Human Caused Climate Change? A Skeptical Look at the Narrative

The Bigger Picture - Climate Changes Through History

(second PDF of 12)

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Find all PDFs in this package & other Climate Related material on their website page.
Other PDFs, exposing the mainstream narrative, can be found here on my website.

Should anyone feel like supporting my continuing this work, a donation button is to be found on my website (left sidebar and on a page shown in the menu). Thank you.

> Note: Please read the first PDF, *Introduction to Human Caused Climate Change? A Skeptical Look at the Narrative* first, where the intent and scope of this project are explained.
>
> Note: Text that is indented both from the right and left (like this paragraph) is quoted from the noted source.

Extra! Extra! Read all about it! Climate Change is Real!

(it's been changing for millions of years)

That is not meant to be funny. It's a fact; probably one everybody knows at some level. But the point is that it has been much warmer and much colder than it is right now. And if, as humans with our relatively comfortable lives these days, there are changes that force us to address them and even adjust how we live, then we should deal with that. But the "sky is falling" attitude that our current climate is unprecedented and only industrialization could possibly be responsible is extremely short sighted.

This PDF takes a look at a much bigger picture than the last few decades. Truncated graphs showing an increase in temperature over a few decades are really meaningless.

Sections:

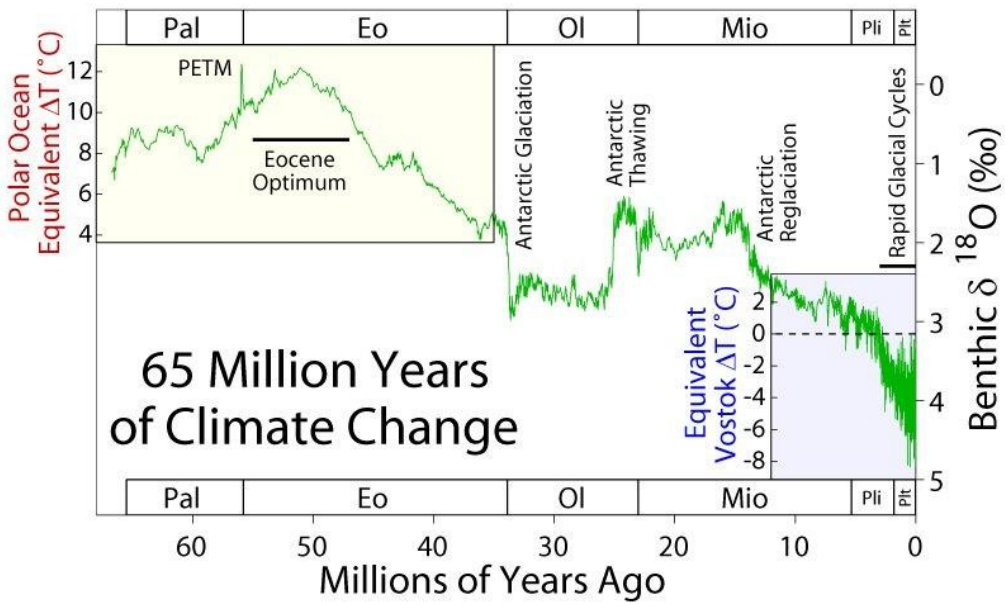
The Big Picture: 65 Million Years of Temperature Swings

From the Jo Nova website, an article by David Lappi, The big picture: 65 million years of temperature swings, includes graphs showing first the biggest picture, then closing in on modern times. Go to the article itself for more details.

From David Lappi:

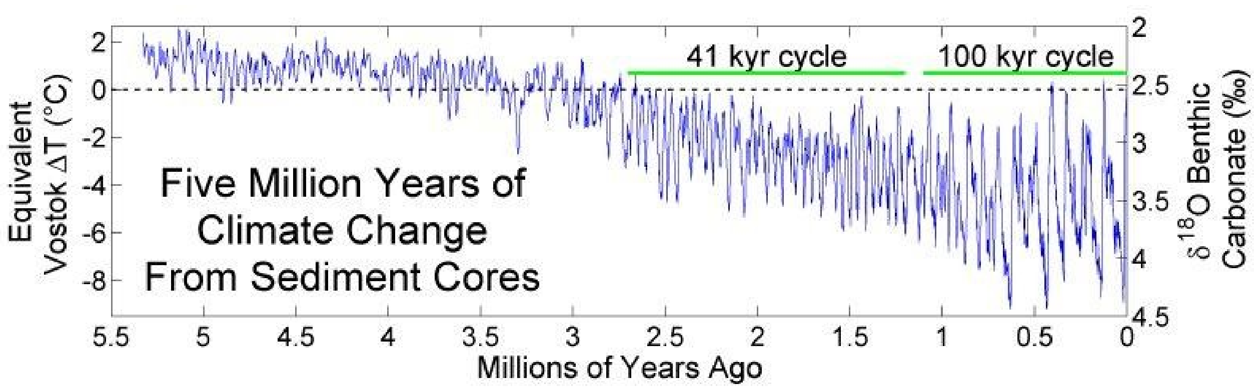
> The following two graphs are climate records based on oxygen isotope thermometry of deep-ocean sediment cores from many parts of the world.
> On both graphs, colder temperatures are toward the bottom, and warmer temperatures toward the top.

- 65 million years of cooling -



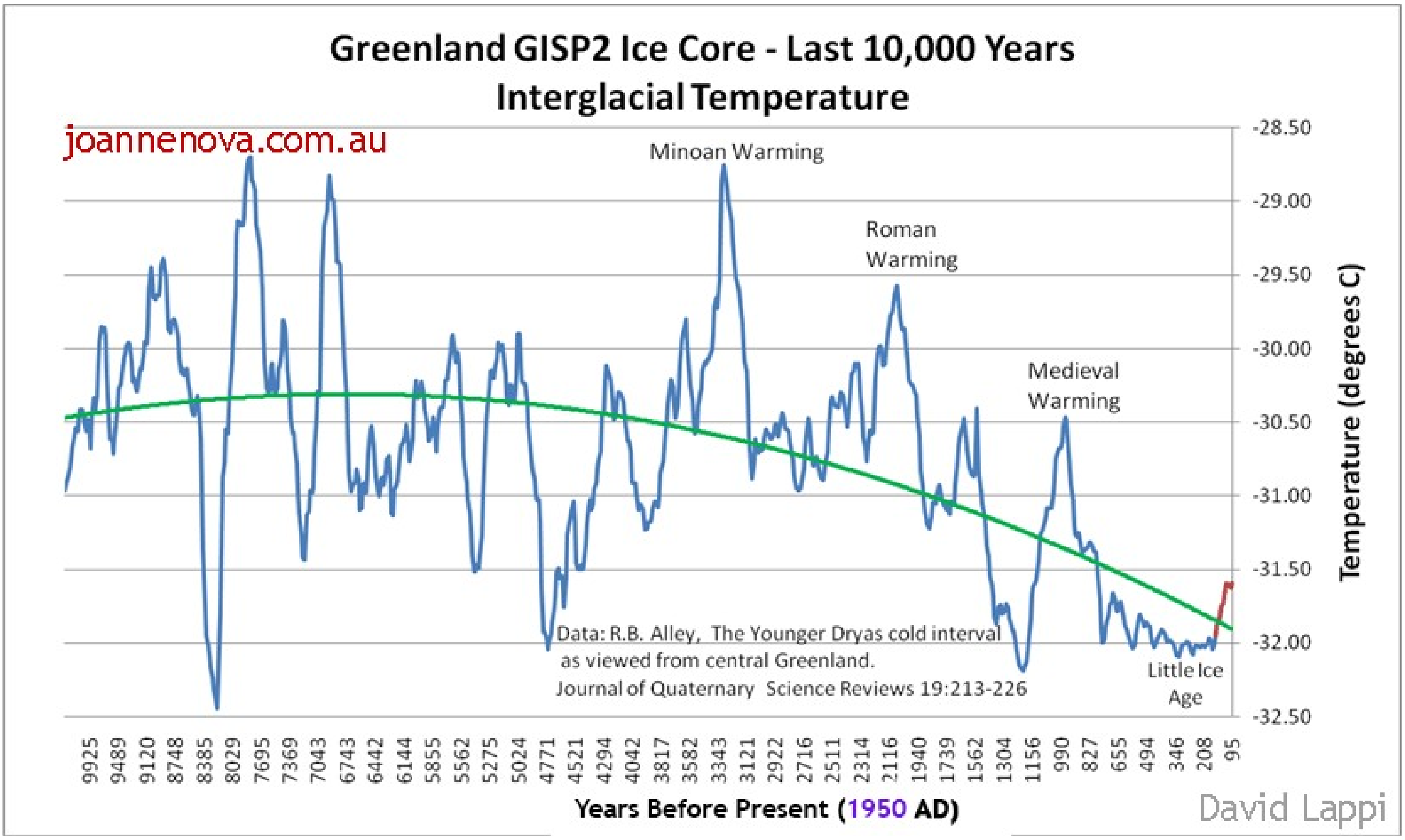
- 5 Million Years of Cooling -

The last five million years of climate change is shown in the next graph based on work by Lisiecki and Raymo in 2005.



- The Last 10 Millenia -

To detail the more recent prehistoric temperature changes, scientists have drilled a number of ice cores in ancient glacial ice. Paleotemperature data from ice cores is considered to be our best continuous record of temperatures on the planet for time-spans up to about 420,000 years ago.



The Medieval Warming Period

Note in the graph above that there was what is known as the Medieval Warming Period, roughly 1000 years ago, that was much warmer than it is now. And that we are now coming out of the Little Ice Age. The graph shows the recent warming in red.

Agreed that the major ice ages and the Earth's initial cooling might not be that relevant, but neither the Medieval Warming 1000 years ago or the Roman Warming are that long ago in terms of civilization.

The IPCC (the United Nations' Intergovernmental Panel on Climate Change) has been publishing overviews of the climate situation dating back to 1990. In their report, Climate Change, The IPCC Scientific Assessment from 1990, they show a graph (figure 7.1(c) on page 202 in the report and shown below) indicating the Medieval Warming Period, and they discuss it briefly, suggesting it may not have been global. Then in their report titled, Climate Change 1995, The Science of Climate Change, their 2nd assessment, they don't show the graph, but they do mention the Medieval Warming Period, although they cast doubt on the records: "The available evidence is limited (geographically) and is equivocal." Likewise in their 3rd assessment (2001). And it did appear once again in AR5, this time referred to as the *Medieval Climate Anomaly*, and again suggesting it was only local.

IPCC 1990 Assessment Medieval Warming Period Graph

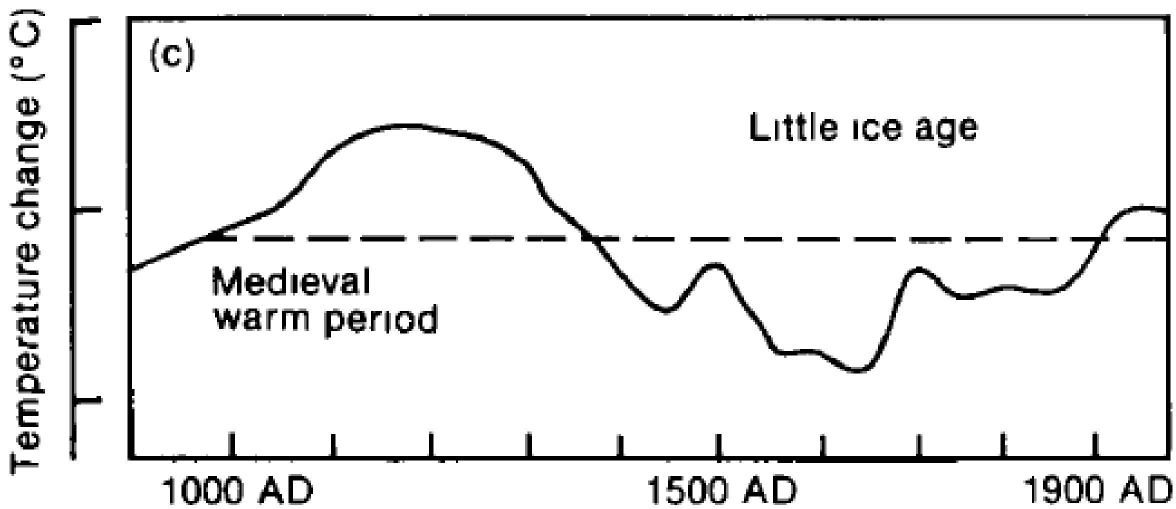


Figure 7.1: Schematic diagrams of global temperature variations since the Pleistocene on three time scales (a) the last million years (b) the last ten thousand years and (c) the last thousand years The dotted line nominally represents conditions near the beginning of the twentieth century

A Second Look at the Bigger Picture

This section shows graphs from the [Climate4you](#) website. For information about the website scroll down a bit on the home page where the author, Ole Humlum, explains his approach including a link to his University of Oslo page.

The Global Temperatures page has lots of fascinating information; note the list of contents for this page alone, each linking to that topic they cover.

Below are shown two figures from the section of the Global Temperatures page, [An overview to get things into perspective](#), with excerpts from the explanation of the figures. See the page for far more detail, including discussions about the issues with various data collecting methods.

From the article:

The last four glacial periods and interglacial periods are shown in the diagram below (Fig.2), covering the last 420,000 years in Earth's climatic history.

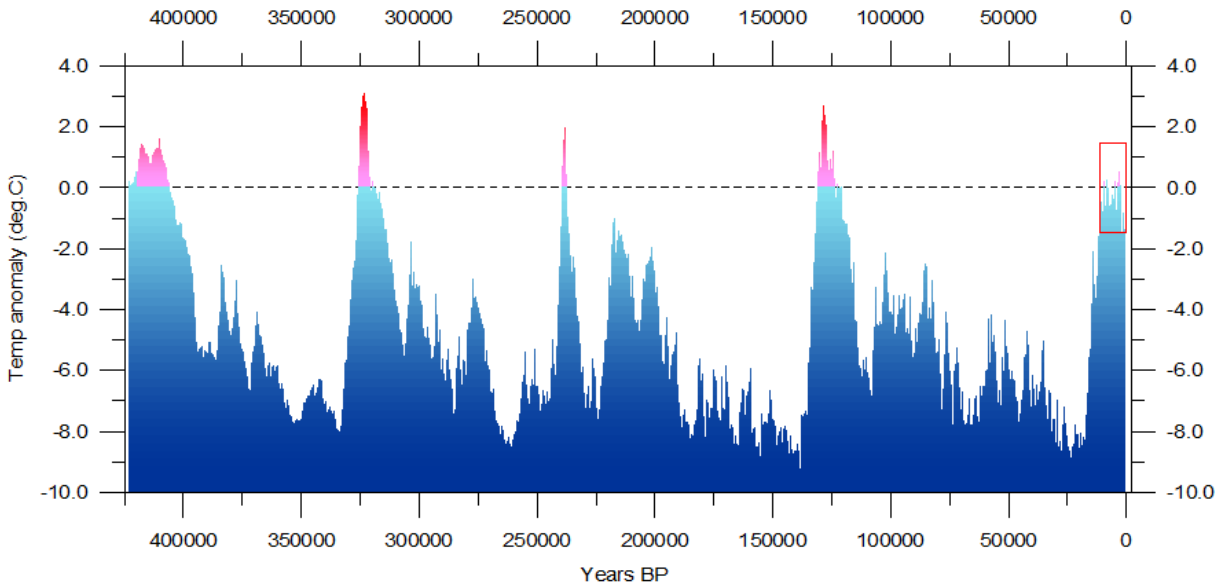


Fig.2. Reconstructed global temperature over the past 420,000 years based on the Vostok ice core from the Antarctica ([Petit et al. 2001]). The record spans over four glacial periods and five interglacials, including the present. The horizontal line indicates the modern temperature. The red square to the right indicates the time interval shown in greater detail in the following figure.

The diagram above (Fig.2) shows a reconstruction of global temperature based on ice core analysis from the Antarctica. The present interglacial period (the Holocene) is seen to the right (red square). The preceding four interglacials are seen at about 125,000, 280,000, 325,000 and 415,000 years before now, with much longer glacial periods in between. All four previous interglacials are seen to be warmer (1-3°C) than the present. The typical length of a glacial period is about 100,000 years, while an interglacial period typical lasts for about 10-15,000 years. The present interglacial period has now lasted about 11,600 years.

Also from the article, information about the relationship of CO2 to the interglacial warming periods:

According to ice core analysis, the atmospheric CO2 concentrations during all four prior interglacials never rose above approximately 290 ppm; whereas the atmospheric CO2 concentration today stands above 400 ppm (by volume or molecular fraction, as of 2018). The present interglacial is about 2°C colder than the previous interglacial, even though the atmospheric CO2 concentration now is about 100 ppm higher.

The last 11,000 years (red square in diagram above) of this climatic development is shown in greater detail in the diagram below (Fig.3), representing the main part of the present interglacial period.

