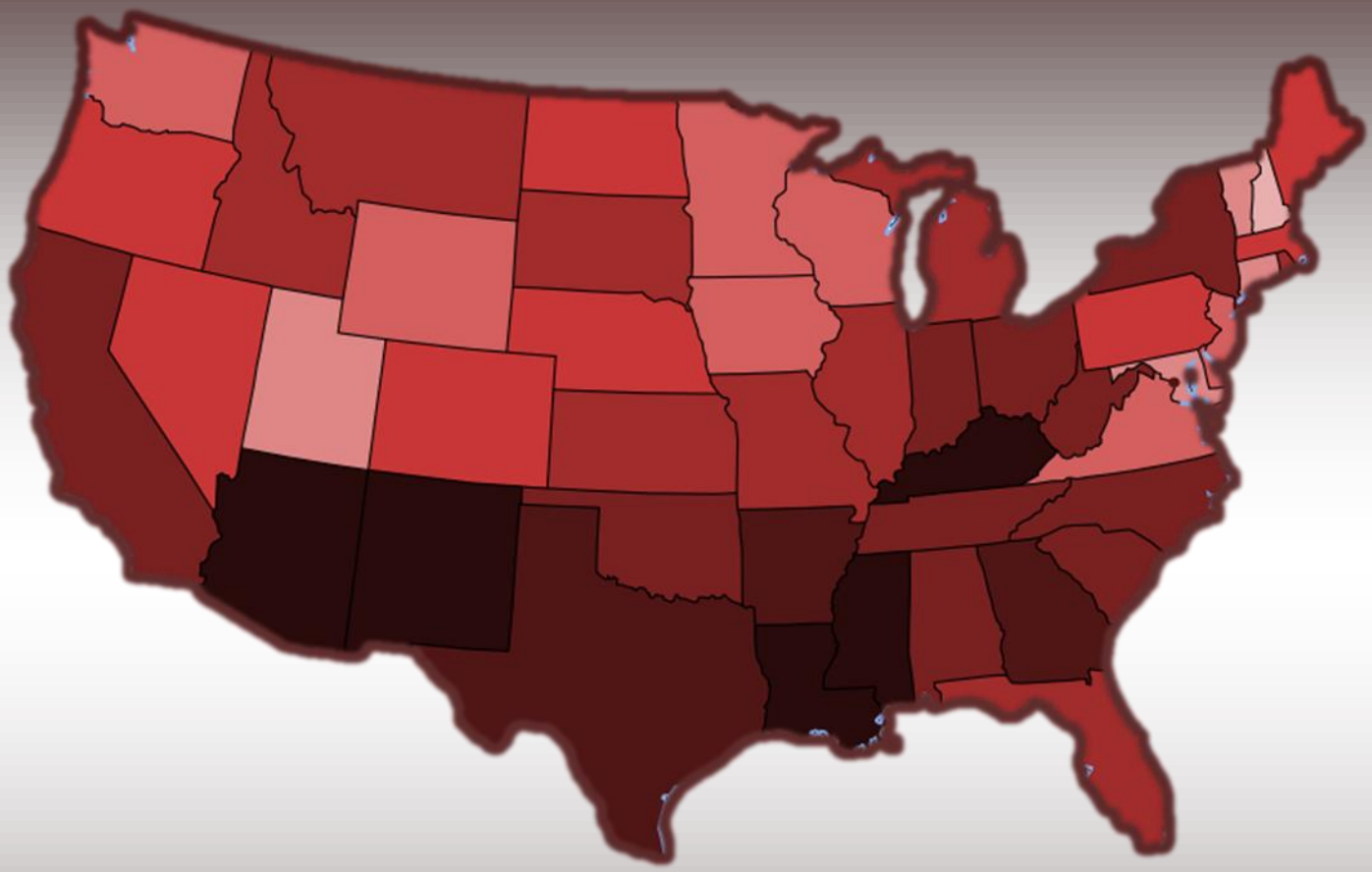
MEDIEVAL WARM PERIOD IN THE CONTIGUOUS UNITED STATES



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MEDIEVAL WARM PERIOD IN THE CONTIGUOUS UNITED STATES

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Climate alarmists claim that rising atmospheric CO_2 concentrations due to the burning of fossil fuels, such as coal, gas and oil, have raised global air temperatures to their highest level in the past one to two millennia. And, therefore, investigating the possibility of a period of equal global warmth within the past one to two thousand years has become a high-priority enterprise; for if such a period could be shown to have existed, when the atmosphere's CO_2 concentration was *far* less than it is today, there would be no compelling reason to attribute the warmth of our day to the CO_2 released to the air by mankind since the beginning of the Industrial Revolution. Thus, in this review of the pertinent scientific literature, results of the search for such knowledge are presented for studies conducted within the confines of the lower 48 contiguous states of the United States of America.

> *On the basis of what they discovered, therefore, there appears to have been nothing unusual about the 20th-century climate of the San Francisco Bay area, because periods of both drought and wetness over the last hundred years of the past millennium were less extreme than similar periods of the preceding six centuries.*

Ingram *et al.* (1998)[1] conducted isotopic ($^{18}O/^{16}O$ and $^{13}C/^{12}C$) and elemental chemical analyses (Sr/Ca and Mg/Ca ratios) of sediment cores taken from Petaluma Marsh, San Francisco Bay, Northern California, USA, in an effort to develop a record of paleoenvironmental change in this region over the past 700 years. And their efforts paid off, as they went on to report that high frequency variations in $\delta^{18}O$, $\delta^{13}C$, Mg/Ca and Sr/Ca were noted throughout the 700-yr record, indicating the presence of oscillations in freshwater inflow, temperature and evaporation at periods of 35-115 years. Between 150 and 400 cal yr BP, however, $\delta^{18}O$ and Mg/Ca were relatively low, indicative of a period of cold and wet climatic conditions associated with the Little Ice Age. Prior to that, $\delta^{18}O$ and Mg/Ca were higher from 480 to 650 cal yr BP, indicating, in the words of Ingram *et al.*, "drier and warmer conditions during the end of the Medieval Warm Period." In addition, they noted that the record "suggests that the duration of wet and dry periods was greater over the past 700 years than in the twentieth century instrumental record."

