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Abbreviations

AGWH: Anthropogenic Global Warming Hypothesis; CP: Causality Principle; GW: Global Warming; CS: Climate Science; GMST: Global Mean Surface Temperature

Keywords

Global Warming; Causality Principle; Climate; Gas Chromatography; Temperature

Review Article

The Anthropogenic Global Warming Hypothesis and the Causality Principle

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Abstract

The scientific viability of the Anthropogenic Global Warming Hypothesis (AGWH) has been evaluated in terms of the Causality Principle (CP) which is the foundation of scientific philosophy. Based on the available experimental data, the relationship that is expressed by the AGWH (that rising CO_2 concentration in the atmosphere is responsible for global warming (GW) as reflected in the rise in temperature) is noncausal because the cause (the change in [CO_2]) lags the change in the temperature in the experimental record, in violation of the CP, regardless of the source of the carbon dioxide. Since the AGWH represents the foundational hypothesis of current Climate Science (CS), it is concluded that CS and the models that have been developed, based on the AGWH, to predict future GW lack a valid scientific basis. Finally, because no causal relationship exists between atmospheric CO_2 and temperature, the Equilibrium Climate Sensitivity (SCS) is zero rather than being 3 ºC/doubling [CO_2] as adopted by the IPCC and as low as 1.54 ºC/doubling [CO_2] estimated by others. All ECS values are estimated from unvalidated models, and no measured values currently exist.

Introduction

The Anthropogenic Global Warming Hypothesis (AGWH) is the foundational hypothesis of Global Warming (Change) Science and assumes that the rise in global mean temperature is directly attributed to human-generated carbon dioxide (CO_2) produced primarily via the burning of fossil fuels [1,2]. This hypothesis also serves as the key hypothesis of various global warming models, particularly those used by the Intergovernmental Panel on Climate Change (IPCC) to predict global temperatures into the future. However, this hypothesis foretells the result that the global mean temperature rises with the concentration of CO_2 in the atmosphere so that it is not surprising that the models predict exactly that. As anyone who is skilled in the fundamentals of modeling complex physico-chemical systems knows, such a hypothesis is illegitimate because of the bias that it imposes on the result. That alone is sufficient reason to reject the results of the models and is a good reason to develop models that are not burdened with this illegitimate hypothesis. However, as devasting as that may be, a much more serious problem exists as to whether the AGWH is even correct. A review of the relevant literature failed to uncover any fundamental, scientifically valid support for the AGWH, and it appears to have been adopted simply because if was seen by some as describing the "obvious" impact of industrialization on the perceived rise in temperature. However, that perception does not meet the rigorous standards of scientific proof.

The fact that the excursion in temperature appears to precede that in the concentration of CO_2 in the atmosphere has been noted by others (e.g., Koonin [1], Morano [2], Paterson [3], and Mudelsee [4] to name but four of many who have noted this relationship) but, to the author's knowledge, it has not been previously interpreted directly in terms of the Causality Principle (CP), as presented here. The CP provides the rigorous scientific basis for establishing scientific validity or lack thereof. Some authors have invoked "causality" in statistical analyses [5-14] of global warming but in the author's opinion, the concept of causality often gets lost in the clutter of the statistical analysis (however, see below). In any event, the general purpose of these statistical analyses of time varying temperature and [CO_2] records are to determine which of these two variables lags the other. However, the records tend to be very noisy, and the above classification is often obtained with difficulty. Instead, coincidence plotting of the two variables often allows the question of what variable lags the other to be resolved visually without invoking complex statistical methods. That is the approach taken in this paper because the result is unequivocal.

Here, the AGWH is examined in terms of the Causality Principle (CP), which as noted above is the foundational principle of scientific philosophy. It is shown that the AGWH is noncausal then everything that flows from it, including all the modeling and legislation lacks scientific validity and must be rejected scientifically and as the basis of policy. To be clear, the author is not challenging the phenomenon of global warming in the Holocene period (11.65 ka before present) as that is an established, empirical fact, just as similar warming cycles have occurred within each Milankovitch cycle that define the ice ages. Instead, he is questioning the scientific basis of the current climate science as embodied in the AGWH.