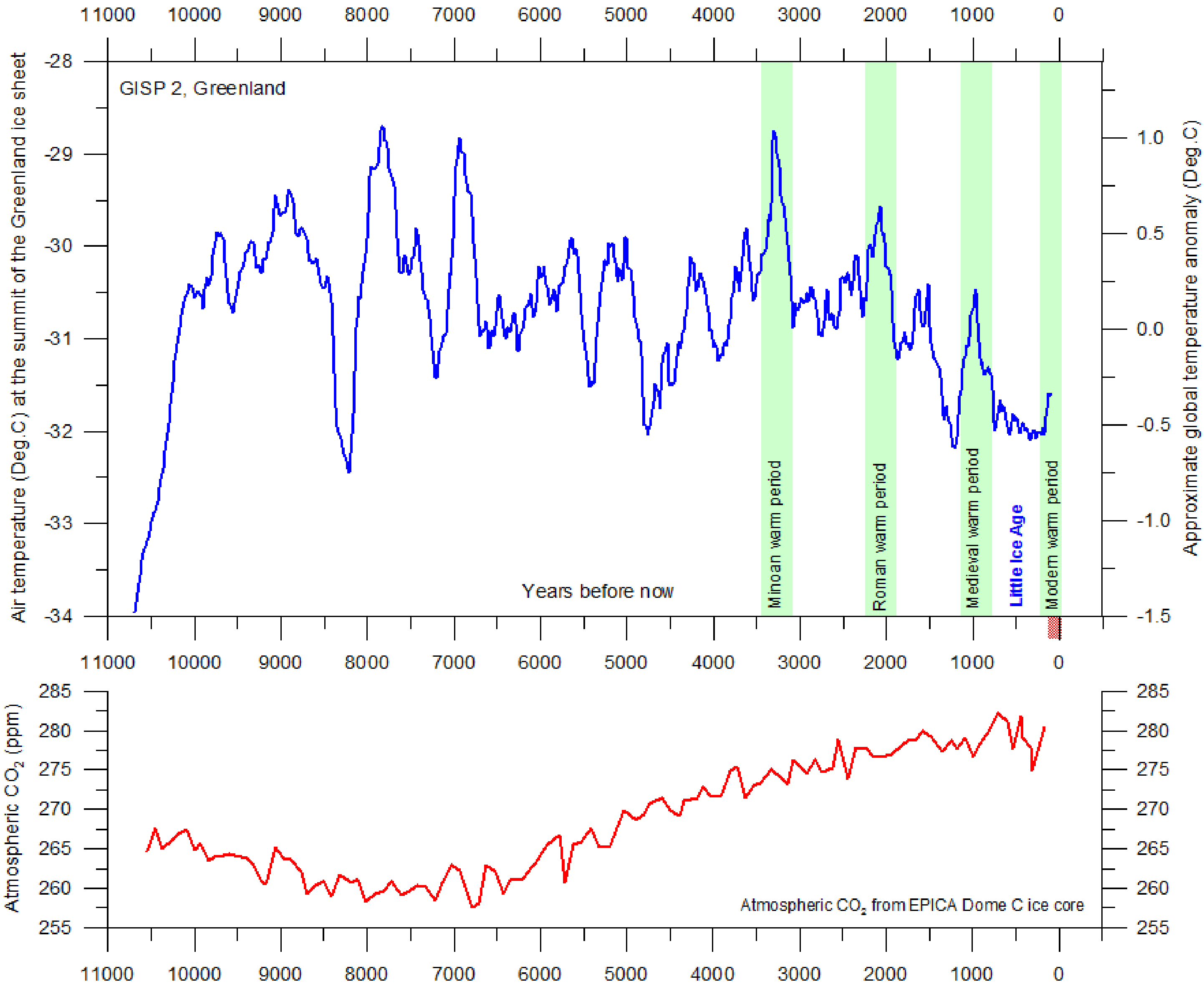


Fig.3. The upper panel shows the air temperature at the summit of the Greenland Ice Sheet, reconstructed by Alley (2000) from GISP2 ice core data. The lower panel shows the past atmospheric CO2 content, as found from the EPICA Dome C Ice Core in the Antarctic (Monnin et al. 2004).

The author reflects on the relevance of the data:

Clearly Central Greenland temperature changes are not identical to global temperature changes. However, they do tend to reflect global temperature changes with a decadal-scale delay (Box et al. 2009), with the notable exception of the Antarctic region and adjoining parts of the Southern Hemisphere, which is more or less in opposite phase (Chylek et al. 2010) for variations shorter than ice-age cycles (Alley 2003). This is the background for the very approximate global temperature scale at the right hand side of the upper panel.

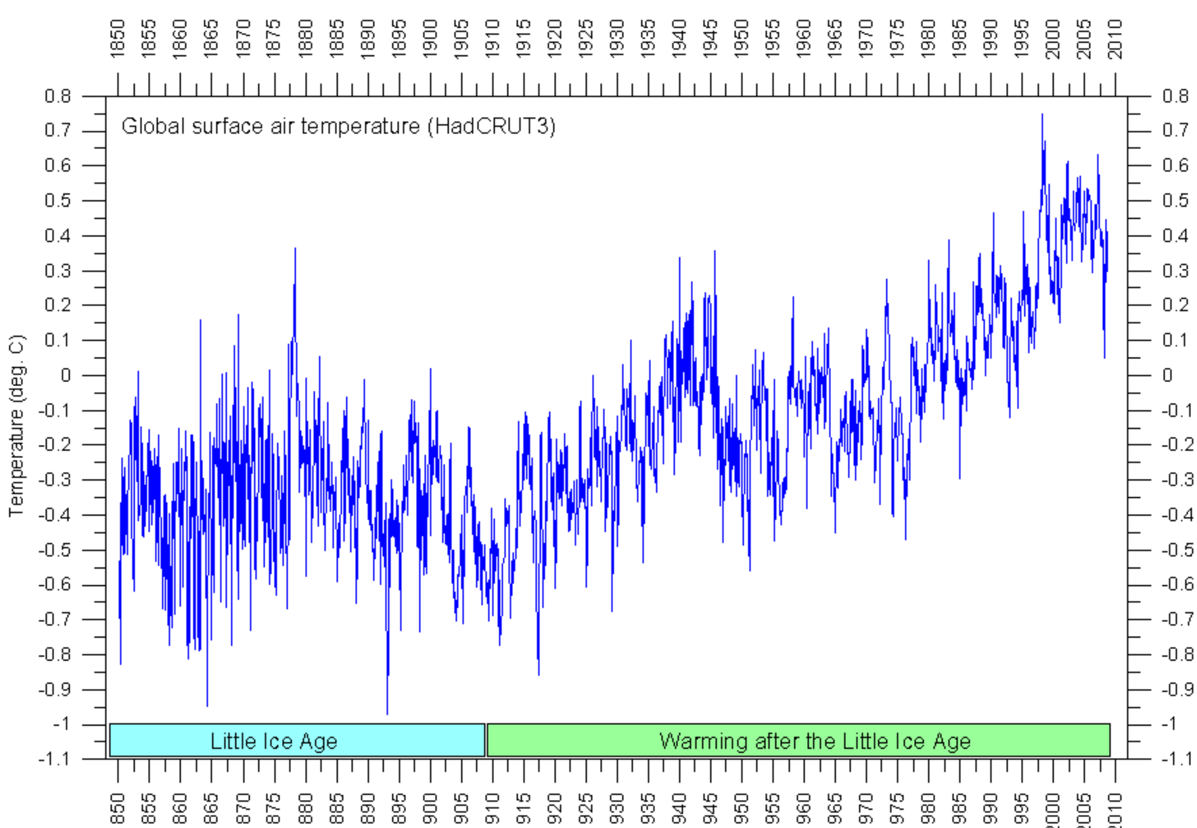
The Bigger Picture of the Little Ice Age Until the Present

On the Climate4You website they ask the question, Is The Global Temperature Increase 1981-2005 Unique Compared To The General Temperature Rise Since The End Of The Little Ice Age?

They are responding to the IPCC's 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change, in which the IPCC uses a graph to demonstrate the escalating rise in temperature during the 25 years 1981-2005.

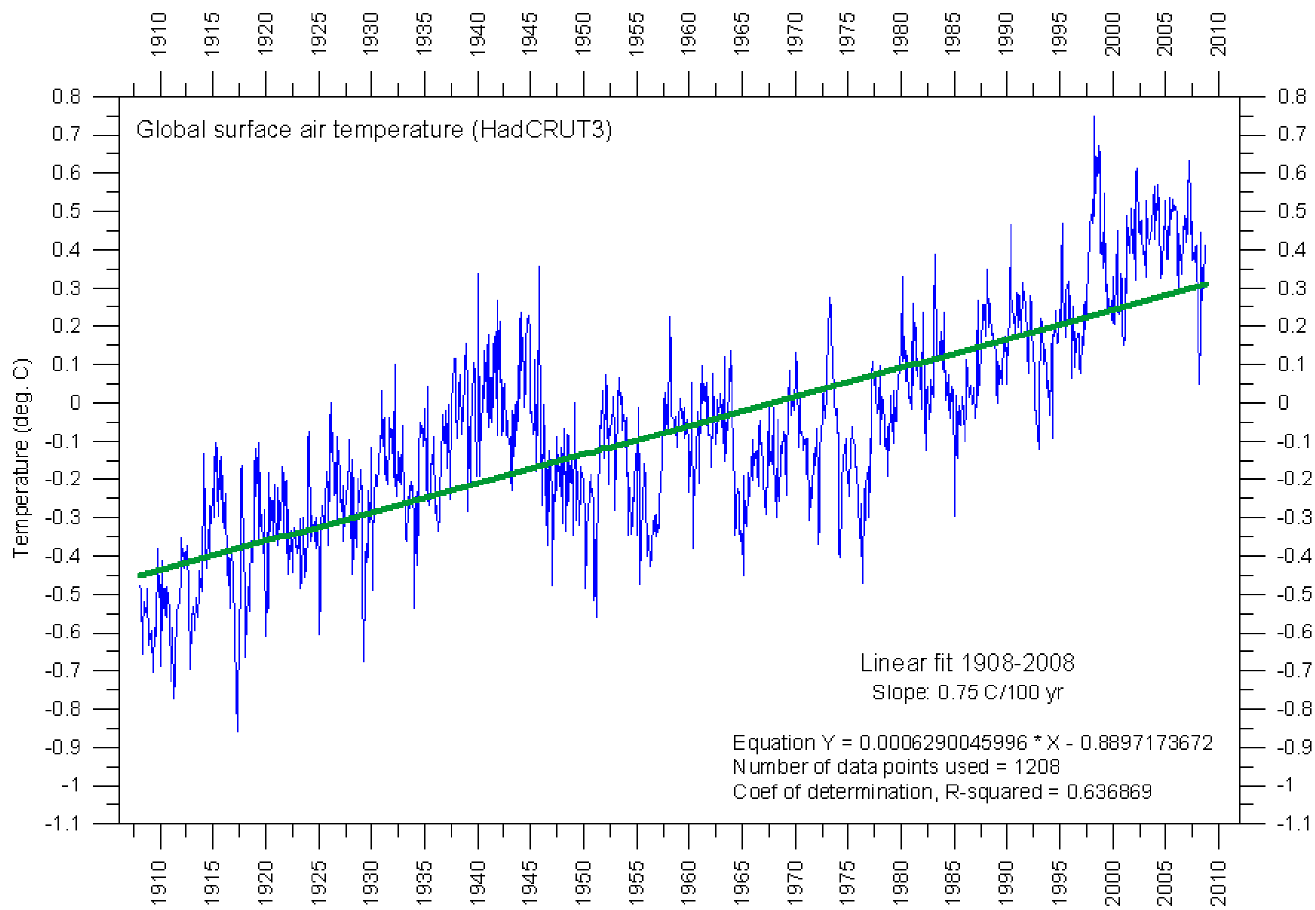
See also PDF 8, *ClimateGate, the IPCC, and Cheating Scientists*, where this article is featured as a critique of the methods used and claims made by the IPCC.

Here, we'll just look at two temperature graphs; the first showing the Little Ice Age and the warming to the present, and the second, just the warming since the Little Ice Age.



From the article:

> The diagram above (Figure B) shows how the HadCRUT3 series may be interpreted to show 1) the final part of the Little Ice Age, and 2) the following period of warming.
>
> In the following diagram (Figure C), only the data points representing the post Little Ice Age period from 1908 are considered.



> In the diagram above a post Little Ice Age linear trend line has been calculated (green line). This trend line has a slope of 0.75° C per 100 year, suggesting that the overall global temperature increase since the termination of the Little Ice Age (here defined as 1908) has been about 0.75° C.

Note that it appears that the rate of increasing temperature between 1910 and 1945 is similar to the rate between 1981 and 2005. Climate4You doesn't rely on lay observation but goes through the details of their analysis in the article. Their summation:

> The temperature increase leading up to the warm peak around 1940 is entirely comparable to that characterising the period 1981-2005.
>
> Thus, the simplest interpretation of the global temperature increase since 1908 is that it represents mainly a natural recovery from low Little Ice Age temperatures, without clear anthropogenic impact.

The Bigger Picture of CO_2

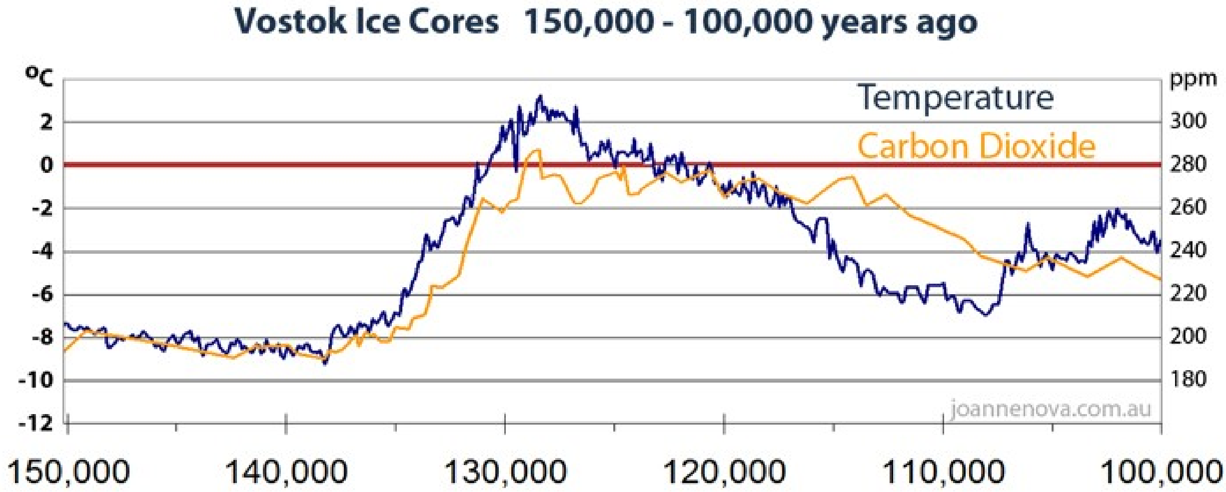
The 800 Year Lag in CO_2 After Temperature

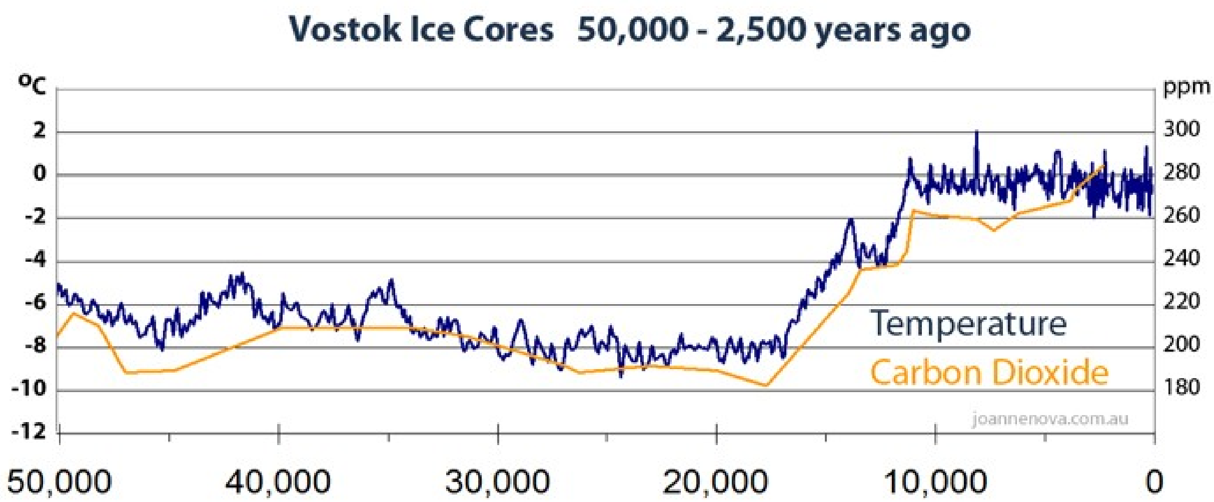
In the article on the Jo Nova website, titled, The 800 year lag in CO2 after temperature – graphed, Joanne Nova demonstrates a correlation between CO_2 and temperature but not the settled science correlation that the climate doom narrative professes.

From the article:

> In the 1990's the classic Vostok ice core graph showed temperature and carbon in lock step moving at the same time. It made sense to worry that carbon dioxide did influence temperature. But by 2003 new data came in and it was clear that *carbon lagged behind temperature*. The link was back to front. Temperatures appear to control carbon, and while it's possible that carbon also influences temperature these ice cores don't show much evidence of that. After temperatures rise, on average it takes 800 years *before carbon starts to move*. The extraordinary thing is that the lag is well accepted by climatologists, yet virtually unknown outside these circles. The fact that temperature leads is not controversial. It's relevance is debated.
>
> It's impossible to see a lag of centuries on a graph that covers half a million years so I have regraphed the data from the original sources, CO2 Data here and Temperature data here (Petit 1999), and scaled the graphs out so that the lag is visible to the naked eye. What follows is the complete set from 420,000 years to 5,000 years before the present.
>
> - NOTE 1: What really matters here are the turning points, not the absolute levels.
> - NOTE 2: The carbon data is unfortunately far less detailed than the temperature data. Beware of making conclusions about turning points or lags when only one single point may be involved.
> - NOTE 3: The graph which illustrates the lag the best, and also has the most carbon data is 150,000-100,000 years ago.
>
> The bottom line is that rising temperatures cause carbon levels to rise. Carbon may still influence temperatures, but these ice cores are neutral on that. If both factors caused each other to rise significantly, positive feedback would become exponential. We'd see a runaway greenhouse effect. It hasn't happened. Some other factor is more important than carbon dioxide, or carbon's role is minor.

