Global warming and CO_2:
Highlights of differing perspectives

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RESUMEN

Una vez aceptado que el calentamiento global es causado por el bióxido de carbono (CO_2), diferentes visiones sobre la culpabilidad del CO_2 antropogénico como principal causante han sido planteadas en base a cuestionamientos y dudas razonables. Se invita al lector a analizar los datos disponibles y juzgarlos por si mismo. El reto tiene dos aspectos: Cuestionar científicamente los datos y ser un buen ciudadano del mundo.

PALABRAS CLAVE

Calentamiento global, bióxido de carbono, antropogénico, perspectivas.

ABSTRACT

Once that culpability of CO_2 over global warming has been accepted, different perspectives have arisen derivated of questions and sufficient doubts of the guilt of anthropogenic CO_2 as a significant contributor. The reader is encouraged to evaluate the data and pass his/her own judgment. The challenge is two-fold: question the data; be good stewards of the Earth.

KEYWORDS

Global warming, carbon dioxide, anthropogenic, perspectives.

INTRODUCTION

The global warming debate has moved from the research laboratories to the public arena; from professional journals to the internet. There has been a trend to politicize science, and to be driven to immediate decisions. On the one hand, anthropogenic global warming is demonstrated in trends in global temperatures when compared to CO_2 and in computer model predictions, see for instance IPCC AR4.[1] On the other hand, there are sufficient uncertainties and questions to be raised. The sections that follow first present the evidence and then raise some of the questions to be yet fully addressed.

THE EVIDENCE

Figure 1 shows the global mean temperatures obtained from recording stations around the globe.[1] It exhibits a rapid increase in temperature following the industrial revolution and the increased use of fossil fuels. A similar and notable increase in temperature is seen in figure 2 for the contiguous United States.[2]

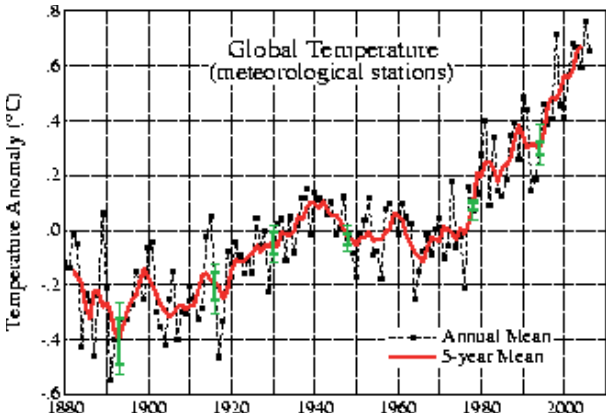


Fig. 1. Global temperatures - Meteorological Stations 1880 – date.

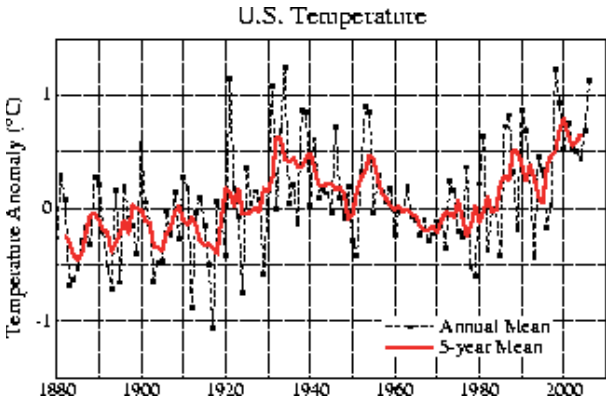


Fig. 2. US temperatures 1880 – date.

The temperatures are given as an anomaly from a common reference value.

The stations used for determining these started with a limited number of rather crude thermometers (and bi-metallic thermal chart records). The number and locations of stations increased rapidly after the Second World War with approximately 11 thousand stations in 1950 growing to 15 thousand in 1970. Thereafter the number of functioning stations decreased to 12 thousand in the late 80's, with a sudden drop to 5 thousand at the start of the 21st. century.[3]

Svante Arrhenius[4] was probably the first in quantifying the expected impact of increases in CO_2 on global warming. Understandably it was expected that CO_2 emissions would be increasing as result of the increase in power plants. For clarity sake this is referred to as "anthropogenic" global warming, or due to human practices.

