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Assessing the Scientific Evidence of Increasing Global Temperature: A Review of Literature.

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ABSTRACT

It is difficult for the scientific community to come to a general consensus over the cause of the increase in average global temperature. Over the past 150 years surface temperatures have increased between 0.3° to 0.6° Celsius. This is due to infrared active gases absorbing thermal infrared radiation, causing an increase of global temperatures. Much emphasis is given to increased fossil fuel combustion. Carbon dioxide is the major greenhouse gas that both dominates in biochemical cycles, and naturally fluctuates throughout the atmosphere. Ice core records show that the escalated temperatures are a natural trend. Based on these sediment records, there has been a steady exchange of CO_2 between natural sinks and the atmosphere. To measure the value of greenhouse gases, focus has been put on records from periods 1000 years before recent anthropogenic CO_2 production. The adjusted records of satellite data indicate an increase in global temperature far lower that what is seen at ground-based thermometer records. Only recently has it been discovered that satellite temperature readings are erroneous. Because of this, more attention is now being given to radiosondes. There are also admitted weaknesses in computer projections. Water vapor is not properly accounted for, and these simulations would not show as much warming if water vapor were not exaggerated. Extensive research is being conducted by both private sectors and government agencies. They aim to create partnerships that benefit both parties and at the same time strengthen the economy.

Keywords: *Global Warming, satellite measurements, scientific debate, ice core measurements.*

INTRODUCTION

The causes of global warming are highly debated by scientists around the world. Some say it is a naturally occurring phenomenon and others say it is caused by the over utilization of fossil fuels by industrialized countries. The burning of these fuels produces greenhouse gases that trap heat in the atmosphere, causing an unnatural warming pattern. Beginning with the Industrial Revolution, usage of such material has kept the wheels of the economy turning. To propose that we bring this practice to a halt, or to cut back considerably seems unpractical and ludicrous to many.

Studies have been undertaken in an effort to match patterns of temperature change at the surface and in the atmosphere to expected patterns from ocean-atmosphere general circulation models. The major flaw with the evidence of global warming trends is that global-scale temperatures do not have deep roots. This is not adequate evidence to base scientific findings on, given the age of the earth. What isn't to say that the climate trends we are experiencing isn't a natural trend? Ultimately, it is difficult for scientists to obtain concrete evidence in the debate over the hypothesis of global warming.

Carbon dioxide (CO_2) is a major greenhouse gas that is believed to have increased in the atmosphere through anthropocentric activity. Carbon is the dominant element in the biogeochemical cycles of earth. It naturally fluctuates throughout the atmosphere because of its uptake due to excess photosynthesis and storage of carbon by plants during the growing season, and during the fall and winter when the plants decay, the carbon is released back into the atmosphere (Houghton, 1997).

Attempts are being made to monitor global temperature increases. Satellite measurements and radiosonde measurements are compared for the lower stratosphere and troposphere. These measurements have shown that since the 1960's it is likely that there has been a downward trend in temperature fluctuations (Christy, 1995). Only later has it been discovered that these measurements are not as reliable as once believed. Satellite and surface temperatures differ significantly, but ultimately they do show global temperature changes and greenhouse gases have been dominant throughout the 20th century (Christy *et al.*, 1997; Jones, 1998).

Ice core sediment inventory implies that current climate is a natural trend. These records can be linked to general climate change that has occurred over the past several hundred million years. These records link mean global temperatures to the role of CO_2 in the atmosphere (Weaver *et al.*, 1998).

DISCUSSION

The Carbon Cycle

The carbon cycle is the mechanism by which carbon dioxide (CO_2) is moved through the environment. Animals contribute to the carbon cycle when they respire. Combustion, rotting wood, and the decomposition of organic matter contribute in the same way. These processes include the intake of oxygen from the atmosphere in sequence with the utilization of carbon to form a product of CO_2. This gas is then

expelled into the atmosphere as a byproduct of the reaction. The process of photosynthesis in plants works in the opposite way creating a "working" balance between the two. About one quarter of the atmospheric CO_2 is cycled through each year. Carbon dioxide is not destroyed as other greenhouse gases. It is recycled throughout the Earth's natural processes (Houghton, 1997).