Shown below is the graph from 150,000 to 100,000 and the most current graph. See the article for eight graphs, most of them showing a 50,000 year span. Also on the website, below the graphs are links to bigger versions of each one. Note time is moving from left to right:





The report referenced by Joanne Nova in the article above: Timing of Atmospheric CO2 and Antarctic Temperature Changes Across Termination III - Caillon et al., 2003

Global Temperature and CO2—Which Drives Which?

In an article, Global Temperature and CO2—Which Drives Which?, by E. Calvin Beisner, June 20, 2017, on the Cornwall Alliance website, he addresses the claim that CO2 increase is driving the rise in temperature. Then he cites studies that gainsay that claim. First from his article, then a look at one of those studies:

> Long-term geological data show a pretty consistent correlation between CO2 and temperature, giving the claim its initial attractiveness.

But there’s a problem. Detailed analysis of the data shows that the time sequence is opposite what the claim requires.

That’s been shown by a variety of studies in the past, including Cornwall Alliance Senior Fellow David Legates’s review article “Carbon Dioxide and Air Temperature: Who Leads and Who Follows?”. Two-and-a-half years ago geologist Euan Mearns contributed “The Vostok Ice Core: Temperature, CO2, and CH4.”

Now Mearns has followed up with “The Vostok Ice Core and the 14,000 Year CO2 Time Lag,” which makes the case more strongly than ever.

The Vostok Ice Core and the 14,000 Year CO2 Time Lag

From the article, The Vostok Ice Core and the 14,000 Year CO2 Time Lag, on the Energy Matters website, posted June 14, 2017 by Euan Mearns (Note that you can see what he is describing in Jo Nova's graph above, as well as in the one he features, below.):

> A detailed analysis of temperature, CO2 and methane variations from the Vostok ice core is presented for the time interval 137,383 to 102,052 years ago. This captures the termination of the glaciation that preceded the Eemian interglacial and the inception of the last great glaciation that succeeded the Eemian. At the termination, CO2 follows dT exactly, but at the inception CO2 does not follow temperature down for 14,218 years. Full glacial conditions came into being without falling CO2 providing any of the climate forcing. This falsifies the traditional narrative that dCO2 amplified weak orbital forcing effects. It is quite clear from the data that CO2 follows temperature with highly variable time lags depending upon whether the climate is warming or cooling.
>
> Methane on the other hand lags temperature by about 2,000 years at the termination but follows temperature down exactly at the inception. It therefore follows that methane and CO2 are not coupled. Each responds in their own time to changing climate. The absence of coupling may be explained by the different bio-geochemical pathways these gasses have in the biosphere – ocean – atmosphere system.

To understand the following two charts, note that time is moving from right to left.

Read Mearns description of his graph below Figure 1, along with his explanation for the time moving from right to left (a computer program's limitations), which is unconventional and opposite of Jo Nova's graphs above:

Figure 1

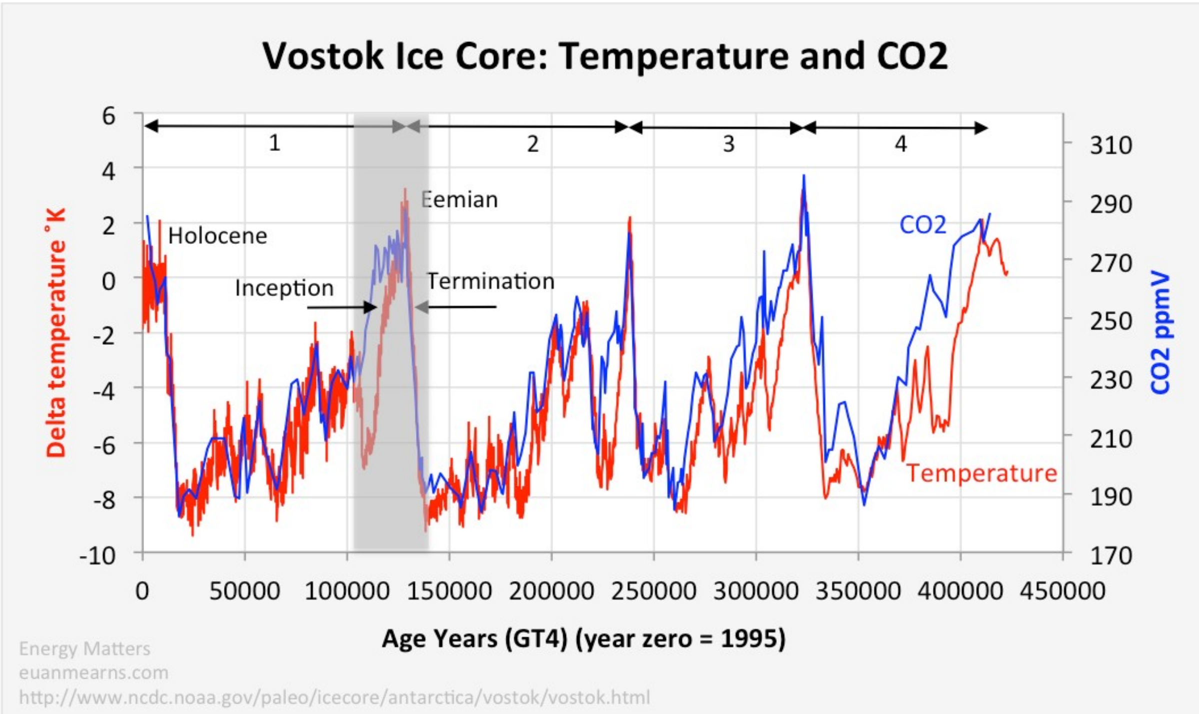


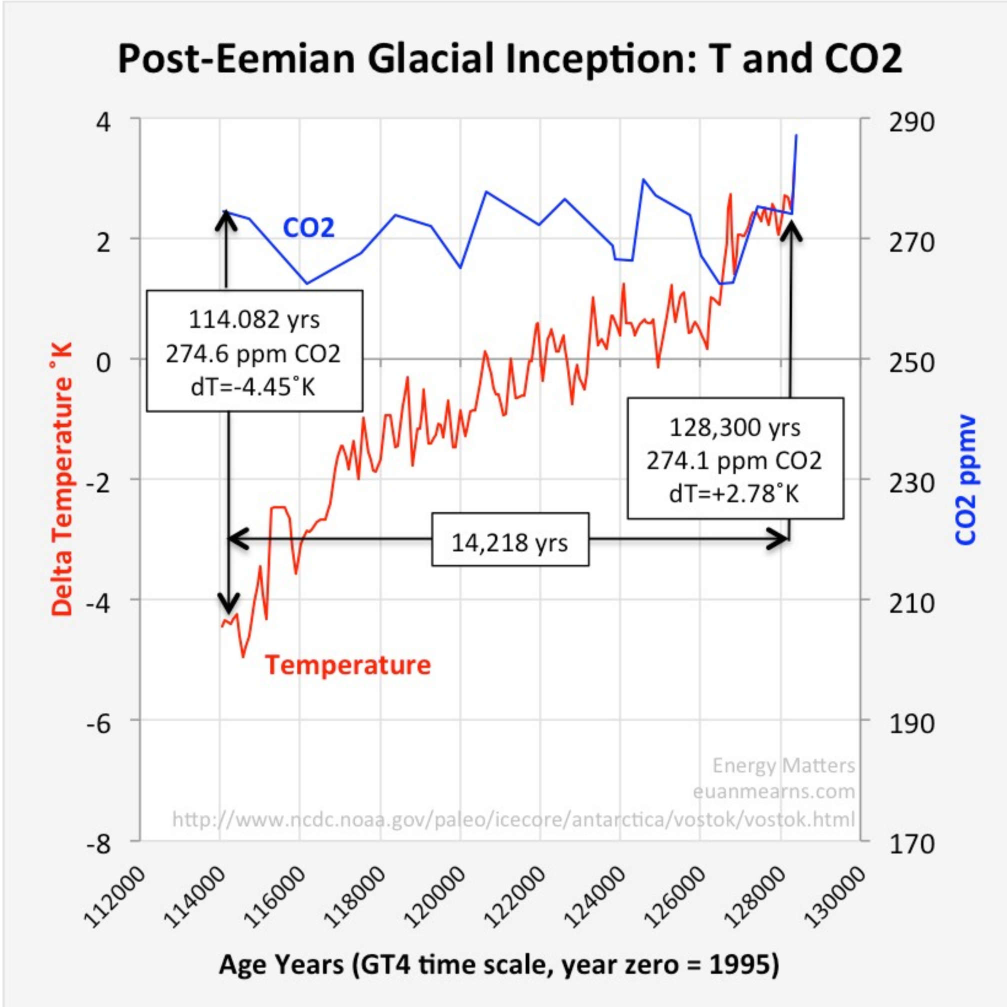
Figure 1 (above)

Temperature and CO2-co-variance in the Vostok ice core. The general picture is one of quite strong-co-variance, but in detail there are some highly significant departures where temperature and CO2 are clearly de-coupled. This is the focus of this post. The grey band is the part of the ice core record examined here. Note that in this chart and all others time is passing from right to left, counter to the normal geological convention, which is a restriction imposed by XL charts that have two primary y-axes. An alternative image showing time passing from left to right is provided in the Appendix at the end of this post.

Figure 3 (below)

The right hand box marks 128,300 years ago that is closest to the T peak. CO2 had been a little higher a short while before, but on the temperature peak a value of 274.1 ppm is recorded at a time when dT registered +2.78˚K. The lefthand box marks 114,082 years ago, chosen because this is the end of the sideways CO2 trend. In the 14,218 years that passed, CO2 changed not at all while temperatures plunged 7.23˚K and full on glacial conditions were established.

Figure 3



The author finishes the first part of his article with the excerpt below, then continues with an extensive discussion about what roles various influences might play in affecting the relationships between CO_2, CH_4 and temperature:

> And finally, if we compare CO_2 and CH_4 we find that they are not coupled (Figure 8). Both do rise in response to warming but not at the same speed and as we have already seen, CH_4 falls at the inception in line with temperature while CO_2 does not. When one considers the different bio-geochemical processes that moderate atmospheric CO_2 and CH_4, the lack of coupling between the two is not surprising.

Environmental Effects of Increased Atmospheric Carbon Dioxide

The paper by Arthur B. Robinson, Noah E. Robinson, and Willie Soon, posted on the Petition Project website, Environmental Effects of Increased Atmospheric Carbon Dioxide, and found in PDF format here, is a huge paper with tons of graphs (see below) on a myriad aspects of the climate, relative to the current increase in CO2.

From the paper, the Abstract:

> A review of the research literature concerning the environmental consequences of increased levels of atmospheric carbon dioxide leads to the conclusion that increases during the 20th and early 21st centuries have produced no deleterious effects upon Earth's weather and climate. Increased carbon dioxide has, however, markedly increased plant growth. Predictions of harmful climatic effects due to future increases in hydrocarbon use and minor greenhouse gases like CO2 do not conform to current experimental knowledge. The environmental effects of rapid expansion of the nuclear and hydrocarbon energy industries are discussed.

And their Summary:

> Political leaders gathered in Kyoto, Japan, in December 1997 to consider a world treaty restricting human production of "greenhouse gases," chiefly carbon dioxide (CO2). They feared that CO2 would result in "human-caused global warming" – hypothetical severe increases in Earth's temperatures, with disastrous environmental consequences. During the past 10 years, many political efforts have been made to force worldwide agreement to the Kyoto treaty.
>
> When we reviewed this subject in 1998, existing satellite records were short and were centered on a period of changing intermediate temperature trends. Additional experimental data have now been obtained, so better answers to the questions raised by the hypothesis of "human-caused global warming" are now available.

24 Graphs

The paper cited above (Robinson et al.) contains lots of graphs. And that's what is to be found below. No text from the article is included here except the text for each "figure". Check out the article for more discussion of each of the graphs' meaning and for more context. Also note that the text for the graphs contains footnotes (in parenthesis) for the sources, of which there are 132, shown at the bottom of the article's page.

Below are the 24 graphs, one per page:

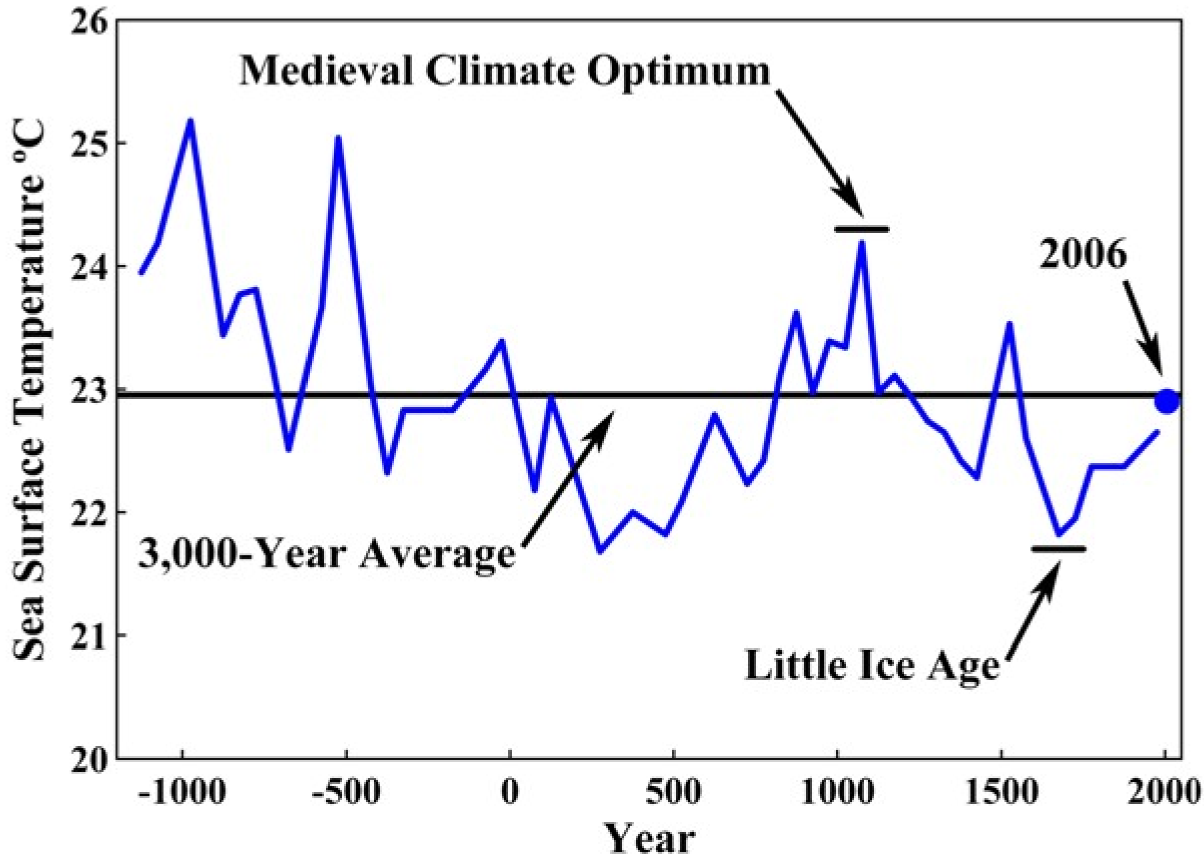


Figure 1: Surface temperatures in the Sargasso Sea, a 2 million square mile region of the Atlantic Ocean, with time resolution of 50 to 100 years and ending in 1975, as determined by isotope ratios of marine organism remains in sediment at the bottom of the sea (3). The horizontal line is the average temperature for this 3,000-year period. The Little Ice Age and Medieval Climate Optimum were naturally occurring, extended intervals of climate departures from the mean. A value of 0.25 °C, which is the change in Sargasso Sea temperature between 1975 and 2006, has been added to the 1975 data in order to provide a 2006 temperature value.

