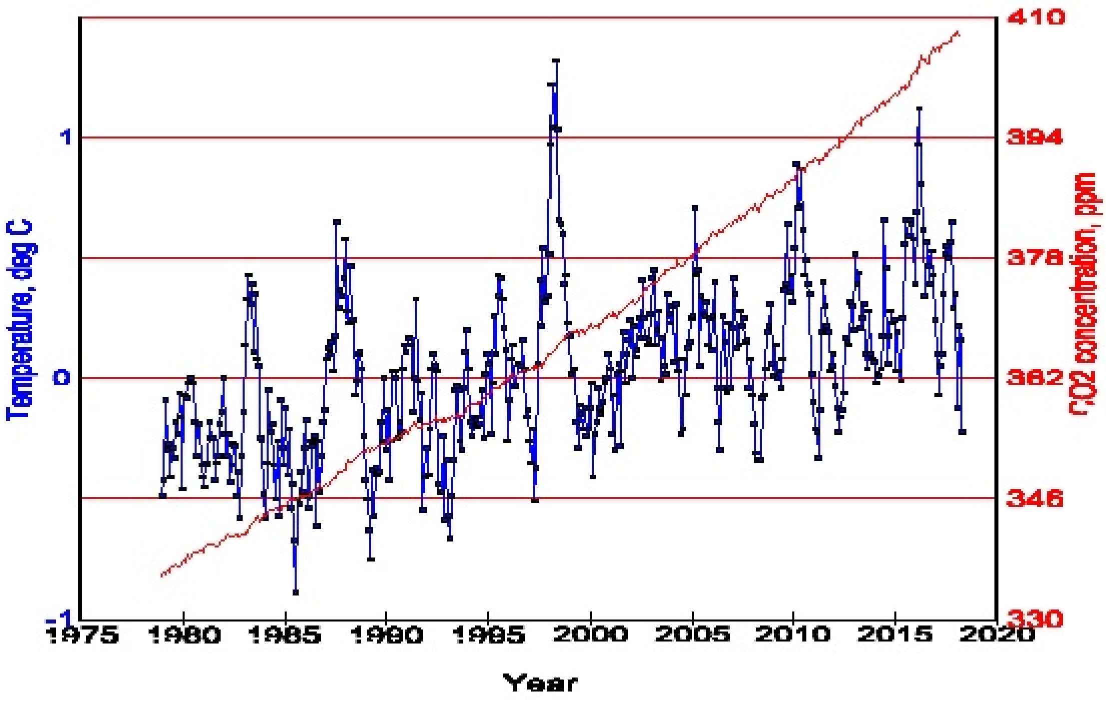
Temperature and CO_2 concentration

Here is 39 years of empirical data, showing a distinct lack of a relationship between the satellite temperature and the atmospheric CO_2 concentration at the Mauna Loa Observatory, Lat.19.5 deg N, Long 155 deg W, elevation 3397m.

Figure 1. Mauna Loa Observatory



Source: [1] http://www.nsstc.uah.edu/data/msu/v6.0/tlt/uahncdc_lt_6.0.txt
[2] http://scrippsco2.ucsd.edu/data/atmospheric_co2/primary_mlo_co2_record

Figure 1 shows the monthly satellite lower troposphere temperature for the Tropics-Land component[1] in blue and the monthly CO_2 concentration[2] in red after removal of the seasonal variation so as to match the residual temperature series. The clear and obvious difference between the two raises the possibility that there may be no common causal factor whereby the CO_2 concentration drives the temperature as claimed by the IPCC.

Calculation of the Ordinary Linear Regression between the two time series gave a correlation coefficient of 0.539 from the 469 monthly data pairs. This is a measure of the relationship between the background linear trend of each of the time series as shown by an almost identical correlation of 0.538 between the temperature and the time. The correlation between the CO_2 concentration and the time was 0.996, that is, the CO_2 concentration time series was practically a linear trend with respect to time. Any pair of linear trends, no matter what their source, will have a high correlation coefficient of about 1.0 which is necessarily of no causal significance as a background linear trend with respect to time can be calculated for any time series.

Detrending of the pair of time series in order to assign a statistical significance to the correlation coefficient gave a value of 0.047 with 467 degrees of freedom. However, the

Durbin-Watson test of the time series gave a value of 0.42 which indicates positive autocorrelation. The autocorrelation was estimated to be 0.79. This mandated the application of a First Order Autoregressive Model to the two time series whereby the transformed series gave a correlation coefficient of 0.036 with 466 degrees of freedom and a t statistic of 0.77 implying a probability of 44% that the correlation coefficient is equal to zero from the two-sided t-test.

The result was supported by data from Macquarie Island in the Southern Ocean at Latitude 54.48 deg South, Longitude 158.97 deg East, altitude 12 m. The Island is in the Southern Extension zone of the lower troposphere satellite temperature data, latitudes 90 South to 20 South. Analysis of the temperature data for the complete zone and its Land and Ocean components with respect to the CO_2 concentration[3] showed that there was positive autoregression in each case requiring a First Order Autoregressive Model to be applied. The result for the whole zone was a correlation coefficient of -0.009, 308 deg. of free., t statistic -0.15, probability of zero correlation 88%. For the Land component, the correlation coefficient was -0.001, 308 deg. of free., t statistic -0.02, probability of zero correlation 98%. For the Ocean component, the correlation coefficient was -0.014, 308 deg. of free., t statistic -0.25, probability of zero correlation 81%.

