C3.php.
[10] http://www.co2science.org/articles/V12/N44/C3.php.

reconstructions may not be as representative of the planet as a whole as they are typically made out to be, because they "are based largely on terrestrial records from extra-tropical or high-elevation sites," while "global average surface temperature changes closely follow those of the global tropics, which are 75% ocean." And, therefore, in an effort to remedy this less-than-desirable situation, the three researchers derived a "continuous sea surface temperature (SST) reconstruction from the IPWP [Indo-Pacific Warm Pool]," which they described as "the largest reservoir of warm surface water on the earth and the main source of heat for the global atmosphere." This temperature history - which was based on $\delta^{18}O$ and Mg/Ca data obtained from samples of the planktonic foraminifera *Globigerinoides ruber* found in two gravity cores, a nearby multi-core (all at 3°53'S, 119°27'E), and a piston core (at 5°12'S, 117°29'E) recovered from the Makassar Strait on the Sulawesi margin - spanned the past two millennia and, more importantly, as they described it, "overlaps the instrumental record, enabling both a direct comparison of proxy data to the instrumental record and an evaluation of past changes in the context of twentieth century trends."

> We now have substantial evidence that throughout portions of both the Roman *and* Medieval Warm Periods, SSTs in the Indo-Pacific Warm Pool were essentially equivalent to those of "the late twentieth century," indicating - *once again* - that there is nothing unusual, unnatural or unprecedented about current air temperatures in this critically important region of the globe.

The fruits of their labors were subsequently manifest in their report that their SST reconstruction "shows cooler temperatures between about AD 400 and AD 950 [the Dark Ages Cold Period] than during much of the so-called Medieval Warm Period (about AD 900-1300)." Of this latter period, they said that "reconstructed SSTs were warmest from AD 1000 to AD 1250," when "SSTs within error of modern SSTs occurred in the IPWP," as also was the case "during brief periods of the first millennium AD," when the Roman Warm Period held sway. Therefore, based on a globally significant SST history, "enabling both a direct comparison of proxy data to the instrumental record and an evaluation of past changes in the context of twentieth century trends," we now have substantial evidence that throughout portions of both the Roman *and* Medieval Warm Periods, SSTs in the Indo-Pacific Warm Pool were essentially equivalent to those of "the late twentieth century," indicating - ***once again*** - that there is

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About this same time, Richter *et al.* (2009)[11] obtained high-resolution (22-year average) planktonic foraminiferal Mg/Ca and stable oxygen isotope ($\delta^{18}O$) data from a pair of sediment cores retrieved from the northeast Atlantic Ocean's Feni Drift, Rockall Trough region (55°39.02'N, 13°59.10'W and 55°39.10'N, 13°59.13'W) from which they derived late Holocene (0-2.4 ka BP) sea surface temperatures (SSTs). These data revealed "a general long-term cooling trend," but "superimposed on this overall trend" were "partly higher temperatures and salinities from 180 to 560 AD and 750-1160 AD," which the three researchers said "may be ascribed to the Roman and Medieval Warm Periods, respectively," the latter of which was followed by the Little Ice Age (LIA) and what they described as the "post-LIA recovery and, possibly, (late) 20th century anthropogenic warming."

Of this latter warming, they said that it "concurs with distinct continental-scale warming, consistently reaching unprecedented maximum temperatures after ~1990 AD." Their use of the word "unprecedented," however, is a bit misleading; for they subsequently wrote that "the SST increase over the last three decades does not, or not 'yet', appear unusual compared to the entire 0-2.4 ka record," and that "the warming trend over the second half of the 20th century has not yet reverted the late Holocene millennial-scale cooling." In fact, their data clearly indicate that the peak temperature of the Medieval Warm Period was approximately 2.2°C greater than the peak temperature of the late 20th century, and that the peak temperature of the Roman Warm Period was about 2.7°C *greater* than that of the late 20th century.

Clearly, the fact that the warmest portions of the Roman and Medieval Warm Periods in the vicinity of the northeast Atlantic were ***so*** much warmer than the warmest portion of the Current Warm Period - and at times when the air's $CO_2$ content was ***so*** much less than it is currently - *strongly* suggests that the atmosphere's $CO_2$ concentration had little to no impact on the late-Holocene climatic history of that part of the planet.

So what *was* responsible for the oscillating temperatures of the surface waters of the northeast Atlantic Ocean? The three Dutch researchers say that "pervasive multidecadal- to centennial-scale variability throughout the sedimentary proxy records can be partly attributed to solar forcing and/or variable heat extraction from the surface ocean caused by shifts in the prevailing state of the North Atlantic Oscillation," as well as to "internal (unforced) fluctuations."

Two years closer to the present, and noting that "the growing concern about global warming has led to renewed interest in past temperature changes, particularly the question of whether the present climate change exceeds the natural variability of the past," Ran *et al.* (2011)[12] reconstructed summer *sea surface temperature* (SST) on the North Icelandic shelf for the period AD 940-2006, based on their high-resolution and precisely dated diatom records, along with the help of "a modern diatom-environmental dataset from around Iceland [that] was established as

[11] http://www.co2science.org/articles/V12/N47/C2.php.
[12] http://www.co2science.org/articles/V14/N19/C3.php.

a basis for quantitative reconstruction of palaeoceanographic conditions on the North Icelandic shelf (Jiang *et al*., 2001, 2002)." So what did they learn?