On the basis of what they discovered, therefore, there appears to have been nothing unusual about the 20th-century climate of the San Francisco Bay area, because periods of both drought

[1] http://www.co2science.org/articles/V9/N20/C3.php.

and wetness over the last hundred years of the past millennium were *less extreme* than similar periods of the preceding six centuries. As for temperature, the results of Ingram *et al*.'s work support the findings of Graumlich (1990), who found tree-ring evidence in the nearby Sierra Nevada Mountains that the period from 510 to 420 cal yr BP *was warmer and wetter than any part of the twentieth century*.

Two years later, Field and Baumgartner (2000)[2] developed "a robust time series of stable isotope [$\delta^{18}O$ from *Neogloboquadrina dutertrei*] variability over the past millennium from the varved sediments of the Santa Barbara Basin," which they related to observed environmental variability within this part of the California Current over the past half-century, thereby demonstrating that "thermal variability dominates the $\delta^{18}O$ signal."

With that point settled, the two researchers went on to report that "an anomalously warm coastal ocean persisted at the multicentennial-scale from roughly AD 1200 to 1450," which time interval, as they described it, "coincides with the age generally assigned to the 'Medieval Warm Period'." They also reported that "the period of positive anomalies in the low-frequency series of $\delta^{18}O$ from *N. dutertrei* that continues from ~AD 1450 to ~1800 is consistent with the dates associated with the cooling and neoglaciation of the 'Little Ice Age' in both the Southern and Northern Hemispheres." In addition, they noted that "the long-term ocean warming and cooling of the California Current region appears to be in phase with the warming and cooling of the midlatitude North Atlantic described by Keigwin (1996)."

The very next year, Brush (2001)[3] analyzed sediment cores obtained from tributaries, marshes and the main stem of Chesapeake Bay for paleoecological indicators of regional climate change and land use variations over the past millennium. This research led to the finding that "the Medieval Climatic Anomaly and the Little Ice Age are recorded in Chesapeake sediments by terrestrial indicators of dry conditions for 200 years, beginning about 1000 years ago, followed by increases in wet indicators from about 800 to 400 years ago." This MCA is what most people refer to as the Medieval Warm Period (MWP), which Brush says is "recognized in many parts of the world from historical and paleocological evidence." The findings of this paper, therefore, represent just one more example of the reality and uniqueness of both the Medieval Warm Period and the Little Ice Age, which are the two *preeminent climatic anomalies* of the past thousand years, which further suggests that there is nothing unusual about the global warming of the past century or so, as it represents but the planet's natural

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[2] http://www.co2science.org/articles/V10/N10/C1.php.
[3] http://www.co2science.org/articles/V5/N3/C3.php.

recovery from the global chill of the Little Ice Age and the start of its return to Medieval Warm Period-like conditions.

Sometime in the following year, in an effort to determine whether climate-driven millennial-scale cycles are present in the terrestrial pollen record of North America, Viau *et al*. (2002)[4] analyzed a set of 3,076 ^{14}C dates from the North American Pollen Database used to date sequences in more than 700 pollen diagrams across North America. In doing so, they found that there were nine millennial-scale oscillations during the past 14,000 years in which continent-wide synchronous vegetation changes with a periodicity of roughly 1650 years were recorded in the pollen records. The most recent of the vegetation transitions was centered at approximately 600 years BP (before present). This event, in their words, culminated "in the Little Ice Age, with maximum cooling 300 years ago." And they add that prior to that event a major transition that began approximately 1600 years BP represents the climatic amelioration that culminated "in the maximum warming of the Medieval Warm Period 1000 years ago." And so it goes, on back through the Holocene and into the preceding late glacial period, with the times of all major pollen transitions being "consistent with ice and marine records."

According to the five researchers, "the large-scale nature of these transitions and the fact that they are found in different proxies confirms the hypothesis that Holocene and late glacial climate variations of millennial-scale were abrupt transitions between climatic regimes as the atmosphere-ocean system reorganized in response to some forcing." And they go on to say that "although several mechanisms for such natural forcing have been advanced, recent evidence points to a potential solar forcing (Bond *et al*., 2001) associated with ocean-atmosphere feedbacks acting as global teleconnections agents." What is more, they note that "these transitions are identifiable across North America and presumably the world."

One year later, Willard *et al*. (2003)[5] examined the late Holocene (2300 yr BP to present) record of the USA's Chesapeake Bay, along with the adjacent terrestrial ecosystem in its watershed, through the study of fossil dinoflagellate cysts and pollen derived from sediment cores. And as a result of these efforts, they were able to report that "several dry periods ranging from decades to centuries in duration are evident in Chesapeake Bay records."

The first of these periods of lower-than-average precipitation, which spanned the period 200 BC-AD 300, occurred during the latter part of the Roman Warm Period, as delineated by McDermott *et al*. (2001) on the basis of a high-resolution speleothem $\delta^{18}O$ record from southwest Ireland. The next such period (~AD 800-1200), in the words of the three researchers, "corresponds to the 'Medieval Warm Period', which has been documented as drier than average by tree-ring (Stahle and Cleaveland, 1994) and pollen (Willard *et al*., 2001) records from the southeastern USA," while other periods consisting of several decadal-scale dry intervals spanned the years AD 1320-1400 and AD 1525-1650.

Willard *et al*. (2003) also went on to state that "mid-Atlantic dry periods generally correspond to central and southwestern USA 'megadroughts', described by Woodhouse and Overpeck

[4] http://www.co2science.org/articles/V5/N40/C1.php.
[5] http://www.co2science.org/articles/V6/N18/C2.php.

(1998) as major droughts of decadal or more duration that probably exceeded twentieth-century droughts in severity." In addition, they further indicated that "droughts in the late sixteenth century that lasted several decades, and those in the 'Medieval Warm Period' and between ~AD 50 and AD 350 spanning a century or more have been indicated by Great Plains tree-ring (Stahle *et al*., 1985; Stahle and Cleaveland, 1994), lacustrine diatom and ostracode (Fritz *et al*., 2000; Laird *et al*., 1996a, 1996b) and detrital clastic records (Dean, 1997)."

This study thus did two important things. First, it demonstrated the reality of the millennial-scale hydrologic cycle that accompanies the millennial-scale temperature cycle that is responsible for producing alternating warm and cold intervals such as the Roman Warm Period, Dark Ages Cold Period, Medieval Warm Period, Little Ice Age and Current Warm Period. Second, it indicates that the global warming of the 20th century has not yet produced *unusually* strong wet and dry periods, contradicting climate-alarmist claims that warming will exacerbate extreme climate anomalies.