Additional support is seen in a statistical analysis of the monthly CO_2 concentration with respect to the satellite lower troposphere temperature for Mt Waliguan, Tibetan Plateau, China, Lat. 36.28 deg.N, Long. 100.9 deg E, altitude 3810 m. Applying a First Order Autoregressive Model to the CO2 concentration [4] for Mount Waliguan as the independent variable verses the Northern Extension zone satellite temperature, latitude 20N to 90N, gave results for the whole zone correlation coefficient of -0.13, 302 deg. of free., t statistic -2.30, probability of zero correlation 2.2%. For the Land component, the correlation coefficient was -0.12, 302 deg. of free., t statistic -2.18, probability of zero correlation 3%. For the Ocean component, the correlation coefficient was -0.13, 302 deg. of free, t statistic -2.32, probability of zero correlation 2.1%.

Further, applying a First Order Autoregressive Model to the CO_2 concentration for Point Barrow, Alaska, as the independent variable verses the North Pole zone satellite temperature, latitude 60N to 90N, gave results for the whole of zone correlation coefficient of 0.06, 462 deg. of free., t statistic 1.23, probability of zero correlation 22.1%. For the Land component, the correlation coefficient was 0.08, 462 deg. of free., t statistic 1.66, probability of zero correlation 10%. For the Ocean component, the correlation coefficient was 0.02, 462 deg. of free., t statistic 0.50, probability of zero correlation 62%.

Further, applying a First Order Autoregressive Model to the CO_2 concentration for the South Pole Station, as the independent variable verses the South Pole zone satellite temperature, latitude 60S to 90S, gave results for the whole of zone correlation coefficient of 0.007, 454 deg. of free., t statistic 0.15, probability of zero correlation 88%. For the Land component, the correlation coefficient was 0.027, 454 deg. of free., t statistic 0.58, probability of zero correlation 56%. For the Ocean component, the correlation coefficient was -0.019, 454 deg. of free., t statistic -0.41, probability of zero correlation 68%.

The same analysis applied to the CO_2 concentration for Cape Grim, Tasmania, as the independent variable verses the Southern Extension zone satellite temperature, latitude 20S to 90S, gave a correlation coefficient of 0.018, 462 deg. of free., t statistic 0.39, probability of zero correlation 70% for the whole of the zone . For the Land component, the correlation coefficient was 0.013, 462 deg. of free., t statistic 0.27, probability of zero correlation 78%. For the Ocean component, the correlation coefficient was 0.015, 462 deg. of free., t statistic 0.33, probability of zero correlation 74%.

A negative correlation implies that an increase in CO_2 concentration caused a decrease in temperature, the complete opposite of the IPCC thesis. However as the probabilities of a positive correlation coefficient were not statistically significant, the IPCC proposition that increased CO_2 caused increased temperature could not be supported and the conclusion must be that the null hypothesis applies, namely that the correlation coefficients were zero.

The above conclusion is totally at odds with the statements from the United Nations climate body, the Intergovernmental Panel on Climate Change. The Policymakers Summary from Climate Change, The IPCC Scientific Assessment, 1990, being the, then, final Report of Working Group 1 of the IPCC, opened with the statement, page XI:

"EXECUTIVE SUMMARY
We are certain of the following:

• there is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be

• emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it." – end quote.

After decades of research into the relationship between the atmospheric CO_2 concentration and temperature, the latest, Fifth Assessment Report, 2015, of the IPCC, the Synthesis Report, Summary for Policymakers, page 8, made the claim:

"SPM 2.1 Key drivers of future climate

Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. ...." – end quote.

Temperature and Rate of Change of CO_2 concentration

Here is 39 years of empirical data clearly showing a relationship between the satellite temperature and the rate of change of atmospheric CO_2 concentration at the Mauna Loa Observatory, Lat.19.5 deg N, Long 155 deg W, elevation 3397m.

