CO_2 Concentrations Affect Temperature, but Does CO_2 Drive the Climate?

Figure 1

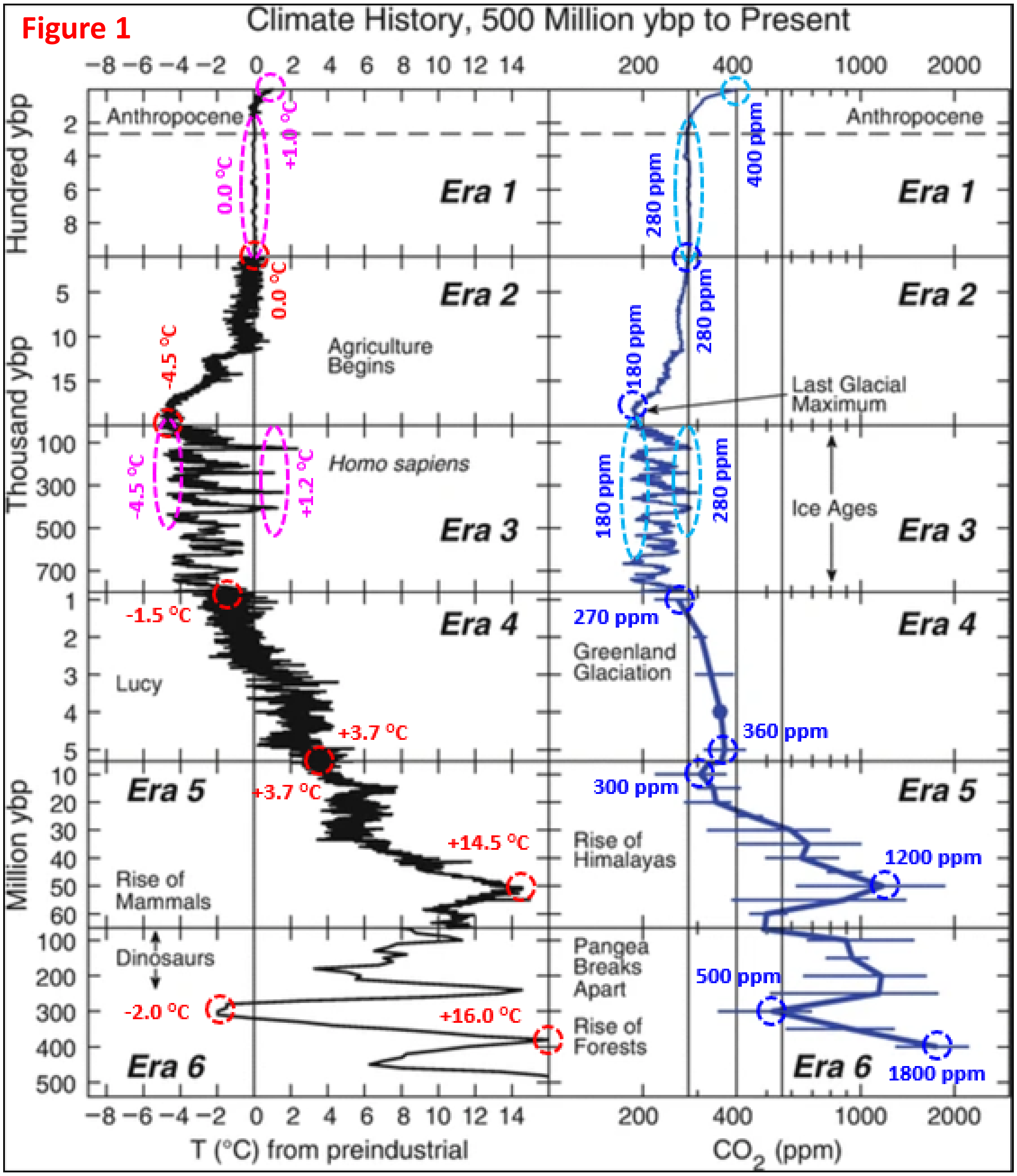


Table 1 — **CO₂ Climate Sensitivity Estimates**

ERA 1 – Temperature Change – 0.8 °C, CO_2 Change – 120 ppm, – CCS – 1.57 °C

ERA 2 – Temperature Change – 4.5 °C, CO_2 Change – 100 ppm, – CCS – 7.06 °C

ERA 3 – Temperature Change – 5.7 °C, CO_2 Change – 100 ppm, – CCS – 8.94 °C

ERA 4 – Temperature Change – 5.2 °C, CO_2 Change – 110 ppm, – CCS – 12.53 °C

ERA 5 – Temperature Change – 10.8 °C, CO_2 Change – 900 ppm, – CCS – 5.40 °C

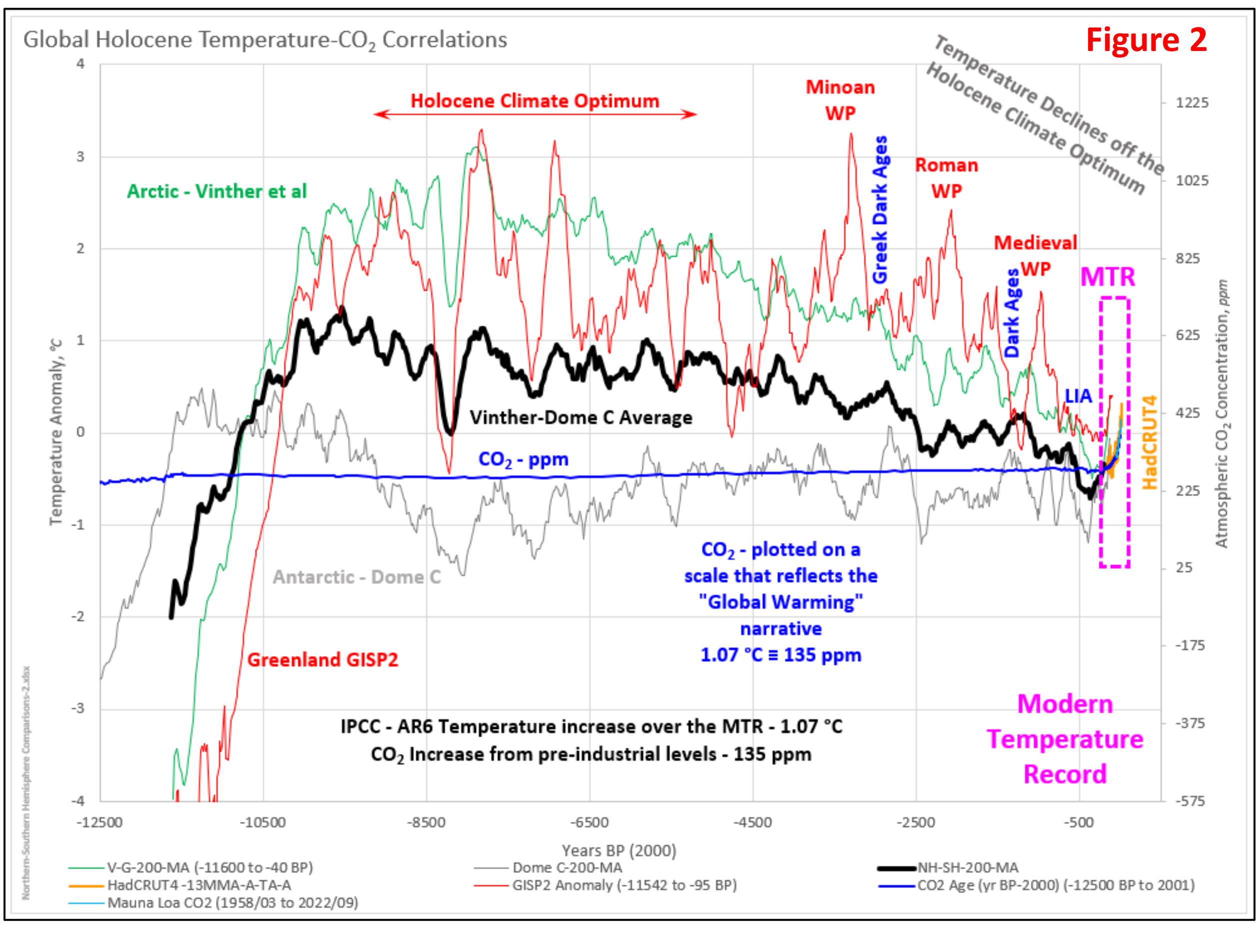
ERA 6 – Temperature Change – 18.0 °C, CO_2 Change – 1300 ppm, – CCS – 9.74 °C