With the passing of another year, Cook *et al*. (2004)[6] developed a 1200-year history of drought for the western half of the United States and adjacent parts of Canada and Mexico (hereafter the "West"), based on annually-resolved tree-ring records of summer-season Palmer Drought Severity Index that were derived for 103 points on a 2.5° x 2.5° grid, 68 of which grid points (66% of them) possessed reconstructions that extended back to AD 800. And this reconstruction, in the words of Cook *et al*., revealed "some remarkable earlier increases in aridity that dwarf the comparatively short-duration current drought in the 'West'." Also of great interest, they reported that "the four driest epochs, centered on AD 936, 1034, 1150 and 1253, all occurred during a ~400 year interval of overall elevated aridity from AD 900 to 1300," which they said was "broadly consistent with the Medieval Warm Period."

Commenting on their findings, the five scientists stated that "the overall coincidence between our megadrought epoch and the Medieval Warm Period suggests that anomalously warm climate conditions during that time may have contributed to the development of more frequent and persistent droughts in the 'West'." After citing nine other studies that provide independent evidence of significant drought during this time period for various sub-regions of the "West," they thus warned that "any trend toward warmer temperatures in the future could lead to a serious long-term increase in aridity over western North America." And if the association between warmth and drought in the "West" is robust, as their data suggest, temperatures of the latter part of the 20th century and the first part of the 21st century must still be *significantly less* than those experienced during large segments of the Medieval Warm Period over much of western North America and the United States in particular.

Contemporaneously, Carbotte *et al*. (2004)[7] located fossil oyster beds within the Tappan Zee area of the Hudson River estuary (New York, USA) via chirp sub-bottom and side-scan sonar surveys, after which they retrieved sediment cores from the sites that provided shells for radiocarbon dating. This work revealed, in their words, that "oysters flourished during the mid-Holocene warm period," when they noted that "summertime temperatures were 2-4°C warmer

[6] http://www.co2science.org/articles/V7/N47/EDIT.php.
[7] http://www.co2science.org/articles/V8/N2/C2.php.

than today (e.g., Webb *et al*., 1993; Ganopolski *et al*., 1998)." Thereafter, they found that the oysters "disappeared with the onset of cooler climate at 4,000-5,000 cal. years BP," but that they "returned during warmer conditions of the late Holocene," which they specifically identified as the Roman and Medieval Warm Periods as delineated by Keigwin (1996) and McDermott *et al*. (2001), explicitly stating that "these warmer periods coincide with the return of oysters in the Tappan Zee." Unfortunately, they also reported that their shell dates suggested a final "major demise at ~500-900 years BP," which timing they described as being "consistent with the onset of the Little Ice Age," noting further that within nearby Chesapeake Bay, "Cronin *et al*. (2003) report a sustained period of cooler springtime water temperatures (by ~2-5°C) during the Little Ice Age relative to the earlier Medieval Warm Period." Last of all, they add that "similar aged fluctuations in oyster presence are observed within shell middens elsewhere along the Atlantic seaboard," citing results obtained from Maine to Florida.

This intriguing study of the periodic establishment and demise of oyster beds in the Hudson River estuary and elsewhere along the east coast of the United States paints a clear picture of alternating multi-century warm and cold intervals over the past two millennia that is *vastly* different from the 1000-year-long "hockeystick" temperature history of Mann *et al*. (1998, 1999) and the 2000-year-long history produced by Mann and Jones (2003), wherein Northern Hemispheric and global mean temperatures experience essentially no low-frequency variability until the advent of the 20th century, when temperatures are portrayed as rising dramatically, allowing them to claim that 20th-century warming was driven by anthropogenic CO_2 emissions. With respect to this contention, however, *they are most certainly wrong*, as papers that tell essentially the same climatic story as that of the Carbotte *et al*. study are published regularly in the scientific literature; and this ever-growing mountain of real-world evidence clearly shows that late 20th-century warmth was by no means unique over the past two millennia, having been equaled, and often *surpassed*, at various times throughout both the Medieval Warm Period of a thousand years ago and the Roman Warm Period of two thousand years ago, during both of which epochs the air's CO_2 concentration was fully 120 ppm

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less than what it is today, signifying that the Current Warm Period is nothing more than the most recent high-temperature phase of this natural *non-CO_2-driven* millennial-scale oscillation of earth's climate.

Two years later, Sridhar *et al*. (2006)[8] studied the orientation, morphology and internal structure of dunes in the easternmost (wettest) portion of the Nebraska Sand Hills, where shallow core and outcrop samples indicate the dunes were formed some 800 to 1000 years ago, when aridity was widespread and persistent across western North America. In addition, based on wind data obtained from six meteorological stations in and near the Nebraska Sand Hills, they employed a computer program to calculate the sand-drift vectors of dunes that would form today if the sand was free to move and not held in place by protective prairie grass. This work revealed that the current configuration of the Sand Hill dunes could *not* have been created by the region's present wind regime, in which air currents from the south in the spring and summer bring moist air from the Gulf of Mexico to the U.S. Great Plains. Instead, their work indicated that the spring and summer winds that formed the dunes some 800 to 1000 years ago had to have come from the southwest, bringing much drier and hotter-than-current air from the deserts of Mexico, along with greatly reduced opportunities for rain.

The findings of this important study clearly suggest that much of western North America was likely both drier and hotter than it is today some 800 to 1000 years ago (and possibly earlier as well), during the global Medieval Warm Period. As Sridhar *et al*. described it, "the dunes record a historically unprecedented large-scale shift of circulation that removed the source of moisture from the region during the growing season." And they suggest that the resultant drier and warmer conditions may then have been *further* "enhanced and prolonged," as they phrase it, "by reduced soil moisture and related surface-heating effects," which effects are not operative in our day to the degree they were 800 to 1000 years ago, as was demonstrated by still other of Sridhar *et al*.'s computer analyses. Hence, their work provided compelling evidence for the likelihood that great portions of western North America were warmer than they are today during the central portion of the Medieval Warm Period.