The Causality Principle

The Causality Principle (CP) originates from Aristotle's treatise that was published in 450 BC [15]. Since that time, the CP and related matters have been subjected to intense debate [16-21] with much of the debate occurring in Departments of Philosophy where it is often discussed in terms of esoteric concepts such as "free will". As interesting as these debates may be, the interest here is in the scientific interpretation of the CP as it applies to physico-chemical systems like those that govern the global climate. Mathematically, the CP may be defined in terms of Cauchy theorem [22-24] and integral transforms, such as the Kramers-Kronig transforms have been used to test the compliance of a system with the CP [25-28]. However, for the purposes here, the colloquial form of the CP is most appropriate especially when presenting it to a general audience. In this form, the CP may be expressed as: Every effect has a cause, and the cause must precede the effect. Furthermore, for a complex system comprising a series of processes, if any step is non-causal then so is the entire process. It is important to note that the CP is independent of the mechanism of the change just as are the Laws of Equilibrium Thermodynamics for which there exists a close parallel. If this were not the case, a process may appear to be causal via one mechanism but noncausal via another, even though the initial and final states or the declared cause and effect had not changed; an intolerable conflict and one via which all processes could be declared as being "causal" for convenience and in defiance of common sense.

The CP can be illustrated by a simple example. A gun is designed to fire (the "effect") only when the trigger is pulled (the "cause"). When that occurs, the process of firing the gun is said to be "causal" and in compliance with the science (via the

firing mechanism). On the other hand, if the gun fired (the "effect") before the trigger was pulled (the "cause") the process is "noncausal" and is not allowed by the firing mechanism (i.e., the "science"). This latter scenario will not happen no matter how long one waits. Other colloquial definitions exist with a popular one being that a system cannot respond (the "effect") before time equal zero, when the perturbation (the "cause") is applied. If the response does occur at t<0, the response and the perturbation are uncorrelated, and no causal relationship exists between them. The role of causality in global warming has been explored by others [1-5,7,8,10] but not (apparently) to determine the scientific legitimacy of the AGWH. For example, Bilancia & Vitale [8] report an updated analysis of global climate change and its relationship with [CO_2] using advanced, econometrics-inspired models to apply a bivariate analysis of climatic time series. They found strong evidence for the absence of Granger causality between CO_2 emissions and global surface temperature. They conclude that the AGWH "still needs a conclusive confirmation using the most appropriate methods for data analysis".

The Anthropogenic Global Warming Hypothesis

The AGWH has been defined above and nothing further will be added to this definition except by noting that a significant literature exists on the subject [1-6,12,14]. Instead, the compliance of the AGWH with the CP will be examined in terms of the reported [CO_2] and temperature data as taken from the published literature. The AGWH appears to have had its genesis in the IPCC's mandate in 1988 that seems to have taken as fact that man is responsible for at least a significant part of the current global warming [1-4] although Ruddiman [29,30] appears to claim that he formulated the hypothesis more than a decade later. Regardless, the AGWH became the foundational hypothesis of climate science as we know it today. The first set of data to be examined are presented in Figure 1. In this case, the [CO_2] was determined from ice cores via GC-MS (gas chromatography-mass spectrometry), which has proven to be a reliable method (see below) while the temperature was determined from oxygen isotope exchange. The determination of temperature therefore appears to be more problematic. Thus, the air bubbles trapped in the ice when the ice formed is analyzed directly using GC-MS to yield the concentrations of all gases in the trapped atmosphere including those that are differentiated by their isotopic compositions. That this measurement is accurate is shown below in Figure in which a direct comparison is made between the measured temperature using calibrated thermometers or thermocouples and that determined from ice cores over the period ca 1955 to 1975 AD. The water that is trapped in the ice comprises the isotopes $^{16}O_8$, $^{18}O_8$, $^{1}H_1$, and $^{2}H_1$. The difference in the molecular weights of water molecules comprising different isotopes leads to slightly different volatilities and the water becomes increasingly concentrated in the heavier isotopes as the temperature decreases so that measurement of the isotopic composition via mass spectrometry and comparison with a standard known as SMOW (Standard Mean Ocean Water) indicates the prevailing temperature when the water was frozen. This method has been tested against recent ice deposits for which directly measured temperatures are available and it is found to be accurate to perhaps ± 0.2 °C [31-33].