Image Source - Earth's Climate System – Salawitch, R., Bennett, B., Hope, A., Tribett, W., Canty, T.
https://link.springer.com/chapter/10.1007/978-3-319-46939-3_1

To have a proper discussion on climate change, you need to know (or at least come to a reasoned/agreed upon value) for the CO_2 Climate Sensitivity, because it does make a difference if the CCS is 1.0 °C or 3.0 °C (the rough average of the IPCC models) or 5.7 °C (the high end of the IPCC model range).

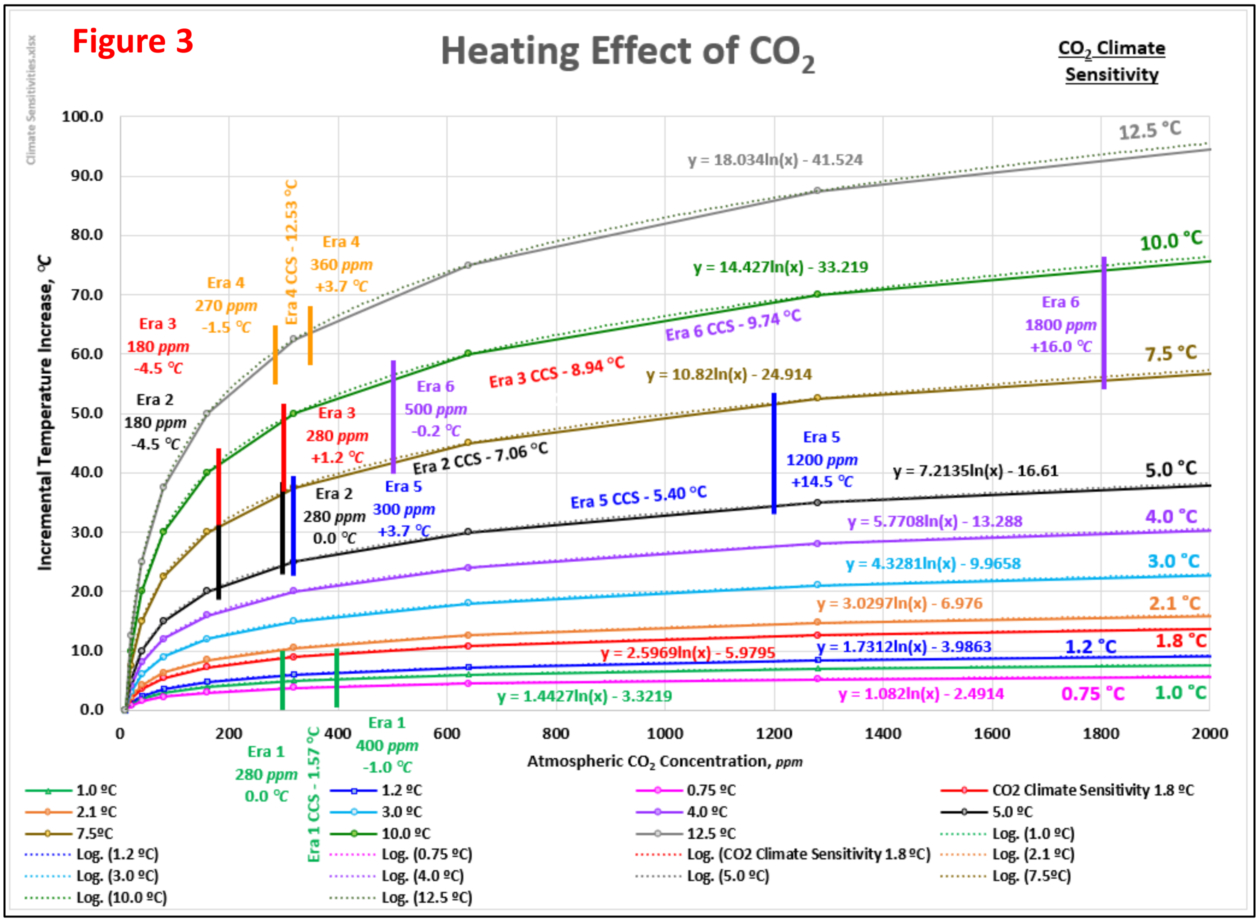
The image on the previous page (Figure 1) was presented to me as proof that CO_2 is driving the climate. Those that believe that do not fully comprehend the relationship between CO_2 and climate and/or some of the subtle differences between correlation and causation. The curves may have similar profiles, but that does not mean that CO_2 is driving those temperatures. They may be contributing to the temperature change, but they are most certainly not responsible for the entire temperature change or even a dominant portion of that temperature change. To start with the CO_2 is plotted on a logarithmic scale and the temperature data is plotted on a linear scale. They do not look as in sync when they are both plotted on properly apportioned scales.

The plot below (Figure 2) covers the Holocene with the vertical scales set based on the premise that all the warming from the pre-industrial era (1.07 °C, based on the IPCC's August 2021 AR6 report) is due to the 135 ppm increase in atmospheric CO_2 levels. Note that the temperatures fluctuate significantly (in both hemispheres) despite a virtually flat CO_2 concentration. The natural forcings (primarily solar, directly and indirectly) causing those fluctuations did not suddenly cease to exist just because the models have been programmed to ignore or turn down their effectiveness.



Secondly, the two curves (from Figure 1) would look very different if the hypothesis proposed to explain the similarities, *"atmospheric CO_2 is controlled by the carbonate-silicate cycle"* was true. CO_2 has a specific climate sensitivity (subject only to transient or equilibrium conditions). You cannot just use a different CO_2 Climate Sensitivity (CCS) for different time periods. That number must be consistent over the entire 500-million-year dataset. That is very much not the case. The values range from 1.57 °C over Era 1 (1850 to the present, based on a CCS of 0.8 °C) to 12.53 °C over Era 4 (the Pliocene and early Pleistocene (Ice Age). These estimates are summarized in Table 1 (below Figure 1).

The best estimate of the CCS (assuming all the warming is due to CO2, which is not actually the case) from Figure 1.1 would be the Era 1 value of 1.94 °C (shown in Table 2). But I do question the flat temperatures shown in Figure 1 from 200 to 1000 years ago (as shown in Figure 2). For the calculations we just need/used the change in temperature (rough estimate, 1.0 °C). If we use the IPCC's 1.07 °C and the 135 ppm CO_2 change from the earlier Holocene plot, the CCS would be 1.86 °C (same ballpark).



For reference, the computer models, those ones that *"run way too hot"*, use a range of CCS from 1.8 °C to 5.7 °C. Given that even the models that use 1.8 °C are running hotter than observed temperatures, the CCS is somewhere below that number. Figure 3 above shows a variety of CCS and their relationships to the Figure 1 temperatures and CO_2 concentrations.