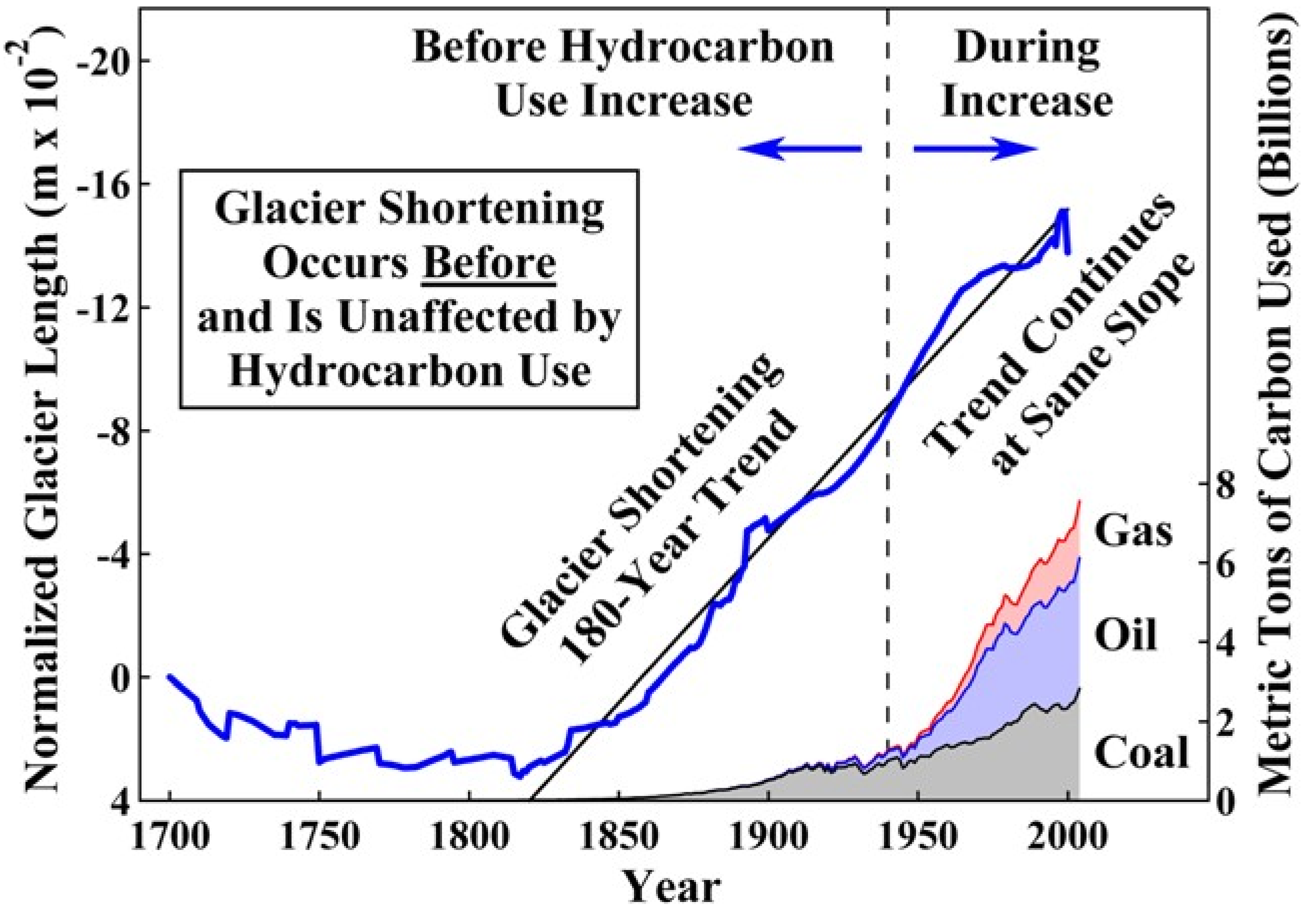


Figure 2: Average length of 169 glaciers from 1700 to 2000 (4). The principal source of melt energy is solar radiation. Variations in glacier mass and length are primarily due to temperature and precipitation (5,6). This melting trend lags the temperature increase by about 20 years, so it predates the 6-fold increase in hydrocarbon use (7) even more than shown in the figure. Hydrocarbon use could not have caused this shortening trend.

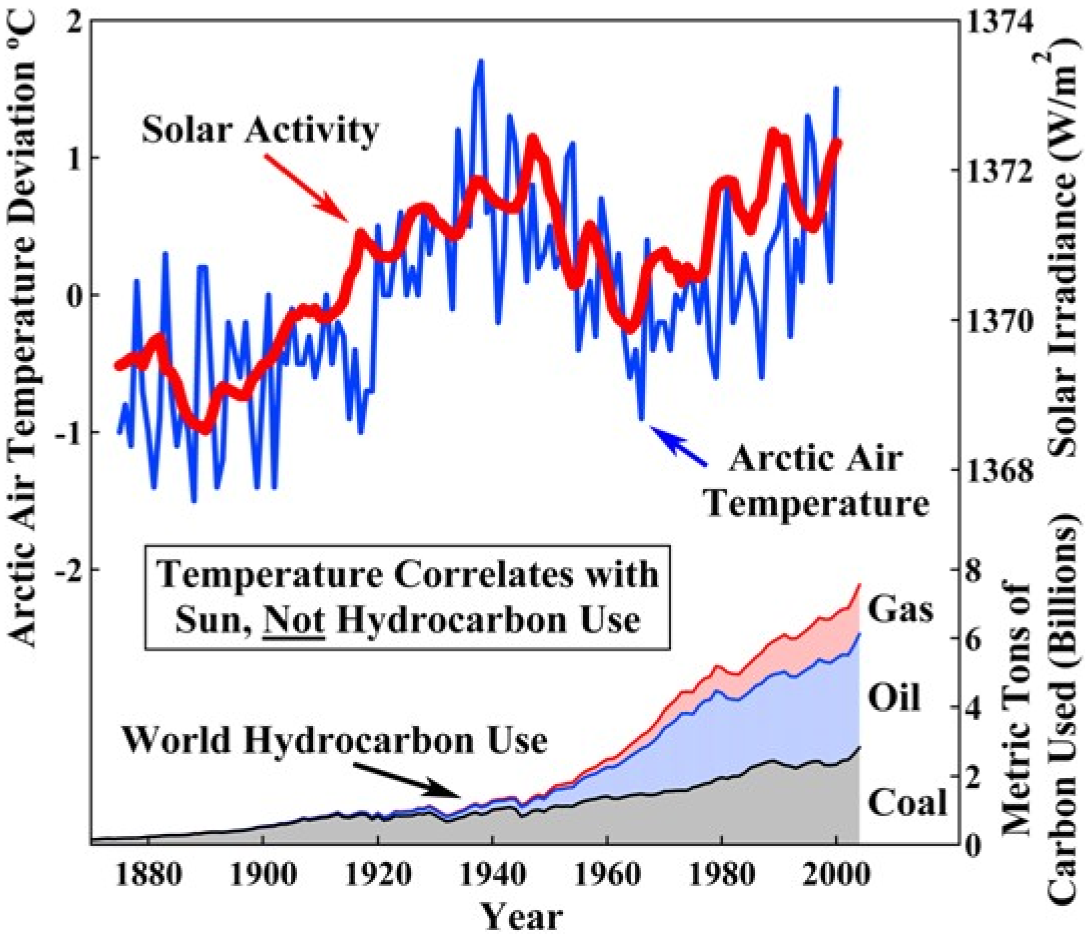


Figure 3: Arctic surface air temperature compared with total solar irradiance as measured by sunspot cycle amplitude, sunspot cycle length, solar equatorial rotation rate, fraction of penumbral spots, and decay rate of the 11-year sunspot cycle (8,9). Solar irradiance correlates well with Arctic temperature, while hydrocarbon use (7) does not correlate.

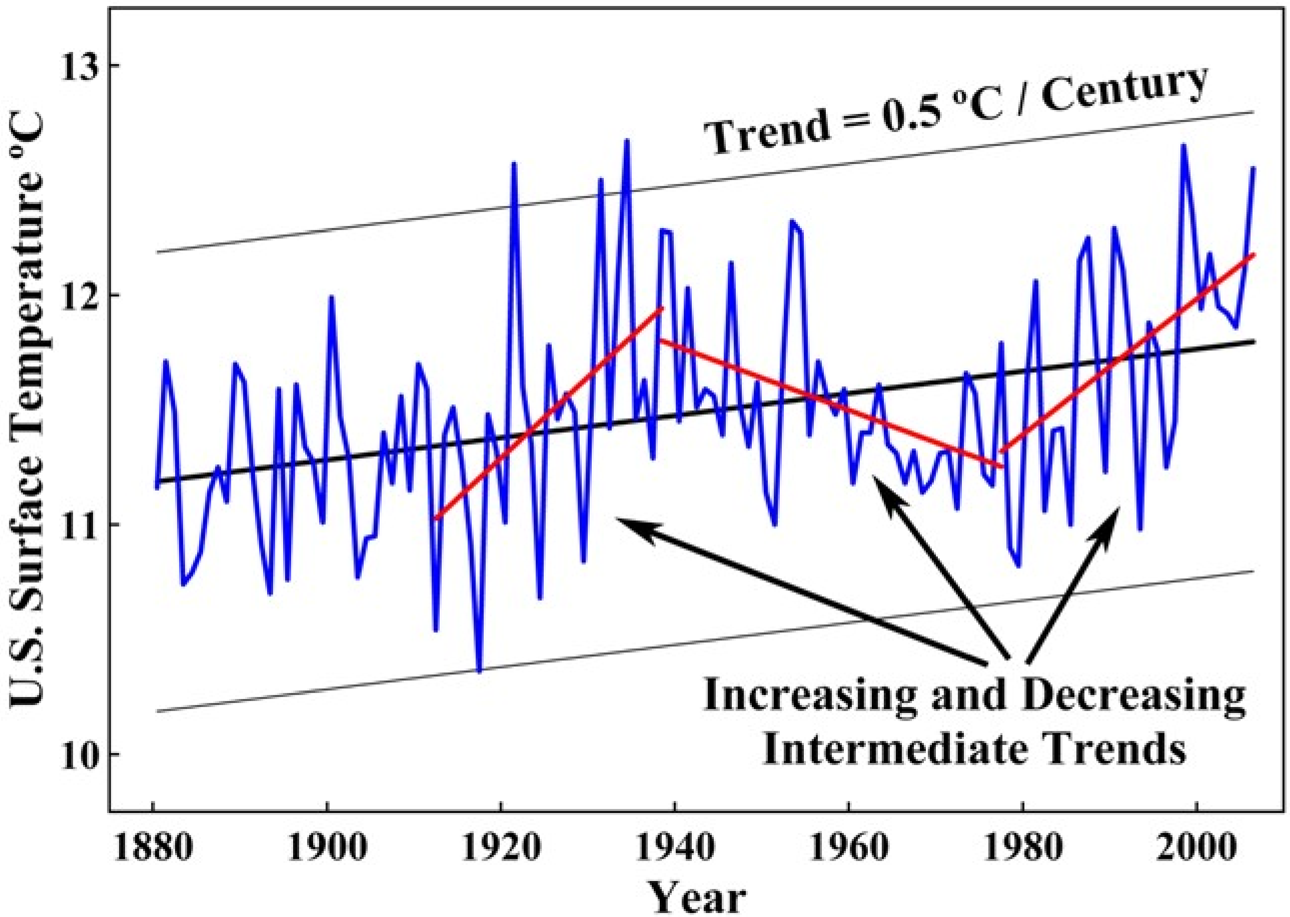


Figure 4: Annual mean surface temperatures in the contiguous United States between 1880 and 2006 (10). The slope of the least-squares trend line for this 127-year record is 0.5 ºC per century.

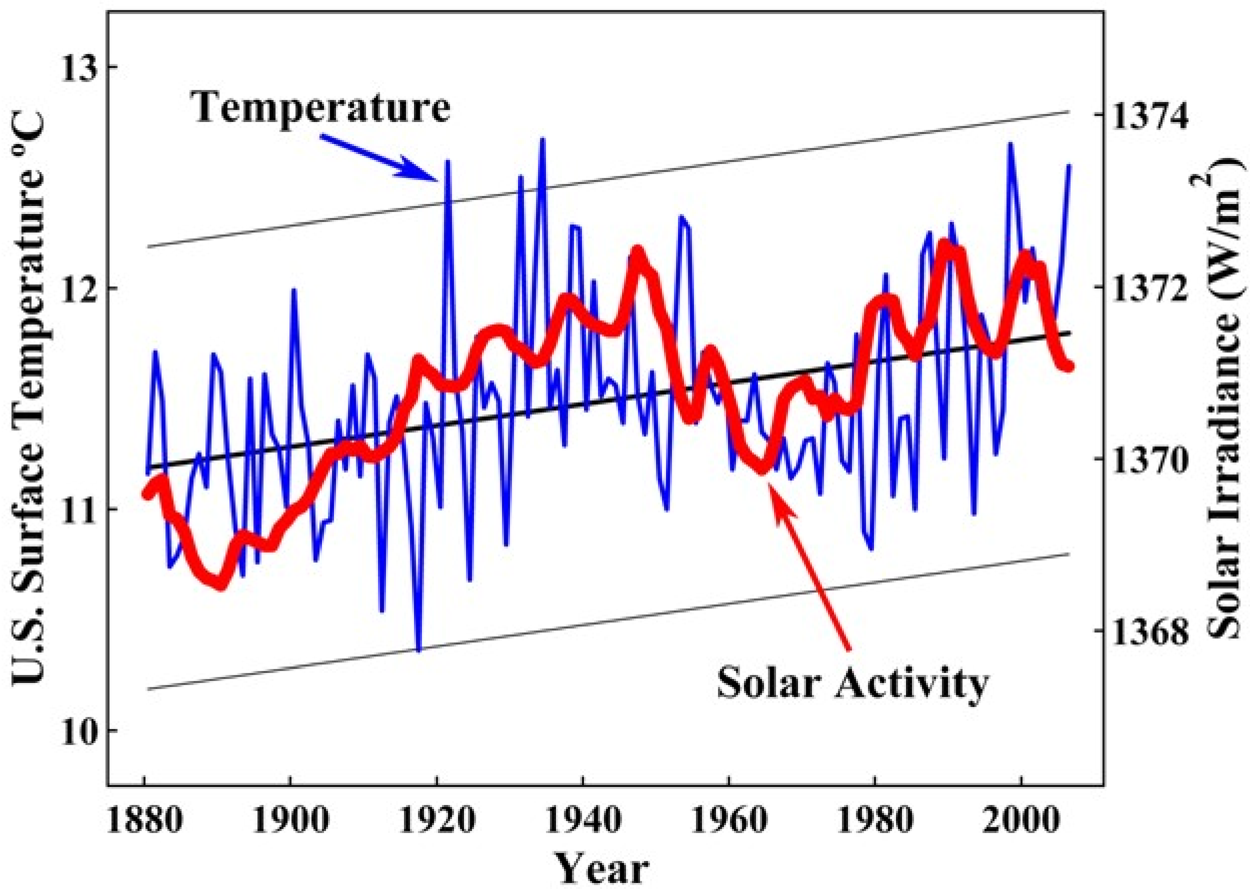


Figure 5: U.S. surface temperature from Figure 4 as compared with total solar irradiance (19) from Figure 3.

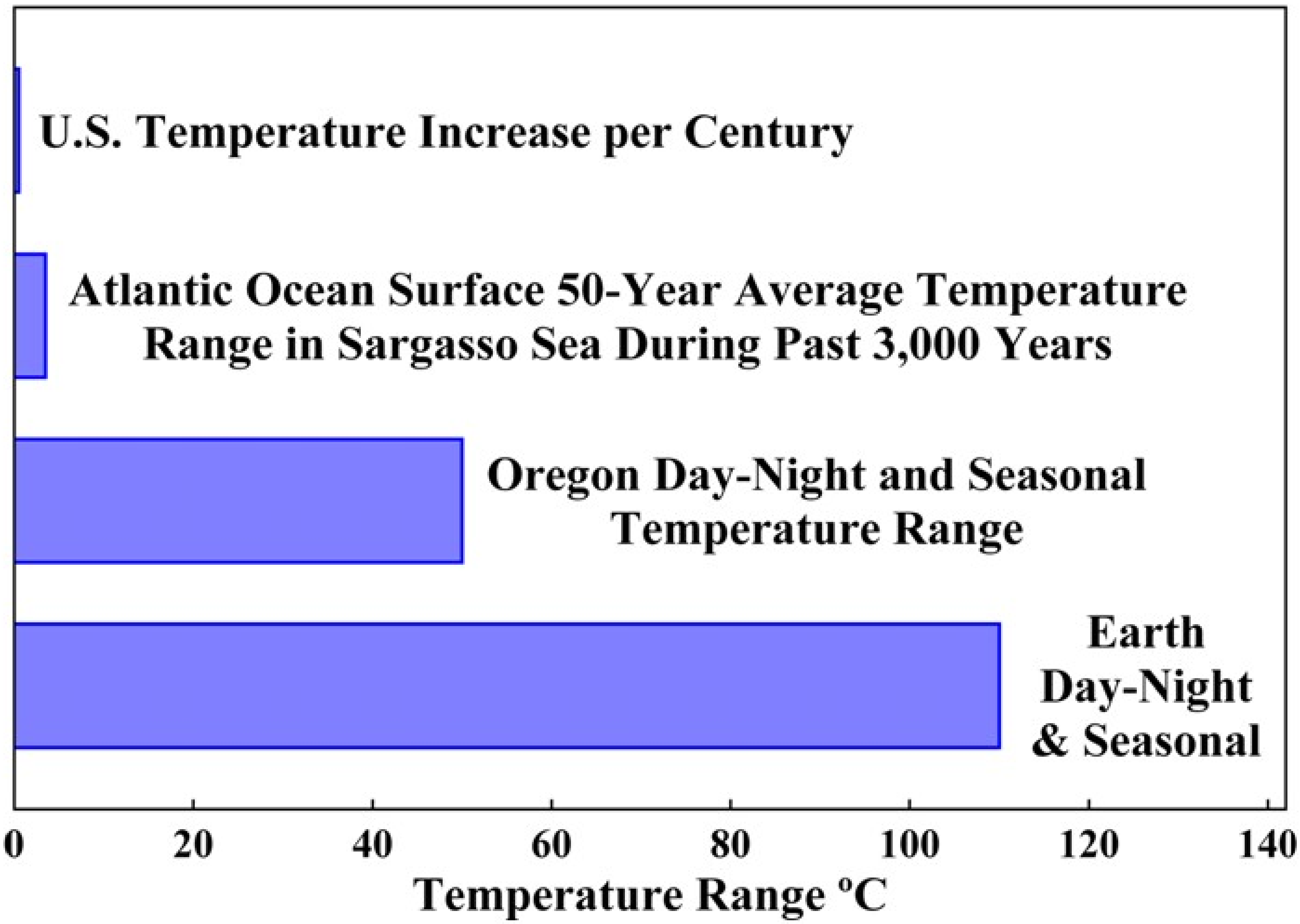


Figure 6: Comparison between the current U.S. temperature change per century, the 3,000-year temperature range in Figure 1, seasonal and diurnal range in Oregon, and seasonal and diurnal range throughout the Earth.