Working and publishing concurrently, Rasmussen *et al*. (2006)[9] - who had previously demonstrated that "speleothems from the Guadalupe Mountains in southeastern New Mexico are annually banded, and variations in band thickness and mineralogy can be used as a record of regional relative moisture (Asmerom and Polyak, 2004)" - continued this tack, concentrating on two columnar stalagmites collected from Carlsbad Cavern (BC2) and Hidden Cave (HC1) in the Guadalupe Mountains. This work revealed that both of these records suggest periods of dramatic precipitation variability over the last 3000 years, exhibiting large shifts unlike anything seen in the modern record. They also discovered that the period from AD 900-1300 "includes severe drought events, consistent with tree-ring data for the western U.S. (Cook *et al*., 2004)," but that the preceding and following centuries (AD 100-750 and AD 1500-1800) "show increased precipitation variability ... coinciding with increased El Niño flooding events."

[8] http://www.co2science.org/articles/V9/N32/C3.php.
[9] http://www.co2science.org/articles/V9/N35/C2.php.

These findings suggest that moisture extremes much greater than those observed in the modern era are neither unusual nor manmade; they are simply a normal part of earth's natural climatic variability. In addition, Rasmussen *et al.*'s data clearly reveal the occurrence of the Medieval Warm Period, as well as the Dark Ages Cold Period that preceded it and the Little Ice Age that followed it, *in terms of the available moisture side of the climate-change coin*; for in this part of the world, global *warmth* is typically manifest in terms of *low available moisture*, while global *coolness* is typically manifest in terms of *high available moisture*.

Contemporaneously, while working with dead tree trunks located *above the current treeline* on the tephra-covered slopes of Whitewing Mountain and San Joaquin Ridge south of Mono Lake just east of the Inyo Craters in the eastern Sierra Nevada range of California (USA), Milar *et al.* (2006)[10] identified the species to which the tree remains belonged, dated them, and (using contemporary distributions of the species in relation to contemporary temperature and precipitation) reconstructed paleoclimate during the time they grew there. This work led them to report that "the range of dates for the deadwood samples, AD 815-1350, coincides with the period identified from multiple proxies in the Sierra Nevada and western Great Basin as the Medieval Climate Anomaly," among which were tree-ring reconstructions indicating "increased temperature relative to present (Graumlich, 1993; Scuderi, 1993) and higher treelines (Graumlich and Lloyd, 1996; Lloyd and Graumlich, 1997), and pollen reconstructions [that] show greater abundance of fir in high-elevation communities than at present (Anderson, 1990)."

Focusing on other of their findings, the five researchers noted that "the Medieval forest on Whitewing was growing under mild, favorable conditions (warm with adequate moisture)," as indicated by "extremely low mean sensitivities [to stress] and large average ring widths." More specifically, they concluded, as reported in their paper's abstract, that annual minimum temperatures during the Medieval Climatic Anomaly in the region they studied were "significantly warmer" (+3.2°C) "than present," while in their final paragraph they say their results "closely compare to climate projections for California in AD 2070-2099 (Hayhoe *et al.*, 2004)," in which "average temperature increases of 2.3-5.8°C were projected." Once again, therefore, we have another example of a paleoclimate study in which the Medieval Warm Period was determined to have been *significantly warmer than it is currently*.

Once again, therefore, we have another example of a paleoclimate study in which the Medieval Warm Period was determined to have been significantly warmer than it is currently.

In yet another paper published in the same year, Malamud-Roam *et al.* (2006)[11] conducted an extensive review of "the variety of paleoclimatic resources for the San Francisco Bay and watershed in order to identify major climate variations in the pre-industrial past, and to compare the records from the larger watershed region with the Bay

[10] http://www.co2science.org/articles/V10/N4/C3.php.
[11] http://www.co2science.org/articles/V11/N46/C1.php.

records in order to determine the linkages between climate experienced over the larger watershed region and conditions in the San Francisco Bay." This work revealed, as they described it, that "intermittent mega-droughts of the Medieval Climate Anomaly (ca. AD 900-1350) coincided with a period of anomalously warm coastal ocean temperatures in the California Current," and that "oxygen isotope compositions of mussel shells from archaeological sites along the central coast also indicate that sea surface temperatures were slightly warmer than present." In contrast, they note that "the Little Ice Age (ca. AD 1450-1800) brought unusually cool and wet conditions to much of the watershed," and that "notably stable conditions have prevailed over the instrumental period, i.e., after ca. AD 1850, even including the severe, short-term anomalies experienced during this period," namely, "the severe droughts of the 1930s and the mid-1970s." In this particular part of the world, therefore, *peak medieval warmth appears to have exceeded peak modern warmth*. Also, as the four researchers noted, when longer paleoclimate records are considered, "current drought conditions experienced in the US Southwest do not appear out of the range of natural variability."

One year later, Benson *et al*. (2007)[12] reviewed and discussed possible impacts of early-11th-, middle-12th-, and late-13th-century droughts on three Native American cultures that occupied parts of the western United States (Anasazi, Fremont, Lovelock) plus another culture that occupied parts of southwestern Illinois (Cahokia). And in doing so, they found that "population declines among the various Native American cultures were documented to have occurred either in the early-11th, middle-12th, or late-13th centuries" - AD 990-1060, 1135-1170, and 1276-1297, respectively - and that "really extensive droughts impacted the regions occupied by these prehistoric Native Americans during one or more of these three time periods." In particular, they say the middle-12th-century drought "had the strongest impact on the Anasazi and Mississippian Cahokia cultures," noting that "by AD 1150, the Anasazi had abandoned 85% of their great houses in the Four Corners region and most of their village sites, and the Cahokians had abandoned one or more of their agricultural support centers, including the large Richland farming complex." In addition, they wrote that "the sedentary Fremont appear to have abandoned many of their southern area habitation sites in the greater Unita Basin area by AD 1150 as well as the eastern Great Basin and the Southern Colorado Plateau," so that "in some sense, the 13th century drought may simply have 'finished off' some cultures that were already in decline." Last of all, they indicate that these "major reductions in prehistoric Native American habitation sites/population" occurred during a period of "anomalously warm" climatic conditions, which characterized the Medieval Warm Period throughout much of the world at that particular time. And as may be seen from the Interactive Map and Time Domain Plot[13] of *co2science.org*, the deadly AD 1150 date falls right about at the midpoint of the *global* MWP time domain plot as defined by all pertinent data assembled there to this point in time.