The most extensive ice core records are those from the Russian station the Lake Vostok in Antarctica and other sites such as the joint European Greenland Ice-core Project (GRIP) at Summit station in east-central Greenland and the American-Danish-Swiss cooperative Greenland Ice Sheet Project (GISP-1) in southern Greenland from 1979 to 1981. The longest record extending back in time is from Lake Vostok and extends back some 400,000 years. The Lake Vostok records are reproduced in Figure 1 with ΔT, [CH_4], and [CO_2] being plotted on the same graph. The scale on the horizontal axis (years before the present) is such that it is difficult to ascertain whether the change in [CO_2] precedes ΔT or whether the reverse occurs. The difficulty is even more if the plots are not coincident as in the lower plots versus that in the upper plot and if thick lines are used to represents the trends in the data. Close examination of the temperature anomaly and atmospheric [CO_2] records, show that the rise/fall in temperature precedes the rise/fall in the [CO_2] as shown by the expanded time scale plot in Figure 2. Since, according to the IPCC/AGWH, the cause of global warming is the emission of human-made CO_2 into the atmosphere, the rise in [CO_2] should precede the rise in temperature, but that is not what is observed. Accordingly, the relationship proposed by the AGWH between [CO_2] and ΔT is non-causal and is not scientifically valid assuming that the ice core records are correct. Rather, the change in temperature precedes the change in [CO_2], which is the reverse of the relationship proposed by the AGWH and hence the AGWH is judged to be noncausal as noted above. It is important to note that regardless of how many contrary observations of this type may be made (i.e., that Δ[CO_2] precedes ΔT) that support the AGWH, only one contrary observation of the type (ΔT precedes Δ[CO_2]) is necessary to disprove the AGWH and hence the foundation of current climate science. In other words, the AGWH has been "falsified".