Figure 2. Mauna Loa Observatory

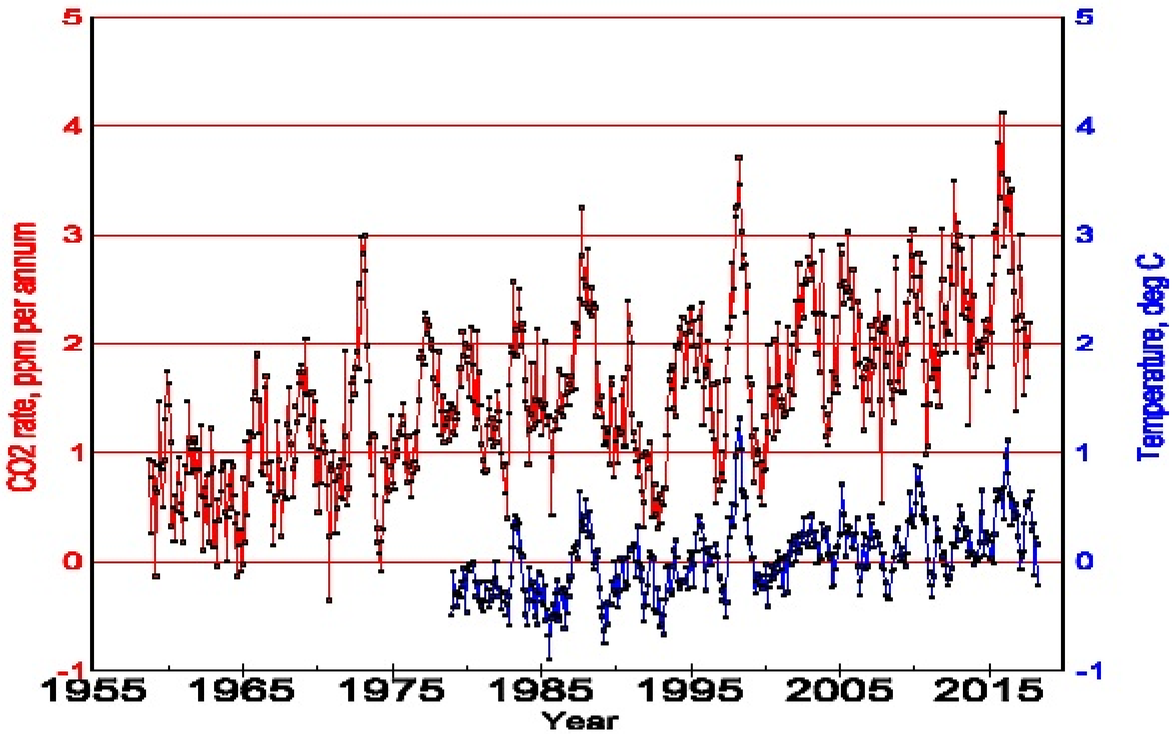


Figure 2 shows the monthly lower troposphere satellite temperature for the Tropics-Land component in blue and the annual change in CO_2 concentration in red. The obvious correlation between the two raises the possibility that there may be some common causal factor whereby the temperature drives the rate of change of CO_2 concentration. It is not possible for the rate of change of CO_2 to cause the temperature level as a time rate of change does not define a base. For example a rate of 2 ppm per annum could be from 0 to 2 ppm in 12 months, 456 to 458 ppm in 12 months or any other pair of numbers that differ by 2.

Note that the satellite temperature data is supplied as a residual after removal of the estimated seasonal variation. This makes it comparable to the annual rate of change of CO_2 concentration as taking the annual rate eliminates the seasonal variation.

Calculation of the Ordinary Linear Regression between the two time series gave a correlation coefficient of 0.66 from the 463 monthly data pairs. Detrending of the time series in order to determine the statistical significance gave a correlation coefficient of 0.56 with 461 degrees of freedom. However the Durbin-Watson test of the time series gave a value of 0.48 indicating positive autocorrelation which means that Ordinary Linear Regression is inapplicable. The autocorrelation was estimated to be 0.52. When applied to the transformed time series, that is, applying a First Order Autoregressive Model, it resulted in a correlation coefficient of 0.26 with 460 degrees of freedom and a t statistic of 5.76, implying an infinitesimal probability that the coefficient is equal to zero from a two-sided t-test.

Applying a First Order Autoregressive Model to the Tropics-Ocean component of the satellite temperature compared to the annual change in CO_2 concentration gave a correlation coefficient of 0.28 with 460 degrees of freedom and a t statistic of 6.28, again implying an infinitesimal probability that the coefficient is equal to zero from a two-sided t-test.

The coincident maxima in Figure 2 between the temperature and the rate of change in CO_2 concentration mark the occurrence of El Nino events. These are not related to any anthropogenic cause as the event was so-named by Peruvian fisherman at least three centuries ago. Thus El Nino is a natural event driven by a rise and fall in the temperature which contributes to the continual rise in CO_2 concentration seen in Figure 1.

It follows that this synthesis of empirical data conclusively reveals that CO_2 has not caused temperature change over the past 38 years but that the rate of change in CO_2 concentration has been influenced to a statistically significant degree by the temperature level. Note that it is not likely for a rise in CO_2 concentration to cause the temperature to increase and for the temperature level to control the rate of change of CO_2 concentration as this would mean that there was a positive feedback loop causing both CO_2 concentration and temperature to rise continuously and the oceans could have evaporated long ago.

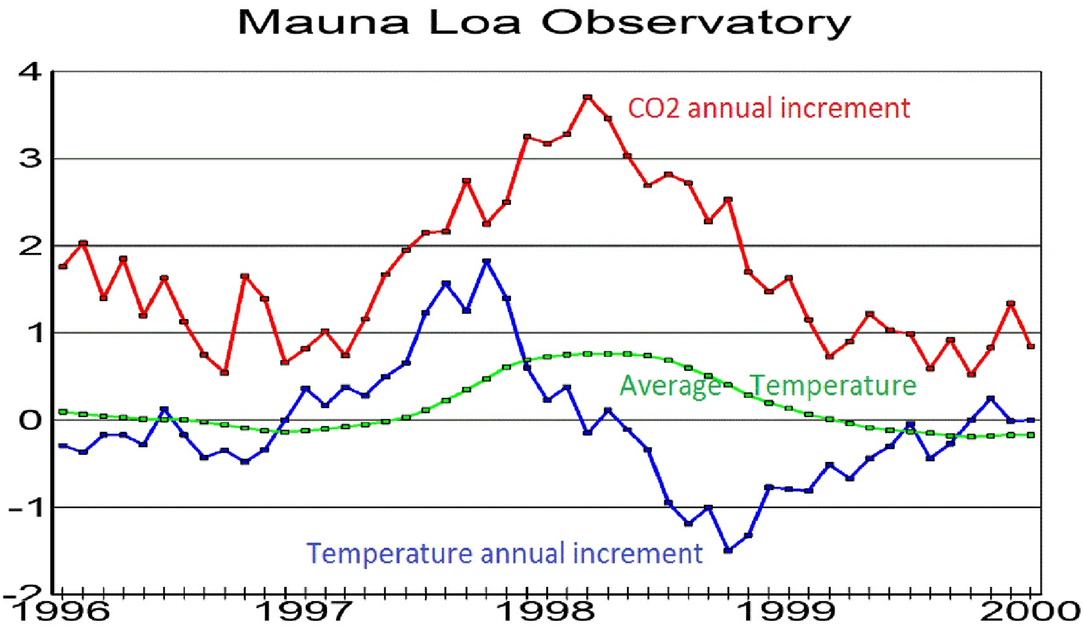
Support for this thesis is seen in a statistical analysis of the annual rate of change of the monthly CO_2 concentration with respect to the 13 month average lower troposphere temperature for Macquarie Island in the Southern Ocean at Latitude 54.48 deg South, Longitude 158.97 deg East, altitude 12 m. Applying a First Order Autoregressive Model to the various components of the satellite temperature, Southern Hemisphere, Tropics, and Southern Extension and their Land and Ocean components gave a maximum correlation coefficient of 0.30, 294 deg. of free., t statistic 5.34, infinitesimal probability of zero correlation for a two month lag of the CO_2 annual rate of change relative to the 13 month average temperature for the Tropics zone, latitude 20S to 20N.