So what does it all mean? Among other things, the fact that the deadly North American droughts of the MWP have *never been equaled* throughout *all the ensuing years* argues strongly that what Benson *et al*. call the *anomalous warmth* of that period has *also* "never been equaled throughout all the ensuing years," which further suggests (since the air's CO_2 content was so

[12] http://www.co2science.org/articles/V10/N32/C2.php.
[13] http://www.co2science.org/data/timemap/mwpmap.html.

much less during the MWP than it is now) that the *lesser* warmth of *today* need not in any way be related to the much *higher* CO_2 concentration of earth's *current* atmosphere.

Appearing around the same time as Benson *et al*.'s study was that of Graham *et al*. (2007)[14], who conducted an extensive review of Medieval Warm Period-Little Ice Age climatic conditions as revealed in a variety of proxy records obtained throughout western North America. The great balance of this evidence pointed, in their words, to "generally arid conditions across much of the western and central US from as early as 400 A.D. until about 1300 A.D., followed by a rapid shift towards a wetter regime resembling modern climate." The *heart* of this Medieval Climate Anomaly (MCA), as they described it (to emphasize that something in addition to temperature was involved, primarily precipitation), "lasted from about 800-1250 A.D. and included episodes of severe centennial-scale drought," which "affected regions stretching from northern Mexico, California and central Oregon, eastward through the Great Basin and into the western prairies of the central US." And in further discussing the *context* of their findings, the eleven researchers said that "medieval times witnessed a distinctive pattern of climate change in many regions around the planet," and "as such, the findings suggest the evolution of the concept of an Atlantic-European 'Medieval Warm Period' into a surprisingly sharp instance of Holocene climate change with near-global manifestations." Or as they rephrase it in the final paragraph of their paper, "the near-global scale of MCA climate change seems to be becoming more apparent."

The fact that the deadly North American droughts of the MWP have never been equaled throughout all the ensuing years argues strongly that what Benson et al. call the anomalous warmth of that period has also "never been equaled throughout all the ensuing years," which further suggests (since the air's CO_2 content was so much less during the MWP than it is now) that the lesser warmth of today need not in any way be related to the much higher CO_2 concentration of earth's current atmosphere.

Sticking to the subject of drought, Stahle *et al*. (2007)[15] used "an expanded grid of tree-ring reconstructions of the summer Palmer drought severity indices (PDSI; Cook *et al*., 2004) covering the United States, southern Canada, and most of Mexico to examine the timing, intensity, and spatial distribution of decadal to multidecadal moisture regimes over North America." This effort revealed, in their words, that to date, during the Current Warm Period,

[14] http://www.co2science.org/articles/V10/N36/C2.php.
[15] http://www.co2science.org/articles/V10/N37/C1.php.

"the Dust Bowl drought of the 1930s and the Southwestern drought of the 1950s were the two most intense and prolonged droughts to impact North America," citing the studies of Worster (1979), Diaz (1983) and Fye *et al*. (2003). During the Little Ice Age, on the other hand, they report the occurrence of three *megadroughts*, which they defined as "very large-scale drought[s] more severe and sustained than any witnessed during the period of instrumental weather observations (e.g., Stahle *et al*., 2000)." However, they report that "much stronger and more persistent droughts have been reconstructed with tree rings and other proxies over North America during the Medieval era (e.g., Stine, 1994; Laird *et al*., 2003; Cook *et al*., 2004)." In fact, these latter megadroughts were so phenomenal that they refer to them as "no-analog Medieval megadroughts."

Again, putting things in their proper *context*, climate alarmists typically claim that CO_2-induced global warming will result in more severe droughts. However, the *much* more severe and sustained *megadroughts* of the Little Ice Age appear to render their claim somewhat dubious. On the other hand, the *still* more severe and sustained *no-analogue megadroughts* of the Medieval Warm Period would appear to bolster their contention. But the incredibly more severe droughts of that earlier period - if they were indeed related to high global air temperatures - would suggest that it is not nearly as warm currently as it was during the Medieval Warm Period, when there was *much* less CO_2 in the air than there is today; and *these* observations undercut the climate alarmists' more *fundamental* claim that the historical rise in the air's CO_2 content has been responsible for what they describe as *unprecedented* 20th-century global warming that has taken earth's mean air temperature to a height that is *unprecedented over the past two millennia*.

Also with a paper published in the same year were Carson *et al*. (2007)[16], who developed a Holocene history of flood magnitudes in the northern Uinta Mountains of northeastern Utah from reconstructed cross-sectional areas of abandoned channels and relationships relating channel cross-sections to flood magnitudes derived from modern stream gage and channel records. And as a result of their efforts in this regard, they were able to report that over the past 5,000 years, the record of bankfull discharge "corresponds well with independent paleoclimate data for the Uinta Mountains," and that "during this period, the magnitude of the modal flood is smaller than modern during warm dry intervals and greater than modern during cool wet intervals," while noting most particularly that "the decrease in flood magnitudes following 1000 cal yr B.P. corresponds to numerous local and regional records of warming during the Medieval Climatic Anomaly."

Based upon the three researchers' graphical results, the three largest *negative* departures from modern bankfull flood magnitudes (indicating *greater than modern warmth*) were found to range from approximately 15-22%, as best as can be determined from visual inspection of their plotted data; and these departures occurred between about 750 and 600 cal yr B.P., as determined from radiocarbon dating of basal channel-fill sediments. Therefore, in addition to demonstrating that the degree of natural variability in northeastern Utah flood magnitudes throughout the Holocene has been much larger (in both positive and negative directions) than what has been observed in modern times (which demonstrates that possible future

[16] http://www.co2science.org/articles/V10/N52/C2.php.

occurrences of greater- or smaller-than-modern floods in the region ought not be regarded as "unprecedented," as climate alarmists are typically prone to claim), Carson *et al*.'s findings demonstrate that the portion of the Medieval Warm Period between about AD 1250 and 1400 was likely significantly warmer than it is at present, which demonstrates that since something *other* than high concentrations of atmospheric CO_2 was responsible for the region's earlier *greater*-than-present warmth, one need not invoke today's much higher CO_2 concentrations as the reason for our actually *lower*-than-Medieval current warmth.

