

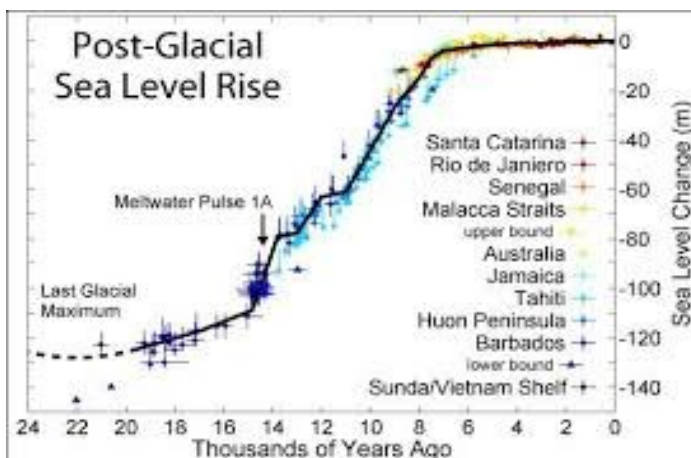
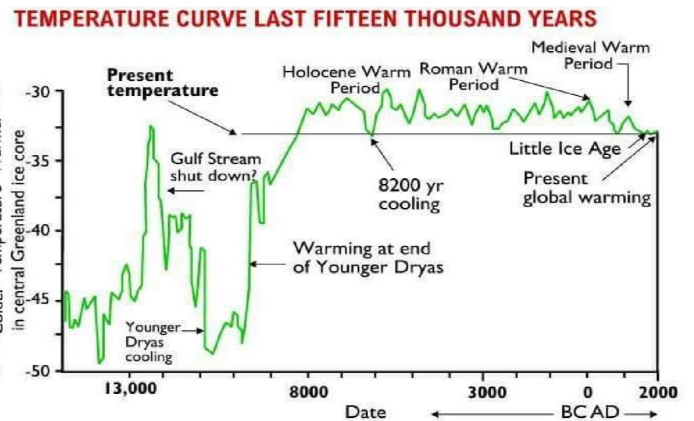
## Climate Science and Policy for Nonscientists

One picture is worth a thousand words.

### CLIMATE HISTORY II - THE HOLOCENE - FROM 11,000 YEARS AGO TO THE PRESENT

There is a surprising amount of disagreement among scientists about important issues over the last 10,000-11,000 years. Scientists disagree during this period: (1) whether there have been temperatures higher than present temperatures, and (2) whether there have been climate cycles caused by natural variation or by forces other than greenhouse gases. If pre-industrial temperatures have been warmer than the present, then today's temperatures are not "unprecedented" as claimed by the IPCC. If cycles caused by natural variation or by forces other than greenhouse gases exist, then some significant amount of the warming over the last 150 years may have been caused by such cycles.

Scientists agree that from roughly 15,000 years ago to 10,000 years ago world temperatures varied dramatically and, overall, shot upward as the most recent glacial period came to an end, and as the current geological period, the Holocene Interglacial, began. Since 10,000 years ago in this reconstruction, there have been three named warm periods with an overall downward trend towards present world temperatures. The IPCC disputes the existence of each of these three warm periods.



The temperature rise was so great from 18,000 years ago that world sea levels rose about 120 meters, or almost 400 feet, over the next 10,000 years, and then in recent millenia have remained relatively stable. It is agreed that all this temperature and sea level rise was caused by natural variability. Human activity had nothing to do with it. As late as around 5000 BC the total human population in the world may have been only 5 million people compared to a present population of over 8 billion.

The traditional understanding of Holocene temperature is the black line with an “optimum” or high point some 8,000 years ago (6,000 BC), which was significantly warmer than the present. It is agreed that, since 5,000 years ago, CO2 and methane atmospheric concentrations have been increasing, but this image shows temperatures declining. The computer climate models (green line), relied upon by the IPCC, project that temperatures should have been rising, so neither the models, nor the CO2 Control Knob Theory can explain the declining temperatures if they existed.

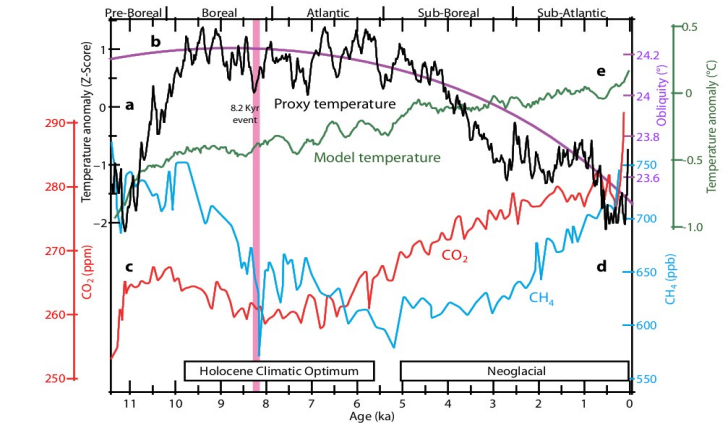
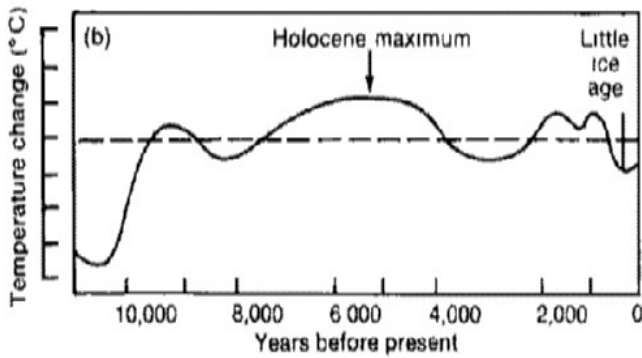


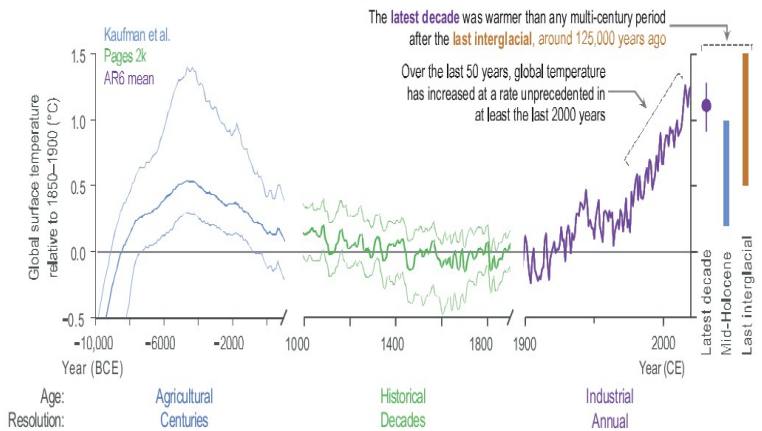
Fig. 4.5 Temperature and greenhouse gases during the Holocene  
 a) Black curve, global temperature reconstruction as in Fig. 4.4b. b) Purple curve, Earth's axis obliquity cycle. c) Red curve, CO<sub>2</sub> levels as measured in Epica Dome C (Antarctica) ice core, reported in Monnin et al. (2004). d) Blue curve, methane levels as measured in GRIP, GISP2, and NEMO (Greenland) ice cores as reported by Kobashi et al. (2007). Notice the great effect of the 8.2 kyr event on methane concentrations. e) Green curve, simulated global temperature from an ensemble of three models (CCSM3, FAMOUS, and LOVECLIM) from Liu et al. (2014), show the inability of general climate models to replicate the Holocene general temperature downward trend. Vertical bar, 8.2 kyr BP ACE. Major Holocene climatic periods are indicated.