Rather thorough measures of the concentration of CO_2 were started in a station in Mauna Loa, Hawaii in 1957[5] Figure 3 shows the constant increase in CO_2 with time – similar results are found in a number of sister stations with measurements starting at later dates. A comparison with the global temperature increases in the correspondant time, especially the last 100 years, provides evidence of the interrelationship between CO_2 and warming.

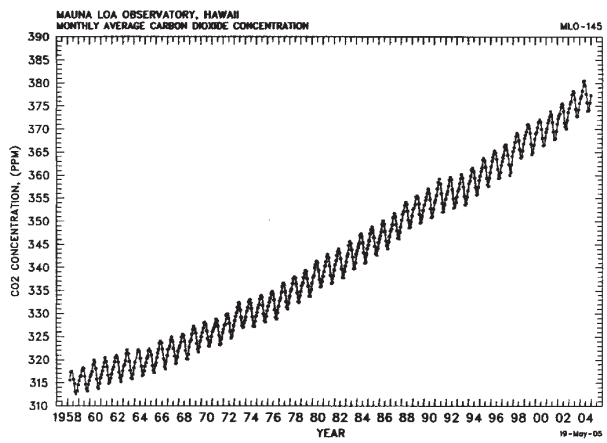


Fig. 3. CO_2 Concentration at Mauna Loa Station.

The simplified analysis of Arrhenius[4] has been considerably improved with the advent of large capacity computers and new understanding of the modeling of atmospheric (turbulent) flows. The governing equations need some empirical parameters in order to become a closed set of equations. Furthermore, the nature of the equations (non-linear partial differential equations) is such that they require a step-wise integration over small steps in space (and time). Richardson[6] was the giant on whose shoulders many have stood in the advance towards proper modeling. Phillips[7] produced the first (albeit rather simplified) global climatic model – and also recognized the inherent instabilities in its solution. Independently, the pioneers reaching estimates of global warming, and taking into account more and more dynamics in their models were Manabe (Manabe and Wetherald;[8] Manabe and Stouffer)[9] and later Hansen.[10] It was their work that led the National Academy of Sciences to state that doubling CO_2 would lead to an increase between 1.5 to 4.5°C.[11] A number of models have evolved in time, each with some new improvements, but all of them generally

predicting under different scenarios temperatures by 2010 1.8 to 4°C higher than during the past century.[1]

Without having to consider likely effects of global warming (such as sea levels rising, strong storms increasing, polar bear population decreasing, glaciers melting), the relationship between temperature and CO_2 and the prediction of the rather sophisticated computer models are substantive enough to demonstrate the culpability of CO_2.

A FURTHER LOOK AT THE DATA – AND EMERGING QUESTIONS

One of the apparent starting points for determining the culpability of CO_2 were the measured increases in temperature. That evolved to the consideration of a postulate that CO_2 would be the guilty party. Modeling and analysis proceeded to demonstrate that culpability. Serious questions such as "What else could cause this warming?" or "Is there a demonstrated cause and effect recorded?" were not fully addressed at that time.

Scientific method calls for first defining the problem (e.g. global warming) then making numerous observations, experiments, records of data, and analysis. Following those steps would come proposing a hypothesis or postulate with final validation with a new set of observations, experiments, and data to assure that none of these were in conflict with the postulate or hypothesis. Unfortunately the scientific method was not followed in the studies of global warming leading to the culpability of CO_2. It started with a postulate and followed by a model to demonstrate that postulate.

It is now in order to address some concerns and raise some questions. The reader will then be left to evaluate whether the case is closed, or whether judgment of CO_2 culpability should be withheld.