Additional support is seen in a statistical analysis of the annual rate of change of the monthly CO_2 concentration with respect to the annual average satellite lower troposphere temperature for Mt Waliguan, Tibetan Plateau, China, Lat. 36.28 deg.N, Long. 100.9 deg E, altitude 3810 m. Applying a First Order Autoregressive Model gave a maximum correlation among the various satellite temperature zones of 0.14 for 290 deg. of free., t statistic 2.5, probability of zero correlation of 1.3% for a two month lag of the CO_2 annual rate of change relative to the annual average Tropics Land temperature.

The above conclusions are supported by the sequence of events recorded at Mauna Loa Observatory for the major 1997 -‘98 El Nino event displayed in Figure 3.

Chronological Sequence

Figure 3: CO_2 annual increment relative to temperature average and annual increment.



The above graph displays the time relationship between atmospheric CO_2 concentration at the Mauna Loa Observatory, Hawaii, from the Scripps Institute, compared to the satellite lower tropospheric Tropics-Land temperature provide by the University of Alabama, Huntsville, for the major 1997-'98 El Nino event.

The maximum in the annual increment of the temperature, at October 1997, preceded the maximum in the annual increment in the CO_2 concentration, at March 1998, by 5 months revealing that the CO_2 change could not possibly have caused the temperature change. Statistical analysis of the complete data set extending from December 1978, when satellite measurements began, until the present determined that the 5 month delay was the average throughout the 38 year period.

Further, it can be seen that the Average Temperature graph, being a plot of the 12 month running average temperature, corresponds with the overall variation in the CO_2 annual increment. Again this is confirmed by analysis of the complete record which gave a statistically significant correlation between the two. It is not possible for a CO_2 time rate of change to set the level of the average temperature but it is possible for the average temperature to cause the rate of change in the CO_2 concentration in the same way that the temperature setting of a stove element determines the rate of evaporation of a pot of water. This supports the contention that the CO_2 change has not caused the temperature change.

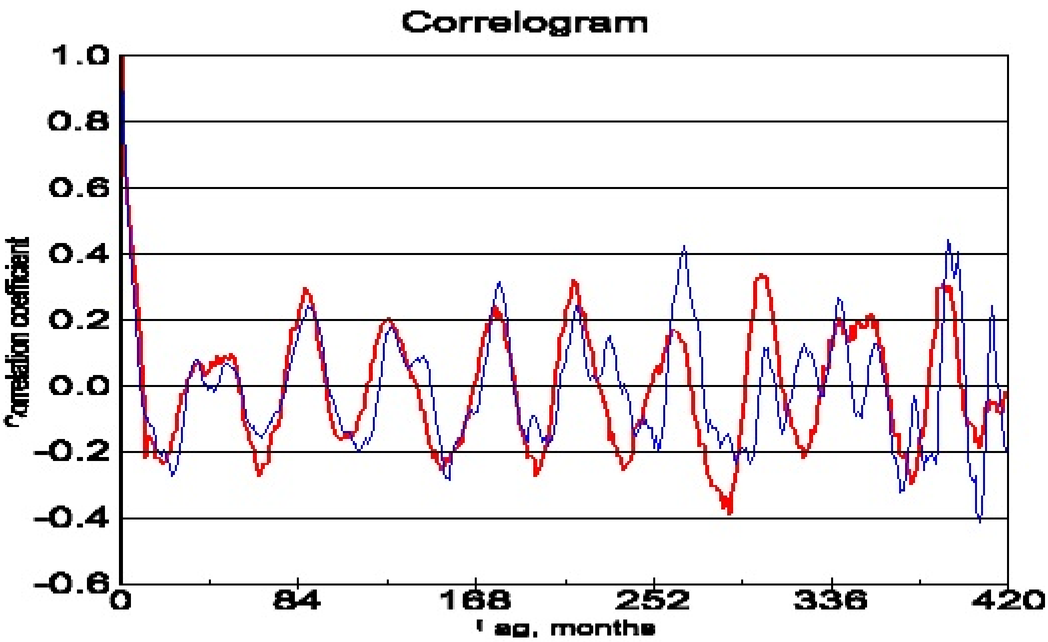
If the temperature level determines the rate of change of the CO_2 concentration then the first derivative of the temperature series, here the annual increment, would correspond with the second derivative of the CO_2 concentration, that is, the rate of change of the rate of change in the CO_2 concentration. Calculation of the second derivative of the CO_2 concentration using annual increments from the original time series gave a series that had a statistically significant correlation with the annual increment temperature series. This confirms that the temperature level determines the rate of change for the CO_2 concentration and rules out the possibility that CO_2 change causes temperature change.

The conclusion that the temperature controls the rate of change of CO_2 concentration explains the well known fact that CO_2 change lags temperature change over a large time range. Ice core data has revealed that the cycle of ice ages and inter-glacial warm periods show CO_2 change lagging temperature change by several centuries to more than a millennium while modern CO_2 and temperature data shows lags of 9 to 12 months, Humlum et el., 2013 [5]. Cross correlation of annual changes in each of CO_2 concentration at Mauna Loa and satellite lower tropospheric Tropics - Land temperature showed that CO_2 change lagged temperature change by 5 months. If temperature controls the rate of change of CO_2 concentration, local maxima in the CO_2 rate must correspond to temperature maxima which, mathematically, must occur after the maxima in the rate of change of temperature. Likewise the CO_2 concentration maxima must post-date the maxima in the CO_2 rate and thus post-date the corresponding temperature maxima. Put simply, CO_2 does not cause global warming.