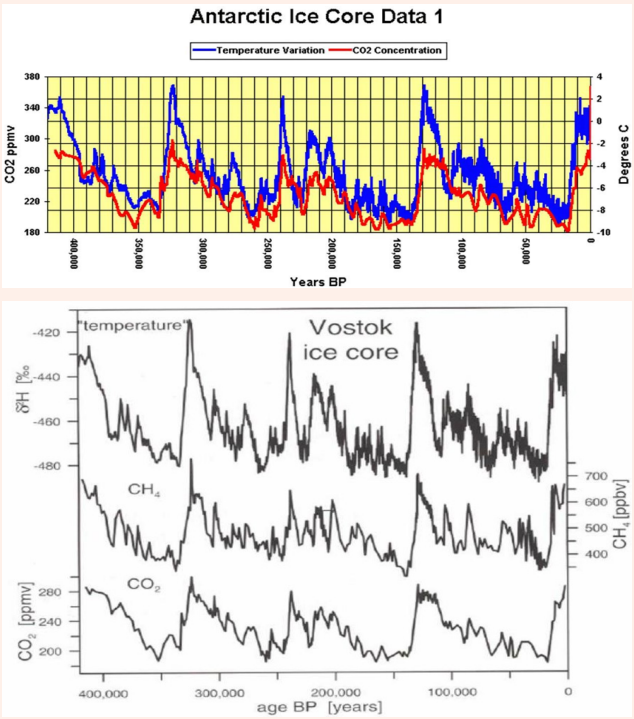

Figure 1: Change in temperature (ΔT) and [CO_2] as a function of time expressed as years before the present (BP) from Antarctica ice ores–upper plot-and change in temperature (ΔT), [CH_4], and [CO_2] from the Vostok ice cores– lower plots-as a function of time expressed as years before the present (BP). Note that increasing time goes from lefttoright.From:www.bing.com/images/search?q=vostok+ice+core+data+graph&qpvt=vostok+ice+core+data+graph&tsc=ImageHoverTitle&form=IGRE&first=1.

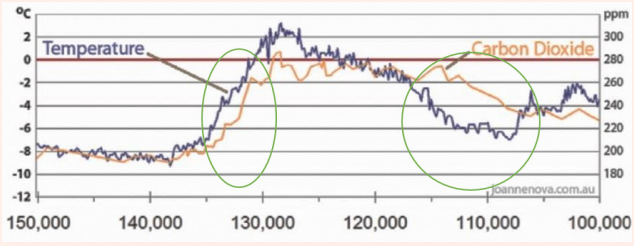

Figure 2: Temperature vs [CO_2] for the period of 100,000 years to 150,000 years before the present. Note that increasing time goes from left to right. From: http://www.indiana.edu/~geol105/images/gaia_chapter_4/milankovitch.htm.

The same relationship is revealed in the ice core data shown in Figure 3. Note that, in this case, increasing time is from right to left. The instances where ΔT precedes Δ[CO_2] are highlighted by the ellipses in Figures 2 & 3. The relative change in temperature and [CO_2] on increasing [CO_2] are difficult to discern on the time scale used in Figure 3 because the changes appear to be essentially coincident as it is evident in Figures 1 & 3. Contrariwise, the differences between ΔT precedes Δ[CO_2] are much more evident when the temperature falls as is highlighted in Figures 2 & 3 by the ellipses in Figures 2 & 3. In these cases the change (decrease) in T precedes that in [CO_2], again emphasizing that the AGWH is noncausal. There are many other sources of CO_2 than humans burning fossil fuels, such as volcanic eruptions, forest fires, animal (including human) expiration upon breathing, decay of plant and animal matter, and the World's oceans that are the great repository of all CO_2 regardless of its source. Thus, if the change in temperature is responsible for the change in atmospheric [CO_2] as indicated by the data in Figures 2 & 3 then a more logical source/sink of the

CO_2 is outgassing/in gassing from/into the oceans as has been noted by many others [Refs. 1 and 2 and citations therein] in response to changes in the irradiance and orbital motion of the sun, as is discussed later in this paper. That process at least has the causal legitimacy of the temperature (cause)/[CO_2] (effect) relationship. It is therefore difficult to find where any direct human element exists in the entire process. In fact, higher CO_2 levels promote plant growth as evidenced by the sharp increase in crop yields and the "greening" of the planet Earth as the concentration of CO_2 in the atmosphere has risen since the onset of the industrial revolution [1,2]. The case can be made that the reason why the Earth can sustain a 7+ billion population is because of the increased crop yields resulting from the higher levels of atmospheric carbon dioxide.

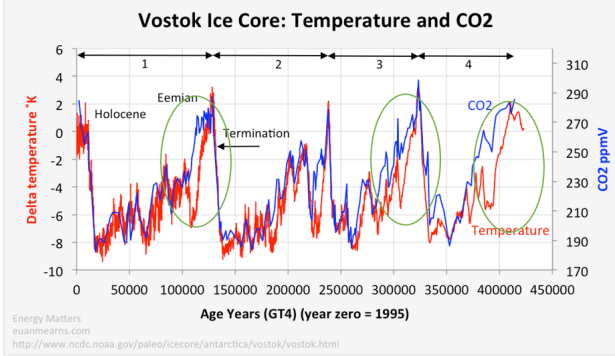

Figure 3: Vostok ice core [CO_2] and ΔT vs time records extending over 420,000 years before the present. Note that increasing time goes from right to left. From: www.bing.com/images/search?q=vostok+ice+core+data+graph&qpvt=vostok+ice+core+data+graph&tsc=ImageHoverTitle&form=IGRE&first=1.