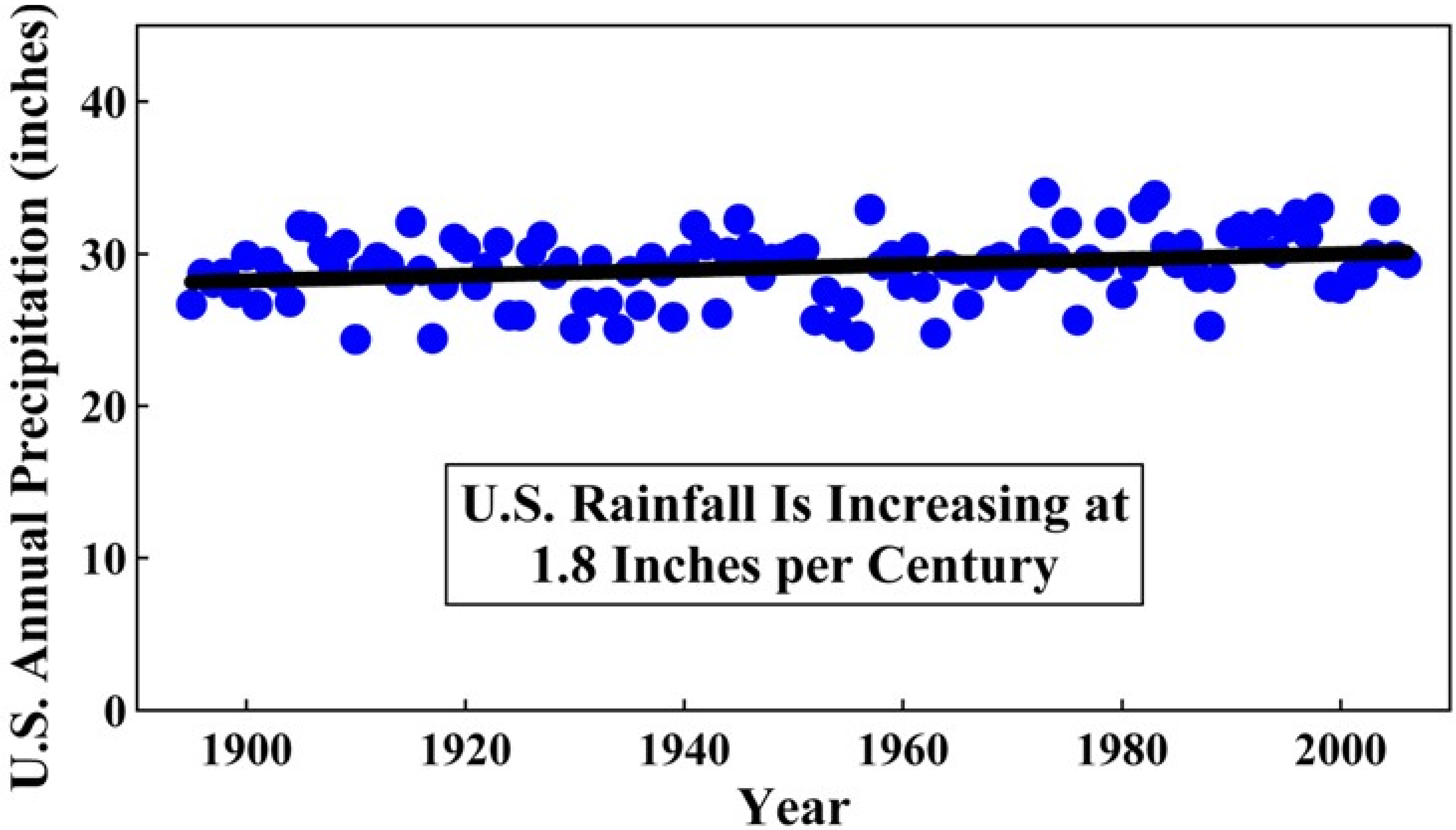


Figure 7: Annual precipitation in the contiguous 48 United States between 1895 and 2006. U.S. National Climatic Data Center, U.S. Department of Commerce 2006 Climate Review (20). The trend shows an increase in rainfall of 1.8 inches per century – approximately 6% per century.

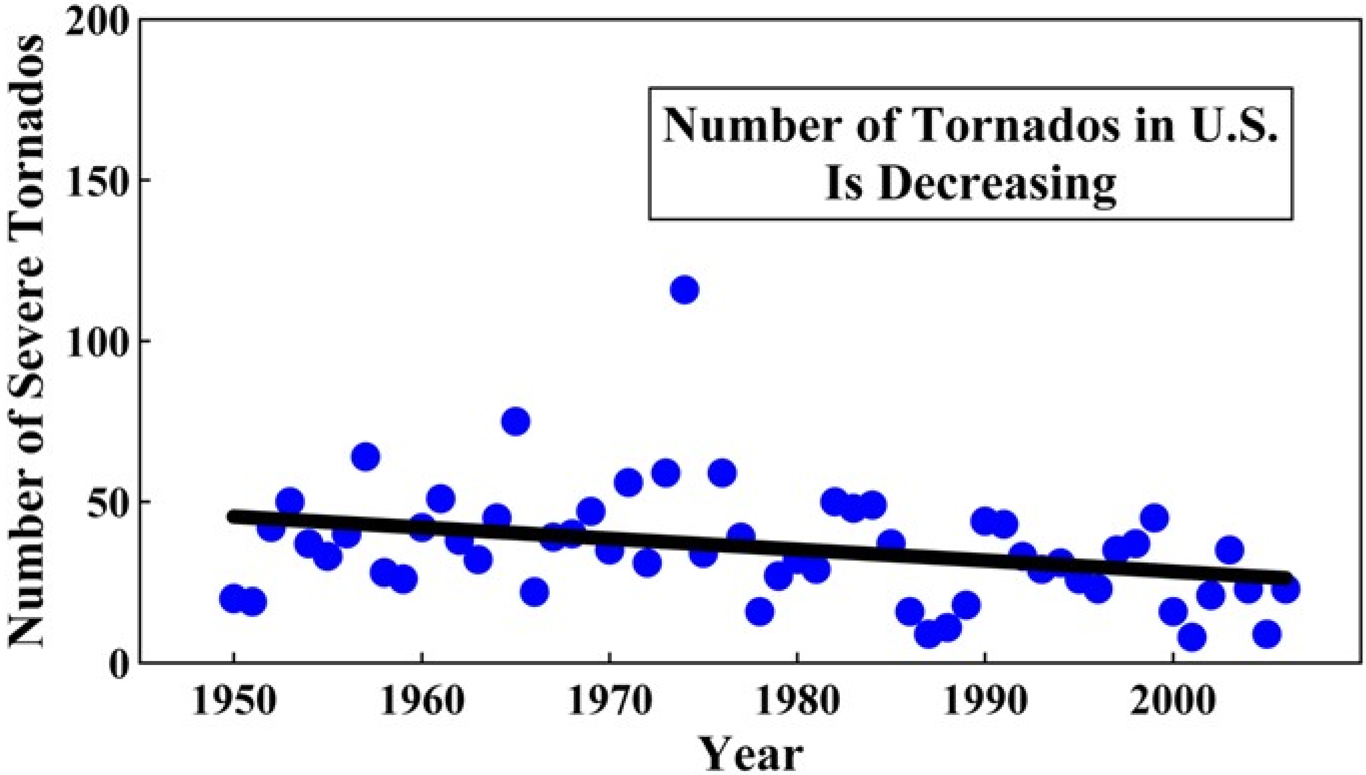


Figure 8: Annual number of strong-to-violent category F3 to F5 tornados during the March-to-August tornado season in the U.S. between 1950 and 2006. U.S. National Climatic Data Center, U.S. Department of Commerce 2006 Climate Review (20). During this period, world hydrocarbon use increased 6-fold, while violent tornado frequency decreased by 43%.

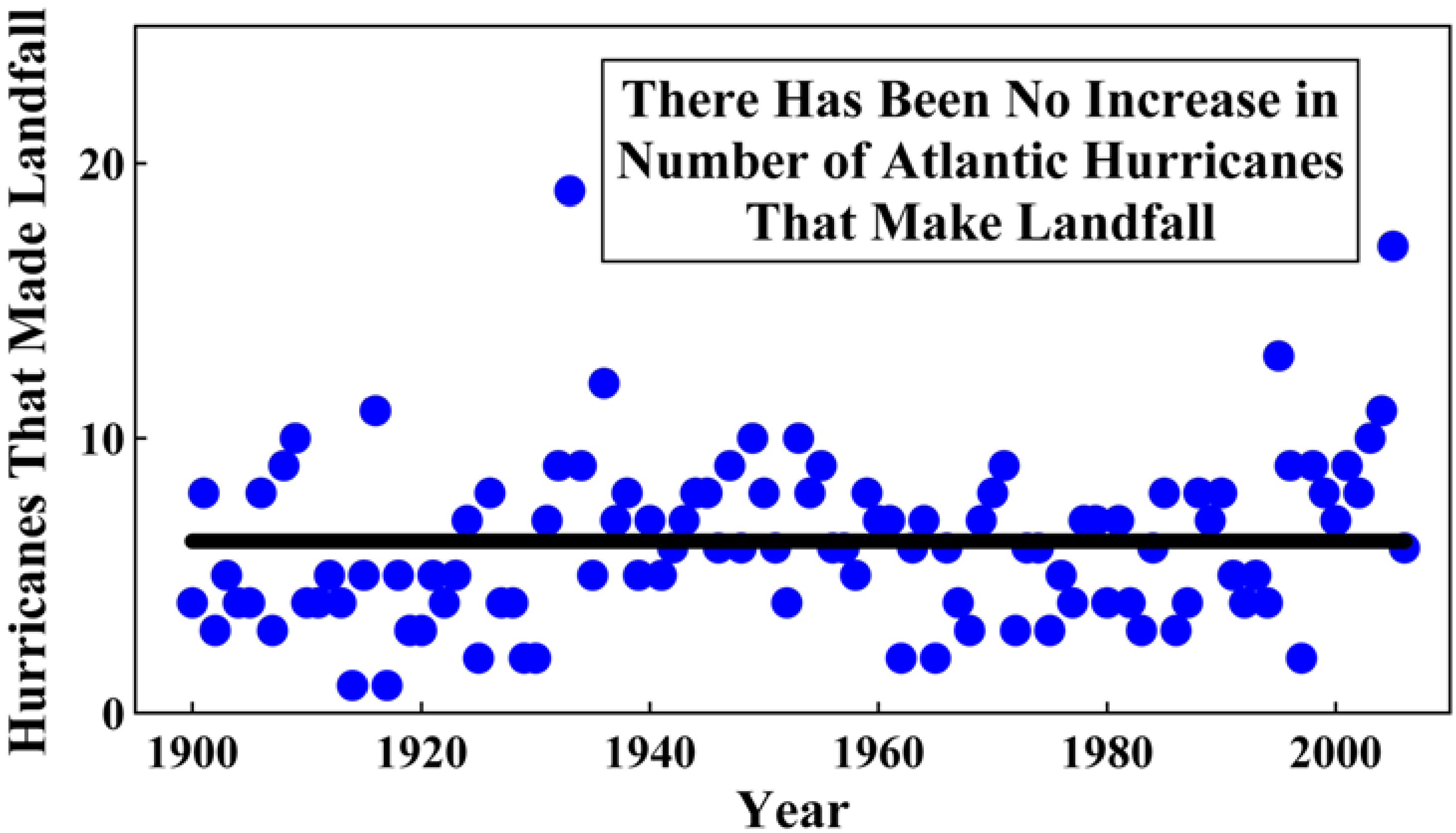


Figure 9: Annual number of Atlantic hurricanes that made landfall between 1900 and 2006 (21). Line is drawn at mean value.

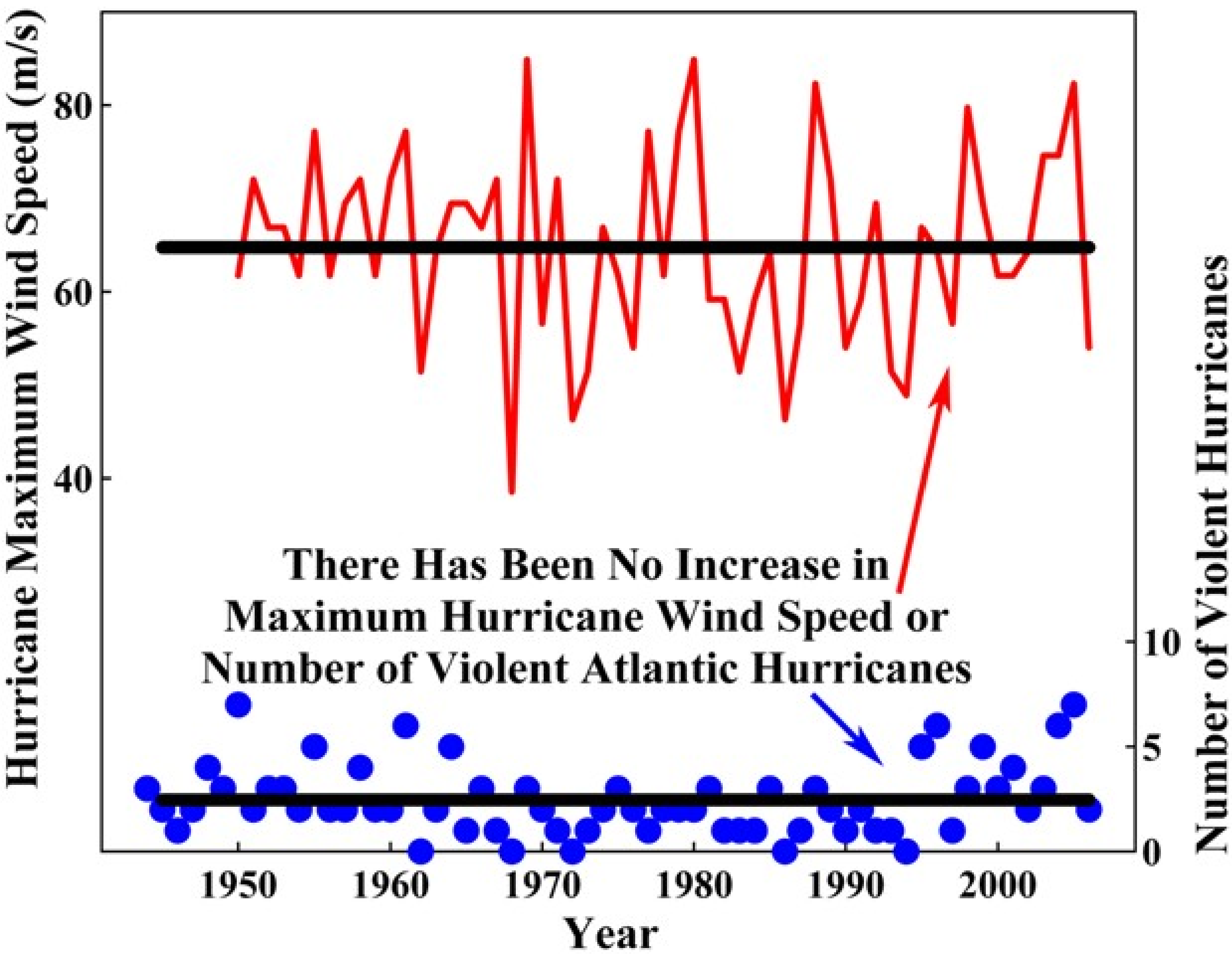


Figure 10: Annual number of violent hurricanes and maximum attained wind speed during those hurricanes in the Atlantic Ocean between 1944 and 2006 (22,23). There is no upward trend in either of these records. During this period, world hydrocarbon use increased 6-fold. Lines are mean values.