> Solid empirical evidence continues to accumulate, demonstrating that (1) the Medieval Warm Period (MWP) was an interval of elevated global temperatures that were equally as warm as, and in many cases even warmer than, those of the Current Warm Period, and that (2) the MWP's elevated warmth was likely solar-induced, which suggests that the Current Warm Period may well be deriving its warmth from the same source, as it is likely nothing more than the most recent manifestation of the warm node of this ever-recurring climate cycle.

Finally closing out the year with one more revealing paper were Richey *et al.* (2007)[17], who introduced their study by noting that the variability of the hemispheric temperature reconstructions of Mann and Jones (2003) over the past one to two thousand years are "subdued (<=0.5°C)," and that their low-amplitude reconstructions are *not compatible* "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 differ from "tree-ring and multi-proxy reconstructions designed to capture multi-centennial-scale variability (e.g., Esper *et al*., 2002; Moberg *et al*., 2005)," which facts further suggest that "the amplitude of natural climate variability over the past 1 k.y. is >0.5°C."

Richey *et al*. then went on to explain how "a continuous decadal-scale resolution record of climate variability over the past 1400 years in the northern Gulf of Mexico was constructed from a box core recovered in the Pigmy Basin, 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." And thanks to this accomplishment, the four researchers were able to report that "two multi-decadal intervals of sustained high Mg/Ca indicate that Gulf of Mexico sea surface temperatures (SSTs) were as

[17] http://www.co2science.org/articles/V10/N44/C2.php.

warm as, or warmer than, near-modern conditions between 1000 and 1400 yr B.P.," while "foraminiferal Mg/Ca during the coolest interval of the Little Ice Age (ca. 250 yr B.P.) indicate that SST was 2-2.5°C below modern SST." In addition, they found that "four minima in the Mg/Ca record between 900 and 250 yr. B.P. correspond with the Maunder, Sporer, Wolf, and Oort sunspot minima."

Clearly, as time marches on, solid empirical evidence continues to accumulate, demonstrating that (1) the Medieval Warm Period (MWP) was an interval of elevated global temperatures that were equally as warm as, and in many cases even *warmer* than, those of the Current Warm Period, and that (2) the MWP's elevated warmth was likely solar-induced, which suggests that the Current Warm Period may well be deriving its warmth from the same source, as it is likely nothing more than the most recent manifestation of the warm node of this ever-recurring climate cycle.

Starting a new year, MacDonald *et al*. (2008)[18] defined the term *perfect drought* as "a prolonged drought that affects southern California, the Sacramento River basin and the upper Colorado River basin simultaneously," while noting that the instrumental record indicates the occurrence of such droughts throughout the past century, but that they "generally persist for less than five years." That they have occurred at all, however, suggests the possibility of even *longer* "perfect droughts," which could well prove catastrophic for the region. And, therefore, the three researchers explored the likelihood of such droughts occurring in the future, based on dendrochronological reconstructions of the winter Palmer Drought Severity Index (PDSI) in southern California over the past thousand years, plus the concomitant annual discharges of the Sacramento and Colorado Rivers, under the logical assumption that what has occurred before may well occur again. So what did they find?

MacDonald *et al*. reported finding that "prolonged perfect droughts (~30-60 years), which produced arid conditions in all three regions simultaneously, developed in the mid-11th century and the mid-12th century during the period of the so-called 'Medieval Climate Anomaly'," leading them to conclude that "prolonged perfect droughts due to natural or anthropogenic changes in radiative forcing, are a clear possibility for the near future." And so they are! Therefore, whether one believes or disbelieves in CO_2-induced global warming, the possibility of a long and sustained perfect drought in Southern California is very real; and measures should be taken to prepare for that possibility.

Another conclusion that could be drawn from MacDonald *et al*.'s findings is that the current warmth of the world is not yet as great as it was during the peak heat of the Medieval Warm Period, else we might have already experienced, or been in the process of experiencing, a multi-decadal perfect drought. That such has not occurred is very encouraging; but it must be remembered that even if the theory of CO_2-induced global warming is incorrect or vastly overstated, further *natural* warming could well push the planet's climate over the "tipping point" that initiates such a drought. The fact that the earth has experienced no net warming over the past decade or so is thus a good sign in this regard; but there is no guarantee that the

[18] http://www.co2science.org/articles/V11/N50/EDIT.php.

globe may not begin to warm again ... at any time and for whatever reason. Clearly, therefore, planning for a significant perfect drought to possibly occur would appear to be warranted.

Concomitantly, McGann (2008)[19] analyzed a sediment core retrieved from the western portion of south bay near San Francisco International Airport (37°37.83'N, 122°21.99'W) for the presence of various foraminifers, as well as oxygen and carbon stable isotopes and numerous trace elements found in tests of *Elphidium excavatum*. And in doing so, the U.S. Geological Survey researcher discovered that "benthic foraminiferal abundances, stable carbon and oxygen isotopes, and Mg/Ca ratios suggest that the climate of south bay has oscillated numerous times between warm and dry, and cool and wet conditions over the past 3870 years," and that "both the Medieval Warm Period [MWP] and the Little Ice Age [LIA] are evident." More specifically, she identified the MWP as occurring from AD 743 to 1343 and the LIA as occurring in two stages: AD 1450 to 1530 and AD 1720 to 1850. In addition, she stated that the timing of the MWP "correlates well with records obtained for Chesapeake Bay (Cronin *et al*., 2003), Long Island Sound (Thomas *et al*., 2001; Varekamp *et al*., 2002), California's Sierra Nevada (Stine, 1994), coastal northernmost California (Barron *et al*., 2004), and in the San Francisco Bay estuary in north bay at Rush Ranch (Byrne *et al*., 2001), and south bay at Oyster Point (Ingram *et al*., 1996)," and that the cooler and wetter conditions of the LIA have been reported "in Chesapeake Bay (Cronin *et al*., 2003), Long Island Sound (Thomas *et al*., 2001; Varekamp *et al*., 2002), coastal northernmost California (Barron *et al*., 2004), and in the San Francisco Bay estuary at Rush Ranch (Bryne *et al*., 2001), Petaluma Marsh (Ingram *et al*., 1998), and in Richardson Bay (Ingram and DePaolo, 1993)." As for the more recent past, McGann notes that "near the top of the core" foraminiferal abundances suggest that, "once again, regional warming has taken place." However, that warming does not appear to have returned the region to the level of sustained warmth it enjoyed during the peak warmth of the MWP.