Carbon cycles through the various reservoirs or "sinks" of Earth's natural operations: the atmosphere, the oceans, and the soil and land biota. Of the carbon that is processed, half of this is through land biota and the other half through physical and chemical processes across the ocean surfaces. The land and ocean sinks are much larger than the atmosphere. A small change in these concentrations could have a large effect on the atmospheric concentration. A release of two percent of the carbon from the ocean would double the amount of atmospheric CO_2. The carbon sinks exchange carbon amongst themselves on a time scale that can range from less than a year to decades to millennia. These time scales are generally longer than the time a molecule of carbon dioxide is in the atmosphere (which is roughly four years). This large turnover rate indicates that the time in takes for a disturbance in the atmospheric carbon cycle to balance cannot be described as any constant. For this reason, a lifetime of one hundred years is often quoted as to provide for a guide. Therefore, the use of a single lifetime can be misleading (Houghton, 1997).

The major distribution of vegetation has been altered by human intervention. In the eastern United States, only a small amount of original forest is traceable. This leaves the current landscape covered with second-growth forests, cropland, and urban developments. In Europe, the hardwood forests have been removed to make way for increased agricultural production. In the Philippines, only 29 million acres has survived from a mass acreage of 70 million. The Amazon rain forests had at one time covered an area nearly half that of the Unites States. They are now being reduced at an average rate of 20,000km^2 per year. (Cotton and Pielke, 1992). Specifically, hard wood forests have been harvested and removed to suit the needs of human activity. This includes timber production and clearing of forests for agricultural purposes, and urban developments. The disappearance of this valuable resource is linked to global warming in two significant ways. First, there is a change in the fraction of solar radiation reflected back to space. Secondly, there is a change in the fraction of heat, which is used to evaporate and transpirate water vapor to the atmosphere. Vegetation provides an effective flow area to extract water from within the soil in the root zone and transfer it back to the atmosphere (Cotton and Pielke, 1992).

Human Impact on Global Climate

The increase of CO_2 in the Earth's atmosphere due to the burning of fossil fuels is believed to be linked to the overall temperature increase of the Earth. Worldwide temperature measurements have been used to estimate that global mean annual surface temperatures have increased between 0.3° and 0.6° Celsius over the past 150 years (Hansen and Lebedeff, 1987). It is suggested that human activity is the cause. Previously, it could not be deducted that the trends in temperature increase were a product of the greenhouse effect. The trend of warm years in the 1980's and 1990's was still believed to be a result of a natural temperature flux. Not until recently had there been such a large agreement in the scientific community about the greenhouse effect (Bender, 1997).

Greenhouse gases are those in the atmosphere, which, by absorbing thermal radiation emitted by the Earth's surface have a blanketing effect. The predominate greenhouse gases that have increased in the atmosphere over the industrial period are CO_2, Methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons CFC-11 (CCl_3F) and CFC-12 ($CCl2F_2$) (Hansen *et al.*, 1998; Schimel *et al.*, 1996). Infrared (IR) active gases, mainly water vapor (H_2O), carbon dioxide (CO_2), and ozone (O_3), absorb thermal IR radiation emitted by the Earth's surface and atmosphere. These gases absorb upwelling thermal IR radiation and heat the absorbed gases. This occurs both upward and downward, causing a loss at the Earth's surface. Without these increased greenhouse gases, a larger fraction of the upwelling thermal IR radiation would escape into space. Consequently, the average surface air temperature of the Earth is nearly 30°C higher than it would be without reradiation and absorption of IR energy (Houghton, 1997; Cotton and Pielke, 1992; Kellogg, 1996).

Greenhouse gases both respond and contribute to climate change. Over a wide time scale, atmospheric CO_2 has interacted in complex ways. This implies that the geological record is not likely to itemize anthropogenic CO_2 emissions. There is no known pattern of geologic increase of atmospheric CO_2 that was not coexistent with changes of other components of the carbon cycle and climate system (Crowley, 1997; Sundquist, 1986, 1993).