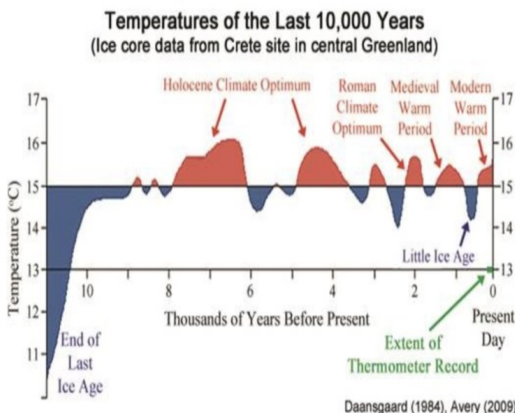
The IPCC in its First Assessment Report (1990) presented this graph (ARI p.202) showing the Holocene maximum significantly warmer than the present, but occurring around 5,000 years ago rather than 8.000 years ago in the prior graph. In his classic text, *Climate History and the Modern World* (2d ed. 1995), H.H.Lamb opined that between 5000 and 3000 BC the world was generally warmer by 1-3 C than it is today.

#### Changes in surface temperature

(a) Global surface temperatures are more likely than not unprecedented in the past 125,000 years



But in AR6 (2021) the IPCC adopted the position that Mid-Holocene temperatures (the blue vertical line on the right) were lower than modern temperatures. (AR6 WGI p.316). Thus the IPCC claims that present temperatures are warmer than any multi-century period in the last 100,000 years, and hence are “unprecedented.”. (AR6 WGI p.6).



This analysis agrees with the prior image from AR1, showing the Roman Warm Period and the Medieval Warm Period, as traditionally understood, each were significantly warmer than the present, and the Little Ice Age, as traditionally understood, was significantly colder. Both images support the theory of warming occurring on a natural climate cycle of about 1,000 years.

Figure 12. A smoothed plot of average temperature over the last 10,000 years as measured by the Greenland ice caps

During the Roman Warm Period wine grapes were grown in England. Tunisia during this period was the “breadbasket” of the Roman Empire. Massive quantities of wheat were grown in parts of North Africa that are now desert. Trade on the Great Silk Road prospered from about 150 BC to 300 AD, when travel was shut down by the changing climate (drought).

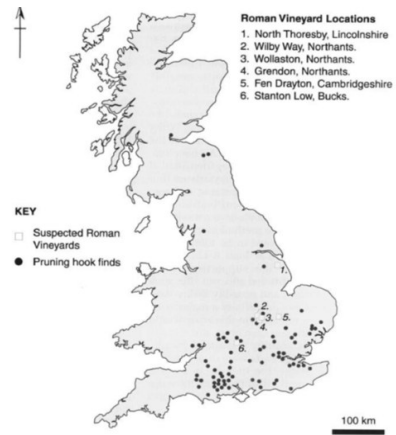
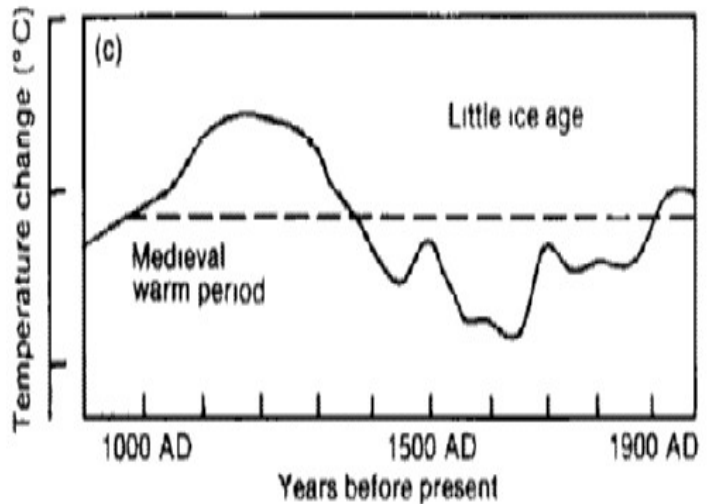


Figure 14. A map of England showing where the Roman's grew wine 2000 years ago, when England had a warmer climate than today

Again during the Medieval Warm Period wine grapes were grown in England, and French wine producers protested the competition. When the Vikings settled Greenland in 1000, it was, in fact, a green land, hence the name. Settlement was possible because barley could be grown there at the time.



But in 2001 the IPCC pronounced as definitive a new study showing world temperatures virtually flat and linear from the year 1000 to 1900 and then rising precipitously. (AR3 WGI p.3). This graph is colloquially referred to as the “hockey stick graph.”

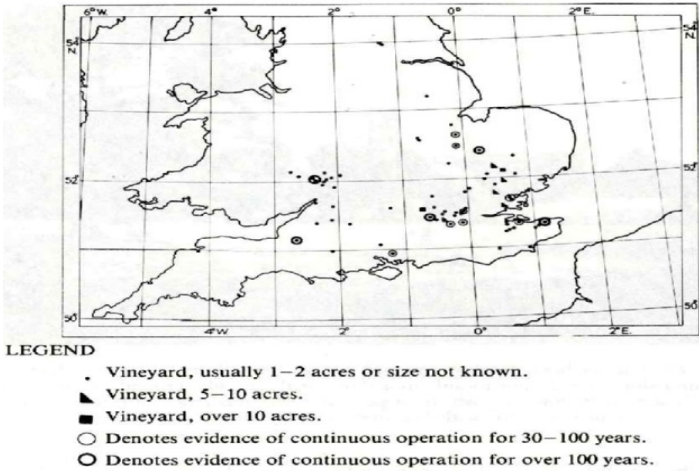
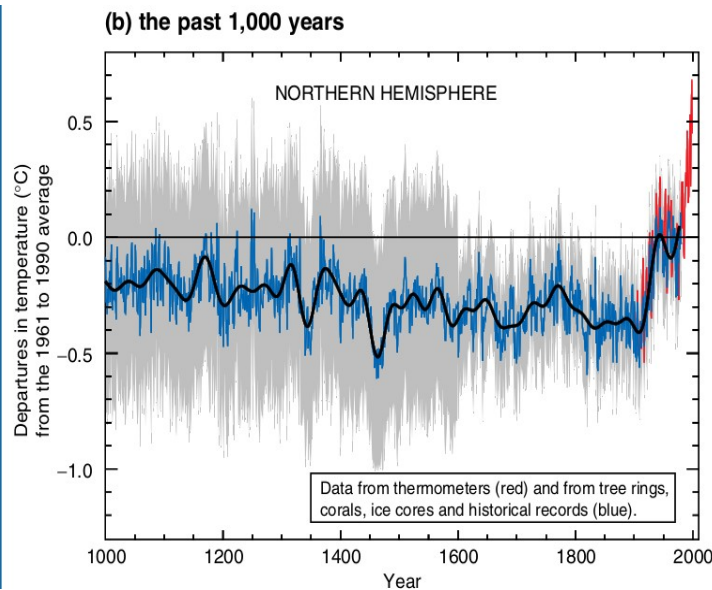
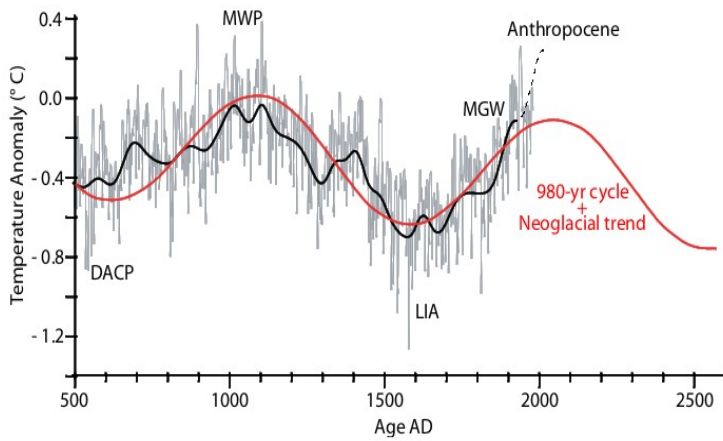


Fig. 65 The distribution of known medieval vineyard sites in England.

This image from IPCC AR1 p.202 (1990) clearly acknowledges the Medieval Warm Period as significantly warmer than today and the Little Ice Age as significantly colder than today. It also shows the present warming starting in the 1600s, long before humans were emitting a significant amount of CO2.