These new results and their concurrence with results obtained by many other researchers - both nearby and across the country on the east coast of the United States - continue to strengthen the likelihood that (1) the warming of the past century or so has been nothing more than the *natural* and *only-to-be-expected* recovery of the earth from the extremely cold conditions of the LIA, which phenomenon has yet to return the planet to the level of sustained warmth characteristic of the MWP, and that (2) this transition has had nothing to do with the increase in the air's CO_2 concentration that has occurred over the same time period.

Also appearing about this time was the paper of Nordt *et al*. (2008)[20], who - based on isotopic soil carbon measurements made on 24 modern soils and 30 buried soils scattered between latitudes 48 and 32°N and longitudes 106 and 98°W - developed a time series of C_4 vs. C_3 plant dynamics for the past 12 ka (ka = 1000 ^{14}C yr BP) in the mixed and shortgrass prairie of the U.S. Great Plains. And *because*, as they describe it, the percent soil carbon derived from C_4 plants "corresponds strongly with summer temperatures as reflected in the soil carbon pool (Nordt *et al*., 2007; von Fischer *et al*., 2008)," they were able to devise a history of the relative warmth of the climate of the region over this protracted period.

[19] http://www.co2science.org/articles/V12/N1/C1.php.
[20] http://www.co2science.org/articles/V12/N6/C3.php.

In doing so, Nordt *et al*.'s data suggested that their region of study was *slightly* warmer than it has yet to be in modern times during parts of both the Medieval and Roman Warm Periods, and that it was *significantly* warmer during a sizeable portion of the mid-Holocene Thermal Maximum or Climatic Optimum, as it is sometimes called. Thus, for a broad swath of the midsection of the United States stretching from the center of Texas all the way to the U.S. border with Canada (and probably some distance beyond), the supposedly *unprecedented warming of the 20th century* (according to claims of the world's climate alarmists) was not unprecedented at all, having likely been surpassed one thousand, two thousand and four to five thousand years ago, when there was *much* less CO_2 in the air than there is today, which observation thus begs the question of what *was* the cause of those earlier and warmer-than-present periods. The answer of Nordt *et al*. is that "these warm intervals ... exhibit a strong correlation to increases in solar irradiance," as per the irradiance reconstruction of Perry and Hsu (2000).

> The many parameters measured by Whitlock *et al.* testify to the non-uniqueness of Yellowstone National Park's 20th-century climate, to the significant warmth of the Medieval Warm Period, which allowed trees in some parts of the Park to grow at higher elevations than they do presently, which in turn suggests that much of the Medieval Warm Period had to have been significantly warmer than the Current Warm Period has been to date.

In another illuminating United States study from the same time period, Whitlock *et al*. (2008)[21] analyzed (at high-resolution) geochemical, stable-isotope, pollen, charcoal, and diatom records found in cores obtained from Crevice Lake - located at 45.000°N, 110.578°W - with the goal of reconstructing its watershed's ecohydrologic, vegetation, and fire history for the last 2650 years, in order to better understand past climate variations at the forest-steppe transition within the canyon of the Yellowstone River in northern Yellowstone National Park (YNP).

The seven scientists reported that their many datasets were "consistent with overall warmer/drier conditions during the Medieval Climate Anomaly," which they noted had been variously dated between AD 650 and 1300 in the western US and Great Plains. More specifically, they found that "the Crevice Lake data suggest a warm interval with dry winters between AD 600 and 850, followed by less dry but still warm conditions between AD 850 and 1100." In addition, they wrote that "other studies in YNP indicate that trees grew above the present-day treeline and fires were more frequent in the Lamar and Soda Butte drainages between AD 750 and 1150," citing Meyer *et al*. (1995).

[21] http://www.co2science.org/articles/V12/N9/C2.php.

As for the modern period, Whitlock *et al*. wrote that their data indicated that "the last 150 years of environmental history since the formation of YNP have not been anomalous within the range of variability of the last 2650 years, and many of the proxy indicators suggest that 19th and 20th century variability at Crevice Lake was moderate compared with earlier extremes." In fact, they went on to state that with the possible exception of the charcoal record, "all of the data show greater variability in the range of ecosystem conditions prior to the establishment of the YNP in 1872." And thus it is that the many parameters measured by Whitlock *et al*. testify to the *non-uniqueness* of YNP's 20th-century climate, but to the *significant warmth* of the Medieval Warm Period, which allowed trees in some parts of the Park to grow at higher elevations than they do presently, which in turn suggests that much of the Medieval Warm Period had to have been *significantly warmer* than the Current Warm Period has been to date.

One year later, and also reporting work conducted at Yellowstone National Park, Persico and Meyer (2009)[22] described how they had used "beaver-pond deposits and geomorphic characteristics of small streams to assess long-term effects of beavers and climate change on Holocene fluvial activity in northern Yellowstone National Park," which feat was accomplished by comparing "the distribution of beaver-pond deposit ages to paleoclimatic proxy records in the Yellowstone region."

In describing their findings, Persico and Meyer stated that "gaps in the beaver-pond deposit record from 2200-1800 and 700-1000 cal yr BP are contemporaneous with increased charcoal accumulation rates in Yellowstone lakes and peaks in fire-related debris-flow activity, inferred to reflect severe drought and warmer temperatures (Meyer *et al*., 1995)." In addition, they noted that "the lack of evidence for beaver activity 700-1000 cal yr BP is concurrent with the Medieval Climatic Anomaly, a time of widespread multi-decadal droughts and high climatic variability in Yellowstone National Park (Meyer *et al*., 1995) and the western USA (Cook *et al*., 2004; Stine, 1998; Whitlock *et al*., 2003)," while their lack of evidence for beaver activity 2200-1800 cal yr BP was concurrent with the Roman Warm Period. And in both of these situations, the two researchers concluded that the severe droughts of these periods "likely caused low to ephemeral discharges in smaller streams, as in modern severe drought," implying that the Medieval and Roman Warm Periods were likely to have been *at least* as dry and warm as it is today.