In any comparison of this kind, the question always arises as to how accurate are the data? Since we have no direct measurements of T and [CO_2] from these ancient periods, we must be satisfied with more recent measurements. Such a comparison for [CO_2] is shown in Figure 4. Although the direct measurements extend back only to about 1955, more recent data are in excellent agreement with ice core values as shown in the figure. Accordingly, it is reasonable to assume that the uncertainty in [CO_2] is about ± 2 ppm and this value is adopted without further justification. The uncertainty in the temperature is another matter, however, because of the processing that is applied to determine the average with running time as is illustrated by the plots in Figure 5. In this plot the results of algorithmically averaging the temperature from central Greenland are displayed. Thus, the Alley data were smoothed, but, apparently, the exact details of the smoothing algorithm were not disclosed. May [33] then smoothed the other data sets to give visually the same resolution as that displayed by the Alley dataset. Both datasets (Kobashi and Vinther) were initially smoothed with a 100-year moving average filter. Then 20-year averages of the smoothed data were taken from the one-year Kobashi data set to match the Vinther 20-year samples. The Alley data is irregularly sampled, but May [33] indicates that he manually averaged 20-year samples where the data existed. If a gap greater than 20 years was found that sample was skipped (given a zero value). Thus, the final data set are possibly quite different than the original, measured data so that processed data sets must be approached with some considerable caution. Ignoring these concerns for the moment, it is evident from the plots in Figure 5 that the variability in temperature is of the order of ± 0.5 °C, which is accepted here as indicating the uncertainty in the plots displayed in Figures 2 & 3. However, it is important to note that it is not possible to delineate the uncertainty of the original temperature measurement from that induced by the algorithms. One of the problems is the algorithm used is not always disclosed so that it may not be examined by others. This is a major problem that extends to the climate models themselves upon which the IPCC makes its projections. Because the models are not available, critique by independent parties is not possible in defiance of normal scientific etiquette.

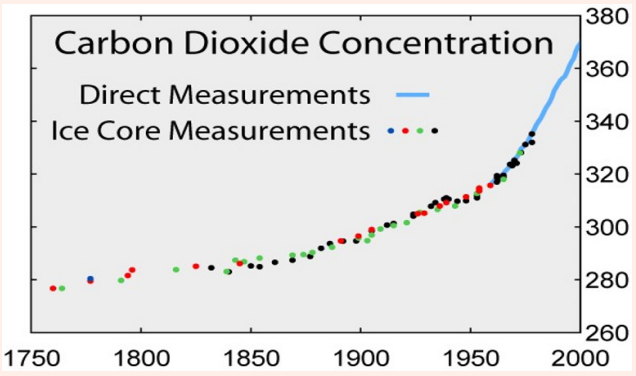

Figure 4: Comparison of the directly measured [CO_2] in the atmosphere and that obtained from ice cores. From: https://www.windows2universe.org/earth/climate/greenhouse_effect_gases.html.

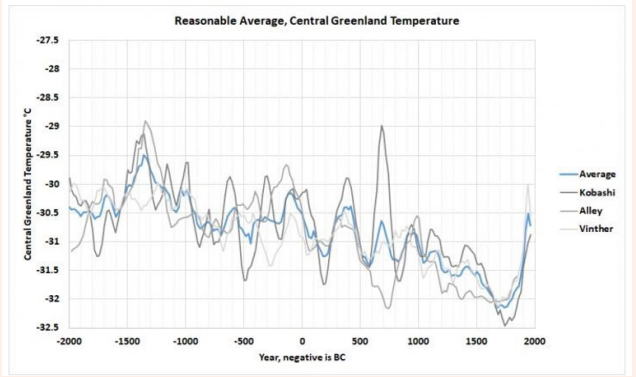

Figure 5: Plots of algorithmically averaged central Greenland temperature vs time. From: Andy May, A Review of Temperature Reconstructions–Andy May Petrophysicist.

