



## Is Global Warming Caused by Human Activity?

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Global warming is the rising average temperature of the Earth's atmosphere and oceans. Since the late 19th century, it is projected continuation [1].

A great number of facts and declarations are often presented with regard to global warming and Mankind's role in it. Most of these assertions are derived from the following clear and simple line of reasoning:

**Fact:** CO<sub>2</sub> is a greenhouse gas whose presence in the atmosphere can cause Earth's temperature to increase.

Fact: Since the beginning of the industrial age,

- A. human activity has produced large amounts of CO<sub>2</sub>.
- B. atmospheric levels of CO<sub>2</sub> have been increasing.
- C. global temperatures (on average) have been rising.

Based on these facts only, it is reasonable to conclude that post-industrial age human activity is the cause of recently observed global warming. It is also reasonable to speculate that continued production of CO<sub>2</sub>, at current or higher rates, will continue to drive the temperature still higher, perhaps to catastrophic results. However, a conclusion based only on these facts is, a good example of how little knowledge can be a dangerous thing. To understand this, let's take a moment to consider how science works and what is required by it for a valid scientific conclusion.

How science works:

Initially, a scientist starts out with a hypothesis which is often formed on the basis of observations. However, the hypothesis may come from virtually anywhere\_ a dream, a guess, among others. The point is, once a hypothesis is formed, the first task is to try to disprove it (i.e. falsify it.) If the scientist is unable to falsify the hypothesis, a next step is to publish it so that other scientists can attempt the falsification process. If their attempts at falsification also fail, then the hypothesis earns a measure of credibility.

Furthermore, if the hypothesis represents a new or alternate explanation for a phenomenon which already has an established theory or explanation, there is an additional hurdle that the new hypothesis must clear. The new hypothesis must show that the established the-

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ory is insufficient to explain some observable phenomena which the new hypothesis can explain and the new hypothesis must also be able to explain or be consistent with the all of the other phenomena which the earlier theory could successfully address.

Essentially, the bar is higher for new explanations. One thing a scientist does not do is try to prove that a hypothesis is correct. That would be the nature of pseudo-science and represents a logical error known as improper induction. This is because it is easy to obtain evidence in favor of virtually any hypothesis, but all it takes is one contradicting example to invalidate the conclusion. This concept of falsifications a central theme of Karl Popper's Theory of Demarcation and was also queenly phrased by Albert Einstein when he said,

**"A consensus of 100 scientists is undone by one fact."**

### The global warming hypothesis

Science also recognizes certain phenomena to be true, even if we don't fully understand the processes responsible for the observed phenomena. For example, you may know that magnets attract or repel each other without understanding the physics of magnetism. The Earth has a moon without knowing where the moon came from. Similarly, we know that the Earth has undergone many global temperature actuations' long before humans existed. Even though we don't know or understand the details responsible for those changes, they were the result of natural processes and not caused by Man. Hence, the recent global warming is not the result of natural processes but is instead the result of human activity, it must be shown that

1. Global warming is taking place.
2. Natural causes cannot account for the observed warming. (Established theory fails)
3. Human-activity can account for the observed warming (new theory succeeds,) plus, the new theory must be consistent with historical data.

Each of these points must be true in order to conclude that human activity is the cause of recent global warming. Let's consider these three points, one-by-one:

1. Global warming is taking place true or false?

The answer to this question depends on the period of time we consider. For example, over the last 2000 years, the temperature trend has been generally downward (cooling.) [1, 2] Over the last 700 years the trend has been constant and during the 19th and 20th centuries, the trend has been upward. The current warming trend began





about 1800. At that time, the Earth had just come out of a relatively cold period we call the Little Ice Age. According to the U.S. NOAA, National Climatic Data Center [3], the temperature trend for the 20th Century (1895 to present) was 0.1 F per decade. This trend, however, was not a straight-line, steady trend. In fact, most of the 20th Century warming occurred between 1910 and 1940.