Jumping ahead two more years, Routson *et al*. (2011)[23] wrote that "many southwestern United States high-resolution proxy records show numerous droughts over the past millennium, including droughts far more severe than those experienced during the historical period (e.g., Woodhouse and Overpeck, 1998; Cook *et al*., 2004, 2010; Meko *et al*., 2007)," while adding that (1) "the medieval interval (ca. AD 900 to 1400), a period with relatively warm Northern Hemisphere temperatures, has been highlighted as a period in western North America with increased drought severity, duration and extent (e.g., Stine, 1994; Cook *et al*., 2004, 2010; Meko *et al*., 2007; Woodhouse *et al*., 2010)," and that (2) "the mid-12th century drought associated with dramatic decreases in Colorado River flow (Meko *et al*., 2007), and the 'Great Drought' associated with the abandonment of Ancient Pueblo civilization in the Colorado

[22] http://www.co2science.org/articles/V12/N26/C2.php.
[23] http://www.co2science.org/articles/V15/N8/C1.php.

Plateau region (Douglass, 1929), all occurred during the medieval period," which observations would appear to suggest that significant Northern Hemispheric *warmth* tends to produce western North America *megadroughts*.

In further exploring this hypothesis, Routson *et al*. used a new tree-ring record derived from living and remnant bristlecone pine wood from the headwaters region of the Rio Grande River in Colorado (USA), along with other regional records, to evaluate what they described as "periods of unusually severe drought over the past two millennia (268 BC to AD 2009)." And in doing so, the three researchers reported that the record they derived "reveals two periods of enhanced drought frequency and severity relative to the rest of the record," and that "the later period, AD ~1050-1330, corresponds with medieval aridity well documented in other records," while "the earlier period is more persistent (AD ~1-400), and includes the most pronounced event in the ... chronology: a multi-decadal-length drought during the 2nd century," which "includes the unsmoothed record's driest 25-year interval (AD 148-173) as well as a longer 51-year period, AD 122-172, that has only two years with ring width slightly above the long-term mean," and where "the smoothed chronology shows the periods AD 77-282 and AD 301-400 are the longest (206 and 100 years, respectively, below the long-term average) droughts of the entire 2276-year record." And they note that this 2nd-century drought "impacted a region that extends from southern New Mexico north and west into Idaho."

Noting that "reconstructed Colorado Plateau temperature suggests warmer than average temperature could have influenced both 2nd century and medieval drought severity," and that "available data also suggest that the Northern Hemisphere may have been warm during both intervals," Routson *et al*. went on to suggest that the southwestern United States could well experience similar or even more severe megadroughts in the future, as they suspect it will continue to warm in response to continued anthropogenic CO_2 emissions. *However*, studies from all around the globe - which depict both a Medieval Warm Period and a Roman Warm Period that were equally as warm as, or even *warmer* than, the Current Warm Period has been to date, at times when there was *way* less CO_2 in the atmosphere than there is today - suggest that there is nothing unusual, unnatural or unprecedented about earth's current level of warmth, and, in fact, that it must be significantly *cooler* now than it was during those two prior multi-century warm periods, since we have not yet experienced droughts of anywhere near the severity or duration of those that were experienced in the Roman and Medieval Warm Periods, which *further* suggests that the planet's current level of warmth is likely *not* a result of historical anthropogenic CO_2 emissions, but rather a result of a milder expression of whatever was the cause of those two *earlier* stellar warm periods.

One year later the study of Sritairat *et al*. (2012)[24] appeared in print, wherein its authors wrote that "the mid-Hudson region contains freshwater peatland archives that have not been investigated," and they therefore stated that "there is a need to identify this base-line information to assess past anthropogenic activities and climatic patterns in relation to projected shifts in climate and vegetation in the Mid-Hudson Valley region," which they indicate is an important resource for over 10 million people. And so it was that Sritairat *et al*. explored, as they described it, "how climate and human impacts have influenced plant ecology, invasive

[24] http://www.co2science.org/articles/V15/N40/C3.php.

species expansion, habitat loss, carbon storage, and nutrient dynamics over the past millennium based on the multiproxy analysis of sediment cores using palynology, macrofossil, sedimentological, and geochemical analyses," while working with marsh sediment cores obtained at the National Estuarine Research Reserve at Tivoli Bays on the Hudson Estuary, New York, USA. And what did they learn?

The six scientists first identified a pre-European settlement period (AD 826-1310) that had a "high percentage of *Carya*, a warmth-loving species (Fowells, 1965)," which finding, as they described it, "supports an increase in temperature." In addition, at a depth dated to AD 1087 ± 72, they found a *charcoal maximum*, referring to it as "a feature that is also found in other Hudson river marsh cores at Piermont (Pederson *et al*., 2005) and Iona (Peteet *et al*., 2006)," which represented, in their words, "the warm, dry Medieval Warm Period (MWP)," which they further stated was "likely a result of a regional Hudson Valley MWP recorded on a larger spatial scale in other parts of North America and the globe."

Acknowledging that "while there is a debate if the MWP is a global phenomenon as the warming is not synchronized at all sites around the globe," Sritairat *et al*. wrote that "many paleoclimatic records suggest widespread climatic anomalies, such as parts of Europe (Mangini *et al*., 2005), Tasmania (Cook *et al*., 1991), Asia (Yang *et al*., 2002), and Africa (Alin and Cohen, 2003) during the same time period." And, thus, the case for the existence of a *global* MWP continues to grow, as demonstrated by the great regularity with which new studies that testify of the MWP's occurrence at new and different locations around the world continue to appear on a fairly regular basis.

The plethora of real-world evidence for a generally warmer-than-present MWP, at a time when the atmosphere's CO_2 concentration was something on the order of 285 ppm, as opposed to the 400 ppm of today, weighs heavily against the climate-alarmist claim that higher atmospheric CO_2 concentrations must invariably lead to warmer mean global temperatures.

In concluding this summary, the plethora of *real-world evidence* for a generally *warmer-than-present* MWP, at a time when the atmosphere's CO_2 concentration was something on the order of 285 ppm, as opposed to the 400 ppm of today, weighs heavily against the climate-alarmist claim that higher atmospheric CO_2 concentrations must invariably lead to warmer mean global temperatures. That is simply *not* how the real world works; and this data-grounded *fact* provides a concrete reason for rejecting the projections of even the very best mathematical models of how earth's climate is *supposed* to operate, according to insufficient theoretical assumptions.

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