A. Temperatures

A. 1. Uncertainties

Figure 1 shows increases in temperature anomaly slightly under 1 C over recent years. Typically even in controlled experiments with heated flows such as wind tunnels accuracy in measurements better than 0.5°C is not expected. The data points should be accompanied by error bands in the measurements reflecting both random and systematic uncertainties; this might have masked the noted trends.

What is known is that: temperature sensors have changed since the 1880s (both in accuracy and time response); the number of operating stations has been changing; and the maintenance and location of the stations haven't been fully taken into account.

In the form of exhibit of the potential effects of changing the number of stations, figure 4 shows a potential correspondence to the loss of some stations and a trend towards increase in temperature.[3] Pielke et al.[12] provide an example of the challenges in getting meaningful averages with a limited number of stations.

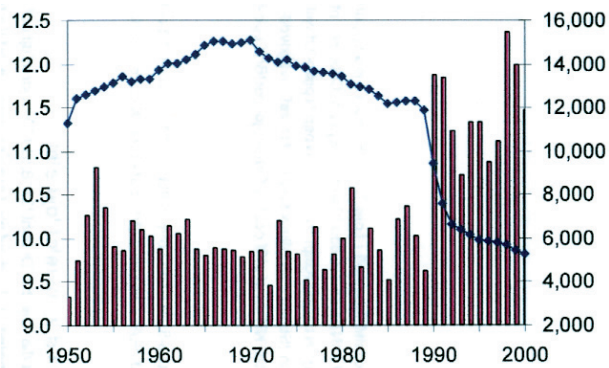


Fig. 4. Comparison of number of GHCN operating stations (diamonds, right ordinate) and average annual temperatures in °C .

There are undoubtedly other effects. Christy et al.[13] while carefully considering the quality of stations, saw different temperature trends for areas that were irrigated and those that were not. Goldstein[14] compared temperature trends based on all measuring stations with those for only stations in rural locations. Figure 5 shows that temperatures from rural stations do not show the warming seen for the entire set of stations within the continental U.S., suggesting an "urban heat island" effect in populated areas. This same potential dependence on population could be inferred from the work by Robinson et al.[15] Figure 6 shows averaged ground temperature trends for the period of 1940 to 1996 from 49 California counties. After averaging values for each county, those with similar population were combined and noted as one point in the plot. The "urban heat island" could explain these differences.

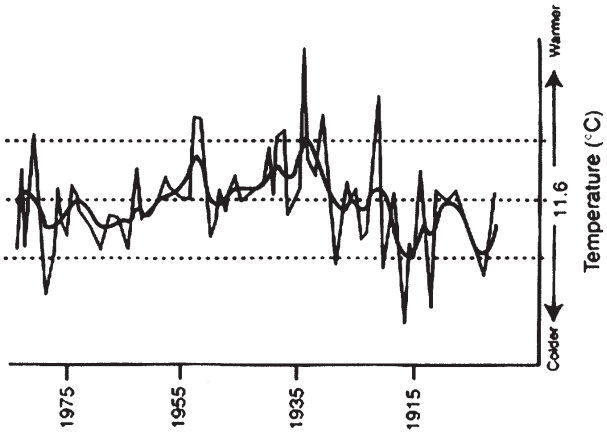


Fig. 5. Rural ground surface temperatures.

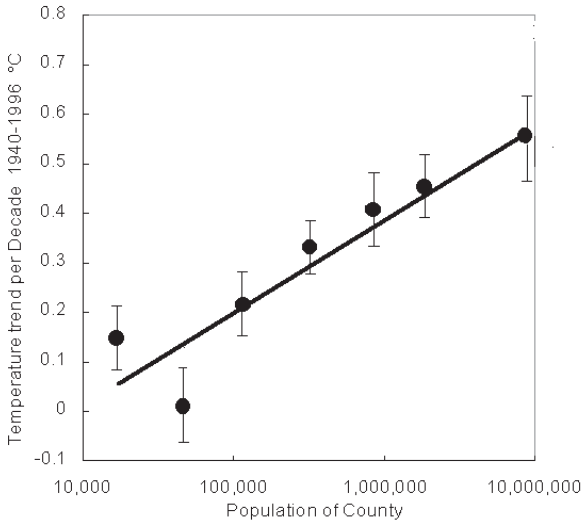


Fig. 6. Temperature trends vs. population.