The uncertainty in the time scale has been reviewed by Steig [31] and he opines that the likely uncertainty is less than ± 2 years. This is less than the line thickness for either [CO_2] or temperature lines in Figure 3, for example, and therefore I conclude that the uncertainty in time is negligible. However, as also noted by Steig [31], significant surface spatial variability exists in ice core measurements because of local micrometeorological effects. Furthermore, May [32] suggests that the uncertainty is ±50 years while Loehle (cited by May [33]) has suggested a time uncertainty of ±100 years based on $^{14}C_6$ laboratory errors. Even if this latter number is correct, the conclusions drawn from Figures 2 & 3 are still valid. The analysis shown here argues that climate change is not the result in rising [CO_2] whether human made or not, since that relationship is noncausal. This begs the question then: "What is the likely cause of the observed rise in global temperatures?". While a complete answer to this question is beyond the scope of this paper, it is worth noting the strong correlation between temperature and solar irradiance shown in the left frame of Figure 6 (see citation in the caption). This correlation is far superior to that between shown in the right frame of Figure 6 suggesting that global warming is a natural phenomenon related to variations in our heat source, the Sun. However, it is prudent to be cautious of correlations, as has been demonstrated in economics and the medical field as being frequently unreliable because of the complexities of the underlying processes and because correlations do not prove causality.

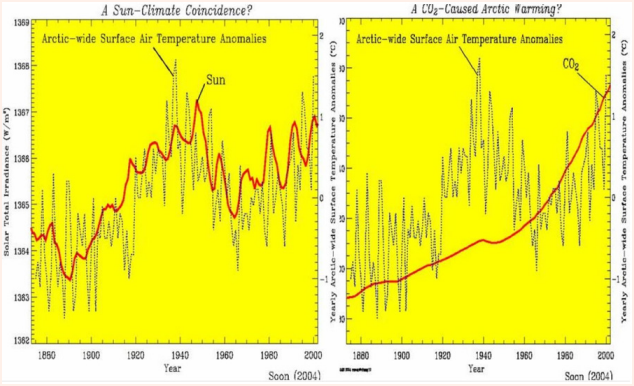

Figure 6: Plots of total solar irradiance (W/m²) and Artic-wide surface air temperature anomalies (ΔT) vs time (Left frame) and [CO_2] and ΔT vs time. From: John McLean, "Fallacies about Global Warming", Science & Public Policy Institute, www.scienceandpublicpolicy.org (2007) [33].