Table 2 Period	CO_2 Climate Sensitivity	Low Temp °C	High Temp °C	Temp Change °C	Low CO_2 ppm	High CO_2 ppm	CO_2 Change ppm	Temp Due to CO_2 °C	CO_2 Share of Temp Rise
Era 1	1.94	0.00	1.00	1.00	280	400	120	1.00	100%
Era 2	7.06	-4.50	0.00	4.50	180	280	100	1.24	27%
Era 3	8.94	-4.50	1.20	5.70	180	280	100	1.24	22%
Era 4	12.53	-1.50	3.70	5.20	270	360	90	0.81	15%
Era 5	5.40	3.70	14.50	10.80	300	1200	900	3.88	36%
Era 6	9.74	-2.00	16.00	18.00	500	1800	1300	3.59	20%

The IPCC's low end 1.8 °C estimate compares reasonably well with the 1.94 °C low end calculation from Figure 1. Over that very short geological period (±174 years), the carbon-silicate cycle is not in play. All the CCS estimates presented to this point assume the warming is anthropogenic based (primarily CO_2). For the purpose of this discussion, we can grudgingly go with that assumption and use a CCS of 1.94 °C. Ultimately; the CO_2 source is irrelevant for the calculations. I will discuss the CCS in more detail later (which I suspect is lower and very likely less than 1.0 °C). And yes, the models *"run way too hot"* as self-acknowledged by the modelers (not the IPCC per se). That quote and others from the likes of Gavin Schmidt can be found in my OPS 55 – The State of Climate Science post. That post also includes the IPCC's position on the implausible RCP8.5 emission scenario. My model discussion confirming the models *"run way too hot"* can be found in my CSS-30 – CMIP6 Climate Models post.

Eras 2 through 6 temperatures are obviously not being driven by CO_2 alone. Even if the CO_2 changes are 100% due to the carbon-silicate cycle, volcanic extrusions, etc. (not solar, ocean, etc. influences) they cannot explain most of the temperature rise/fall. To believe that scenario you also must put aside the ice core data over the last million years which definitively shows that temperature was the dominant driver, not CO_2. More accurately, orbital dynamics were driving temperature, which in turn drove CO_2 concentrations. Did temperatures suddenly start driving CO_2 concentrations a million years ago and then just as suddenly quit 174 years ago? Not likely.

Most of the major temperature changes over the Cenozoic (66 million years ago to the present) are related to plate tectonics and some celestial impact events. Plate tectonics have initiated and terminated many major ocean circulation patterns, progressively reducing temperatures from the very hot Eocene Climate Optimum (±50 million years ago) to the Pleistocene Ice Age we are currently living through. It appears that the dual impacts (Popigai and Chesapeake Bay) helped initiate the Antarctic ice cap formation at the Eocene/Oligocene boundary (±34 million years ago). When you cross plot temperature and CO_2 concentrations over the Holocene you will find that major events (like the impacts, the Tethys Sea closing, the Panama Isthmus closing and the Drake Passage opening) separate stable temperature platforms (minimal temperature fluctuations) that are characterized by significant CO_2 changes (i.e.: the CO_2 concentrations are changing but the temperatures remain generally flat. These data presentation and detailed discussions are included in my CSS-10 – A Ride through the Cenozoic post. My post and Figure 1 use the same carbon and oxygen isotope ratio data set, Westerhold et al 2020.

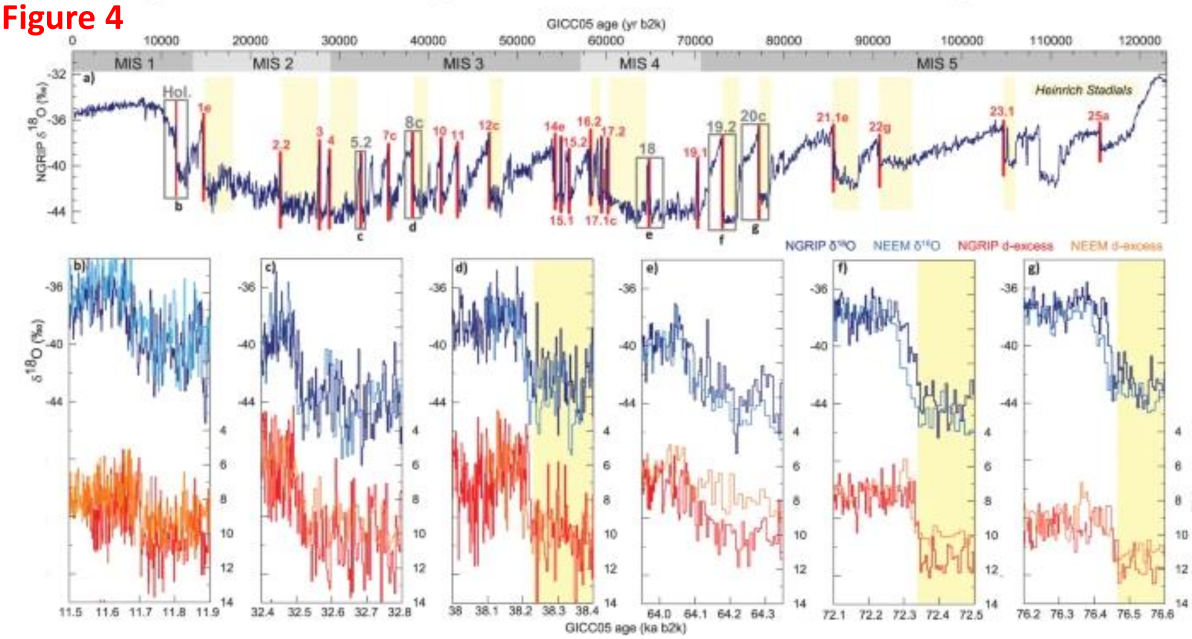
The older data (discussed in my CSS-12 – Cosmic Ray Discussion post), the bulk of the Phanerozoic (66 to 500 million years ago) correlates very poorly to CO_2. On these very long time frames our position in the galaxy dictates whether we are in ice ages or hot houses. If our solar system is located within one of the

Milky Way's spiral arms, we are subjected to much higher Cosmic Ray Flux (CRF) which increases cloud cover (i.e.: albedo) cooling the planet. The opposite is true when we are located between the arms or above/below the galactic plane. This does not affect our day to day lives, but we are currently in the Milky Way's Sagittarius-Carina arm, and we are in a glacial period that started 34 million years ago with the formation of the Antarctic ice cap and deepened when the Panama Isthmus closed 2.6 million years ago, initiating our Arctic polar ice cap.

But back to the present, and forcings that will affect us in our lifetimes. As shown in the Figure 2 (Holocene temperatures and CO_2 levels), natural forcings that have nothing to do with CO_2, routinely affect temperatures and the climate on time frames that affect our lives directly. That is likely happening right now. Our planet is routinely subjected to rapid warming and cooling due to a variety of solar and oceanic cycles. The expression of those cycles can be easily seen in the Greenland ice core data. The larger Holocene features (the warm Climate Optimum and Neoglacial temperature declines) are visible in many datasets (discussed in my [CSS-56 – The Holocene & Solar Activity] post). There have been many abrupt temperature increases (Dansgaard-Oeschger (DO) events) far more dramatic and rapid than the minor 1 °C temperature rise over the last 174 years (as shown in the ice core data below, Figure 4).

Fig. 1: Abrupt climate variability recorded in Greenland water isotopic records.