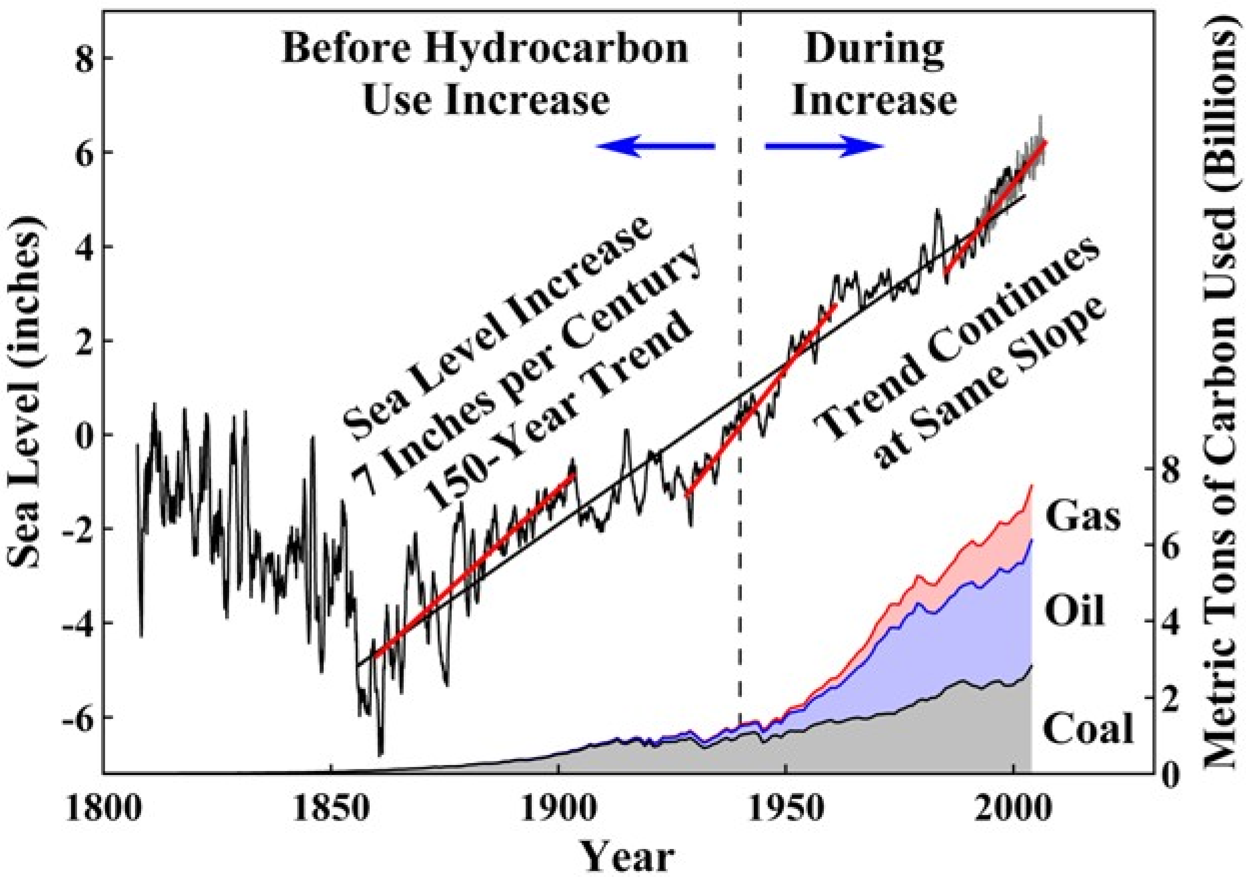


Figure 11: Global sea level measured by surface gauges between 1807 and 2002 (24) and by satellite between 1993 and 2006 (25). Satellite measurements are shown in gray and agree with tide gauge measurements. The overall trend is an increase of 7 inches per century. Intermediate trends are 9, 0, 12, 0, and 12 inches per century, respectively. This trend lags the temperature increase, so it predates the increase in hydrocarbon use even more than is shown. It is unaffected by the very large increase in hydrocarbon use.

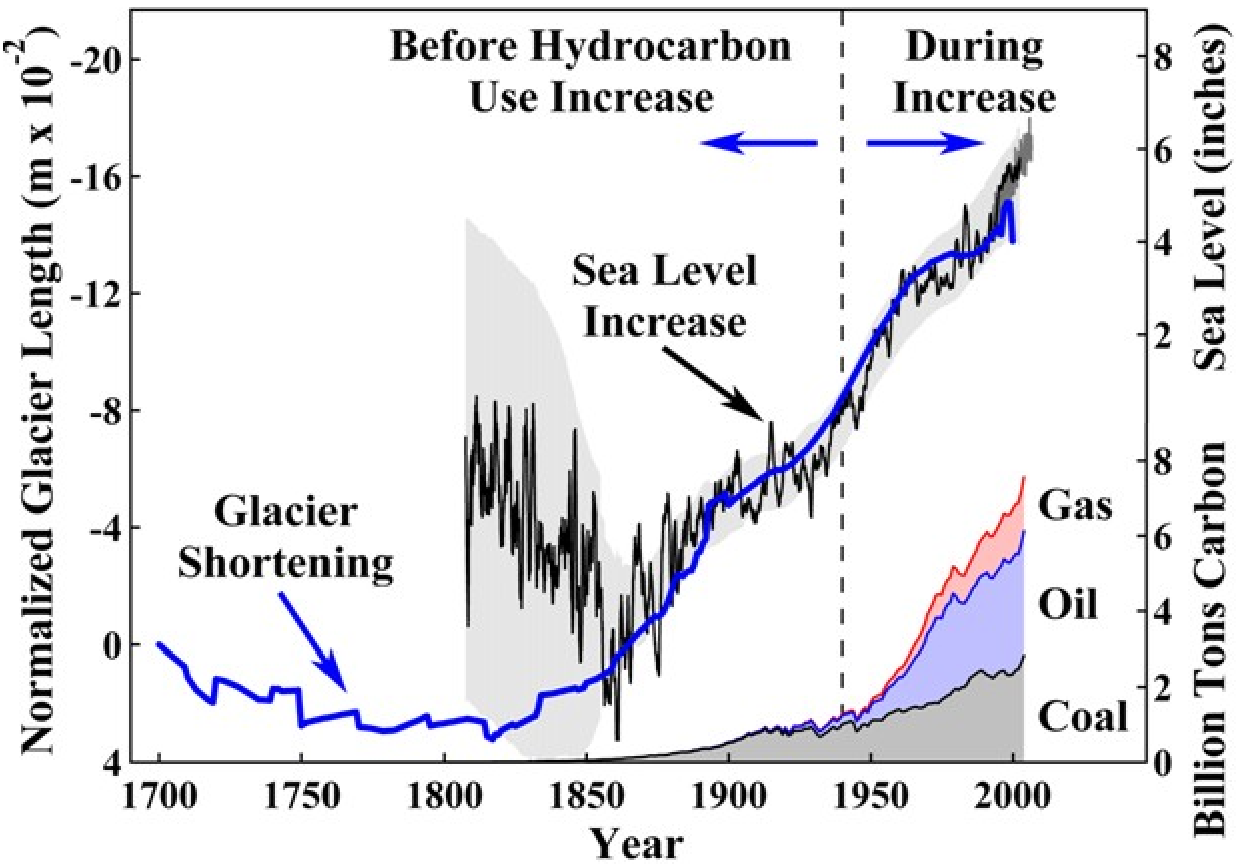


Figure 12: Glacier shortening (4) and sea level rise (24,25). Gray area designates estimated range of error in the sea level record. These measurements lag air temperature increases by about 20 years. So, the trends began more than a century before increases in hydrocarbon use.

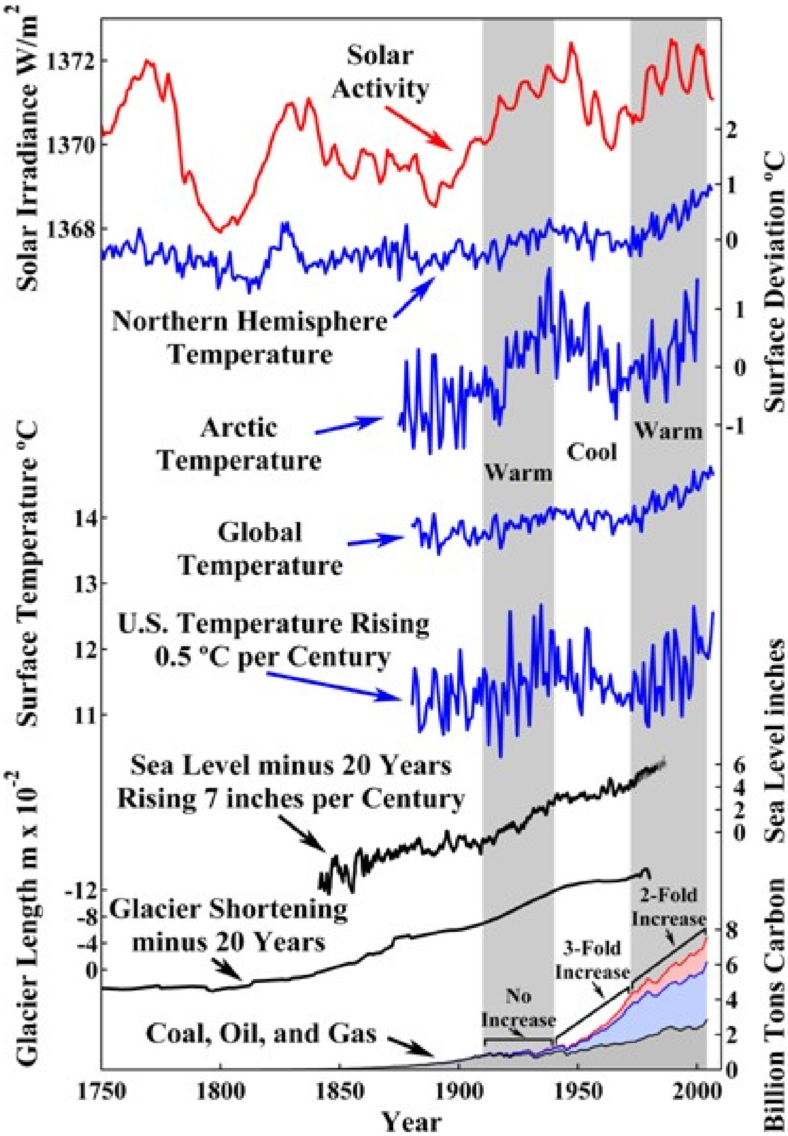


Figure 13: Seven independent records – solar activity (9); Northern Hemisphere, (13), Arctic (28), global (10), and U.S. (10) annual surface air temperatures; sea level (24,25); and glacier length (4) – all qualitatively confirm each other by exhibiting three intermediate trends – warmer, cooler, and warmer. Sea level and glacier length are shown minus 20 years, correcting for their 20-year lag of atmospheric temperature. Solar activity, Northern Hemisphere temperature, and glacier lengths show a low in about 1800.

Hydrocarbon use (7) is uncorrelated with temperature. Temperature rose for a century before significant hydrocarbon use. Temperature rose between 1910 and 1940, while hydrocarbon use was almost unchanged. Temperature then fell between 1940 and 1972, while hydrocarbon use rose by 330%. Also, the 150 to 200-year slopes of the sea level and glacier trends were unchanged by the very large increase in hydrocarbon use after 1940.

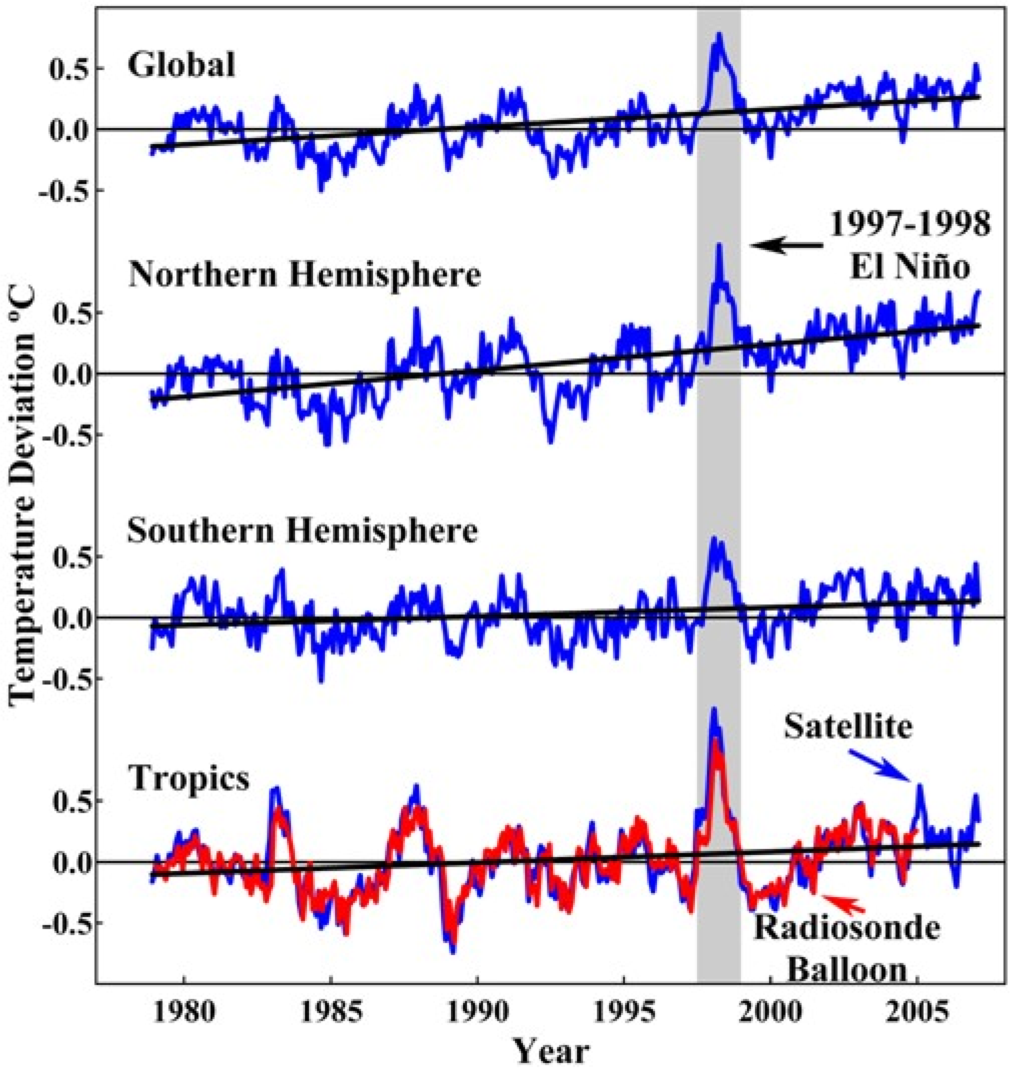


Figure 14: Satellite microwave sounding unit (blue) measurements of tropospheric temperatures in the Northern Hemisphere between 0 and 82.5 N, Southern Hemisphere between 0 and 82.5 S, tropics between 20S and 20N, and the globe between 82.5N and 82.5S between 1979 and 2007 (29), and radiosonde balloon (red) measurements in the tropics (29). The balloon measurements confirm the satellite technique (29-31). The warming anomaly in 1997-1998 (gray) was caused by El Niño, which, like the overall trends, is unrelated to CO_2 (32).

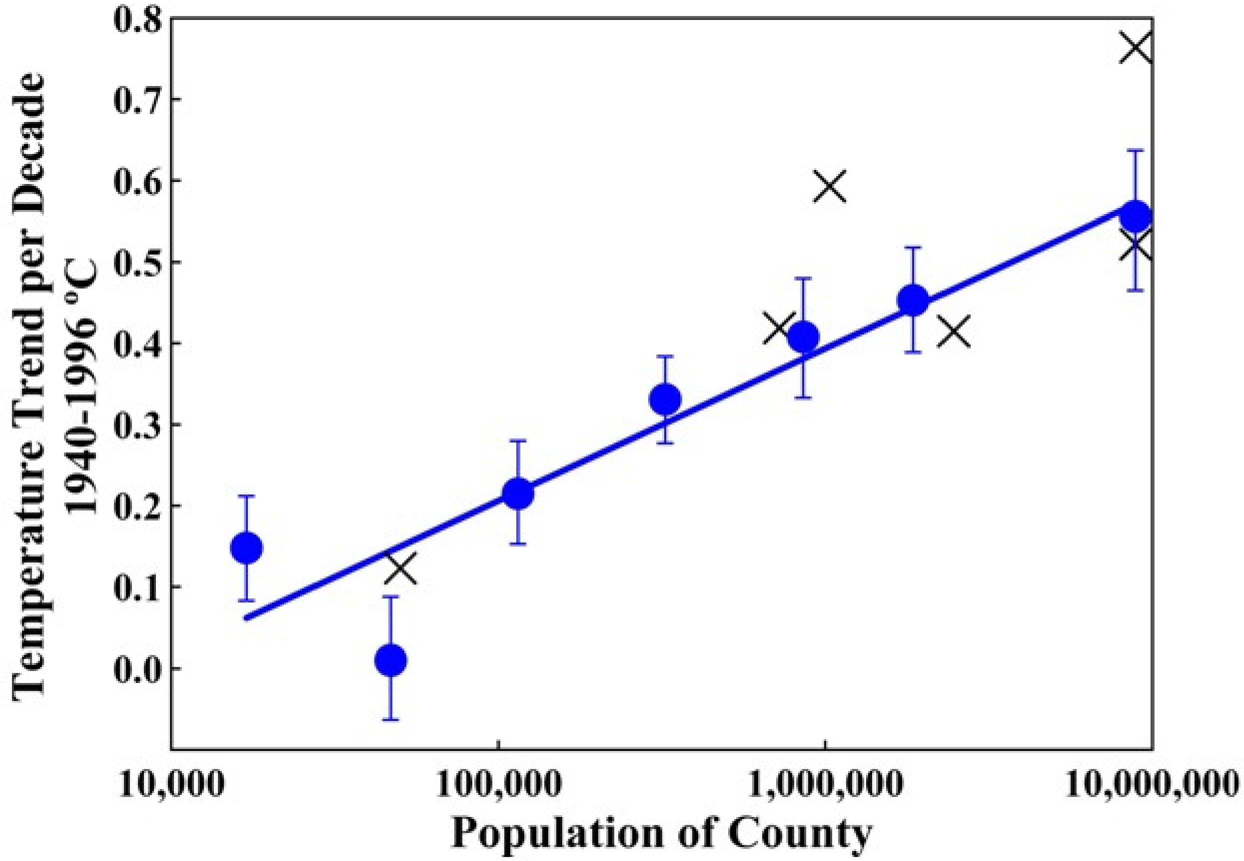


Figure 15: Surface temperature trends for 1940 to 1996 from 107 measuring stations in 49 California counties (51,52). The trends were combined for counties of similar population and plotted with the standard errors of their means. The six measuring stations in Los Angeles County were used to calculate the standard error of that county, which is plotted at a population of 8.9 million. The "urban heat island effect" on surface measurements is evident. The straight line is a least-squares fit to the closed circles. The points marked "X" are the six unadjusted station records selected by NASA GISS (53-55) for use in their estimate of global surface temperatures. Such selections make NASA GISS temperatures too high.