As noted by many authors, the Global Mean Surface Temperature (GMST) has displayed a significant downward trend since about 1998, as shown in Figure 7. None of the climate models employed by the IPCC had predicted this cooling, which is now termed the "pause". It is not surprising to learn that this period (1998 to the present), known as the "pause", corresponds to the maximum in the Total Solar Irradiance (TSI), Figure 8(a), in which the TSI is not changing significantly with time or is slightly decreasing towards the next solar cycle minimum [34,35]. We should have experienced another solar maximum in 2018-9 and now be on the path to the next solar minimum in about 2030. From Figure 8(b), it is seen that the TSI is directly proportional to solar activity as expressed by the Greenwich Sunspot Activity (GSSA); a finding that was first discovered by NASA's SMM/ACRIM1 experiment (see attribution in the caption). The GSSA represents the general level of solar activity. However, the temperature changes, as indicated in Figure 7, has remained constant within the differences in the four records published in Figure 7. This throws some doubt on TSI being the sole driver of temperature change so that the caution expressed previously concerning correlations is well justified. If this interpretation is correct, the GMST will continue to decrease over the next few years before again increasing. Only time will tell. In recent years, attention has been focused on the possible synergistic interaction of CO_2 and water vapor (gaseous H_2O), which is a much stronger greenhouse gas than is carbon dioxide and is present at a much higher concentration, apparently to overcome the limit imposed by the logarithmic variation of temperature with [CO_2] [36]. The hypothesis of "feedback loops" is that the small increase in temperature induced by an incremental increase in [CO_2] causes an increase in [H_2O] due to evaporation that in turn induces an even larger increase in the temperature and hence, in turn, a larger increase in [CO_2] presumably due to degassing of the oceans. There are significant difficulties with this hypothesis. First, the experimental work of Myhre et al. [37], indicate that the radiative forcing of [CO_2] decreases with increasing [CO_2] (Figure 9) although the data (Figure 9) suggest the CO_2 does not lose its potency as a greenhouse gas until the concentration is more than 2000 ppmv (vs the current concentration of about 410 ppmv). Secondly, any significant increase in [H_2O] would likely induce further cloud formation that would reduce the solar irradiance received on the Earth's surface or even result in precipitation that would counter the effect of the synergistic interaction between CO_2 and H_2O. Finally, it is possible that the "pause" that is evident in Figure 7 reflects the fact that the synergistic CO_2/H_2O effect has simply saturated in inducing an increase in temperature (if one accepts the AGWH). From the available evidence that is reviewed above the rise (fall) in temperature that precedes the rise (fall) in [CO_2] that correlates so well with the TSI may simply reflect the outgassing (in gassing) of the oceans, which are the great storehouse of CO_2. If this is the case, then "anthropogenic global warming" is an entirely natural process that accounts for the lack of a causal relationship between T and [CO_2] as proposed by the AGWH. In other words, "global warming", as promoted by its proponents, is one more myth among many "scientific" myths, such as N-rays, polywater, and cold fusion, to name but a few. I close this paper on a historical note. The AGWH, which attributes global warming to human activity in the release of CO_2 from the burning of fossil fuels, was proposed in the very early days of climate science (apparently in 1988 with the establishment of the IPCC). The problem appears to be that the AGWH was formulated before sufficient experimental evidence had been collected to carefully define the relationship (if any exists) between the [CO_2] and temperature, which is contrary to the normal formulation of hypotheses in science where hypotheses are taken to be factually correct, as opposed to assumptions, but others [1,2] insist that it was simply a political statement.

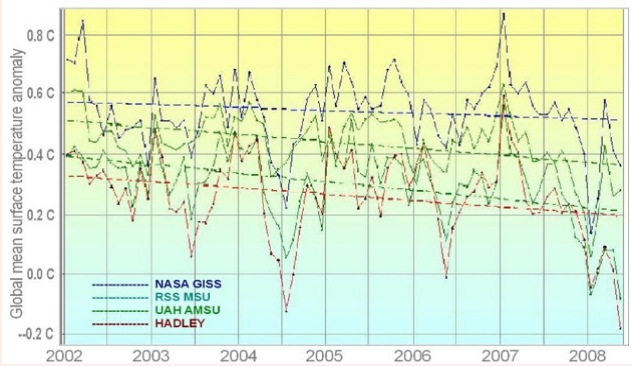

Figure 7: Comparison of four temperature anomaly records for the period 2002 to 2008. Note that none of the IPCC climate models predicted this lack of warming; in fact, there has been no global warming since 1998. From: John McLean, "Prejudiced authors, prejudiced findings. Did the UN bias its attribution of "global warming" to humankind?", John McLean [34].