Figure 4



a NGRIP $\delta^{18}O$ record[5]. Studied abrupt warming transitions are highlighted with red vertical bars and Greenland Interstadials (GI) are numbered[38]. Gray boxes indicate intervals shown in (**b**–**g**), illustrating the variety of abrupt GS–GI transitions across the Last Glacial; stadials containing Heinrich events are indicated in yellow following refs. [53,85], and Marine Isotope Stages (MIS) are indicated in gray. **b**–**g** High-resolution $\delta^{18}O$ from NGRIP (dark blue) and NEEM (light blue) and d-excess from NGRIP (red) and NEEM (orange) over 400 yr time intervals centered on the Holocene abrupt onset (**b**) and the abrupt transitions into GI-5.2 (**c**), GI-8c (**d**), GI-18 (**e**), GI-19.2 (**f**), and GI-20c (**g**).

Those same processes (active through the glacial periods) are active during the warm interglacial periods, like the Holocene. The expression of those events is far more muted, but they are still there. The Minoan, Roman, Medieval and Modern warm periods are the most recent examples of warm interstadials. The Greek Dark, the Dark, and Little Ice Ages are the most recent examples of cold stadials. There are many others over the Holocene.

The current interstadial began forming (i.e.: warming) in the late 1600s. That is centuries prior to any significant emissions from humanity were present, since 86%+ of our emissions occurred post-1950. We are very likely approaching the peak of that interstadial/DO event since both the Atlantic Multi-decadal Oscillation (AMO) and solar activity (Total Solar Irradiance (TSI)) are transitioning to their cold phases. The transition from warming to cooling during an interstadial happens abruptly and progresses rapidly. These colder stadials (Heinrich events) likely form when large icebergs migrate into the mid latitudes and/or there are massive cold, freshwater releases from the Beaufort Gyre into the North Atlantic, disrupting the existing ocean cycles. The cycles are complex, but they do exist. Additional discussion can be found in my CSS-58 – More Solar Cycles post. The solar cycles are complex, and they are not built into the IPCC computer models.

The IPCC has chosen to use an average of just two of the roughly 40 available Total Solar Irradiance (TSI) reconstructions available. There are TSI reconstructions available that can be used to model the Modern Temperature Record (with no CO_2 contribution) more accurately than the current CO_2 obsessed models. I reviewed a couple of recent papers that looked at the TSI reconstructions in detail. Those looks (the general discussion and history matches) can be found in my CSS-42 – The Role of the Sun – Scafetta 2023 and CSS-51 – Soon-Connolly – Solar Forcings posts.

Early in my writings I found the Naval Research Labs' NRLTSI2 TSI reconstruction on a NASA site. I have always used that version in my writings and in some simple climate models that I have built over the years. As it turns out, the NRLTSI2 TSI reconstruction is close to a representative average, and I do not have to go back and redo my earlier work. The first model I built (OPS-8 – Basic Climate Model and Open Letter Addendum posts) was based on just TSI and the AMO. Is my model correct? Absolutely not, but the fit was far better than CO_2 alone.

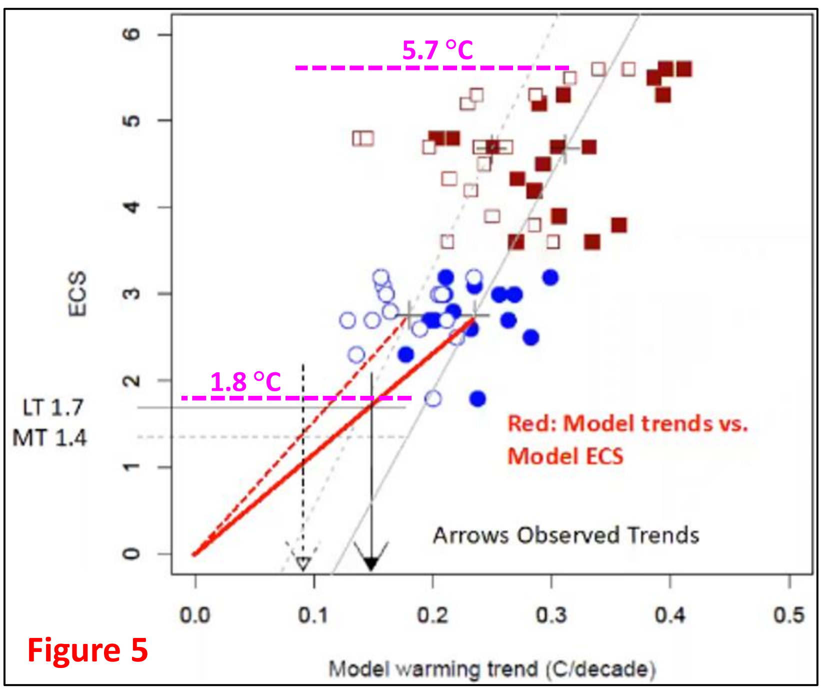


Figure 5

I upgraded the model, added in CO_2 and history matched the much longer Central England Temperature (CET). I discussed that model in my CSS-29 – Climate Model – TSI-AMO-CO_2 post. Again, not a perfect match but far superior to CO_2 alone. These models are not correct, but neither are the expert models that are self-acknowledged to *"run way too hot"*. The right answer will never be achieved, but the

IPCC et al are never going to come close until they start recognizing the very real natural forcings they are currently and knowingly ignoring.

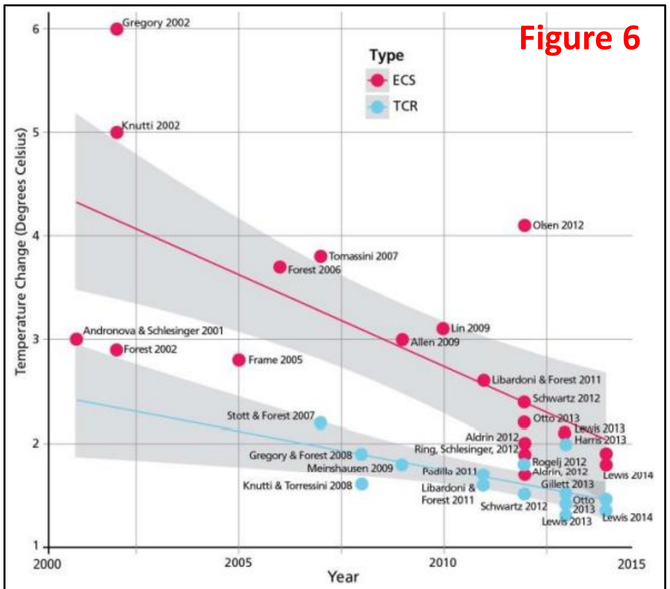


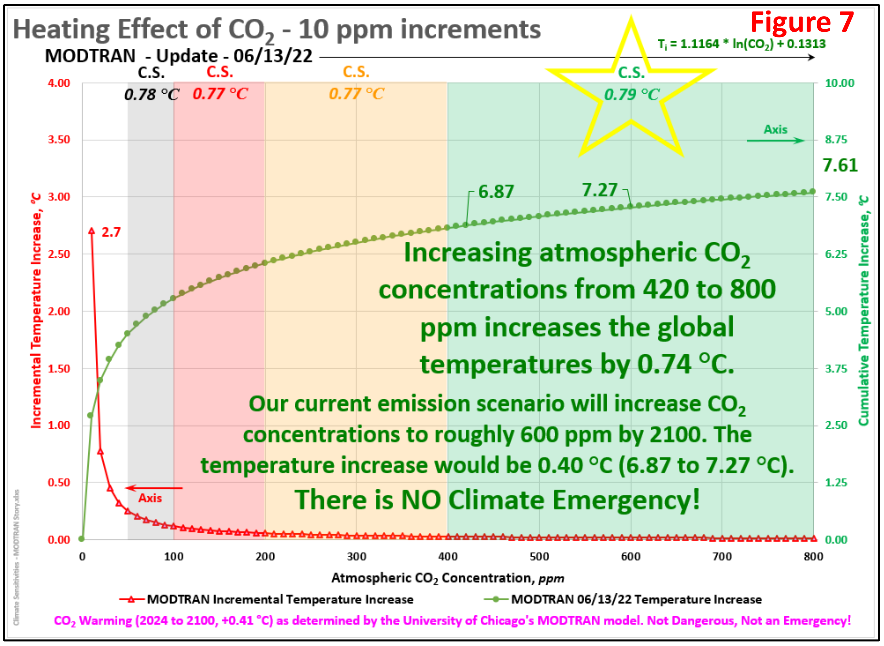
Figure 7. Compilation of published transient climate response (TCR) and equilibrium climate sensitivity (ECS) values to atmospheric CO2 doubling. (Adapted from Figure 1 in Refs. [20,27] where all references listed in the figure are reported: from link)