Measured temperatures can also be dependent on the proper installation of the measurement stations. Figures 7 shows temperature trends for two stations relatively near to each other.[16] One of these is posted near asphalt pavement, exhaust from air conditioners and other sources of error, and shows a warming trend. The other one distant from pavements and other influences shows quite a different temperature trend. The question must be asked as to how dependable are these global measured temperatures. Even further, there are some that even question the validity of the concept of a "mean global temperature",[17] as well as the ability to determine an average surface temperature for a planet.[18]

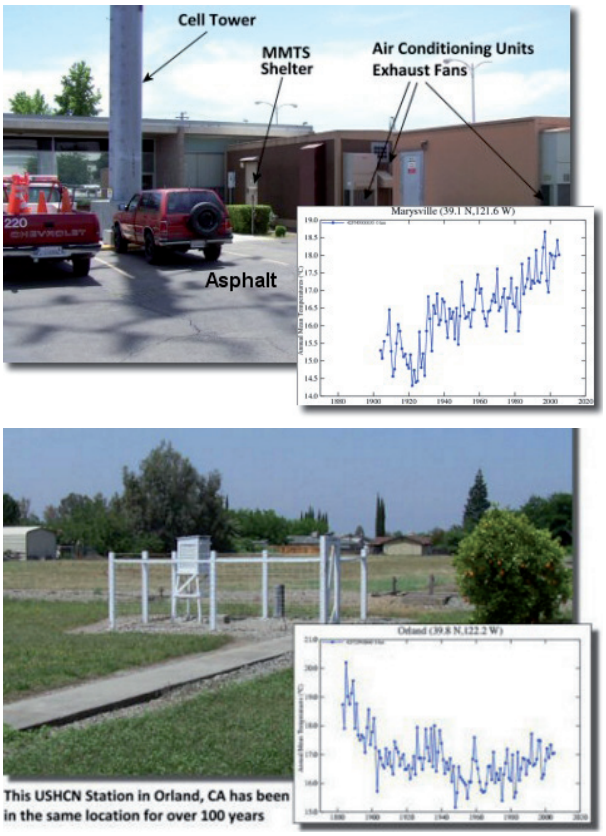


Fig. 7. Temperature Trends in Neighboring Stations.
Marysville CA. 39.8° N, 122.2° W.
Orland CA, 39.1° N, 121.6° W.

A. 2. The issue of temperature maxima

Global warming should be accompanied by two effects – record high temperatures being broken in larger numbers, and annual mean temperatures consistently increasing. Figure 8 shows a decreasing number of reports of record breaking measurements within the United States.[19] A listing of years during

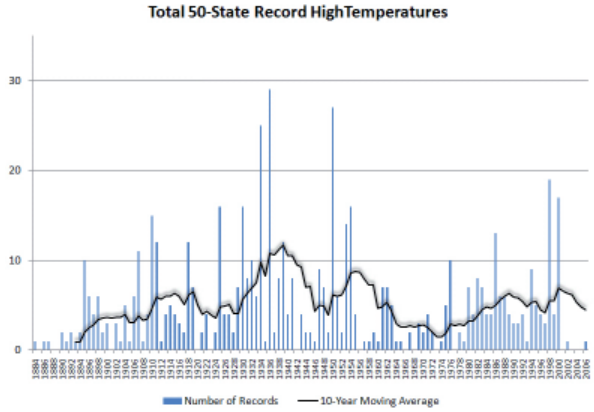


Fig. 8. Total US Record Breaking Temperatures.

record high temperatures were noted (up through 2003) at each of the 50 U.S. states is found in NCDC.[20] It is interesting to note that most of the record breaking temperatures were in the 1930's (37%) with less than 10% in the 1990's. There has been some controversy in the claims that recent years have been the warmest on record. A recent amendment by NASA[21] clarifies that, unlike earlier reports, 1998 was not a record breaking year, but rather that 1934 still remains as the warmest year on record (that is since 1880), with five of the 10 warmest years prior to 1945. This raises some question on the common understanding of unprecedented warming during the last few years.