In the words of the four researchers, their diatom-based SST record indicated that the sea surface on the North Icelandic shelf "was not as warm during the last century as during the Medieval Warm Period (MWP)." More specifically, they stated that "warm and stable conditions with relatively strong influence of the Irminger Current on the North Icelandic shelf are indicated during the interval AD 940-1300, corresponding in time to the MWP," and that "a considerable cooling at ~AD 1300 indicates the transition to the Little Ice Age (LIA) with increased influence of Polar and Arctic water masses deriving from the East Greenland and East Icelandic currents." After that came "an extended cooling period between AD 1300 and 1910," followed by "a two-step warming during the last 100 years" that was "interrupted by three cool events around AD 1920, in the AD 1960s and in the late AD 1990s."

Once again, therefore, we have a situation where the warmth of the more distant past clearly exceeded that of the recent past, with the peak temperature of the MWP exceeding that of the Current Warm Period by about 0.6°C, as best as can be determined from the graphical representation of Ran *et al*.'s data, which thus indicates there is nothing unusual, unnatural or unprecedented about the earth's current level of warmth in this particular part of the planet. And they end by stating that "the data suggest that solar radiation may be one of the important forcing mechanisms behind the palae-oceanographic changes."

*The warmth of the more distant past clearly exceeded that of the recent past, with the peak temperature of the MWP exceeding that of the Current Warm Period by about 0.6°C, as best as can be determined from the graphical representation of Ran et al.'s data.*

Creeping forward one more year, and giving the same reason that has inspired much of the research of this nature, Wu *et al*. (2012)[13] wrote that "one of the key questions in the reconstruction of late Holocene climate is whether or not the 20th-century warming is unusual over the past two millennia," noting that "a clear answer to this question is crucial for the assessment of the relative contribution of human activities and natural processes to the observed warming." Thus, as *their* contribution to this important quest for knowledge, Wu *et al*. developed a bi-decadal-resolution record of *sea surface temperature* (SST) in the Southern Okinawa Trough that covered the past 2700 years. This they did by analyzing tetraether lipids of

[13] http://www.co2science.org/articles/V15/N51/C3.php.

planktonic archaea in the ODP Hole 1202B (24°48'N, 122°30'E), which they described as "a site under the strong influence of the Kuroshio Current and East Asian monsoon."

As a result of this effort, the five Chinese researchers reported finding SST anomalies that "generally coincided with previously reported late Holocene climate events, including the Roman Warm Period [120 BC-AD 400], Sui-Tang Dynasty Warm Period [AD 550-790], Medieval Warm Period [AD 900-1300], Current Warm Period [AD 1850-present], Dark Age Cold Period [AD 400-550] and Little Ice Age [AD 1300-1850]." And they made a point of mentioning that "despite an increase since AD 1850, the mean SST in the 20th century is still within the range of natural variability during the past 2700 years." In addition, they noted that climate records from East China (Ge *et al*., 2004), the North Icelandic Shelf (Patterson *et al*., 2010) and Greenland (Kobashi *et al*., 2011) also exhibited "centennial-scale warm periods during the first millennia AD, comparable to or even warmer than mean 20th-century conditions."

Wu *et al*. thus answered their own question about whether or not 20th century warming was *unusual* over the past two millennia," finding - for their site (and several others) - that it was *not*. And this answer, in turn, suggests that modern warming cannot be distinguished from warming induced by what they called "natural processes," which ultimately suggests that there is no compelling reason to attribute modern warming to anthropogenic $CO_2$ emissions.

Contemporaneously, and based on new oxygen isotope data of three planktonic foraminiferal species, Mg/Ca-derived sea-surface temperature data, alkenone biomarker paleothermometry, coccolith abundance, species counts and diatom census data, which they derived from a sediment core extracted from Reykjanes Ridge at 58°56.327'N, 30°24.590'W in the North Atlantic Ocean, Moros *et al*. (2012)[14] inferred late-Holocene trends and variability of the East Greenland Current's influence on the Sub-Arctic Front in the study area. And this work revealed, in their words, the presence of "increasingly colder millennial-scale cooling events," which were centered on 5.6, 3.8, 2.7, 1.3 and 0.3 ka, the latter and *coldest* of which was the Little Ice Age, while in between the third and fourth of these cold events was the Roman Warm Period, which they described as the *warmest* period of the late Holocene.

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Yes, climate change is *real* ... just like the world's climate alarmists vehemently contend. In fact, it's the *norm*. And in the several oceanic studies briefly reviewed above, as well as studies pertaining to the terrestrial surface of the planet, earth's climate has been recognized as having shifted over the past century or so from the coldest period of the current interglacial to a significantly warmer state, but one that appears not yet to have achieved the level of warmth characteristic of the prior Medieval Warm Period or the earlier Roman Warm Period, as is also

[14] http://www.co2science.org/articles/V16/N1/C2.php.

demonstrated by the *hundreds* of other such studies reviewed on the *co2science.org* website. And since *none* of these "warm-ups," as well as still earlier ones, were driven by increases in the air's $CO_2$ concentration (which hovered around 285 ppm until the Industrial Revolution started it on its upward course towards today's 400 ppm), there is *no compelling reason* to believe that the 20th century warming of the globe was driven by concurrent anthropogenic $CO_2$ emissions.

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