That was followed by a cooling trend from 1940[4] to 1975 (which resulted in world-wide fear of an impending Ice Age.) That cooling was then followed by another warming trend through 1998. However, during the last decade, 1998 to 2008, there has been a net cooling of 1.1 F (0.6C) [5]. The recent cooling has brought temperatures back to their 1980 levels, which is where we were shortly after the 1940 - 1975 cooling. However, the large drop during 2007-2008 was probably anomalous and not a trend. Meanwhile, there has clearly not been any upward trend during the last decade while the trend has been slightly downward.

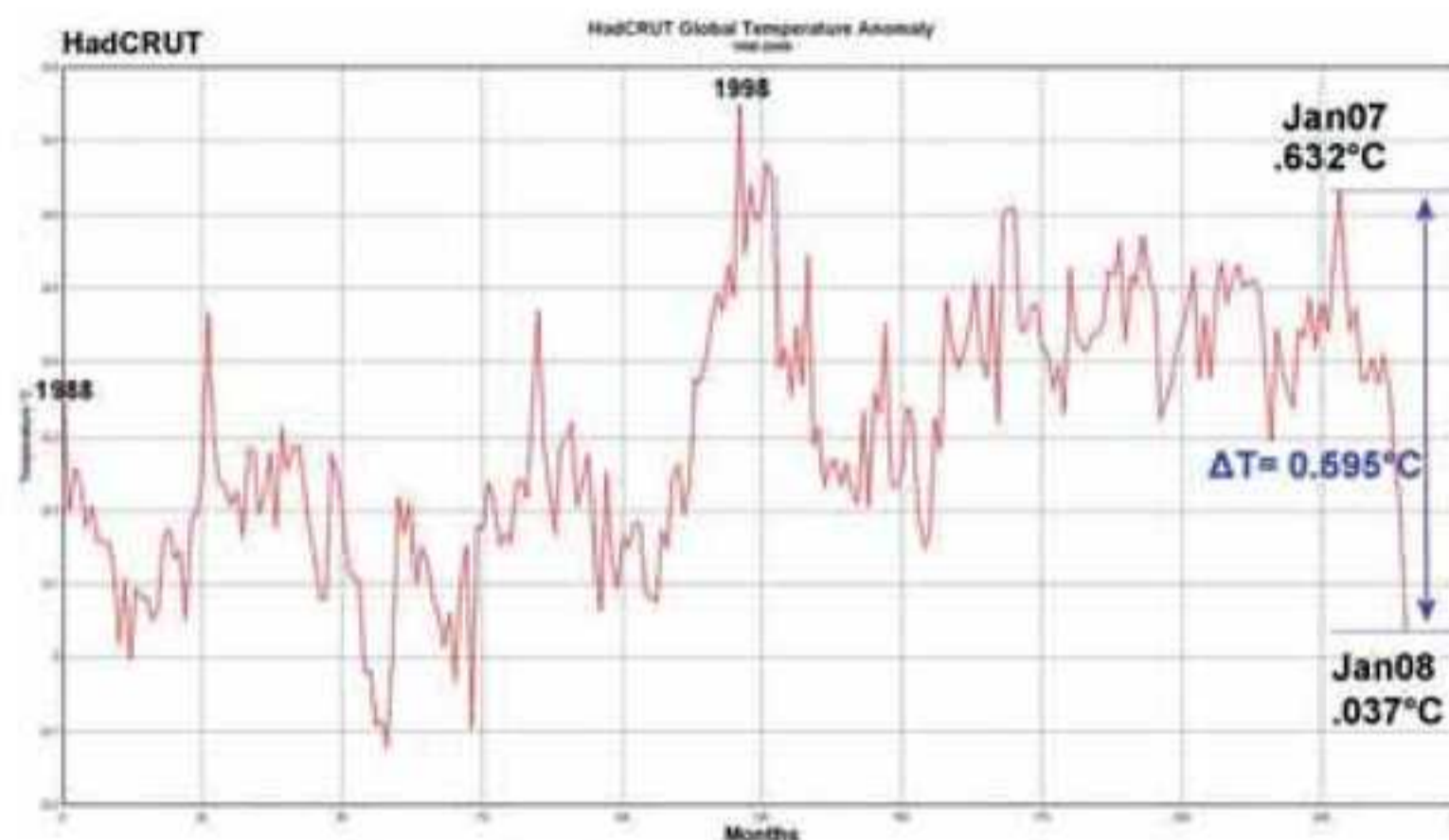


Fig (1) Global temperature anomaly from 1988 to 2008.