As a side comment, if warming is to be due to CO_2 and CO_2 has similar increases world-wide, there should be increases in temperature throughout the world. This is not the case; there are numerous examples of areas where cooling trends have been noted. One example, figure 9 shows evidence of considerable cooling in a great part of Antarctica. Similar results are found in Chapman and Walsh,[23] showing definite regions of cooling in Antarctica, and raise doubts of any recent trends towards warming. To date the models predicting anthropogenic global warming fail to account for these regions of cooling.

B. Solar effects: twenty-two year cycle and solar intensities

Records of sunbursts have been taken since 1700[24]. Figure 10 depicts some of the more recent data. The data suggest a 10 to 11 year period.

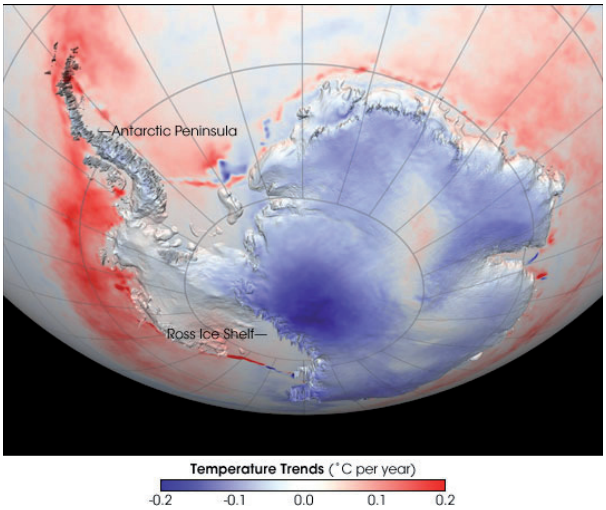


Fig. 9. Cooling in Antarctica (NASA).[22]

However, whenever the burst count goes to zero there is a reversal in the magnetic field of the sun; so the effective period is 20 to 22 years. Figure 11 compares the solar magnetic cycle lengths – lighter line and right ordinate (years) to a moving 11-year average temperature anomalies for the Northern hemisphere, suggesting a potential impact of the burst cycle on temperatures.[15] There are other effects as well that might be related to the solar cycle. Papineau[25] documents that Alaskan researchers recognized that the catch of fish varied with a period of 20 to 30 years; Mantua et al.[26] note that the Pacific Ocean temperature varies with a period of 20 to 30 years; and Alexander et al.[27] report on studies made by Alexander on 198 rivers showing that their flow exhibited a 21 year periodicity.

While not considered a scientific study, it is interesting to track the reports in popular publications reporting the threat of an ice age or the eminence of global warming. These warnings also appear to exhibit a 20 to 30 year cycle.[28]

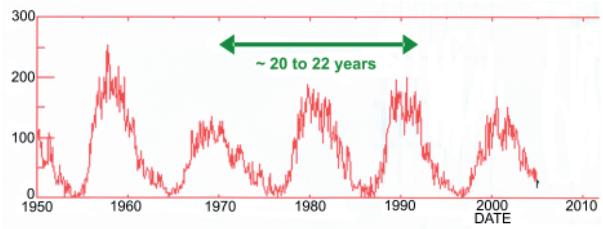


Fig. 10. Sunspot count for recent years.