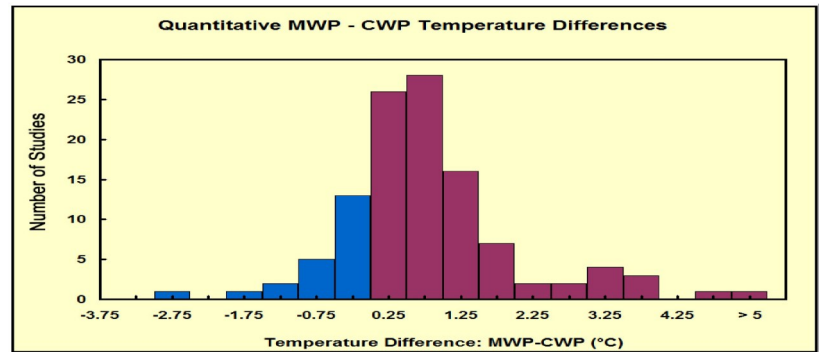




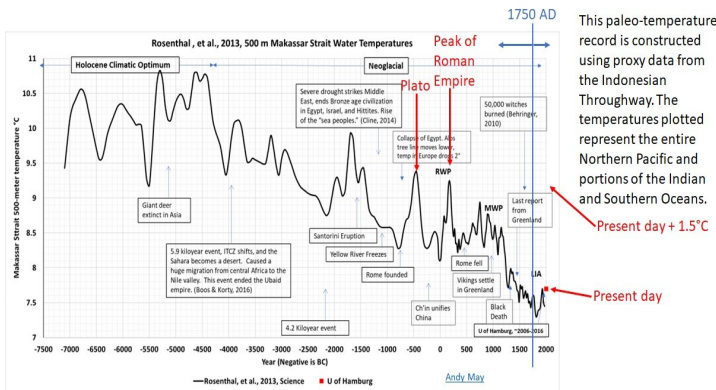
**Fig. 12.3 Warming and cooling periods of the past 1500 years, fitted to known climate cyclic behavior**  
 Moberg et al. (2005), reconstruction of Northern Hemisphere temperature anomaly for the period AD 500–1978 (thin grey curve), and its low frequency component (black curve). The 980-year Eddy cycle is shown by the red sinusoidal, with a declining Neoglacial trend of  $-0.2\text{ }^{\circ}\text{C}/\text{millennium}$ . As Moberg's reconstruction ends in 1978, the dotted line represents the 1975–2000 warming, that is similar in magnitude to the 1910–1945 warming. DACP, Dark Ages Cold Period. MWP, Medieval Warm Period. LIA, Little Ice Age. MGW, Modern Global Warming. Peak natural warming is expected in AD 2050–2100.

Some scientists, who support the theory of a natural 1,000 year cycle, attribute it to the solar Eddy Cycle, which would explain most of the world's warming over the last 400 years.

Roughly 3/4s of the over 100 papers that have been published rebut the hockey stick and support the theory that the Medieval Warm Period was significantly warmer than today. The issue is unsettled, but a clear majority of the papers support the existence of a Medieval Warm Period. None of this debate is acknowledged or discussed in recent IPCC reports.



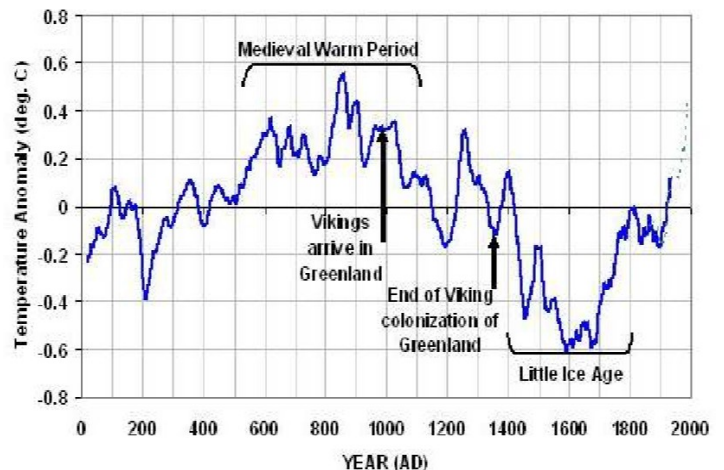
**Figure 4.2.2.2.** The distribution, in  $0.5^{\circ}\text{C}$  increments, of studies that allow the identification of the degree by which peak Medieval Warm Period temperatures either exceeded (positive values, red) or fell short of (negative values, blue) peak Current Warm Period temperatures.

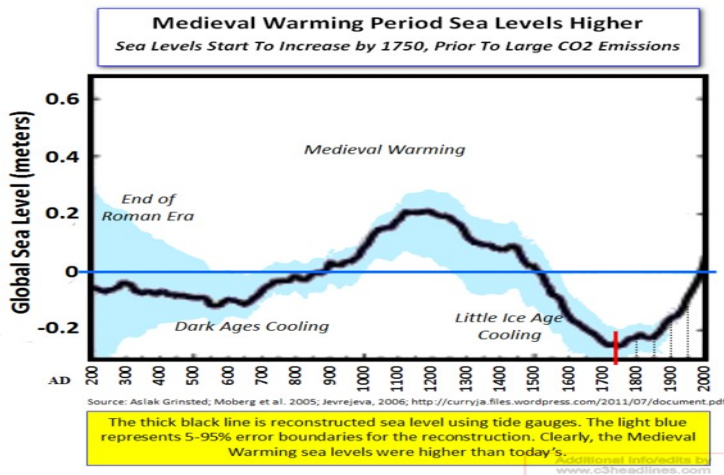


This paleo-temperature record is constructed using proxy data from the Indonesian Throughway. The temperatures plotted represent the entire Northern Pacific and portions of the Indian and Southern Oceans. Present day +  $1.5^{\circ}\text{C}$   
 Present day

Supporters of the hockey stick graph argue that there may have been medieval warming in Europe, but that this was not typical of the world as a whole. There are, however, a large number of studies from around the world, like this study from Indonesia, that support the theory of global periods of warming during the Holocene, during the Roman Warm Period, and during the Medieval Warm Period.

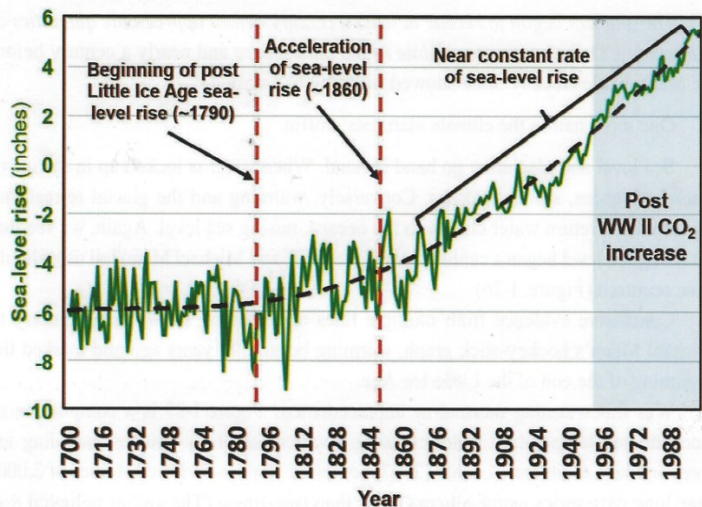
Part of the dispute over the hockey stick graph involves the reliability of tree ring proxies for temperature. One critic of tree ring reliability, Craig Loehle, published this reconstruction in 2007 based on 18 non-tree ring proxies, finding both a Medieval Warm Period significantly warmer than today's temperatures, and a Little Ice Age, running from around 1400 to 1700, significantly colder. Reconstructions such as this suggest that the world's present warming is the normal, natural recovery from the unusual cold of the Little Ice Age.





The history of settlement in Iceland supports the theory of a Medieval Warm Period, giving way to the Little Ice Age., at least in Western Europe. In England the Thames regularly froze in the 1600s, and in some parts the yearly number of burials exceeded the births from the 1660s until about 1730.