So, is global warming taking place? Over the last ten years, there has been global cooling.

The last hundred years has seen warming. The last 2000 years has been cooling, the last 10,000 years has been cooling. The last 200,000 years has been warming. It's a matter of choosing a time-scale. A 30-year trend was long-enough to prompt fears of a coming Ice Age (which turned out to be short-lived.) Then, after only a ten-year warming trend, new concerns about catastrophic warming began (and that warming only continued for another ten years, to 1998). Now we are ten years into a new cooling trend. Clearly, a few tens of years are not enough to establish a long-term trend. It is probably fair to say that the last 200 year warming trend is a recov-



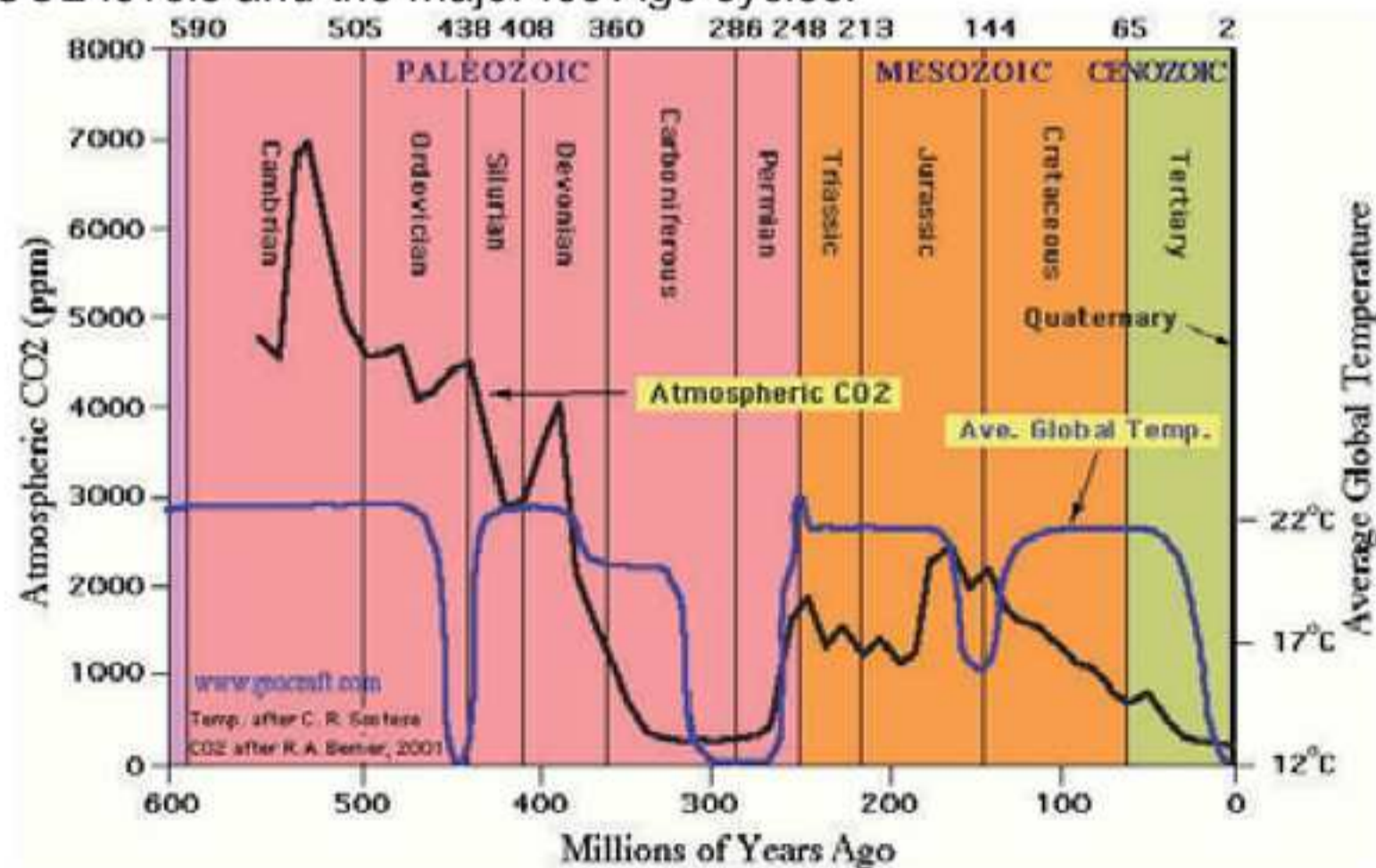


ery from the Little Ice Age and that the warming was a real trend. But we cannot say if more warming is in store or if the present cooling trend will continue. So it is impossible to say, at this time, if there is global warming or not. Therefore, Point (1) stands as neither true nor false. (Remember, Point 1 must be true in order to conclude that human activity is the cause of global warming.)

2. Natural causes cannot account for the present warming true or false?

For the purpose of this discussion, we will define 'natural causes' as any causes which are not the result of human activity. In the context of global warming, human causes are any phenomena which result from large amounts of CO2 produced by human activity. This limits the influence of human activity on global warming to within the last hundred years when quantities of human produced CO2 became significant.

By looking at climate variations which occurred longer ago than a hundred years, we can gain insight about natural variations and natural causes. Then we can determine if the current climate behavior is within the domain of natural variation. On very long time scales, as shown in Fig. 2, we see that there have been at least four warm and cold periods of major proportions. The warm periods are characterized by temperatures about 10 C warmer than we see today. The warm periods are typically about 100 million years in length. Between the warm periods are the major ice ages, which typically last a few million years. The major ice age cycles are believed to be related to changing land mass positions (Continental Drift) which affect the ocean currents and distribution of heat. From the figure, note that there is essentially no correlation between atmospheric CO2 levels and the major Ice Age cycles.