A great deal of concern is directed at human activity. The concern relative to the potential of industrial and other anthropocentric emissions of CO_2 on the net radiation budget began early in the 20th century. In 1958 regular measurements of CO_2 were being taken at widely spaced locations. This gives only roughly 40 years for direct assessment of the changing concentrations of CO_2 (Cotton and Pielke, 1992).

Before human activity became a significant upheaval, the exchange rate between the sinks was exceptionally constant. Based on measurements taken from ice cores, prior to around 1750, a steady balance was maintained for several thousand years. This marks the beginning of industrialization. The Industrial Revolution has resulted in an increase in CO_2 concentration by 30 percent. Content has changed

from 280 parts per million (ppm) around 1700 to over 360 ppm at the present day. Measurements that have been recorded since 1959 shows carbon dioxide levels have increased on average by 1.5 ppm each year. This increase distributed throughout the atmosphere adds 3.3 thousand million gigatonnes (Gt) to the atmospheric carbon sink each year (Houghton, 1997).

The Role of Ice Core Measurements

An indirect assessment of CO_2 concentrations can be made through the examination of airtight bubbles in glacier ice. Glaciers are present on every continent except Australia. This makes them excellent dispersed regional indicators of climate change. Studies of these glaciers have shown substantial recession of many of the ice caps and non-tide water since the early 19th century (Dyurgerov and Meier, 1997).

It is difficult to piece together the records of the past few thousand years because subsidiary data is available. There is evidence that climatic conditions were sometimes cooler and sometimes warmer than modern temperatures. There is also evidence of intense climate changes that surpass recent happenings. These climate fluctuations occurred at a time when variations in atmospheric CO_2 were minute. These records show that the global climate system has been influenced by many factors other than greenhouse gases (Dahl-Jensen *et al.*, 1998; Bond *et al.*, 1998).

To measure the value of geological evidence of greenhouse gases, focus is put on records from periods when changes in atmospheric CO_2 were much larger than those that occurred during the millennia immediately before the recent increase in anthropogenic CO_2 production (Ledley *et al.*, 1999).

Significant natural variations in atmospheric CO_2 have been discovered from the geological past. Gas-bubbles trapped in glacier-ice cores show a variation of 80-100ppm. This is linked to glacial oscillations that reflect low CO_2 concentrations and interglacial climatic oscillations that reflect high CO_2 concentrations. Ice core profiles show a similar equivalence with climate (Chappellaz *et al.*, 1990; Wahlen, 1998).

Larger former variations in atmospheric CO_2 have been estimated using geological models fettered by the ice-core sediment record. These larger and slower CO_2 changes can be correlated with general features of climate change that have occurred over the past several hundred million years. These paleoclimate model simulations support the explanation of global mean temperatures of the past, giving direct importance to CO_2 (Weaver *et al.*, 1998).

Satellite Data Validity

Over the past several years, new weaknesses have been found in satellite data. Much of these findings lead to assumptions that prior data may not be as accurate as once believed. Many major findings in the area of global warming research have proven to be erroneous. Creditability is also finding to be weak. Ichtiaque S. Rasool (1999), author of *Scientific Responsibility in Global Climate Change Research,* suggests that misinterpreted information is released to the press and believed to be fact. Satellites that have been collecting surface temperature readings were not designed to do so. Information is then published with weak credibility. The satellites are either so new that the technology is still not fully understood, or is so old that sensors are malfunctioning, orbits are declining, and there is inconsistency in the local observation time (Rasool, 1999).

Errors occur in the machinery as well (Rasool, 1999). The U.S.-French satellite *Topex-Poseidon* was discovered to have an error with one of its algorithms. Because of this error, the estimated global sea-level rise over a period of three years was reported as zero. After further analysis of this data, it had been found that there has actually been a positive increase of 1 to 2 mm per year. The accuracy of this data is very critical when predicting what areas of the globe will be flooded by the rise of the sea level (Rasool, 1999; Kovoski 1998).