Figure I-26: Greater than 200 years of sea-level rise



(Source data: Jevrejeva 2008, PSMSL 2008)

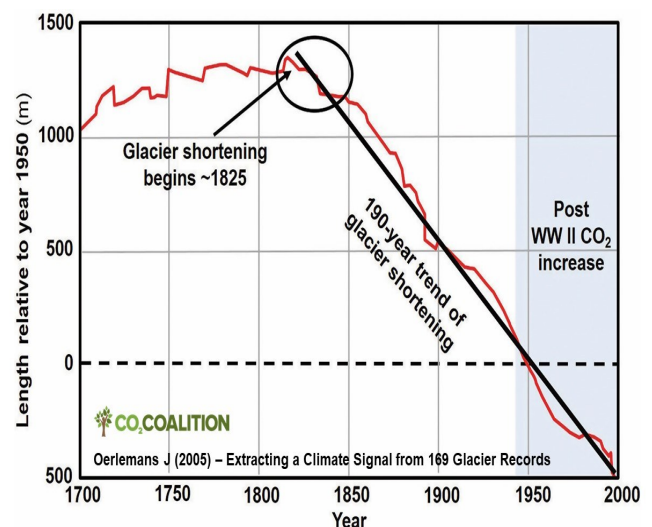
The modern glacier retreat started in the 1820s, again long before human activity or CO<sub>2</sub> could have been a significant cause. All of these images suggest a multi-century cycle of natural temperature change.

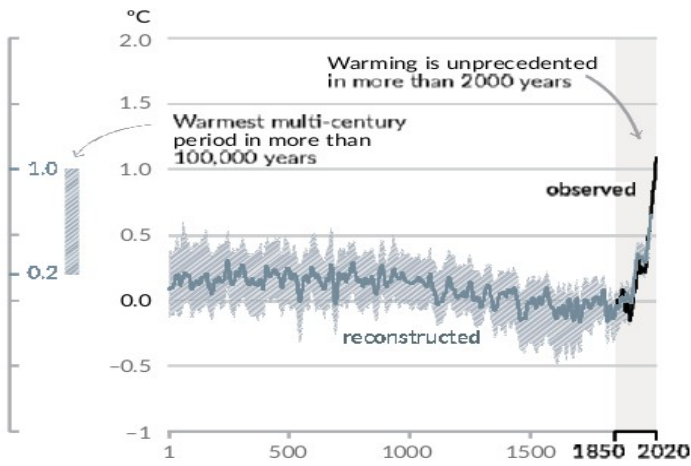
Sea level changes are caused by global warming and cooling. The sea level data shown here supports the temperature reconstructions showing a warm Medieval Warm Period and a cold Little Ice Age, bottoming out around 1750.

## AN ICELAND CHRONOLOGY

- 800 First Europeans arrive and find a "land of ice," hence the name.
- 900 Grain being cultivated as conditions improve. Populations growing.
- 1200 The population has started to decline
- 1500s Cultivation of grain abandoned
- 1695 Sea ice entirely surrounds the island for much of the year. Ships barred for many months
- 1756 Sea ice still at the coast for 30 weeks of the year.
- 1780s Population down by about 50% from the Medieval high.
- 1784 Danish government debates whether to evacuate Iceland.

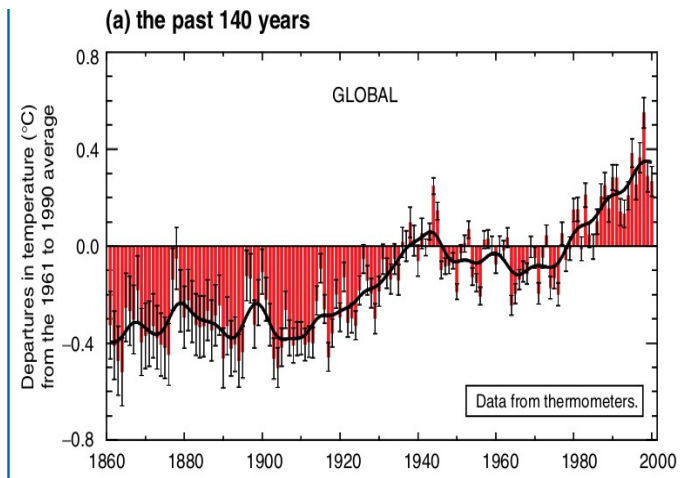
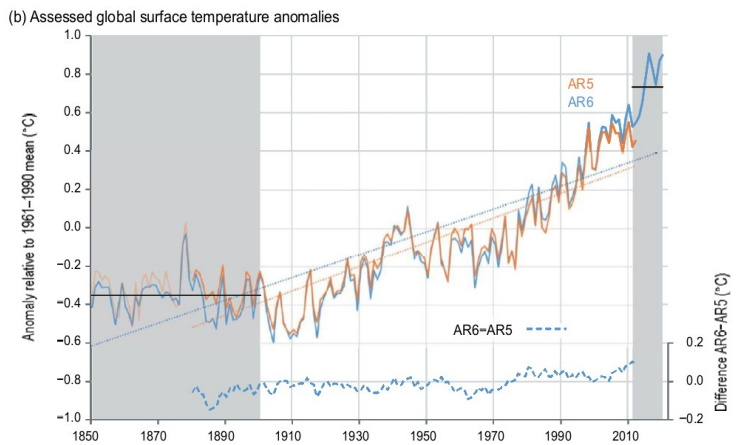
This more detailed global sea level graph shows the modern rise starting about 1790 and then becoming linear from around 1870, long before human activity or CO<sub>2</sub> could have been a significant cause of rising temperatures or rising sea levels. Global sea level rise is driven by global, not regional, warming.





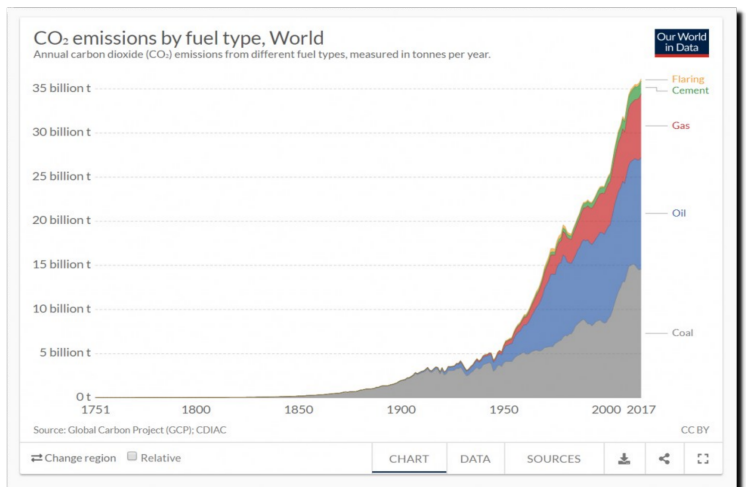
This graph of world temperatures from 1850 appeared in AR6 WGI p.322 (2021). Even with measured temperature data, there are different ways to graph the data to suggest different trends. This graph suggests that temperatures have been rising in roughly linear way since around 1900 with some recent acceleration. The IPCC concluded in 2021 that the world had warmed 1.1 C since 1850-1900 (AR6 WGI p.5), so the rate of warming has been about 1 C per century.

Yet this is the reconstruction that the IPCC chose to feature in the AR6 Summary for Policy Makers. [AR6 WGI p.6 (2021)]. The IPCC may reasonably be accused of covering up the extent of the disagreement among scientists as to the reconstructed temperatures of the 1,000 years prior to the beginning of the modern temperature record around 1850, when temperatures for the first time were actually measured by scientific instruments rather than being estimated from proxies, the accuracy of which are much debated.



By contrast, this graph appeared in IPCC AR3 WGI p.3 (2001) showing the temperature rise from 1860-2000. It shows three distinct periods of temperature movement - a rise 1910-1940, a decline from 1940-1975, and then a rise 1975-2000.

Human emissions of CO2 did not become significant until roughly the 1940s, and they have risen dramatically ever since at a roughly linear rate.