Temp. after C. R. Scotese  
CO2 after R. A. Berner, 2001



Fig (2) The average global temperature and atmospheric CO<sub>2</sub> for the last 600 million years [6].



On a somewhat shorter time scale, like millions or hundreds of thousands of years, we can consider the glacial and interglacial periods which have occurred within the present Ice Age.

These periods correlate well with the Milankovitch Cycles which are related to variations in Earth's orbit, rotation and tilt. Although the correlation of the Milankovitch Cycles with climate variation is very good, the variations in solar flux due to the orbital variations are not, by themselves, sufficient to account for the observed glacial/interglacial temperature variations. However, this has been explained through a positive feedback mechanism: Longer snow seasons resulting from Milankovitch cooling bring about increased reflectivity which add to the cooling and further increases the reflectivity, etc., and is sufficient to lead to the observed results.

On somewhat shorter time scales (tens of thousands of years) we finally see some correlation between temperature and CO<sub>2</sub>. But in all cases, we see that changes in CO<sub>2</sub> follow changes in temperature by about 800 years. Because changes in temperature occur before changes in CO<sub>2</sub> levels, changes in CO<sub>2</sub> levels cannot possibly be the cause of the observed changes in temperature.

However, it is simple to understand why temperature controls CO<sub>2</sub> and why there is a several hundred year delay. It is explained by the fact that the solubility of CO<sub>2</sub> in water is inversely proportional to temperature (see Fig.3). When the oceans warm, they release CO<sub>2</sub>. When the oceans cool, they absorb CO<sub>2</sub>. You can demonstrate this principle yourself by pouring room-temperature glass of soda and leaving it sit at room-temperature, and also pouring a cold glass of soda and letting it sit in the refrigerator. The warmer glass will lose its 'fizz' within minutes while the colder glass retains much more. The 'fizz' is CO<sub>2</sub> dissolved in the water. Furthermore, since the oceans have a very large heat capacity compared to the atmosphere, it takes hundreds of years for the ocean temperatures to respond to changes in atmospheric temperatures.