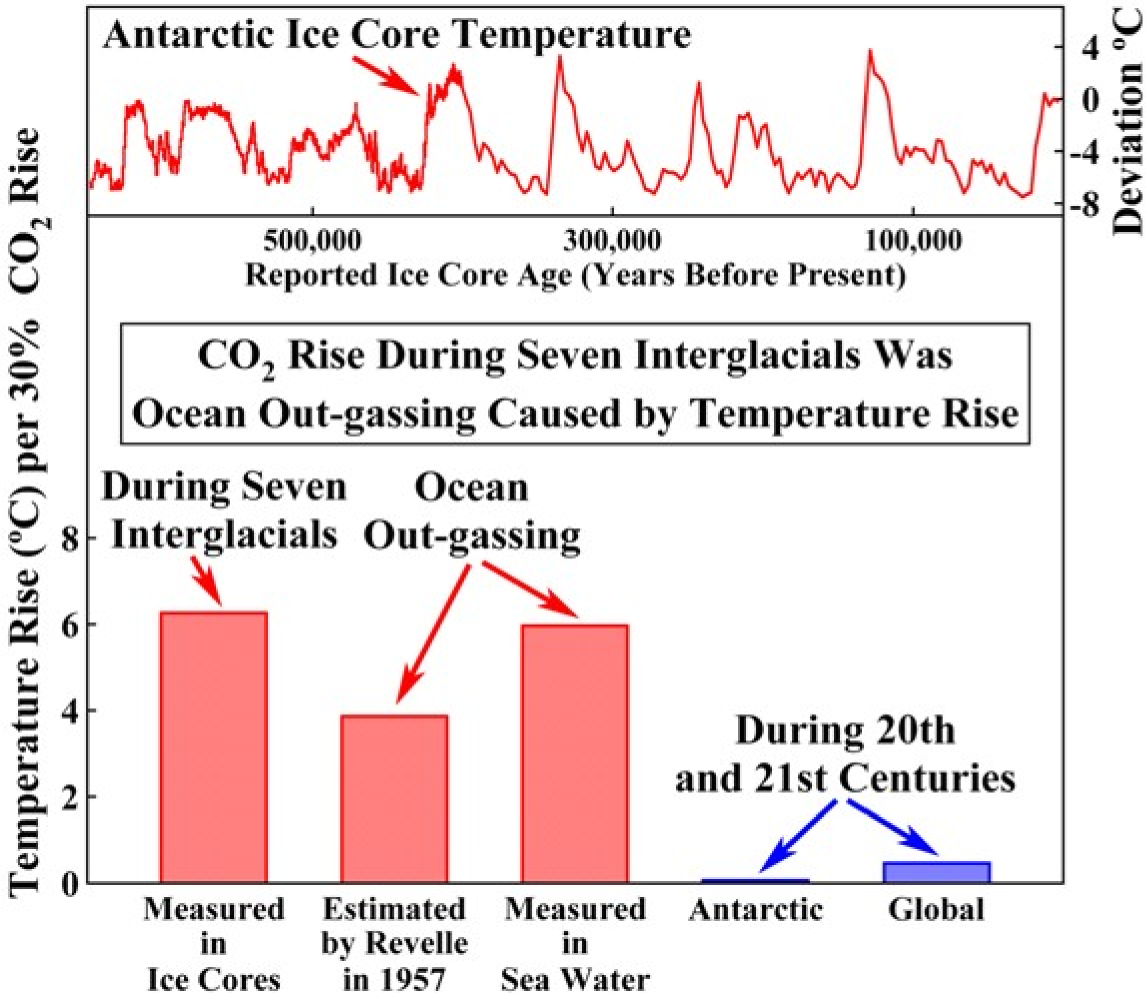


Figure 16: Temperature rise versus CO2 rise from seven ice-core measured interglacial periods (63-65); from calculations (69) and measurements (70) of sea water out-gassing; and as measured during the 20th and 21st centuries (10,72). The interglacial temperature increases caused the CO2 rises through release of ocean CO2. The CO2 rises did not cause the temperature rises.

In addition to the agreement between the out-gassing estimates and measurements, this conclusion is also verified by the small temperature rise during the 20th and 21st centuries. If the CO2 versus temperature correlation during the seven interglacials had been caused by CO2 greenhouse warming, then the temperature rise per CO2 rise would have been as high during the 20th and 21st centuries as it was during the seven interglacial periods.

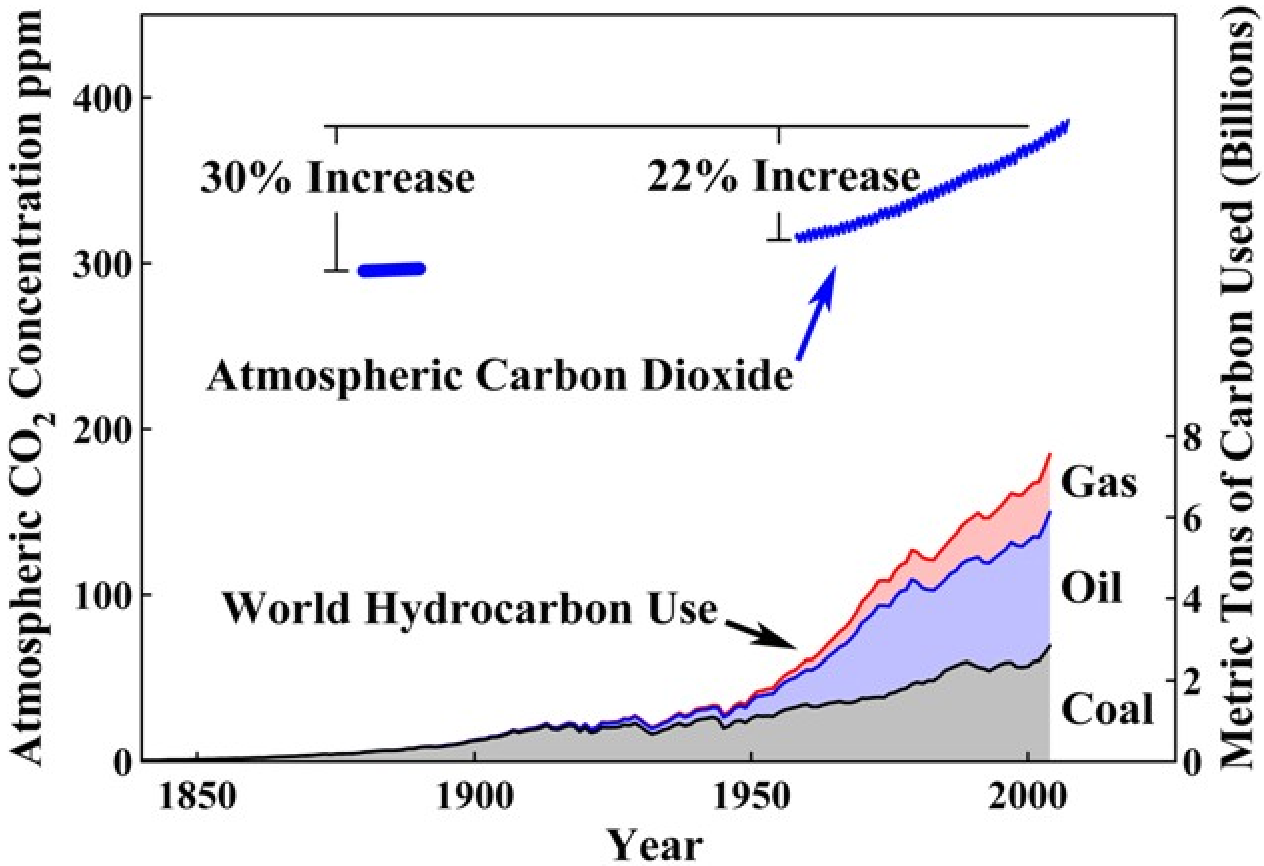


Figure 17: Atmospheric CO2 concentrations in parts per million by volume, ppm, measured spectrophotometrically at Mauna Loa, Hawaii, between 1958 and 2007. These measurements agree well with those at other locations (71). Data before 1958 are from ice cores and chemical analyses, which have substantial experimental uncertainties. We have used 295 ppm for the period 1880 to 1890, which is an average of the available estimates. About 0.6 Gt C of CO2 is produced annually by human respiration and often leads to concentrations exceeding 1,000 ppm in public buildings. Atmospheric CO2 has increased 22% since 1958 and about 30% since 1880.

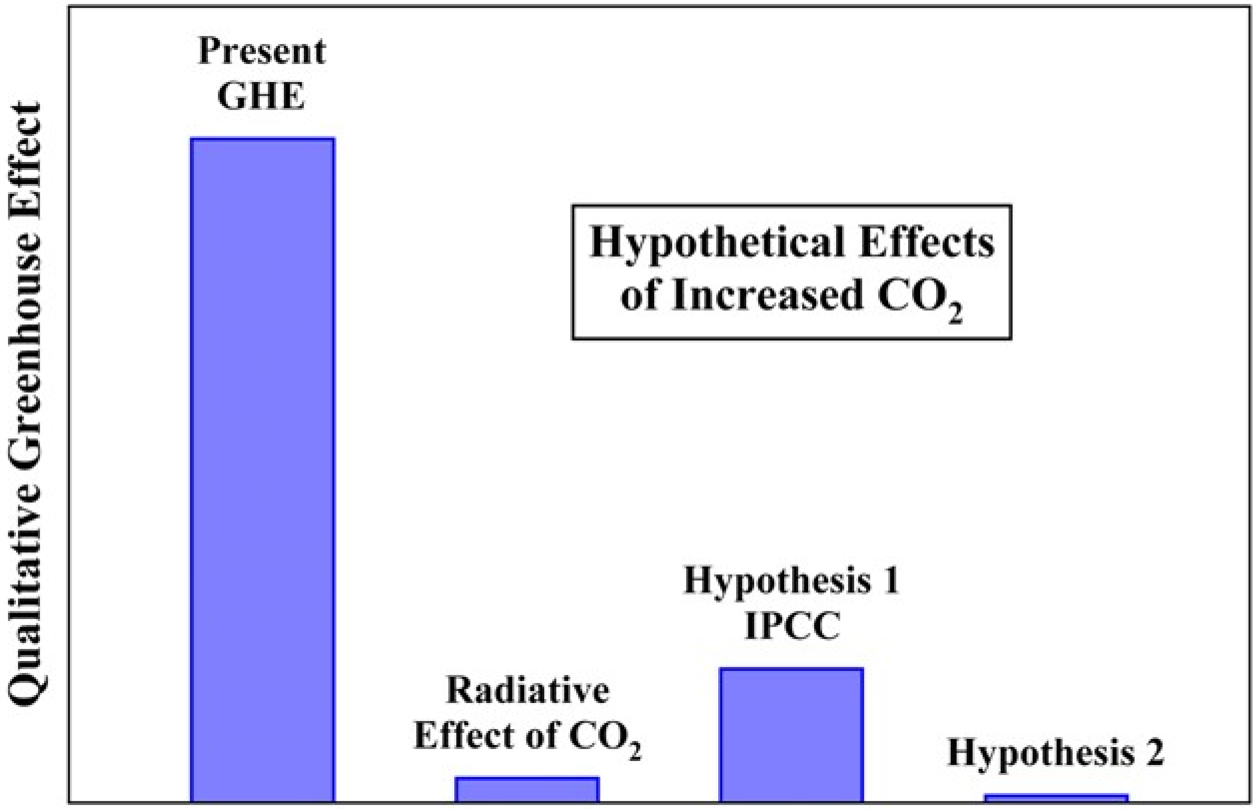


Figure 18: Qualitative illustration of greenhouse warming. "Present GHE" is the current greenhouse effect from all atmospheric phenomena. "Radiative effect of CO2" is the added greenhouse radiative effect from doubling CO2 without consideration of other atmospheric components. "Hypothesis 1 IPCC" is the hypothetical amplification effect assumed by IPCC. "Hypothesis 2" is the hypothetical moderation effect.

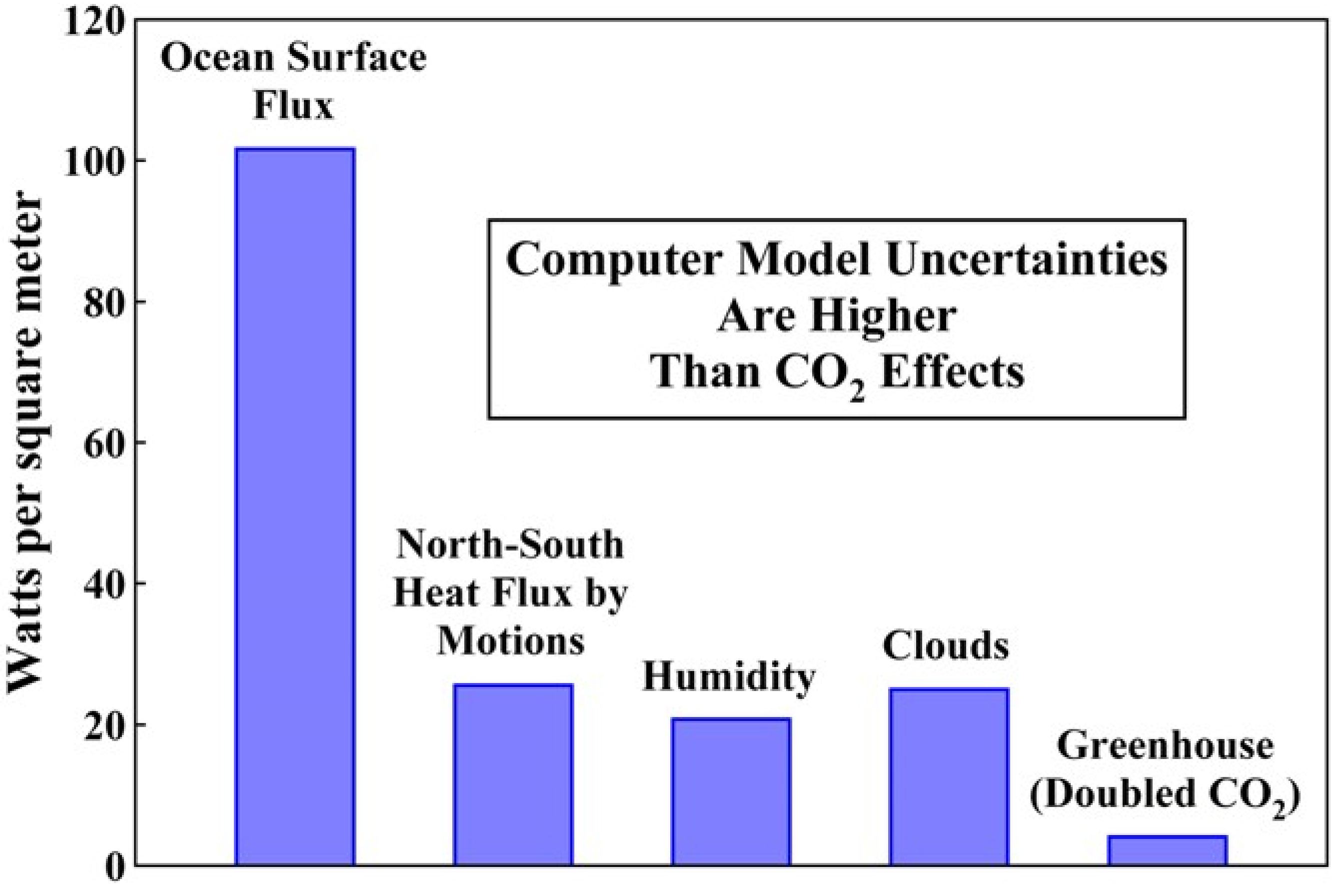


Figure 19: The radiative greenhouse effect of doubling the concentration of atmospheric CO2 (right bar) as compared with four of the uncertainties in the computer climate models (87,93).