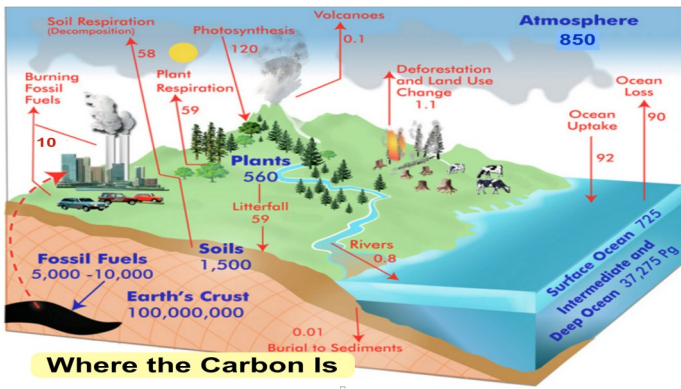


Figure 3. Depiction of the global carbon budget in Gt of carbon. Values in blue are stocks of carbon while values in red are annual flows. Note that the ocean contains nearly 50 times as much carbon as the atmosphere does, and the ocean and atmosphere are in constant flux.<sup>17</sup>

It is the atmospheric concentration of CO<sub>2</sub> that has a greenhouse effect, not the total human emissions, about half of which are promptly removed from the atmosphere by various natural processes. As of 1800 the atmospheric CO<sub>2</sub> concentration was 280 parts per million. By 1960 this had risen only to 315, much too small an increase to have caused the 1910-1945 temperature rise. Since 1960 the CO<sub>2</sub> concentration has increased by 100 ppm.

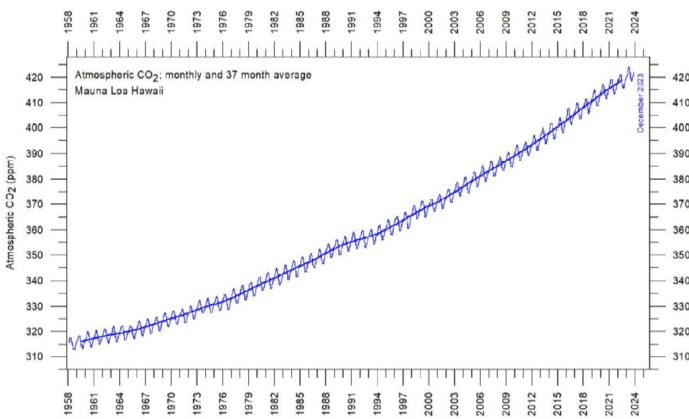


FIGURE 25: Monthly amount of atmospheric CO<sub>2</sub> since March 1958, measured at the Mauna Loa Observatory, Hawaii. The thin line shows the monthly values, while the thick line is the simple running 37-month average, nearly corresponding to a running 3-year average.

The IPCC in AR5 WGI p.17 (2013) conceded that the warming 1900-1950 was due to natural causes, and that up to half of the post-1951 warming might have been due to natural causes. Then in 2021 the IPCC concluded that virtually all of the warming since 1900 was “human-caused,” and that greenhouse gases were the “main driver of tropospheric warming since 1979.” (AR6 WGI p.5). In addition to CO<sub>2</sub> emissions, human causes include urbanization and other changes in land use.

The annual global carbon budget shows that soil respiration and plant respiration each release per year about 6 times the amount of CO<sub>2</sub> that is released by burning fossil fuels. Nearly 50 times as much carbon is stored in the oceans as in the atmosphere, and over 100,000 times as much is stored in the earth’s crust

## INCREASE IN CO<sub>2</sub> BY YEAR

YEAR	CONC	INCREASE
• 1800	280 ppm	
• 1960	315 ppm	35 ppm
• 2020	415 ppm	100 ppm
• CO <sub>2</sub> from Natural Sources	abt 70%	

Scientists have high quality instrumental measurements of atmospheric CO<sub>2</sub> levels since 1958, which show a basically linear but slightly accelerating rate of rise. The rate of CO<sub>2</sub> rise from 1800 to 1960 was 0.2 parts per million per year, and then 1.7 ppm per year from 1960 to 2020. Despite all the past human emissions in 2020 only about 30% of the CO<sub>2</sub> in the atmosphere came from human activity.

## IPCC #5 2013 REPORT - CONCLUSION ON CAUSATION

“It is EXTREMELY likely that MORE THAN HALF of the observed increase in global average surface temperature from 1951-2010 was caused by the increase in greenhouse gas.”



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DEPARTMENT OF GEOLOGICAL SCIENCES  
(401) 863-2240

December 3, 1972

The President  
The White House  
Washington, D. C.

Dear Mr. President:

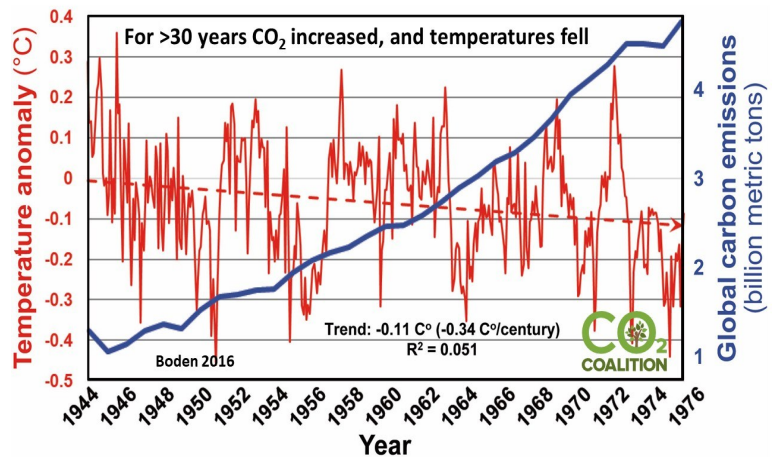
Aware of your deep concern with the future of the world, we feel obliged to inform you on the results of the scientific conference held here recently. The conference dealt with the past and future changes of climate and was attended by 42 top American and European investigators. We enclose the summary report published in Science and further publications are forthcoming in Quaternary Research.

The main conclusion of the meeting was that a global deterioration of climate, by order of magnitude larger than any hitherto experienced by civilized mankind, is a very real possibility and indeed may be due very soon. The cooling has natural cause and falls within the rank of processes which produced the last ice age. This is a surprising result based largely on recent studies of deep sea sediments.

Currently supporters of the CO2 Control Knob Theory dispute the seriousness of the cooling period from 1945-1975. But in 1965-66 the Baltic Sea was completely ice covered. In 1968 sea ice surrounded Iceland for the first time since 1888. As shown by this 1972 letter to President Nixon, scientists took this cooling period very seriously in the 1970s.

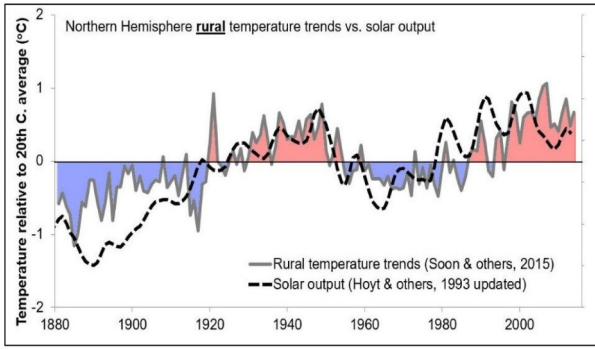


Time Magazine featured the coming Ice Age on a cover in 1977. Concern about global warming only become significant in the 1980s after world temperatures had resumed rising.



From roughly 1945 through 1976 CO2 emissions were increasing significantly, but world temperature fell, suggesting that the CO2 greenhouse effect is less powerful than the force or forces that were driving the temperature down during this period.