So, what is CO_2's Climate Sensitivity (CCS)? Let us start with the IPCC's programmed range (1.8 to 5.7 °C, shown on the previous page (Figure 5)). All the models run too hot (even with reasonable emission scenarios) suggesting that the CCS is less than 1.8 °C. The best estimate from Figure 1 is 1.94 °C. That is also likely a maximum that assumes all the warming (roughly 1.0 °C) since 1850 is due to rising CO_2 levels. The resolution is also poor in Figure 1, and the temperature rise on that plot may be less than 1.0 °C. If the temperature rise is 0.8 °C, the CCS drops to 1.57 °C.

Assuming all the warming since 1850 is due to human activity (primarily CO_2), is simplistic and unscientific for a few reasons. First, over 86% of humanity's emissions occurred post-1950, but half of the 1.07 °C temperature rise laid out by the IPCC in their 2021 AR6 report, occurred prior to 1950. Secondly, the temperature rise out of the Little Ice Age (LIA) began in the late 1600s. The CO_2 rise began much later, around 1850. As shown earlier (Figure 2), atmospheric CO_2 concentrations were virtually flat throughout the Holocene until 1850. There are many studies that have estimated CO_2's climate sensitivity over the years and those results have trended down over the years. The ECS estimate is down below 2.0 °C (Figure 6, consistent with the earlier discussion). The TCR is down into the 1.35 °C range. These estimates still assume that all the warming is due to anthropogenic causes.

Several other factors could be contributing to the temperature rise since 1850 that will ultimately reduce the CCS estimate. Total Solar Irradiance (TSI) has risen from its lowest levels in the last 7,000+ years to the highest levels in the last 7,000+ years. The TSI change is small but the proportionate change in CO_2 is smaller (OPS-78 – The Climate Change and Arsenic Paradox). So, which one is the more important parameter? As shown earlier, the modern temperature record can be modeled more accurately using natural forcings (primarily solar, directly and indirectly) than the current CO_2 focused approach. Both solar and CO_2 contribute, as do a wide range of other factors (ocean cycles, Cosmic Ray Flux, cloud cover (hours of sunshine), electromagnetic field strength, etc.). Temperature rises pre-1950 are primarily natural with a small contribution from natural CO_2 increases (minimal human influence).

Another factor that will drop the CCS is the Urban Heat Island (UHI) effect. Most weather stations around the planet are in urban areas. Urban areas are warmer than rural areas and most of the urban area warming occurs at night. But like most topics in 'climate science', the UHI effect is not 'settled science'. The magnitude of the UHI effect may be open for debate, but the UHI effect is real.



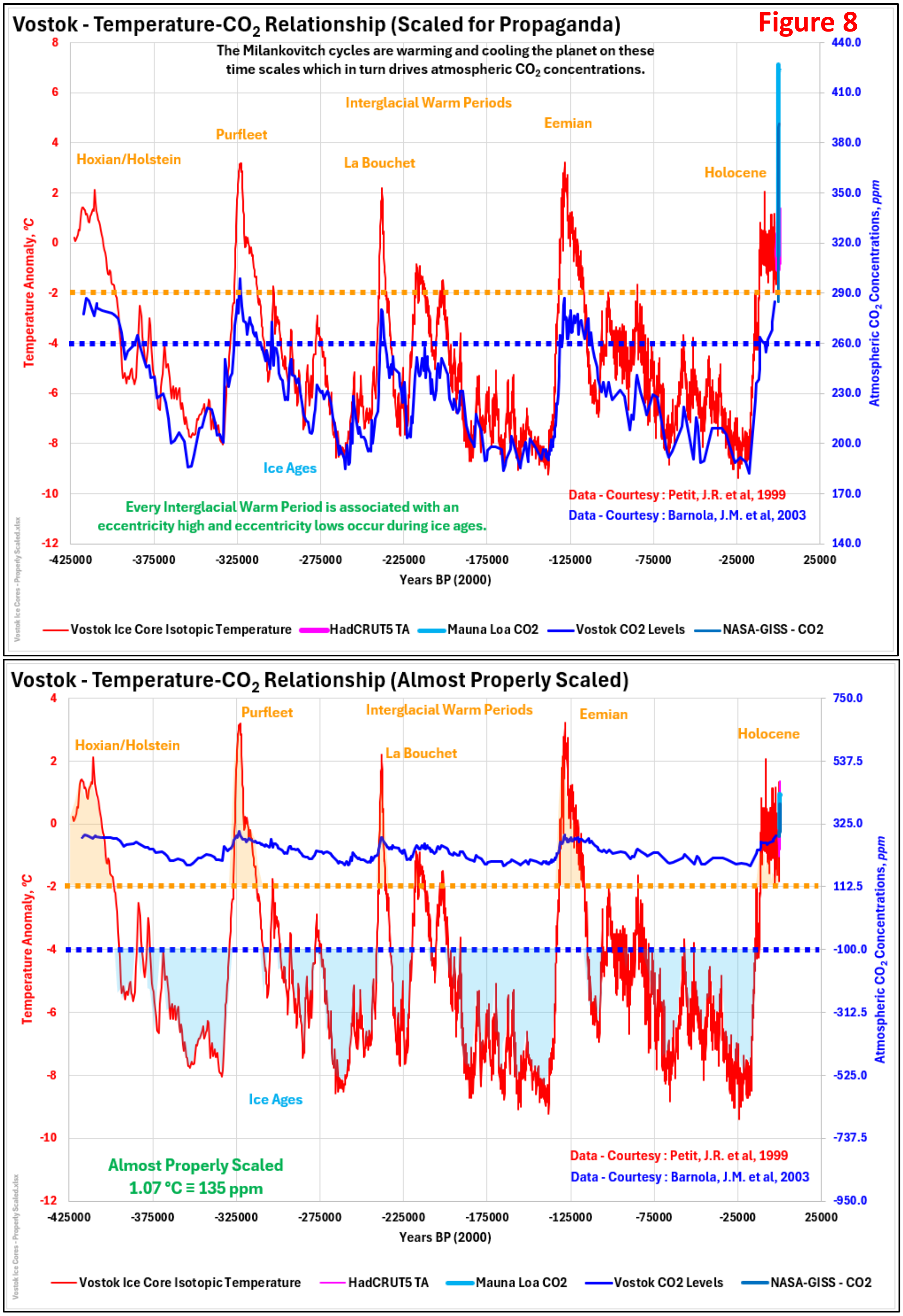
Factoring in solar influences and the UHI effect could easily lead to CCS estimates that are down into the 1.0 °C range or less. Lindzen, Happer and van Wijngaarden use a value of 0.75 °C in their 2024 *"Net Zero Averted Temperature Increase"* paper. That corresponds closely to the intrinsic value imbedded in the University of Chicago's MODTRAN model (Figure 7, ±0.78 °C) to estimate the radiation emanating out to space. The model has been closely calibrated to the satellite measurements. There is a lot of information that points to CCS estimates that are in the 0.8 °C range. So, how would that affect the CO_2 contribution levels in Figure 1? The answer to that question lies in the adjusted table below.