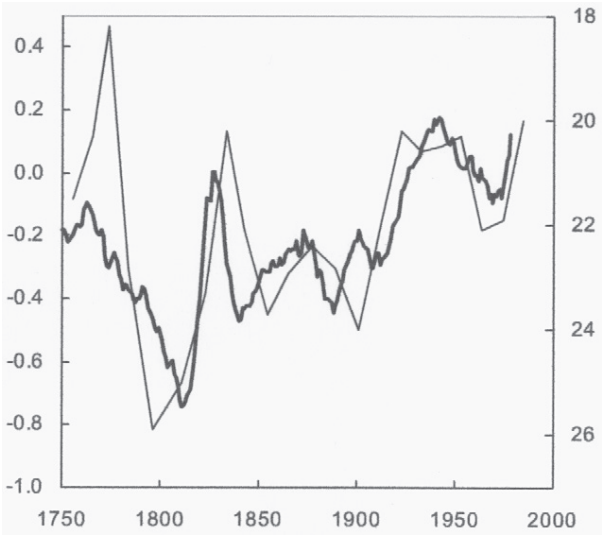


Fig. 11. Sun burst period compared to 11 year averaged NH temperatures.

Figures 12 compares trends in Arctic temperatures with measures of solar intensity (12a) and with Mauna Loa CO_2 concentration (12b). The poor correlation between temperature and CO_2 is evident when compared with the direct correlation with trends in solar intensity. This might appear rather surprising as the actual changes in solar intensity are relatively small. A possible amplification mechanism is that as solar intensity increases so does the solar wind which mutes some of the cosmic ray flux which in turn would affect the formation of low level clouds.[29] Changes in low level clouds lead to changes in surface temperatures. This has been explained in some detail by Svensmark and Calder.[30] It is a source of considerable controversy, but a hypothesis capable of explaining cooling trends in the Southern Pole.

Additional periodicities have been proposed. As an example: the DeVries-Suess solar cycle of 210 years, and the Gleissberg solar cycle of 87 years. It has been suggested that these can combine to exhibit a cycle of close to 1470 to 1500 years (210x7=1470, and 87x17 = 1479). This is close to the1500 year period that has been well documented, see for instance Singer and Avery.[31]

A question arises when one notes that none of these solar effects are effectively included in the current IPCC presented predictions of global warming.

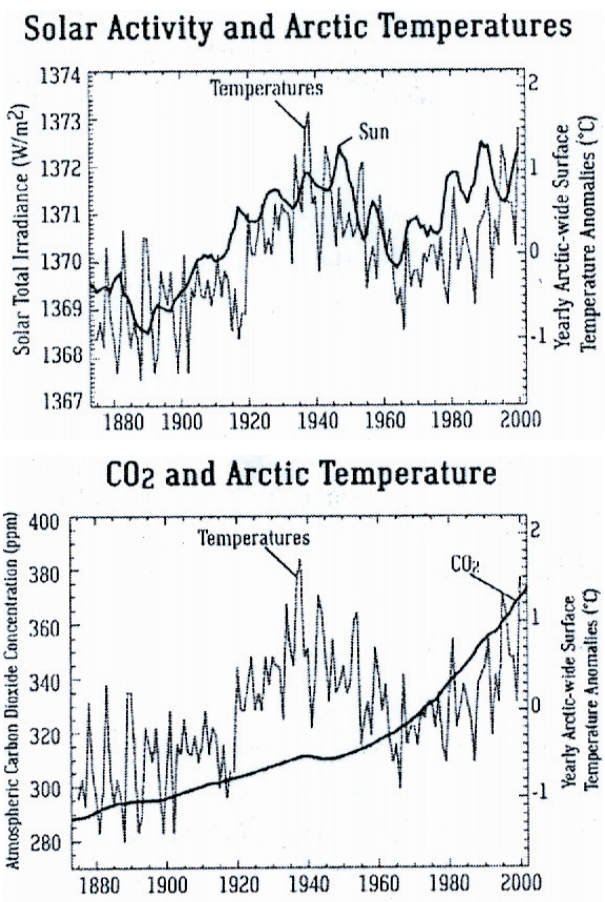
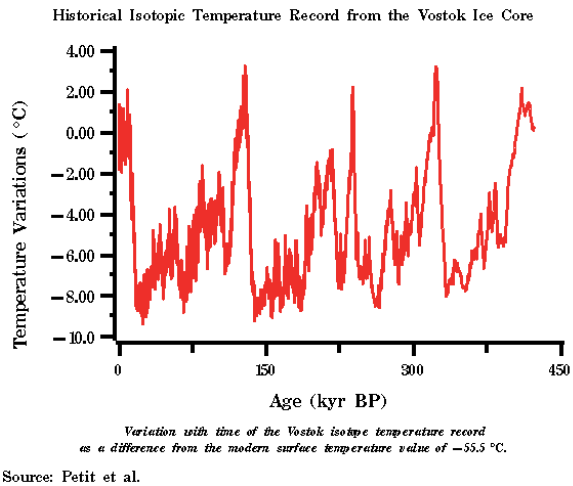