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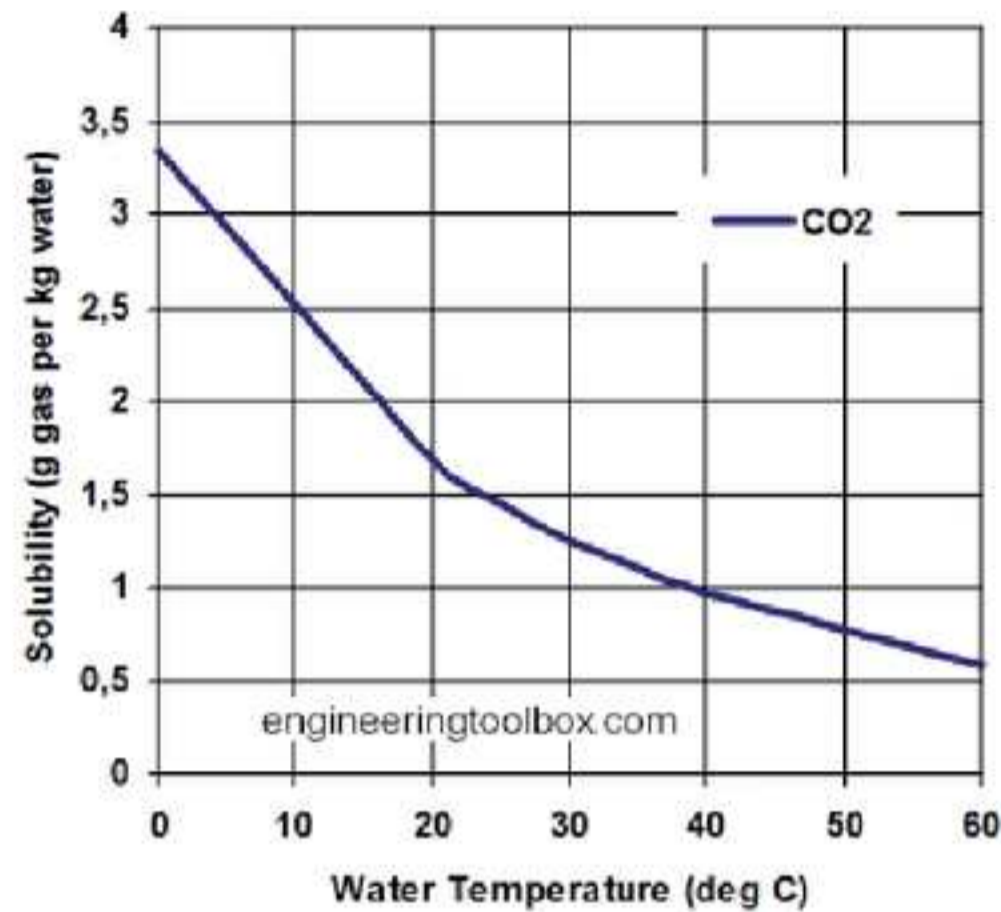


Fig (3) the solubility of CO2 in water as a function of temperature.

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On still shorter timescales, we can consider solar variability. There are several solar cycles, typically on the order of tens of years. Like the Milankovitch cycles, there is a very good correlation with temperature and solar activity. Since the correlation is good and since it is not possible for the Earth's temperature to affect solar activity, it must be true that solar activity affects Earth's temperature. An aspect of this theory which is not completely understood is that variations in solar luminosity are not, by themselves, sufficient to account for observed changes in temperature. Therefore, a feedback mechanism must also be involved.

One such mechanism has been proposed which is based on the observation that increased solar activity is also accompanied by increased solar wind which shields the Earth from cosmic rays. Cosmic rays, meanwhile, have been shown to play a role in cloud formation.

So when the sun is more active, the solar wind deflects more cosmic rays. This leads to a decrease in low-altitude cloud formation, permitting more sunshine to strike the Earth. This feedback appears to be sufficient to account for the remaining temperature variation.

However, it is irrelevant whether this is the correct feedback mechanism or not if the fact remains of a strong correlation between solar/sunspot activity and arctic temperature.