Table 3 Period	**CO_2 Climate Sensitivity**	Low Temp *°C*	High Temp *°C*	Temp Change *°C*	Low CO_2 *ppm*	High CO_2 *ppm*	CO_2 Change *ppm*	Temp Due to CO_2 *°C*	CO_2 Share of Temp Rise
Era 1	1.94	0.00	1.00	1.00	280	400	120	0.40	40%
Era 2	7.06	-4.50	0.00	4.50	180	280	100	0.50	11%
Era 3	8.94	-4.50	1.20	5.70	180	280	100	0.50	9%
Era 4	12.53	-1.50	3.70	5.20	270	360	90	0.33	6%
Era 5	5.40	3.70	14.50	10.80	300	1200	900	1.57	15%
Era 6	9.74	-2.00	16.00	18.00	500	1800	1300	1.45	8%

Despite the many changes in temperature and CO_2 over the 500 million years shown in Figure 1, CO_2 has only played a minor role in those historical temperature changes. Assuming the high-end CCS estimate (1.94 °C) is correct, CO_2's contribution to the historical temperature changes (Era 2 to 6) is somewhere between 15 and 36% (shown earlier in Table 1). The 36% contribution level covers most of the Cenozoic (12% of the 500-million-year history shown). The pre-Cenozoic period of the Phanerozoic covers about 86.8% of the data with a 20% CO_2 contribution level. Even at the highly inflated 1.94 °C level, CO_2 is still a minor player in the historical climate records.

If the more realistic 0.8 °C sensitivity is used, the CO_2 contribution level drops down to 40% (roughly 0.40 °C of the ±1.0 °C increase since the pre-industrial era). The CO_2 contribution levels (Era 2 to 6) are now in the 6% to 15% range. The pre-Cenozoic period (the bulk of historical data) now has an 8% CO_2 contribution level.

There are certainly examples where CO_2 and Global temperatures (all of which are estimates) do correlate. And realistically, there should be. When the oceans warm, CO_2 is released to the atmosphere, increasing the atmospheric CO_2 concentration. In the Vostok, Antarctica ice core data, shown below (Figure 8), those



CO_2 increases follow the temperature increase centuries later. The opposite is true when the oceans cool. CO_2 concentrations go down, but with a longer delay. The Milankovitch Cycles (Precession, Obliquity, and Eccentricity) are driving the global temperatures which in turn drive the CO_2 concentrations. The Milankovitch Cycles drive our planet into and out of deep ice ages as shown in Figure 9 (on the previous page). Unfortunately for humanity, the interglacial warm periods are much shorter than the deep ice ages. We thankfully are living in the tail end of one of those warm periods. Figures 8 and 9 reflect the detail from Era 3 on Figure 1. Note, Figure 1 is somewhat useless for determining causation. The resolution does not allow the viewer to see which parameter (CO_2 or temperature) is acting as the driver.

Note, Figures 8 and 9 present the same data. Figure 8 is scaled for propaganda (you must make that CO_2 rise look scary); Figure 9 is scaled to represent the alarmist position that the 1.07 °C warming (based on the IPCC's 2021 AR6 report) since the pre-industrial era is due to the ±135 ppm atmospheric CO_2 concentration increase. Figure 9 is labeled as "Almost Properly Scaled" because not all the 1.07 °C warming is due to CO_2. You might also note that the 1.07 °C warming is within the natural temperature variation limits of the Holocene. The planet started warming out of the depths of the Little Ice Age (the Maunder Minimum, in the late 1600s) centuries before CO_2 concentrations started rising in the late 1800s. Also, roughly half of the 1.07 °C temperature rise since 1850 happened prior to 1950 (with minimal human influence, since 86%+ of our emissions have occurred since 1950). A properly scaled chart would incorporate the CO_2 Climate Sensitivity (CCS), compressing the CO_2 curve further (i.e.: not much impact).