Periodic cycles

Additional analysis of the Mauna Loa data gave the following autocorrelation function, Figure 3, for both the annual rate of change of the CO_2 concentration (red line) and the satellite lower troposphere Tropics Land monthly temperature (blue line). The CO_2 data covered the period March 1958 to October 2017 while the satellite Tropics temperature data was from December 1978 to October 2017. Considering the different lengths of the time series, the variables show a striking match in their periodic response. The fact that neither autocorrelation function decreases with increasing lag shows that neither time series is stationary in the statistical sense and dictates that the First Order Autocorrelation Model be applied as was done in calculating the above results.

Figure 3: Autocorrelation functions for Mauna Loa rate of change of CO_2 concentration and Tropics Land satellite temperature.



These are basically identical upon taking into account that the temperature series was 459 months long while the CO_2 rate of change was 696 months long, resulting in better definition of the periodicity. The maxima at about 135 and 270 months is the response of both series to the 11 year solar cycle due to the orbital period of Jupiter. Another prominent periodicity is apparent with maxima at about 90 and 180 months while a lesser maximum at about 45 months coincides with the El Nino Southern Oscillation period. This result suggests that perturbations in the Sun's irradiance, under the influence of the gravity effect of the planetary orbits largely control the temperature variation of the Earth which, in turn, controls the rate of change of the CO_2 concentration in the atmosphere.

The matching response can also be seen in the Fourier Transform amplitude spectrum for each, as shown below:

Figure 4: Fourier Transform Amplitude spectrum – Satellite Lower Troposphere Tropics – Land

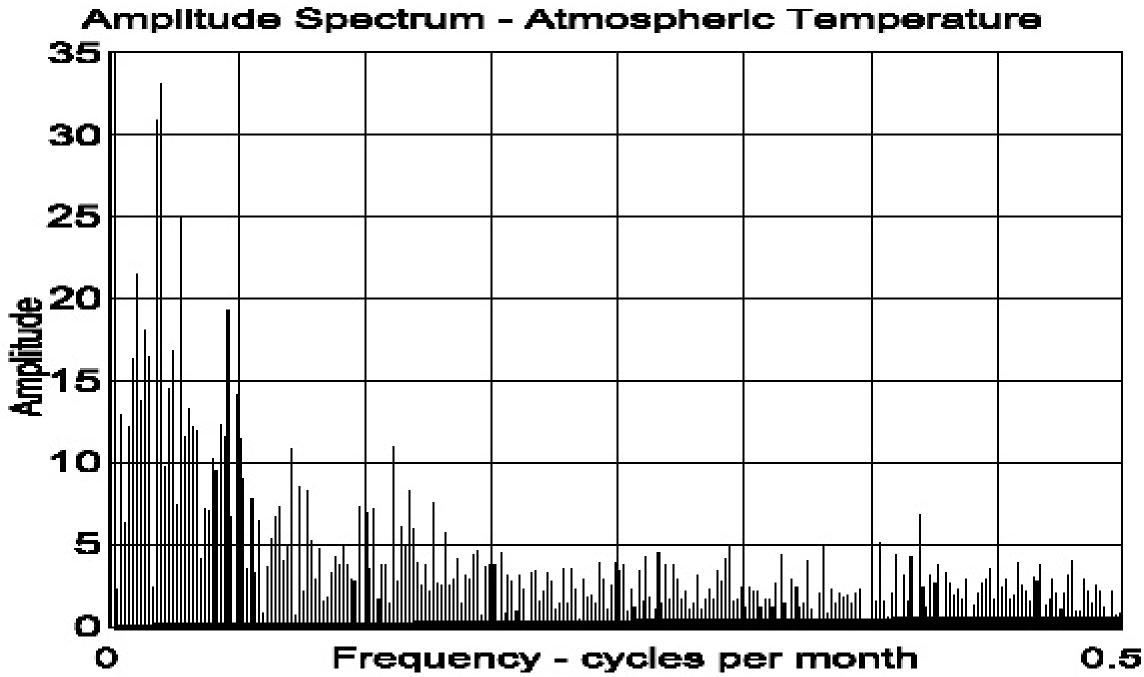
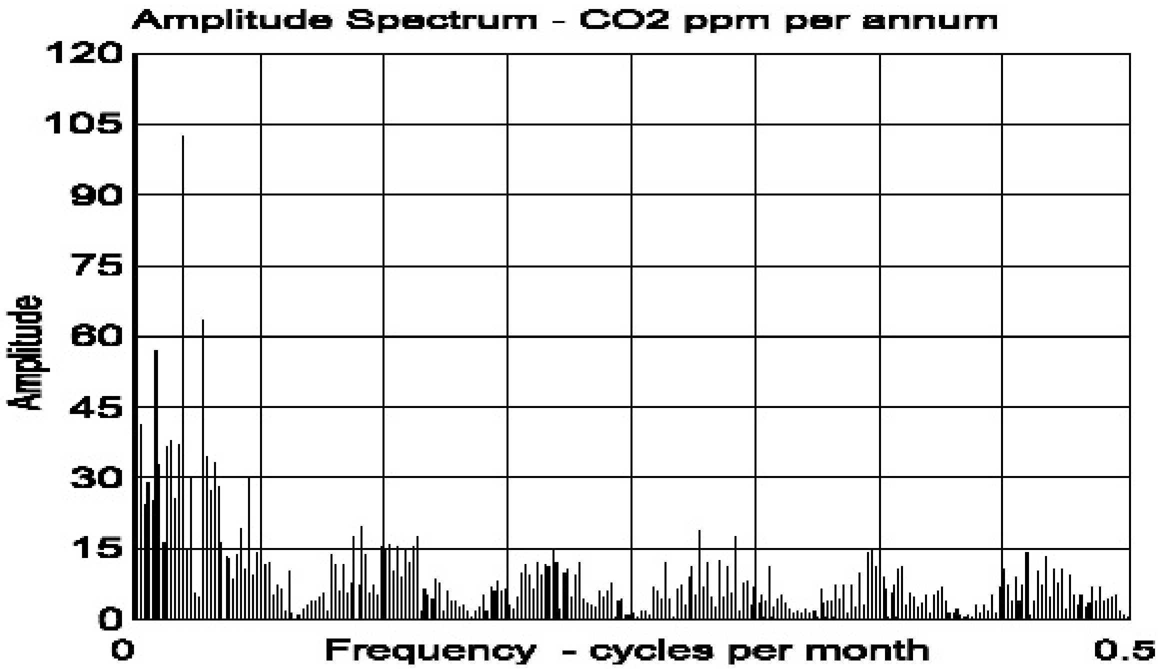