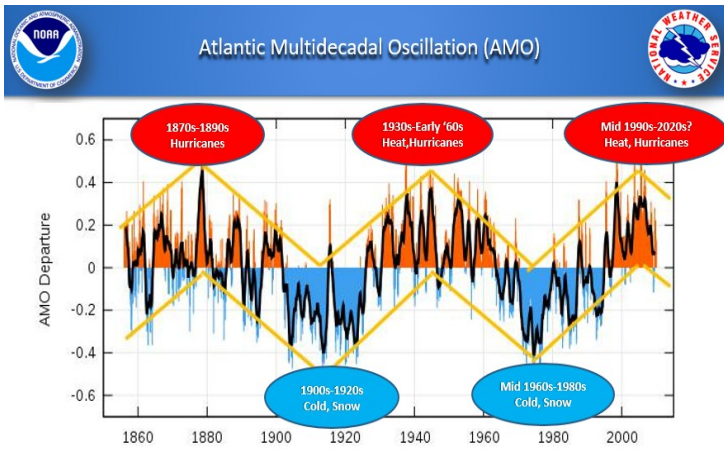
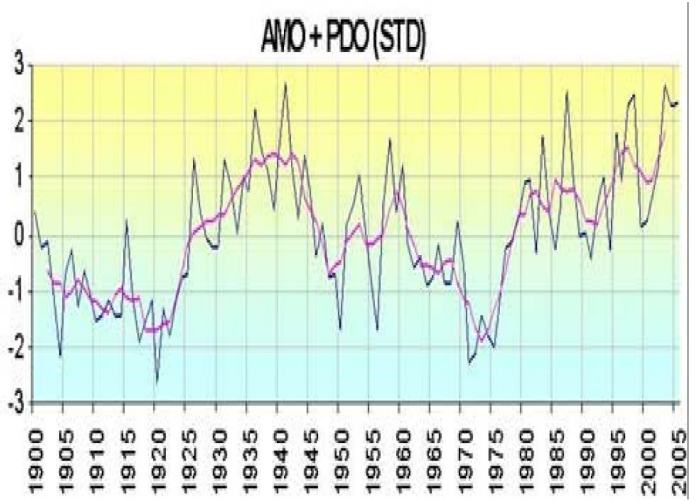
Northern Hemisphere rural temperature trends vs. solar output



Red and blue represent positive and negative temperature anomalies from twentieth-century average for a Northern Hemisphere temperature reconstruction using primarily rural surface stations (to control for urban heat island effect). Dashed line is solar output according to Hoyt and Schatten (1993) as updated by Scafetta and Willson (2014). Source: Adapted from Soon et al., 2015, Figure 27, p. 442.

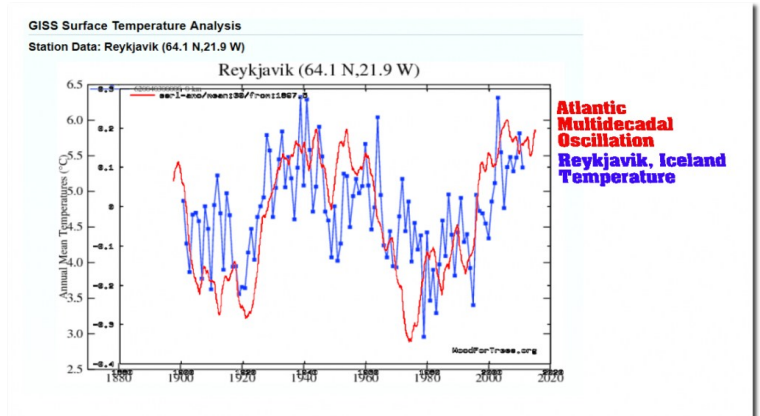
Solar scientists have published papers noting correlations, such as this one, between various solar cycles and world temperatures, but this is much disputed. The IPCC routinely denies that solar variation is at all significant. (AR6 WGI p.7). There is no agreement among scientists about the contribution of the sun to climate change in recent centuries, so the science can reasonably be described as unsettled.

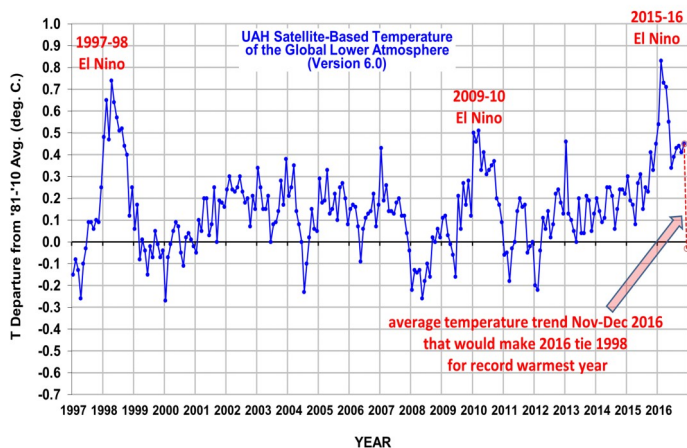
Oceanographers have established that two massive ocean currents, the Atlantic Multidecadal Oscillation (“AMO”) and the Pacific Decadal Oscillation (“PDO”) go through surface temperature cycles roughly 60 years in length. These cycles show greater correlation with world temperatures during the period 1900-2000 than does atmospheric CO2 concentrations, but the IPCC denies that “internal variability,” which includes ocean currents, have had any significant effect on temperatures. (AR6 WGI p.7)



The US National Oceanography and Atmospheric Administration (“NOAA”) has acknowledged the AMO effect on heat transfers and hurricane activity. In 2013 the IPCC admitted that natural forces had caused the global warming between 1900 and 1950. (AR5 WGI p.17). The IPCC in 2021 changed its mind and now claims that virtually all of the post-industrial warming is caused by “human activity” (which can include urbanization and other changes in land use), but the IPCC only claims that greenhouse gases were the “main driver” of warming since 1979. [AR6 WGI p.5 (2021)].

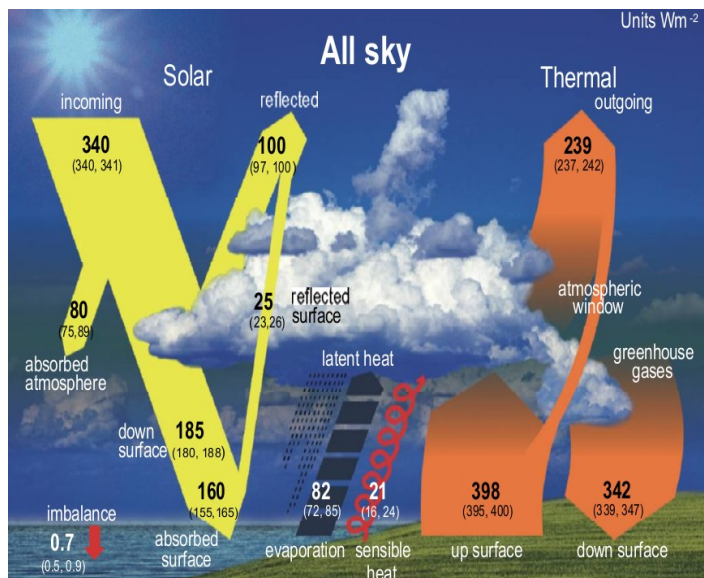
There is a strong correlation between AMO temperatures and surface temperatures in Iceland, and it is generally agreed that the PDO strongly influences the climate of Western Canada and the North-Western US. So it is clear that ocean cycles can have significant effect on regional climates.



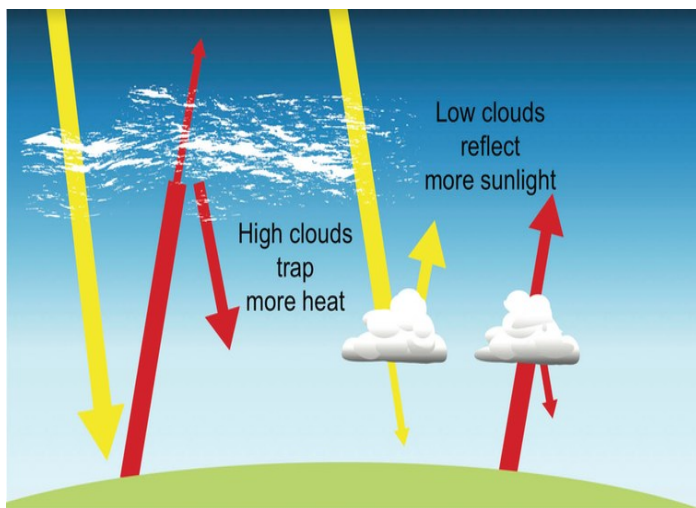


Since 1979 scientists have been able to measure world temperatures by satellite. The adjacent graph shows such temperatures through 2017 and particularly the impact of El Ninos, an example of how ocean currents affect, not just regional, but world temperatures.