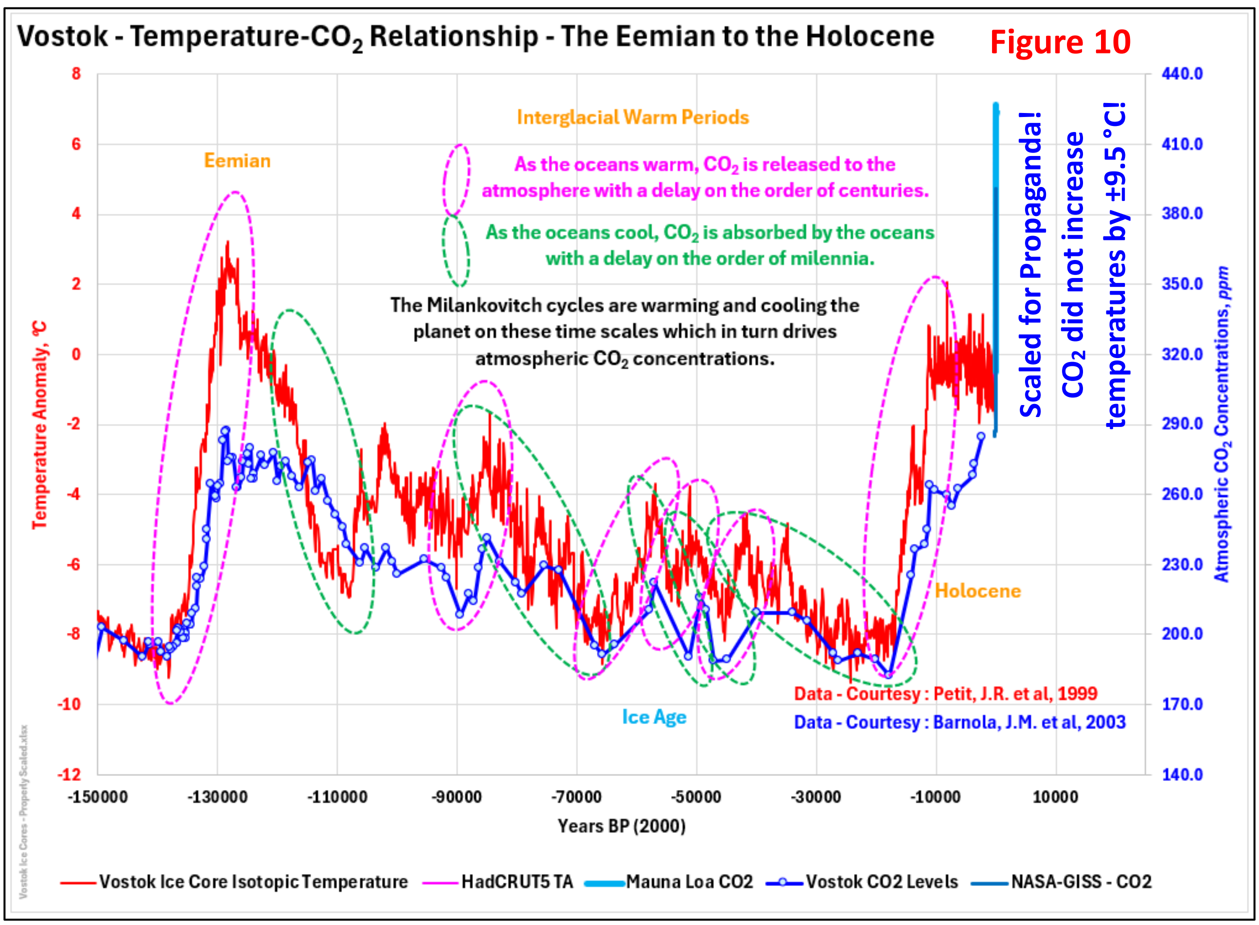
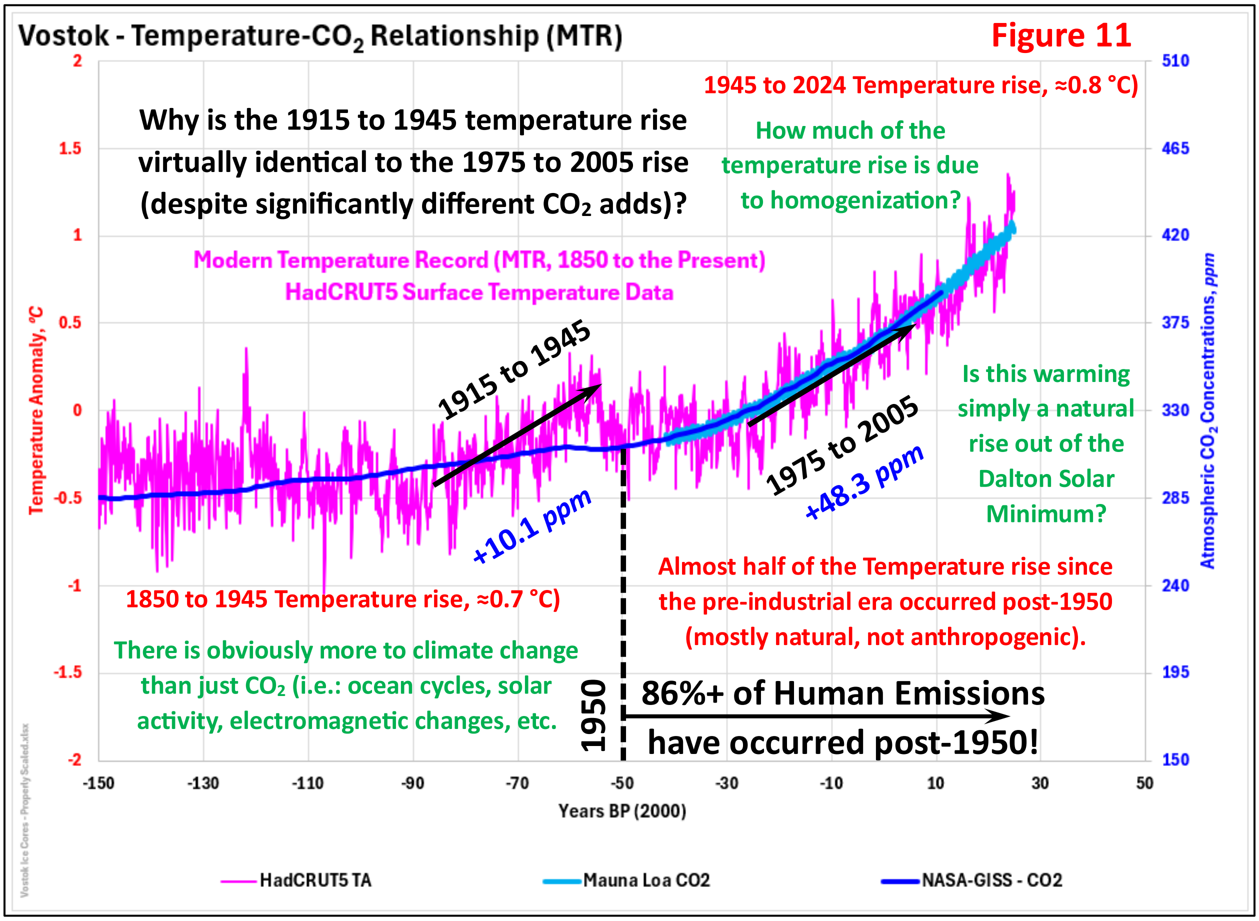


Figure 10 above, shortens the time frame and shows more clearly that the temperature moves first (whether rising or falling), followed by CO_2. As mentioned earlier, the CO2 rises centuries after the temperature rises and drops millennia after the temperature drops. With an appropriate CCS (0.8 °C), the CO_2 rise would be roughly equivalent to 0.4 °C (as shown in Table 3, Era 1) on the temperature scale (to the left) instead of the roughly 9.5 °C shown on this propagandized version.

Figure 11 focuses in on the Modern Temperature Record (MTR, 1850 to the present). These data are also plotted on Figures 8, 9, and 10, just not readily visible. The time frame is just too short to provide the



proper resolution for easy visibility. Temperature and CO_2 have been scaled to represent the alarmist position (1.07 °C ≡ 135 ppm (i.e.: Almost Properly Scaled)). Properly scaled would be proportionately closer to ±0.4 °C ≡ 135 ppm but that unfortunately, for the alarmist *"All CO_2, All the Time"* narrative, does not correlate very well. CO_2 concentrations are characterized by a generally smooth but accelerating growth. The temperature profile is characterized by rapid short-term fluctuations that overlay a longer term warming and cooling cycle (roughly 60 years, corresponding to the Atlantic Multi-decadal Oscillation (AMO)). There is obviously more to 'climate change' than just CO_2, as touched on in Figure 11 and discussed earlier (i.e.: the MTR can be modeled more accurately with natural forcings alone (i.e.; solar/ocean cycles) than CO_2 alone). The answer is somewhere in between but likely weighted to the natural contributions that have dominated for billions of years.

CO_2 may be contributing significantly (±40% is my estimate) to the MTR temperature rise, but the magnitude is ultimately dependent on the CCS. I suspect that the CCS is in the 0.8 °C range (for the reasons discussed earlier) but there are other studies/papers available that suggest CO_2's contributions levels are even lower. A couple of recent examples are shown below that make 0.8 °C seem more than reasonable. CO_2's Climate Sensitivity (CCS) is not "settled science". Until CCS is better understood, CO_2 emissions should not be driving our policy decisions.

***"CO_2 Back-Radiation Sensitivity Studies under Laboratory and Field Conditions"*, October 2024**

Hammel, E., Steiner, M., Marvan, C., Marvan, M., Retzlaff, K., Bergholz, W. and Jacquine, A.

"Our measurements align with limitations to an increase of maximum 3W/m^2 back-radiation by doubling the CO_2 content from 400 to 800 ppm. This minor contribution should not exceed a temperature increase of more than 0.5K a value, which is not within the range of significant impact for climatic changes and much lower than annual temperature variations in all regions of the earth".