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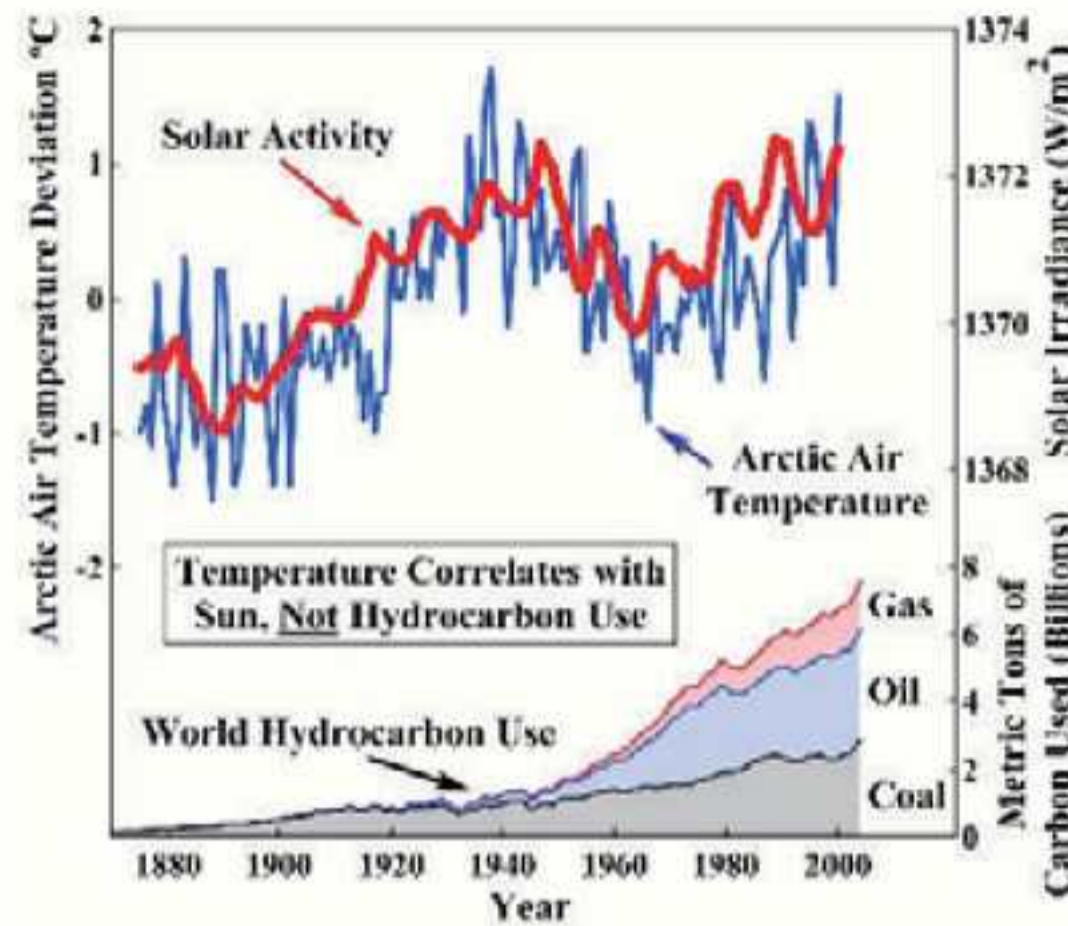


Fig (4) The Arctic surface air temperature, solar irradiance and world hydrocarbon use.

The data in Fig. (4) show that solar irradiance correlates well with Arctic temperature while hydro carbon use does not. Although this positive correlation between temperature and solar irradiance does not necessarily prove that solar irradiance is the cause and temperature is the effect, to argue otherwise, one must offer a physical mechanism by which temperatures in the Arctic are able to affect the behavior of the sun.

If the current temperature trend can be shown to be outside the limits of what we know to be natural variability, then a strong case can be made for an un-natural or man-made cause. So Point 2 is false. (Point 2 must be true in order to conclude that human activity is the cause of global warming.)

3. Human activity can account for the present warming true or false? As we have noted earlier, there has been an approximately 0.1 F per decade rise in temperature over the last hundred years. Could this be the result of human activity?

To address this question, let us first appeal to some basic rules of logic so that we may quickly and easily disqualify some obviously invalid lines of reasoning.