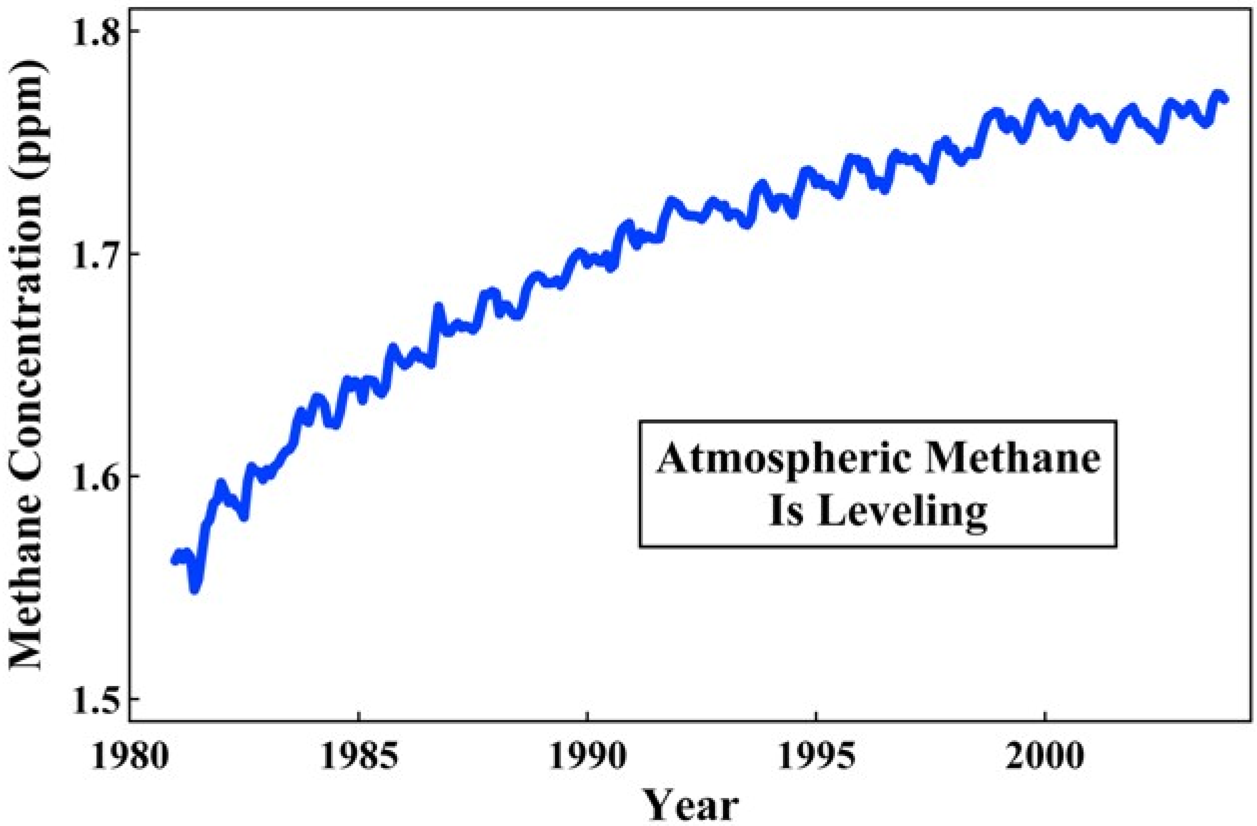


Figure 20: Global atmospheric methane concentration in parts per million between 1982 and 2004 (94).

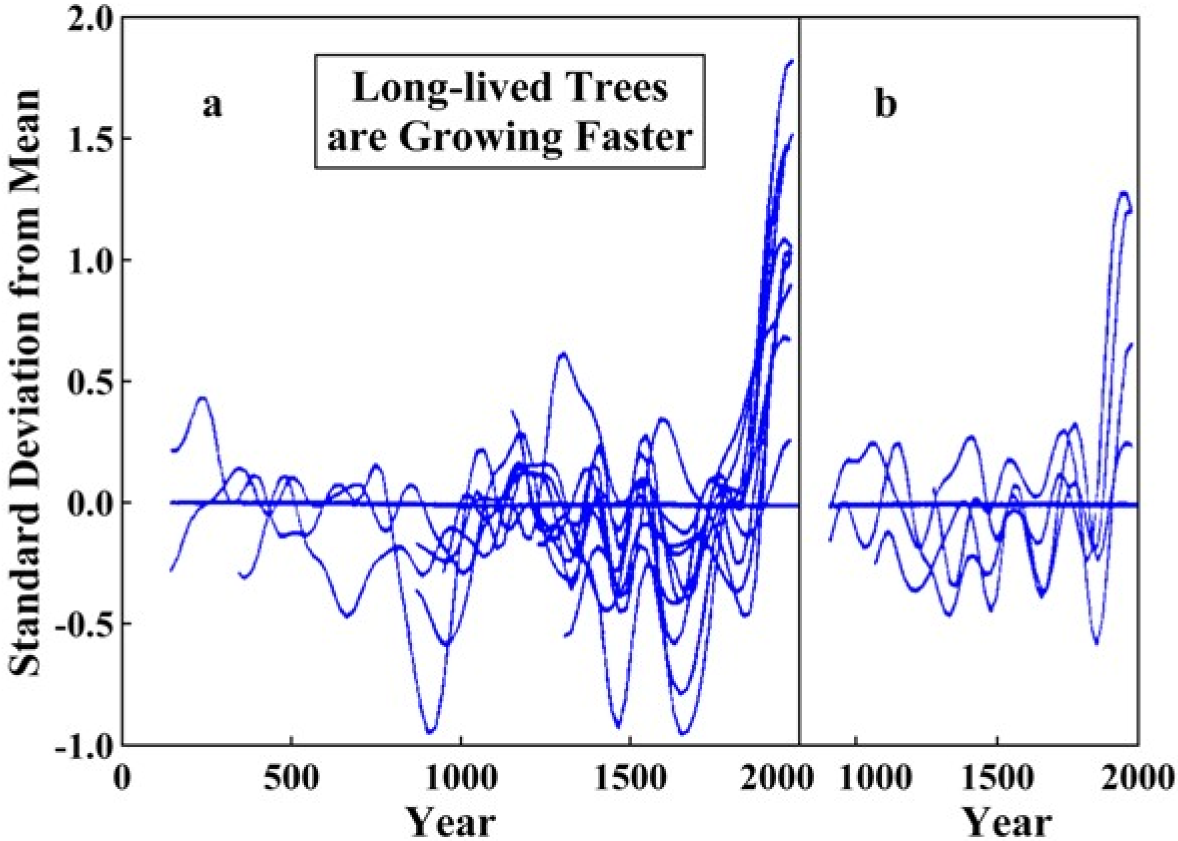


Figure 21: Standard deviation from the mean of tree ring widths for (a) bristlecone pine, limber pine, and fox tail pine in the Great Basin of California, Nevada, and Arizona and (b) bristlecone pine in Colorado (110). Tree ring widths were averaged in 20-year segments and then normalized so that the means of prior tree growth were zero. The deviations from the means are shown in units of standard deviations of those means.

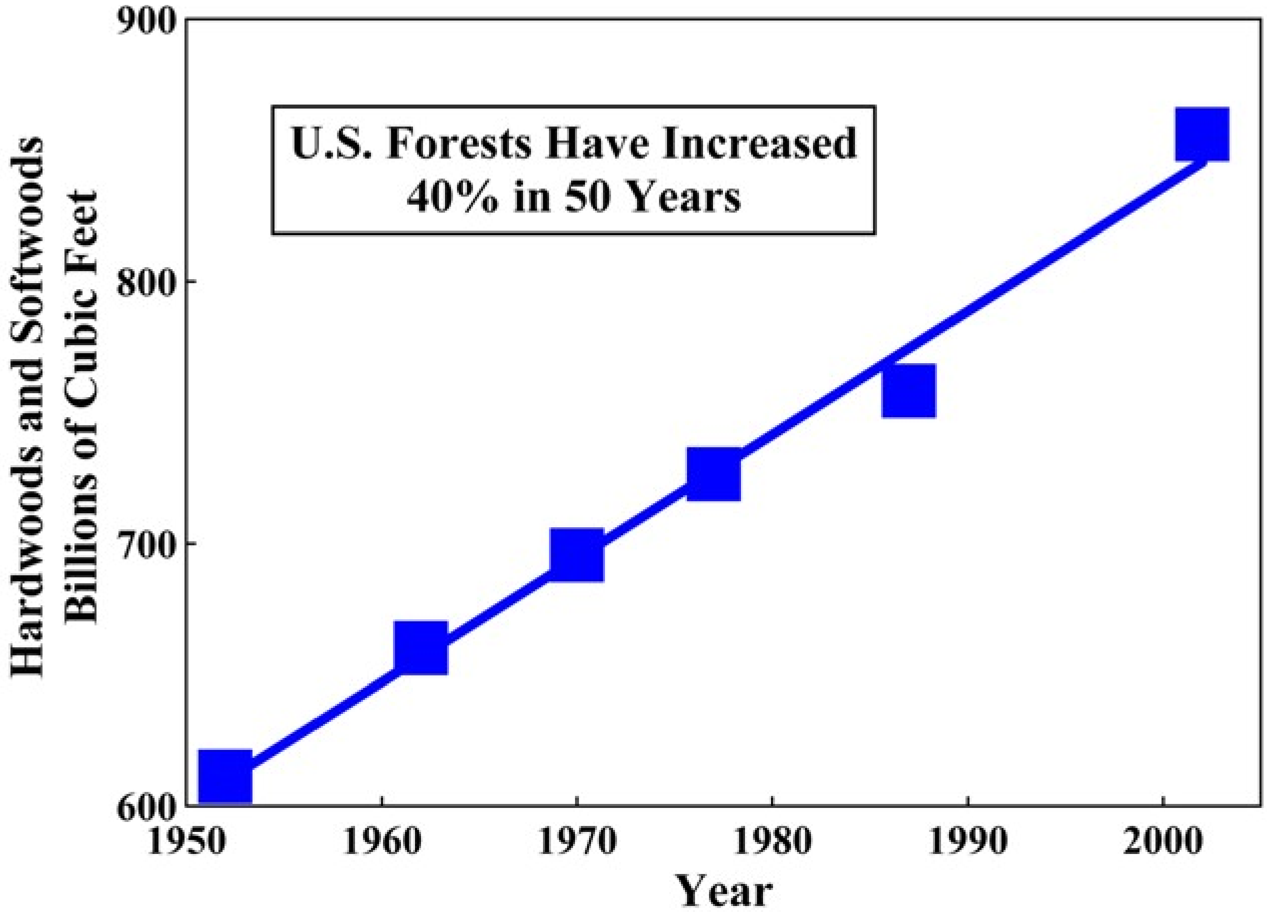


Figure 22: Inventories of standing hardwood and softwood timber in the United States compiled in Forest Resources of the United States, 2002, U.S. Department of Agriculture Forest Service (111,112). The linear trend cited in 1998 (1) with an increase of 30% has continued. The increase is now 40%. The amount of U.S. timber is rising almost 1% per year.

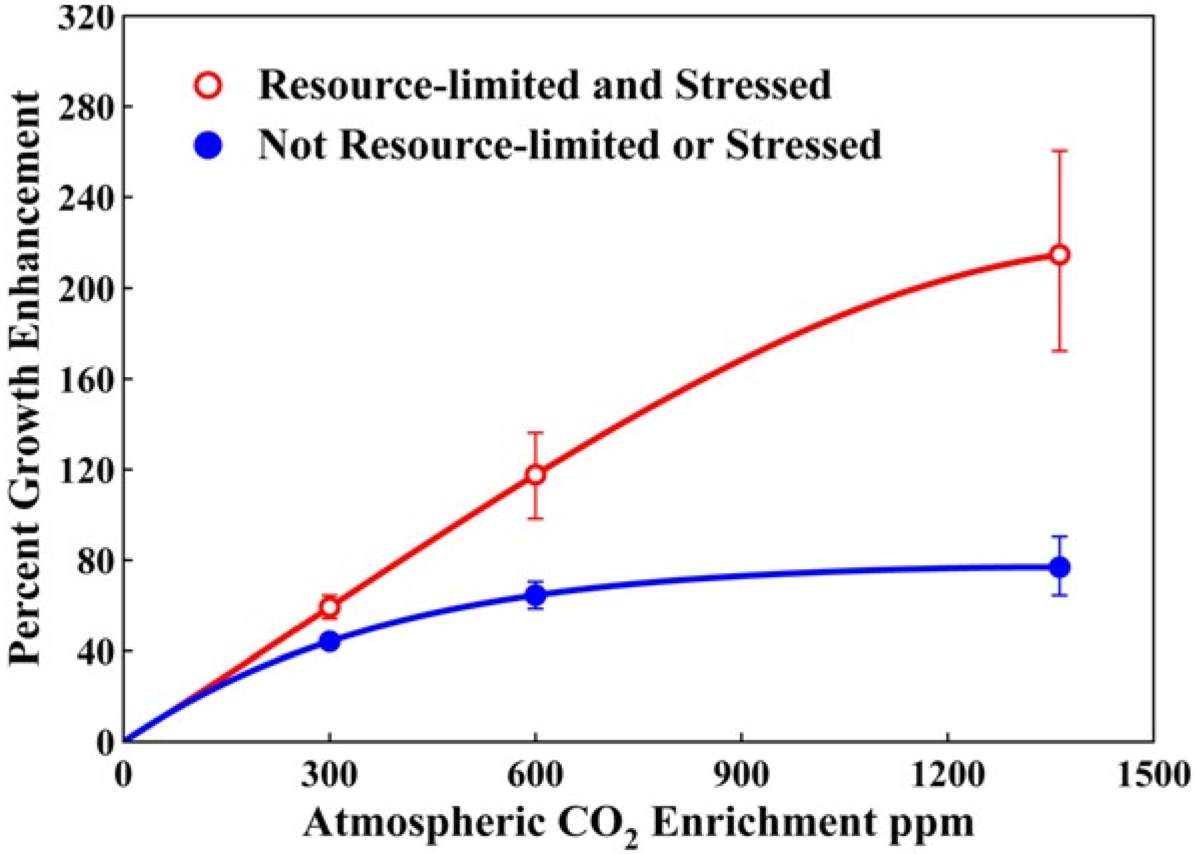


Figure 23: Summary data from 279 published experiments in which plants of all types were grown under paired stressed (open red circles) and unstressed (closed blue circles) conditions (114). There were 208, 50, and 21 sets at 300, 600, and an average of about 1350 ppm CO2, respectively. The plant mixture in the 279 studies was slightly biased toward plant types that respond less to CO2 fertilization than does the actual global mixture. Therefore, the figure underestimates the expected global response. CO2 enrichment also allows plants to grow in drier regions, further increasing the response.

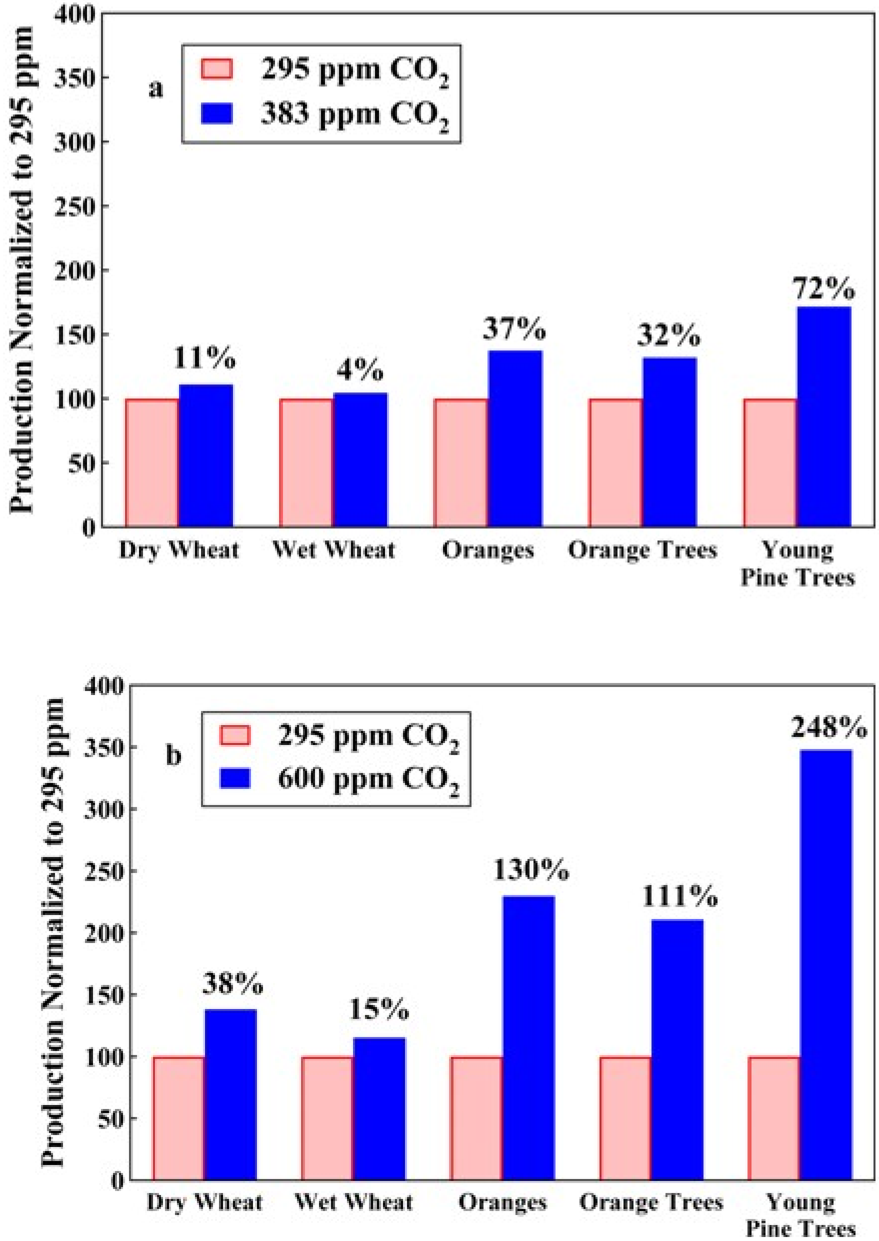


Figure 24: Calculated (1,2) growth rate enhancement of wheat, young orange trees, and very young pine trees already taking place as a result of atmospheric enrichment by CO2 from 1885 to 2007 (a), and expected as a result of atmospheric enrichment by CO2 to a level of 600 ppm (b).