https://www.scirp.org/pdf/acs2024144_44701276.pdf

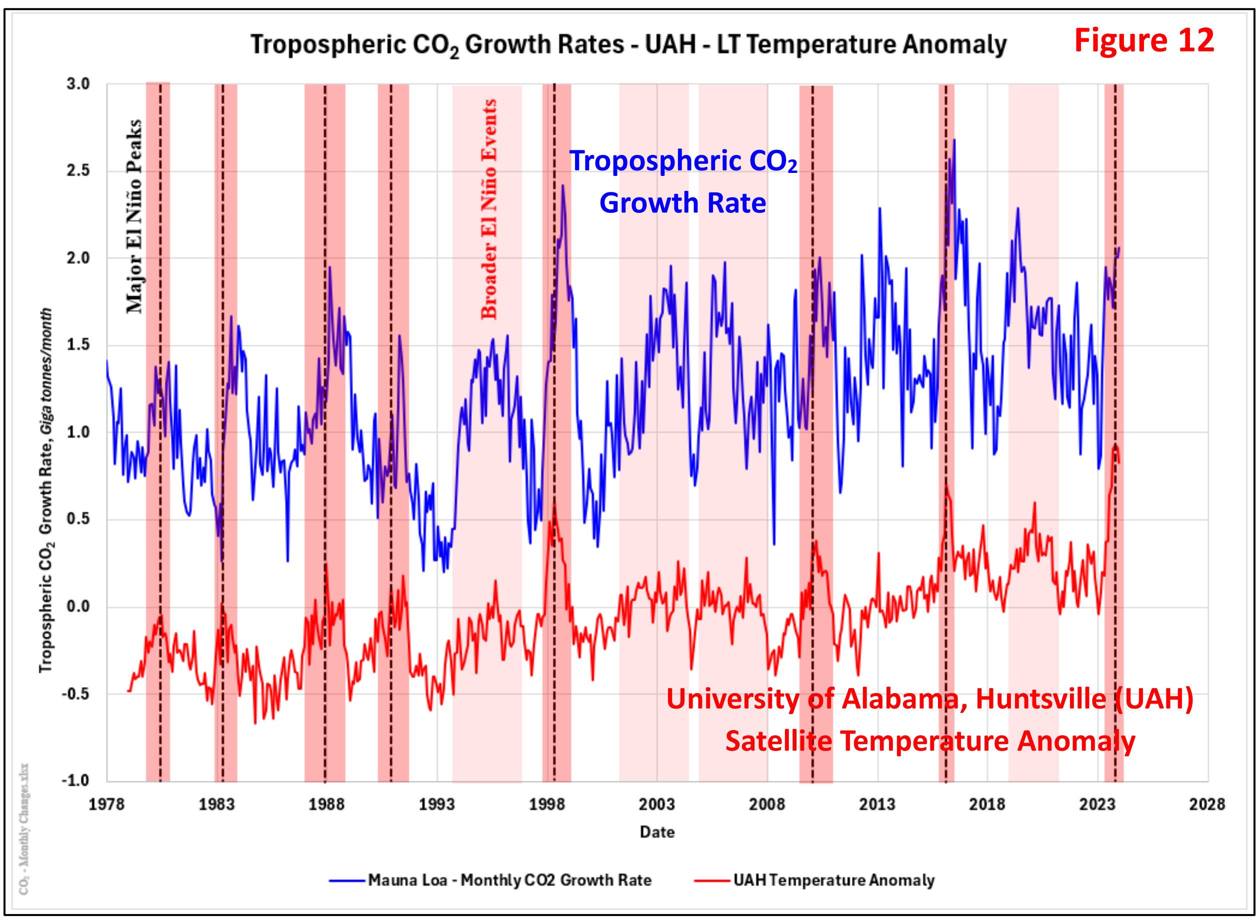
***"Thermal processes affected by carbon dioxide near ground surface"*, December 2024**

Wei, P-S., Chen, W-C., Lee, C., Ting, T-C., Chiu, H-H., Hsieh, Y-C., Tsai, Y-C. and Su, D.

"The temperature at 5 m above the ground increases by approximately 0.3 K and then maintains constant as carbon dioxide concentrations rise from 100 to 350 ppm and from 350 to 400 ppm over a 5-year period".

https://www.sciencedirect.com/science/article/pii/S2590123024015548#abs0001

The influence CO_2 has on temperature is hidden in the natural variability over the MTR. And the influence temperature has on CO_2 is just as elusive in the measured data. However, the temperature influence can



be readily seen when the monthly change in CO_2 is plotted against the satellite temperature data (Figure 12, previous page). The response is delayed by a month or two, but CO_2 is definitely reacting to the temperature changes.

There are many natural forcings on long- and short-time scales that are driving the climate. But Figure 1's 1.94 °C completely ignores the temperature fluctuations over the last several thousand years (pre-1850) that had nothing to do with CO_2, Since CO_2 concentration was virtually flat. Those forcings were still active post-1850 and will continue to be active in the future. Those cycles are pointing to colder temperatures, which are far more dangerous than the mild, beneficial warming that rising CO_2 levels might provide. My [CSS-53 – CO_2's Moneyball Moment] post provides a look at the recent data showing just how ineffective CO_2 really is at warming (or cooling) our planet. *"If CO_2 is such a good climate driver, why doesn't it drive climate good?"*

Atmospheric CO_2 concentration changes do affect global temperature. But they are generally not driving the climate. As a general rule, CO_2 has been declining over the last 500 million years due to natural sequestration mechanisms like carbonate rock and coal deposition. Those overall declines are occasionally interrupted by periods of major volcanic activity (the breakup of Pangea, the Deccan Traps, etc. highlighted in the Cenozoic and Phanerozoic discussion laid out earlier in CSS-10 and CSS-12) that took CO_2 levels from the suppressed 200 to 400 ppm range present during the Carboniferous/Permian deep ice age up to the 1,200 to 2,000+ ppm levels of the Triassic and Jurassic periods. Without that infusion of CO_2, the planet may never have recovered from the low CO_2 levels of the Carboniferous/Permian deep ice age. A similar process is playing out right now (but on a much smaller scale). We have contributed significantly to the increased CO_2 levels since 1950, but we will never match the output levels of those historical volcanic events. We are still at CO_2 concentration levels that are typical through ice age periods (425 ppm), but we have provided the planet with a few more million years of life. Not surprising since we are living through the Pleistocene ice age. While volcanic activity can certainly add CO_2 to the atmosphere, they also add aerosols and/or water. CO_2 warms, aerosols cool, and water vapor can warm (it is the major greenhouse gas) or cool (based on increased cloud cover). The recent Hunga-Tonga eruption is very likely to have contributed significantly to the anonymously high 2023/2024 temperatures by introducing large volumes of water up into the stratosphere (a ±10% increase). CO_2 had NO detectable role in the temperature anomaly increase from -0.4 °C in January 2023 to +0.94 °C in April 2024 (based on the UAH satellite data). The temperature has dropped down to +0.64 °C in November 2024 and is returning to the longer-term trends/cycles. No parameter can be looked at in isolation and certainly not CO_2.

The temperature changes of the Cenozoic are driven by plate tectonics which have altered the ocean cycles taking the planet from the ice-free conditions of the Eocene Climate Optimum to the depths of the Pleistocene ice age we are currently living through. Our current residence in the Sagittarius-Carina arm of the Milky Way has also played a role in driving us into that deep ice age. On shorter time scales, the Milankovitch cycles (easily visible in the ice core data) have driven us in and out of the mostly deep ice ages and interglacial warm periods of the Pleistocene ice age. Those cycles go back further and can be seen in the isotope ratio data pulled from the fossilized benthic foraminifera buried in ocean sediments. However, the resolution does deteriorate the further you go back in time. Temperatures still fluctuate on shorter time scales independently of CO_2 concentrations. The Holocene temperatures fluctuate significantly despite a virtually flat CO_2 concentration. Those fluctuations will continue regardless of what CO_2 levels have been doing recently. And yes, the rising CO_2 levels have contributed to the temperature rise since 1850, but probably only 40% at the high end. Differentiating between natural and anthropogenic influences is extremely difficult and as mentioned before is not settled science. Additional CO_2 increases will push the temperature higher but not by much. CO_2's influence is largely irrelevant and will be overpowered by the other natural forcings as they continue through their natural cycles, most of which are transitioning into cooling. We should be preparing to adapt to 'climate change' whether it warms or cools, not focusing on warming. Humanity thrives with warmer temperatures and dies at ±10 times the rate with colder temperatures.