Figure 5: Fourier Transform Amplitude Spectrum – Mauna Loa CO2 annual rate of change



There is a prominent maximum in both spectra at a frequency of 0.0234 cycles per month, that is, a wavelength of 42.7 months which corresponds to the 43.2 month average interval between the maxima in the correlogram, allowing for the coarse one month sample interval for each of the time series.

Remarkably, the 42 month period was known by the Babylonians and Israelites 2500 years ago, being mentioned in the Book of Daniel in the Old Testament and the Book of Revelation in the New Testament of the Bible. It is the synodic period for the Sun, Earth, Moon combination whereby the three form the same configuration every 42 months. This is not to be confused with the Earth - Moon synodic period of 29.5 days which applies to the conjunction of the Earth and the Moon with respect to the Sun. Furthermore the 42 month period is similar to the El Nino cycle and may be the source of the heat that drives this event.

This is in agreement with the paper from Geli Wang et al [6] who used wavelet analysis to detect a 3.36 year cycle in the Central England Temperature dataset, which they attributed to the El Nino Southern Oscillation.

The maximum with the second greatest amplitude on both the temperature and the CO_2 rate of change is at a frequency of 0.033 cycles per month, that is, a period of 30.12 months.

The third greatest amplitude on the temperature response is at a frequency of 0.012 cycles per month, that is, a period of 85.3 months, while for the CO_2 rate of change it is at a frequency of 0.0097 cycles per month, that is, a period of 102.4 months. It may represent the synodic period of Mercury and Venus being the near coincidence of 20 cycles of Mercury and 5 cycles of Venus which has a period of 95 months.

The fourth greatest amplitude on the temperature response is at a frequency of 0.057

cycles per month, that is, a period of 17.7 months. There is a coincident local maximum on the CO_2 rate of change. This may be due to the 19.2 month synodic period of Venus.

Accurate predictions as to the period and source of the local maxima in the amplitude spectra are not feasible due to the course sample interval of one month, the short time series of only 467 months and the use of uneven monthly sample intervals which were 28, 29, 30 or 31 days in length.

This has been partly resolved by using the weekly Mauna Loa atmospheric CO_2 concentration time series as proxy for the atmospheric temperature. Unfortunately this was not ideal either as there were breaks in the time series that have had to be filled by interpolated values. The 3062 data points were padded with values of zero at each end to give the Fourier amplitudes for 4096 data points. Once again the greatest maximum was at a wavelength of 42.82 months and is considered to be the heat source for the El Nino event. Other local amplitude maxima were at wavelengths of:-

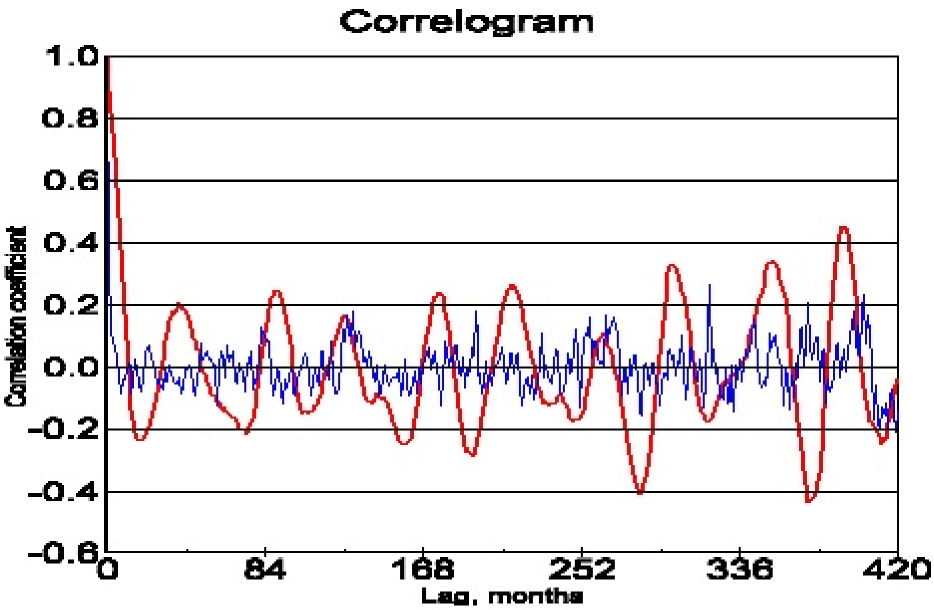
29.56 days attributed to the Moon's synodic period of 29.53 days,
27.18 days attributed to the Moon's draconic period of 27.32 days,
573.44 days attributed to the synodic period for Venus of 583.94 days,
225.76 days attributed to the sidereal period for Venus of 224.7 days,
367.59 days attributed to the sidereal period for Earth of 365.256 days,
796.44 days attributed to the synodic period for Mars of 778 days,
699 days attributed to the sidereal period for Mars of 687 days,
404 days attributed to the synodic period for Jupiter of 399 days.

These may also relate to the periodicities resulting from the Short-term orbital forcing described in Cionco and Soon[8]

It is notable that both the synodic and draconic periods of the Moon are apparent in the weekly series. An explanation for the synodic period is that each New Moon reduces the incoming Sun's radiation to the Earth and its atmosphere as it passes between the Sun and the Earth.