#### Disqualified evidence

Evidence of warming is often presented as evidence of human-caused warming. The logical construction of this argument is as follows: If human activity causes global warming, then the Earth will warm. The Earth is warming. Therefore, human activity causes global warming.

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This argument is invalid because the conclusion is drawn from a common logical error known as the converse error.

Another invalid argument is the claim that, "If there is a consensus of scientists that global warming is human-caused, then human-caused global warming must be true." This argument is invalid for at least two reasons: First of all, the premise is not true. There is not a consensus of scientists as proved by a recent petition of 32,000 scientists who object to the premise.

However, even if there were a consensus, it is still a logically invalid conclusion by reason of improper induction. Consider, for example, the consensus of scientists long ago who believed the Sun and stars revolve around the Earth. Clearly, consensus does not make it true. Computer climate models do not provide evidence of human-caused global warming. There are many reasons to discount the predictions of the computer climate models. Most importantly, is the fact that the computer models are not real and they have not been validated against real observations? The validations have consisted of comparing one computer model to another.

#### Valid evidence

The fundamental mechanism through which human activity is believed to affect global temperature is based on the greenhouse gas effect of atmospheric CO<sub>2</sub>. This effect is combined with the additional premise that human activity produces quantities of atmospheric CO<sub>2</sub> that are, presumably, large enough to affect global temperature (through the mechanism of greenhouse gas warming.) This is a valid line of reasoning, and should be examined.

Greenhouse gas theory is often explained with an overly simplified (and incorrect) model.

The typical overly simplified model is represented in Fig. 5, from the British National Space Center. This model depicts the cooling of the Earth by thermal radiation from the surface. One of the reasons this model is incorrect is because the surface of Earth is not cooled primarily by thermal radiation.