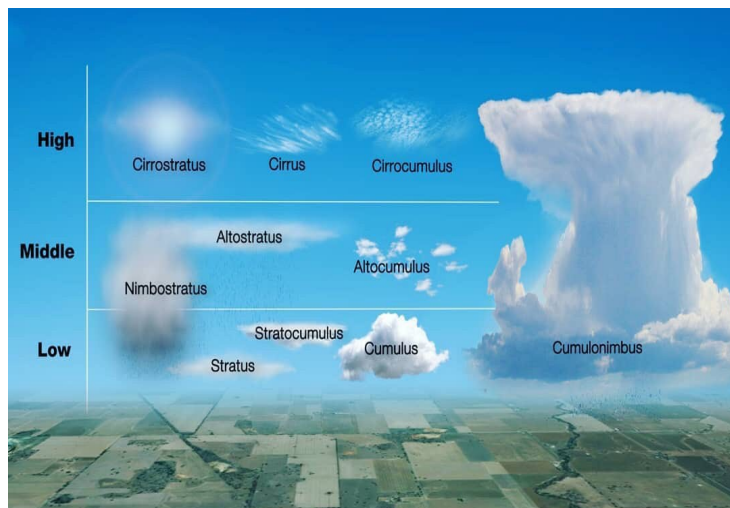
This image from AR6 WGI p.934 shows what is known as Earth's Energy Budget. It shows the central importance of clouds. Earth's warming is caused by the 0.7 watts/square meter net energy flow imbalance shown in the lower left corner of the image. A central issue in modern climate science is the cause of this imbalance, which is calculated as the net of a significant number of large incoming and outgoing energy flows. The IPCC maintains that all of these energy flows are remaining relatively fixed, except that the greenhouse effect is increasing, thereby causing most all of the 0.7 w/m2 imbalance.



But scientists do not understand cloud formation. Cloud formation feedback effects are crucial. The IPCC claims that such effects amplify global warming, but admits the the probability that such effects actually reduce global warming can not be ruled out. (AR6 WGI p.975). Clouds of different types at different altitudes have different effects on world temperatures.



There are 10 different types of clouds, existing at different altitudes, and each having different effects on energy flow both towards earth and away from earth..



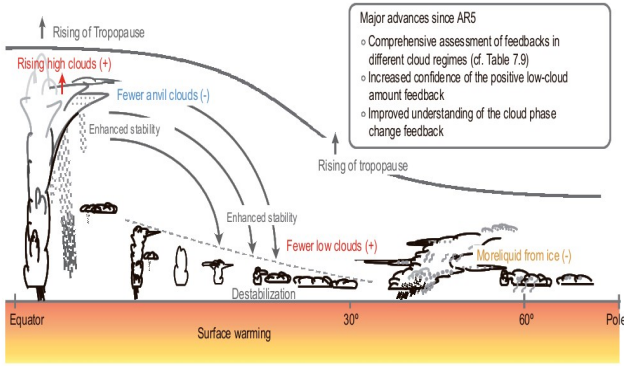


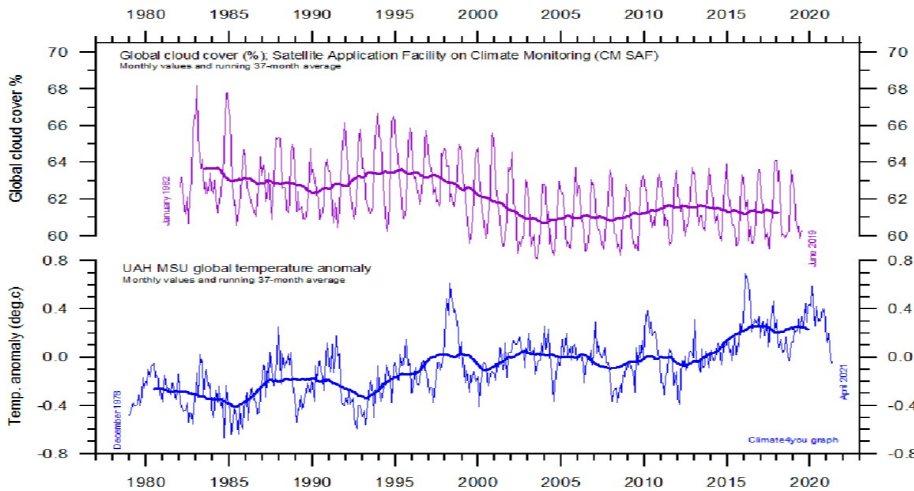
Figure 7.9 | Schematic cross section of diverse cloud responses to surface warming from the tropics to polar regions. Thick solid and dashed curves indicate the tropopause and the subtropical inversion layer in the current climate, respectively. Thin grey text and arrows represent robust responses in the thermodynamic structure to greenhouse warming, of relevance to cloud changes. Text and arrows in red, orange and green show the major cloud responses assessed with high, medium and low confidence, respectively, and the sign of their feedbacks to the surface warming is indicated in the parenthesis. Major advances since AR5 are listed in the box. Figure adapted from Boucher et al. (2013).

And the distribution of clouds and cloud types varies with latitude.

Water vapor and clouds have a far more significant greenhouse effect than CO<sub>2</sub> and methane, mostly because there is so much more water vapor and clouds in the atmosphere than CO<sub>2</sub> and methane. One molecule of methane has 20-30 times the greenhouse effect of one molecule of CO<sub>2</sub>, but, since methane's atmospheric concentration is so low in relation to CO<sub>2</sub>, it has a much lesser overall effect. There is significant disagreement as to the relative contributions of these three greenhouse gases, and the contributions vary by region around the world, mainly because of varying cloud cover.

## What are the 3 Most Important Greenhouse Gases?

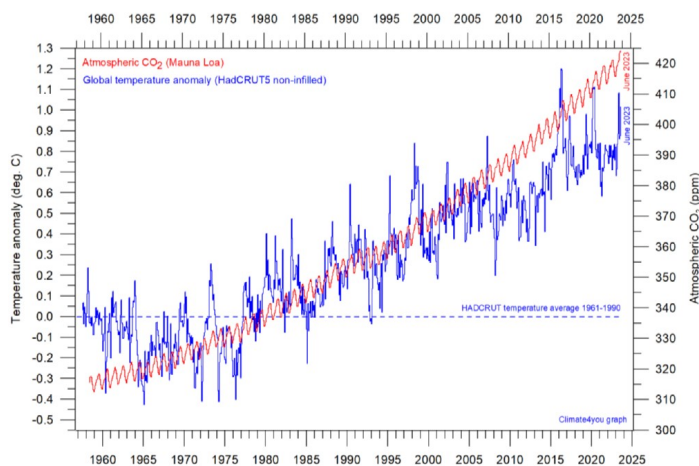
	Concentration in the Air ppm	% Total Effect
<b>Water vapor/ Clouds</b>	<b>10,000-40,000</b>	<b>70-95%</b>
<b>CO<sub>2</sub></b>	<b>415</b>	<b>4-20%</b>
<b>Methane</b>	<b>&lt;2</b>	<b>1-10%</b>



Clouds cover roughly 2/3ds of the earth's surface (AR6 WGI p. 1022), and there is more cloud cover over the oceans than over land. When the PDO and the AMO change ocean surface temperature, this has a significant effect on the amount and types of clouds over the oceans.