Evidence that the 42 month cycle causes the El Nino event is seen in the responses over the South Pole as shown below. Once again the time series are of different lengths with the annual rate of change of the CO_2 concentration (red line) covering the period June 1957 to December 2016 and the satellite lower troposphere South Pole Land monthly temperature (blue line) covering the period December 1978 to October 2017.

Figure 6: Autocorrelation functions for South Pole rate of change of CO_2 concentration and South Pole Land satellite temperature.



There is an obvious difference between the time series. The periodic nature of the annual rate of change of the CO_2 concentration repeats the wavelength of that from Mauna Loa while it is barely discernable for the South Pole satellite lower troposphere temperature series. The power spectra confirm the difference as seen here:

Figure 7: Fourier Transform Amplitude spectrum – Satellite Lower Troposphere South Pole Land

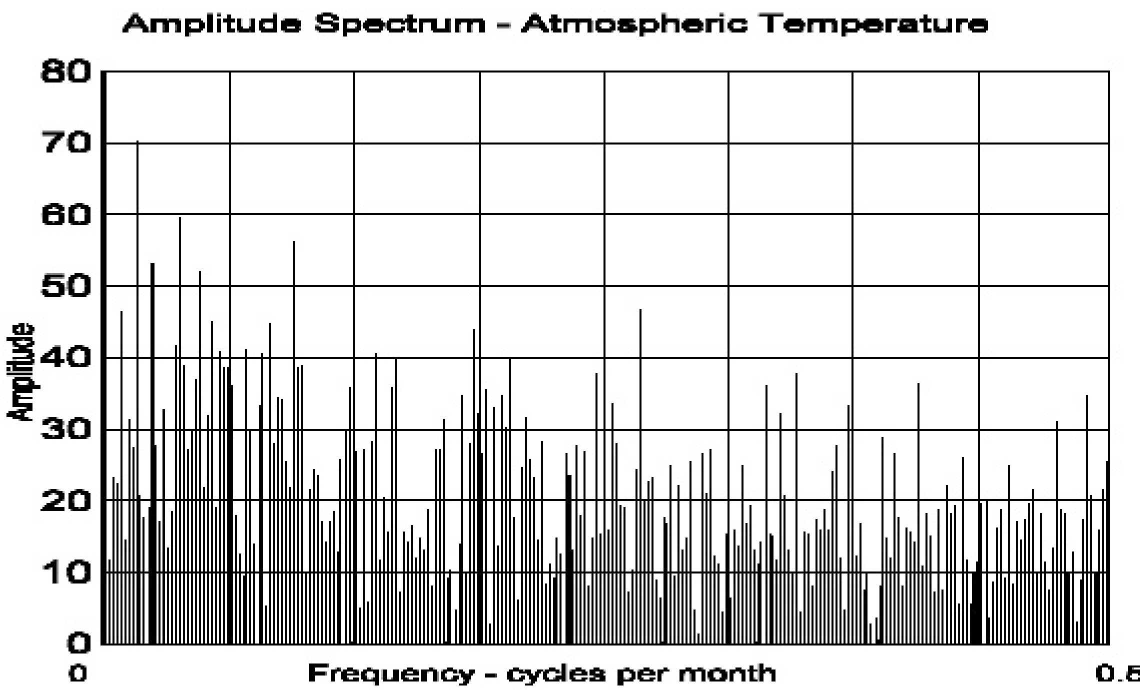
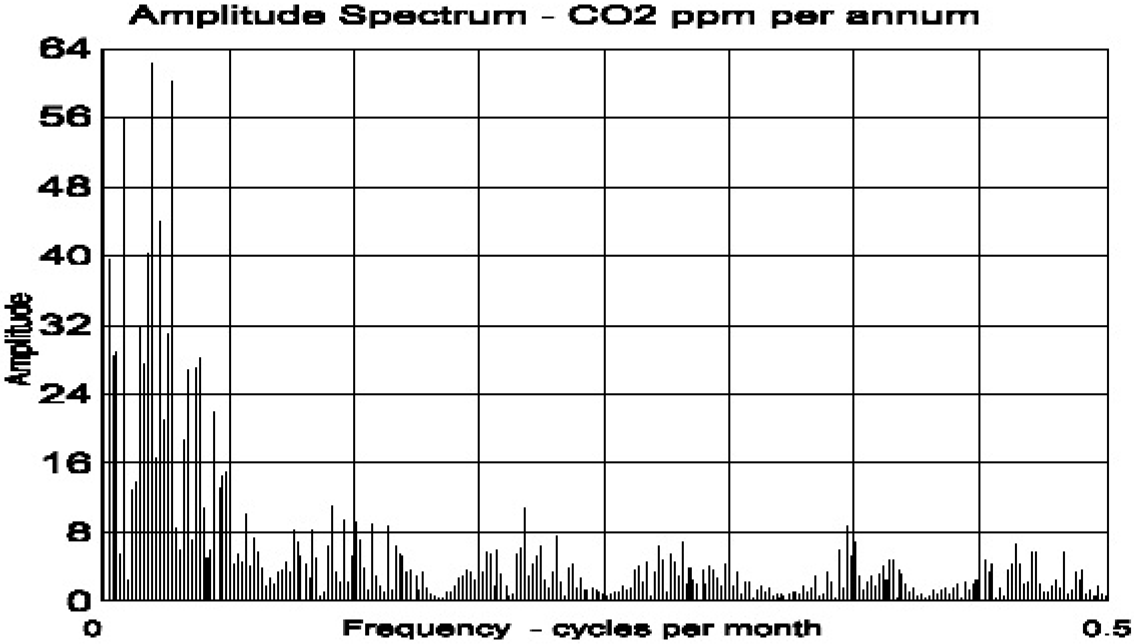


Figure 8: Fourier Transform Amplitude Spectrum –South Pole CO_2 annual rate of change



The peak in the amplitude spectrum for the annual rate of change of CO_2 concentration remains at the wavelength of 42.7 months. However the power spectra for the satellite lower troposphere temperature has the 42.7 month peak in fourth spot with greater amplitude peaks occurring at wavelengths (in decreasing amplitude) of 64 months (which may be the synodic period for the Moon and Mercury and/or Jupiter), 26.9 months (which may be the synodic period for Mars and/or Jupiter) and 10.7 months (which represents 11 synodic cycles of the Moon). The reduction in the 42.7 month peak is reasonable considering the fact that the Sun's rays are practically tangential to the polar surface or do not impinge on part of that surface for months at a time and the Moon's orbit is inclined at 5° to the elliptic.