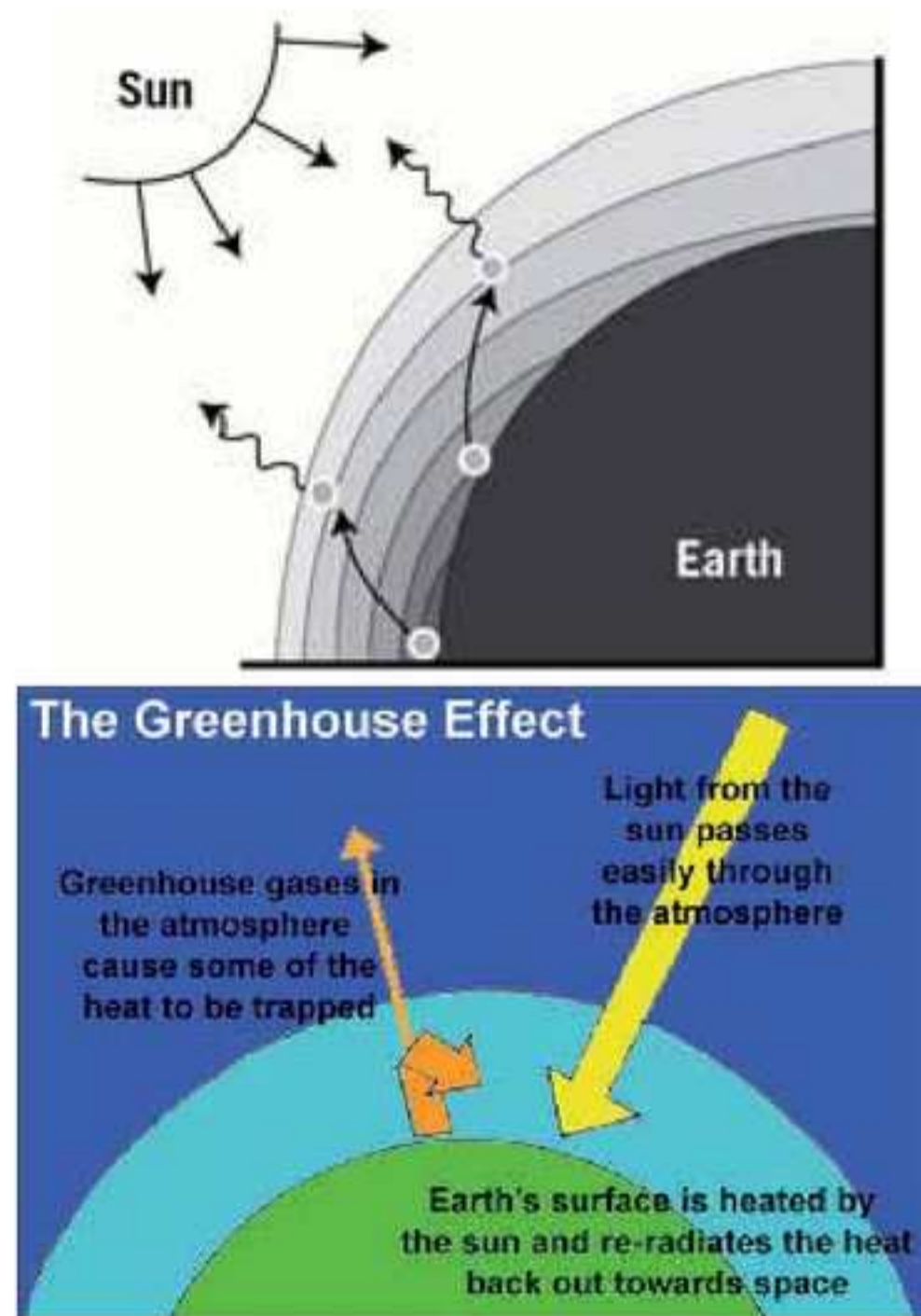


Fig (5) overly simplified model of  
Fig (6) more realistic greenhouse gas phenomenon.  
Greenhouse model.

Lighter shading represents reduced opacity due to diminishing water vapor density. A more accurate (but still simplified) greenhouse gas model is depicted in Fig.6. In this model, the effect of water vapor, the main greenhouse gas, is strongest near the Earth's surface in the tropics. The effect decreases sharply with both altitude and latitude. The dark bands indicate the largest effects while the lighter bands indicate diminishing effects as latitude and altitude increase. In the tropical latitudes near the surface, there is sufficient greenhouse opacity that the surface cannot effectively cool by thermal radiation emission. As a result, heat is conducted away from the surface by fluid motions (shown by solid lines in Figure (6)). These motions carry the heat up in altitude and in latitude (toward the poles) to levels where it is possible for thermal radiation emitted from these levels to escape to space, shown by the wavy line. This is how the standard greenhouse gas model works. Indeed, all climate models predict that, if greenhouse gases are driving global warming, there will be a unique 'fingerprint' of the effect in the form of a warming trend in the tropical troposphere which increases with altitude. Furthermore, since climate changes due to solar variability





or other known natural factors will not show this characteristic pattern, this is a good test of the greenhouse hypothesis. Putting in some numbers, Lee et al. (2007) investigated four different General Circulation Models to examine how temperature, according to the models, should change with CO<sub>2</sub>.

### Conclusion

Recall our conditions that, in order to justify the new proposition that recent global warming is not the result of natural causes but is, instead, the result of human activity, and the following conditions must be true:

### Global warming is taking place

Natural causes cannot account for the observed warming. Human activity can account for the observed warming and the new theory must be consistent with historical data what we've shown in the previous sections is that Condition (1) is not true. Condition (2) is not true and Condition (3) is not true. Since all three of these conditions must be true in order to justify the theory of human-cause global warming, we must conclude that there is no logical basis on which to believe that theory.

One can also look at this situation from a more practical point of view. On the one hand, we have the natural explanation.

There is good correlation between temperature and Earth's orbital variations

There is good correlation between temperature and solar variations. There is historical evidence of natural climate cycles. There is historical evidence that changes in temperature cause changes in atmospheric CO<sub>2</sub>. There is scientific basis for each of these observations. On the other hand, we have the anthropogenic greenhouse gas explanation.

The physical evidence for greenhouse gas warming is absent.

The correlation between CO<sub>2</sub> and temperature is absent.

The historical evidence is not consistent with CO<sub>2</sub> acting as a driver of temperature.

Temperature trends during the most recent decade have displayed the exact opposite behavior than predicted by the greenhouse theory.



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