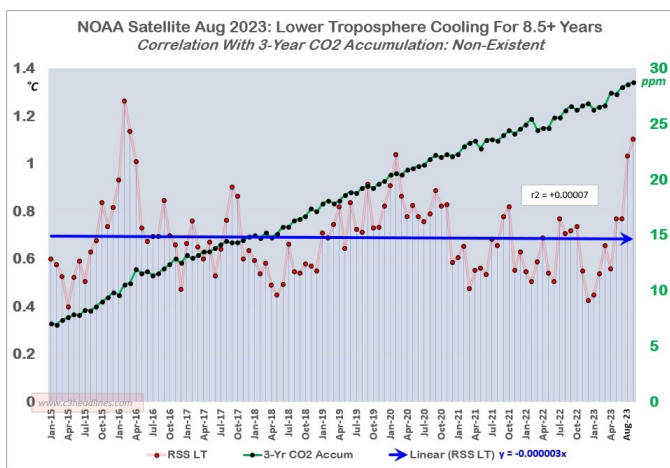
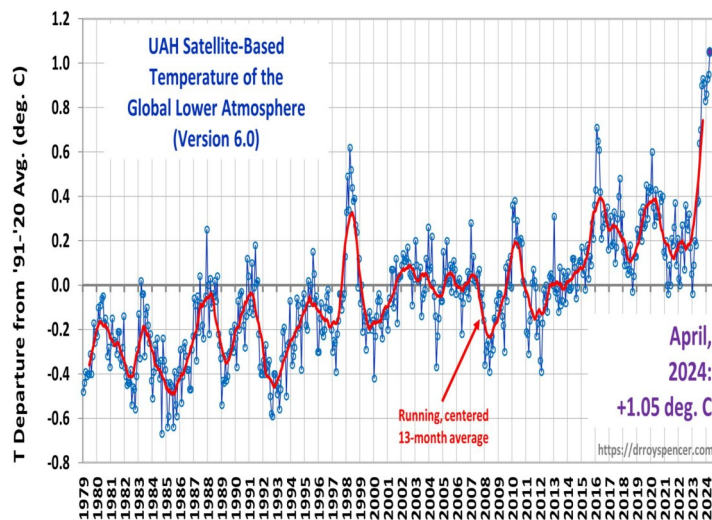
From 1982 to 2019 satellite data shows that global cloud cover has been declining, which would allow more solar radiation to reach the earth (see the Earth Energy Balance above), which could cause more than the measured 0.7 w/m<sup>2</sup> energy imbalance and hence could be the cause of most of the global warming over this period. The IPCC admits that global climate models have disagreed on how clouds will change in the future and whether the change will amplify or suppress global warming. [AR6 WGI p.1022 (2021)]. Treatment of clouds and their feedback effects is a major source of uncertainty for climate science.

Scientists were confounded by what is now known as “The Pause,” a cessation in the rise of world temperatures that occurred from the 1998-1999 El Nino to the 2015-2016 El Nino. The causes of this pause and its significance are disputed, but it is clear that during this period any and all greenhouse warming effect was offset by cooling forces, suggesting that the greenhouse warming effect is weak in relation to other forces affecting global temperatures. Scientists do not agree on the strength of the greenhouse effect.



The red line shows the rise of atmospheric CO<sub>2</sub> concentration from 1960 to June 2023 versus global temperature rise.. If anything, the rate of temperature rise appears to be slightly slowing in relation to the rate of CO<sub>2</sub> rise.

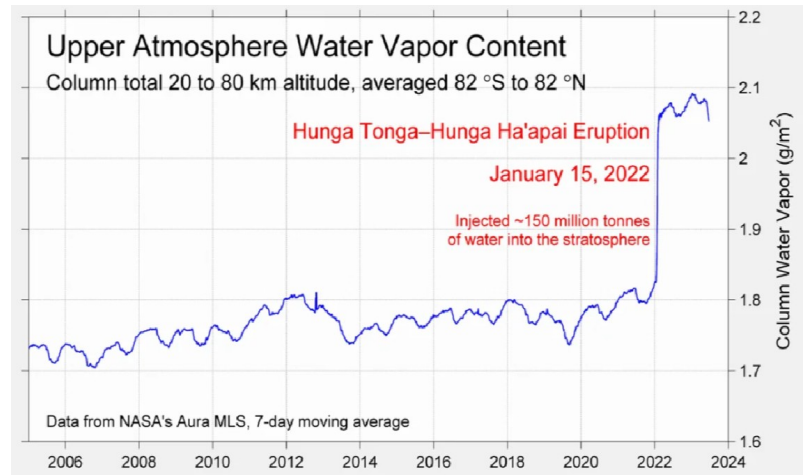
In April 2023 the monthly temperature measurements show the start of a very unusual temperature spike that resulted in the year 2023 being the warmest year at least since the peak of the Medieval Warm Period. The 2023 temperature spike, which is still continuing, has been much commented upon in the media.



Prior to the 2023 spike world temperatures had been relatively flat since the 2015-2016 El Nino. Temperature change over this period shows no correlation with steadily rising CO<sub>2</sub> levels. Scientists do not yet agree on the causes of the 2023 spike. One theory was that it was caused by the 2023 El Nino. But the El Nino peaked in late 2023, and world temperatures have not started to decline, as would have happened if the El Nino was the principal cause of the spike.

RSS reports temp rebound due to long-awaited El Nino onset combined with impact of the 2022 gigantic Tonga volcanic ejection of water vapor into stratosphere. With an empirically non-existent correlation between global temps and 3-year increases in atmospheric CO<sub>2</sub> levels, the August 2023 global temp spike likely NOT a result of humans burning fossil fuels.

Another theory is that the 2023 spike is due to the Hunga-Tonga volcanic eruption in January 2022, which launched a remarkable and unprecedented quantity of water vapor into the stratosphere. The temperature effects of volcanic eruptions usually take around one year to appear after the eruption and then perhaps 2-4 more years to clear. As yet there is no consensus on this theory. The debate reflects, in part, the debate as to how strong water vapor is as a greenhouse gas at different altitudes in the atmosphere.



## CONCLUSION

Temperatures for the Holocene Interglacial are estimated from proxy data through about 1850, the beginning of the instrument period. Proxy measurement is much more uncertain than instrument measurement. Contrary to the claims in IPCC AR6, there is significant debate and uncertainty about Holocene proxy temperatures. In particular, there is disagreement among scientists as to the maximum temperatures of the Holocene Optimum, of the Roman Warm Period, and of the Medieval Warm Periods. There are also disagreements as to how cold was the Little Ice Age.

Based on instrumental measurements, scientists agree that over the post-industrial period (since 1850) the world has warmed by roughly 1.1 C and at a rate of roughly 1 C per century. [AR6 WGI p.5 (2021)]. Also based on instrumental measurements, scientists agree that CO<sub>2</sub> levels have risen at a mostly linear rate since 1958. But over much of this period the correlation between CO<sub>2</sub> rise and temperature rise is disputed. In particular the CO<sub>2</sub> Control Knob Theory has difficulty explaining the temperature decline 1945-1975 and the temperature pause 1999-2015, and it also can not explain the temperature rise 1910-1945.

The temperature disagreements have a major bearing on theories as to the causes of the modern warming. The IPCC asserts that virtually all of the modern warming has been caused by human activity. [AR6 WGI p.5 (2021)]. But some scientists support theories that significant amounts of the modern warming have been caused by: (1) solar variations, (2) ocean variations, (3) cloud variations and/or feedbacks, (4) a 1,000 natural cycle of undermined causation (perhaps solar), or (5) urbanization and other human-caused changes in land use.

While the IPCC claims that human activity has caused virtually all of the global post-industrial warming, it only claims that greenhouse gases have been the "main driver" of warming only since 1979 [AR6 WGI p.5 (2021)]. In AR5 the IPCC admitted that natural forces might have caused some significant part of the warming from 1910-1945 [AR5 WGI p.17 (2013)]. But scientists do not agree what all these non-greenhouse causes were. So they can not be excluded as causes of the post-1979 warming.

There is no agreement yet on the cause of the 2023-2024 temperature spike, but the warming shows no correlation with greenhouse gases.

For a discussion of possible solar variations affecting world temperatures see the Science Topic: Sun on the CLISCIPOL website.



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