The CO_2 concentration over the South Polar region has been, on average, 2.2 ppm less than over the Tropics for the 58 years of recording during which time the concentration at the South Pole increased by 86.8 ppm and at Mauna Loa the increase was 88.3 ppm with the difference being statistically significant at the 99% level.

The clear similarity between the autocorrelation function and the power spectra for the two time series, temperature and rate of change of CO_2 concentration, from the Equatorial zone support the original contention that the temperature drives the rate of change of CO_2 concentration. As the Tropics has the highest average temperature it must produce CO_2 at the greatest rate. That CO_2 must diffuse North and South away from the Equator into the Polar regions. As the solubility of CO_2 increases with decreasing temperature it must be precipitated at the Poles within the ice and snow or as dry ice when the temperature is below its sublimation point of -78 degrees Celsius. That is, there may be a continuous circulation of carbon from the Equatorial Zone, through the atmosphere as CO_2, to the Poles where it is locked into the Polar ice sheets until those sheets move sufficiently far from the Pole to melt. The CO_2 is then concentrated in sea water and may return to the Equatorial zone via the Earth's oceans.

That is, the Tropics is a source for the atmospheric CO_2 and the Polar regions are a sink. As the seasonal variation from photosynthesis can be as great as 20 ppm in amplitude, it is possible that the almost 2 ppm per annum increase in CO_2 concentration over the past 38 years has arisen from biogenetic sources driven by the natural rise in temperature following the last ice age. The Tropics has the greatest profusion of life forms throughout the Globe, so this may be a feasible source for the increase in CO_2 concentration for that period. That could include an increase in the population of soil microbes thereby increasing the fertility of the soil leading to the greening of the Earth as can now be seen in satellite imagery. This is supported by an extensive study of global soil carbon which, quote: "provides strong empirical support for the idea that rising temperatures will stimulate the net loss of soil carbon to the atmosphere" end quote, Crowther et el 2016 [7].

Conclusion

The analysis of satellite lower troposphere temperature data compared to observatory CO_2 concentration data contradicts the IPCC claim that CO_2 causes atmospheric warming. Instead, the analysis shows that there is a statistically significant probability that the temperature controls the rate of change of the CO_2 concentration. This is supported by the fact that the temperature and the rate of change of CO_2 concentration have identical autocorrelation functions and Fourier Transform spectra. These reveal that there is a prominent 42 month cycle for the temperature due to the synodic period of the Sun, Earth, Moon configuration which is expressed in the Earth's climate as the El Nino event. The same cycle is revealed in the rate of change of CO_2 concentration. Furthermore the cycles in these spectra may relate to the orbital cycles of the planets indicating that, at least in terms of years, the orientation of the planets with respect to the Sun may determine the changes in the Earth's temperature. That is, climate change is the result of the continually changing position of the Moon and the planets relative to the Earth and the Sun and has nothing whatsoever to do with the concentration of CO_2 in the atmosphere.

Referrences:

[1] The satellite temperature data for the Tropics zone is freely available from the University of Alabama, Huntsville, Dr Roy Spencer's Web site at: http://www.nsstc.uah.edu/data/msu/v6.0/tlt/uahncdc_lt_6.0.txt

[2] The CO2 concentration data for the Mauna Loa Observatory is freely available from the Scripps Institute via the Web page: http://scrippsco2.ucsd.edu/data/atmospheric_co2/primary_mlo_co2_record

[3] The CO2 concentration data for Macquarie Island is available at: http://ds.data.jma.go.jp/gmd/wdcgg/pub/data/current/co2/monthly/mqa554s00.csiro.as.fl.co2.nl.mo.dat

The CO2 concentration data for Mount Waliguan is available at

[4] http://ds.data.jma.go.jp/gmd/wdcgg/pub/data/current/co2/monthly/wlg236n00.cma_noaa.as.fl.co2.nl.mo.dat

and http://ds.data.jma.go.jp/gmd/wdcgg/pub/data/current/co2/monthly/wlg236n00.cma.as.cn.co2.nl.mo.dat

The CO2 concentration data for Point Barrow is available from the Scripps Institute via the Web page: http://scrippsco2.ucsd.edu/data/ptb

and for the South Pole Station at: http://scrippsco2.ucsd.edu/data/atmospheric_co2/spo

and for Cape Grim, Tasmania, at: http://www.csiro.au/greenhouse-gases/

[5] Ole Humlum, Kjell Stordahl, Jan-Erik Solheim, “The phase relation between atmospheric carbon dioxide and global temperature”, Global and Planetary Change 100 (2013) 51-69.

[6] Identification of the driving forces of climate change using the longest instrumental temperature record. Geli Wang, Peicai Yang & Xiuji Zhou
Scientific Reports 7, Article number: 46091 (2017), doi:10.1038/srep46091

[7] T.W. Crowther, et el, “Quatifying global soil carbon losses in response to warming” Nature, Vol. 540, 104-108, 01 December 2016, Letter

[8] Cionco and Soon, Short-term orbital forcing: A quasi-review and a reappraisal of realistic boundary conditions for climate modeling, Earth-Science Reviews 166 (2017) 206-222, Elsevier B.V.