Fig. 12. a) Solar intensity compared to Arctic Temperatures; 13 b) CO_2 concentration compared to Arctic Temperatures.

C. Message from the deep cores - astronomical effects

Figure 13 and figure 14 present proxy temperature measurements.They were obtained from Vostok ice cores[32,33] and from ocean cores[34] respectively. The 100 thousand year periodicity is undeniable; it suggests we are currently in an interglacial period. These two plots are representative of quite a few examples obtained from various ice and ocean cores – all showing interesting periodicities and sudden changes in climate.



Source: Petit et al.

Fig. 13. Vostok temperature (based on proxies).

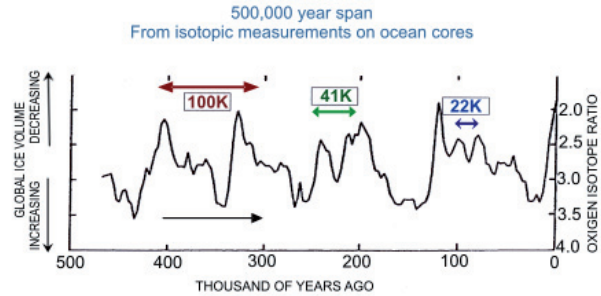


Fig. 14. Ocean core temperatures (based on proxies).

Milankovich[34] was able to relate the occurrence of glacial ages based on the orbital nature of our earth. It has an elliptical path around the sun with an aspect ratio exhibiting a 100 thousand years periodicity. Kepler was the first to note the elliptical trajectory of the earth, and LeVerrier was able to compute its periodicity. Newton demonstrated that the earth would not be a perfect sphere, and hence its axis of rotation would undergo a cyclic precession. The period of the precession was determined by D'Alembert to be 22 thousand years. LeVerrier also proposed that the axis of rotation of the earth would have to undergo a cyclic tilt. Pilgrim found that to be 41k thousand years. These three periods can be seen in figure 14.

None of these effects appear to be accounted for in the current global warming predictive models, raising major questions on the validity of the assessments.

D. Carbon Dioxide

D. 1. Measured concentration histories

Figure 3 presented recent trends in CO_2 concentration taken in Hawaii, and administered by the Scripps institute in cooperation with ORNL. The noted trends are almost identical to those noted in nine other stations in various locations[35]. It is interesting to note that all 10 stations have similar mean values, but their fluctuations are dependent on latitude (increasing from south to north, first slowly through the southern hemisphere, then increasingly north of the equator).

D. 2. Message from the deep cores

Figure 15 presents measured CO_2 concentrations within the Vostok ice core.[36] While there might be some question as to the actual values of these measurements (effects of compaction, potential for diffusion, trapping time and location) there is no doubt that the 100 thousand years periodicity is present leading to high concentrations – even in the absence of anthropogenic sources long before the last millennium.