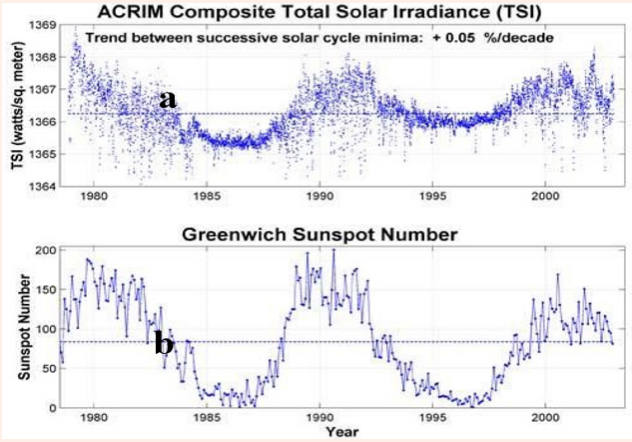

Figure 8: Comparison between Total Solar Irradiance (TSI) and Greenwich Sunspot Activity (GSSA). From: ACRIM3 Science Team (R. Willson), NASA Study Finds Increasing Solar Trend That Can Change Climate- March 20, 2003.

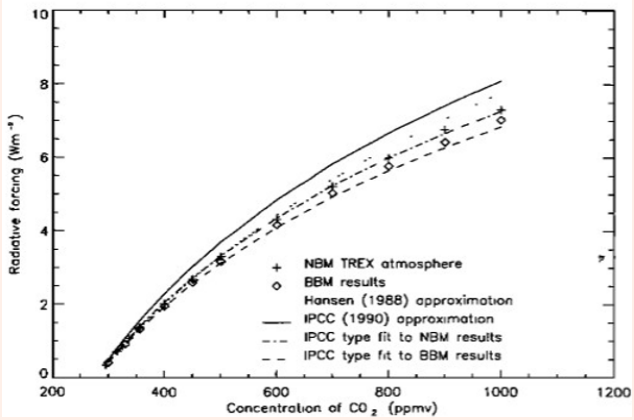

Figure 9: Radiative forcing of CO_2 as a function of [CO_2] [37]. Citations in the figure are given in the original paper.

Equilibrium Climate Sensitivity

The Equilibrium Climate Sensitivity (ECS) is defined as the increase in temperature upon doubling the concentration of atmospheric CO_2. The assumption behind this metric is that the AGWH is valid, and that global warming is due to rising human-made [CO_2] in the atmosphere as discussed above. However, because no causal relationship exists between atmospheric CO_2 and temperature, the ECS is zero rather than being 3 °C/doubling [CO_2] as adopted by the IPCC and as low as 1.54 °C/doubling [CO_2] estimated by others. All ECS values are estimated from generally unvalidated models, and no measured values currently exist, so that the lack of a generally accepted value is not surprising. It is of interest that as time has passed the trend in the ECS is toward a lower value with the value reported here being the lowest ever reported [38].

Summary and Conclusion

In this paper, the scientific viability of the Anthropogenic Global Warming Hypothesis (AGWH) has been evaluated in terms of the Causality Principle (CP) that is the foundation of scientific philosophy. Based on the available experimental data, the relationship that is expressed by the AGWH (that rising CO_2 concentration in the atmosphere is responsible for global warming as reflected in the rise in temperature) is noncausal because the cause (the change in [CO_2]) lags the change in the temperature (the effect) in violation of the CP. Since the AGWH represents the foundational hypothesis of current Climate Science (CS), it is concluded that CS and the models that have been developed to predict future GW that employ the AGWH as a foundational hypothesis lack a valid scientific basis. The problem appears to be that the AGWH was formulated before sufficient experimental evidence had been collected to carefully define the relationship (if any exists) between the [CO_2] and temperature, which is contrary to the normal formulation of hypotheses in science. Because no causal relationship exists between atmospheric CO_2 and temperature, the Equilibrium Climate Sensitivity (SCS) is zero rather than being 3 °C/doubling [CO_2] as adopted by the IPCC and as low as 1.54 °C/doubling [CO_2] estimated by others. All ECS values are estimated from unvalidated models, and no measured values currently exist.

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