D. 3. Cause and effect concerns

There is heavy debate on whether changes in CO_2 lead or follow changes in temperature. Within

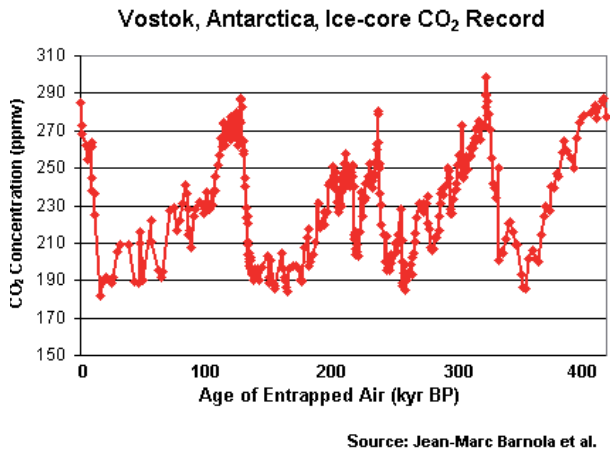


Fig. 15. Vostok carbon dioxide (as measured in trapped gas bubbles).

the published literature we find early articles such as Kuo et al.[37] showing a careful analysis exhibiting a lag with CO_2 following temperature, and more recent published articles such as Khilyuk, L.F. and G.V. Chilingar,[38] suggesting that CO_2 changes follow temperature, rather than precede. On the other hand, the "blogs" appear to be extremely active in their attempt to discredit the published data that exhibits that temperature precedes carbon dioxide concentration. See for instance Real Climate.[39] However, analyses of simultaneous measures of temperature proxies and CO_2 in most cores exhibit areas of lag with CO_2 changes following temperature changes – and raising some concern on the culpability of CO_2, and the likelihood of other effects masking any amplifying influences of CO_2 causing notable temperature increases.

A FURTHER LOOK AT THE MODELS – LACK OF VALIDATION

The fundamental equations used in the global climatic models include those used in turbulent flows. These equations suffer from the fact that they are non-linear, and furthermore require empiricism to lead to their solution. Different flows generally require different empirical relations, or coefficients. This in essence means that the equations are not truly predictive, but rather "postdictive". As more and more data is acquired, the models may be "tuned" by changing the empirical coefficients to provide better predictions.

The physics and exchanges in the earth/atmosphere/sun/space are extremely complex, and they have to be simplified and assumptions made in order to be able to get even approximate predictions. The uncertainties are manifold. Feedback effects are not fully understood, and some are ignored. Furthermore variations in solar intensity are not accounted for, heat transfer from the core of the earth is not included, cloud formation is not fully represented, ocean currents not fully accounted for. Some of these impacts might be insignificant or even subdued by feedback effects. But others might completely mask the anthropogenic effects. The major shortcoming of the models is evident in their inability to predict the past (and the periodic events) – raising serious doubt on their capability to predict other than the immediate future.

CONCLUSIONS

The uncertainty in the measurements of temperatures, the lack of validation of the predicting global climatic models, and the effects of natural cyclic effects affecting climate make it very difficult to ascribe culpability on anthropogenic carbon dioxide for global warming. Political dynamics have led to discussions moving from scientific and technical levels to emotional levels and bitter disagreement. The debate has moved from peer reviewed professional publications to personal attacks through internet blogs. These two camps can be unified as we recall that we humans are on loan on this earth and called to be good stewards and embrace the ideal of sustainability. This in turn calls for effective generation of power, effective use of energy, and control of pollution and emissions.

ACKNOWLEDGEMENTS

The words in this paper are not final. They are evolving as additional data becomes available. In particular I want to acknowledge the many concerned scientists and engineers willing to "ask questions". Unfortunately they are classed by some as "deniers", while in actuality they are embracing one of the main aspects of true science and technology – to always include a question mark together with an assertion. Without the courage of question marks Einstein would have remained silent, and so would have Galileo. Also I want to acknowledge many in different settings that listened attentively to my lectures, many while I served as a DL for ASHRAE. Not only did they listen, they also provided input and asked great questions!

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