Gradual decay in the orbital satellites produces a false cooling effect in the temperature readings. These satellite records indicate a warming rate of 0.07 degrees Celsius per decade. This is only half of the ground-based trend of 0.13 degrees Celsius per decade (Kovoski, 1998).

One of the most important points to consider is that the adjusted records indicate an increase in global temperature far lower than what is seen at ground-based thermometer records. Satellite figures may be exaggerated by a factor of three. This claim may now draw more attention to the third main tracking method--data collected from balloon-carried devices, called radiosondes. Because separate evidence is an overruling component of science, radiosondes may be used as a middleman regarding this disagreement between orbital and surface measurements (Kovski, 1998).

John Christy, an atmospheric scientist at the University of Alabama at Huntsville says that Wentz and Schable are overcorrecting this data. They are giving no room to investigate the raw data collected from these satellites in an attempt to understand the compensating correction procedures that must be made (Christy *et al.*, 1997). After all the adjustments have been made on the satellite data, it shows a warming trend of 0.04 degrees Celsius per decade, one-third of the ground-based trend. This would only amount to 0.4 degrees Celsius in one century. Verification of Christy's estimated data is coming from balloon data. After analysis of this data, a close agreement has been found with satellite data, which could take the air out of accusations of dangerous warming (Christy *et al.*, 1997).

Computer Projecting

In addition to the flaws associated with satellite

projections, there is also skepticism associated with that of computer projecting. One of the main reasons models are developed is to predict what climate changes may be to come in the next century and beyond. Because model simulations are based on assumptions of future emissions of greenhouse gases, which in turn are dependent on factors of human behavior, it is inappropriate to call these simulations "predictions." Therefor, they are generally referred to as "projections" to what may come to pass if trends in human activity continue at the assumed rate (Houghton, 1997).

Gerald T. Westbrook of TSBV Consultants, Houston, points out that computer models that mimic global warming trends could be flawed, and their projections are questionable. Westbrook insists that proper attention is not given to water vapor in these projections and that the role of water vapor has been modified to fit the models. Allegedly, global climate projections would not show so much warming if they did not exaggerate water vapor (Richards, 2001).

Computational models predict that the global climate will warm significantly over the next century due to human activity. J.D. Mahlman defends the validity of computer generated projections. The climate models do a reasonably good job of capturing the essence of the large-scale aspects of the current climate and its considerable natural variability on time scales ranging from 1 day to decades. Despite the many success stories of projecting, it is admitted that there are weaknesses in these models, and this provides unreliable information to model projections of human-influenced climate changes (Mahlman, 1997).

Combating Global Warming

Extensive research is being conducted in both private sectors and by government agencies. They aim to create partnerships that benefit all parties involved and at the same time strengthen the economy. Individual states are actively pursuing policies and programs that will reduce and/or prevent emissions. These goals would be accomplished through energy efficiency, renewable energy technologies, better municipal planning, and progressive sustainable energy and resource practices. They aim to combine energy efficiency with pollution prevention within industry (EPA, 2000).

Summary

In summary, during the industrial period, greenhouse gases have increased in the atmosphere significantly. This includes CO_2, CH_4, N_2O, CFC-11(CCl_3F) and CFC-12 ($CCl2F_2$). It is suggested that this is the result of human activity. With the increase of these gases (especially CO_2) comes an increase in the IR energy that is absorbed by the atmosphere. This ultimately produces a warming effect on the Earth's surface.

The role of carbon and CO_2 is very important for the Earth's cycles to carry out. Carbon cycles throughout the sinks and a small change in these concentrations could have a dramatic effect on the atmospheric concentration. The change of the solar radiation that is reflected back into space and the change in the heat that is used to evaporate water vapor contributes to average global temperature increases.

Ice core records show that current climate conditions could be a natural trend. It also shows a steady balance of the exchange of CO_2 between the atmosphere and natural sinks. Ice core measurements also show that the global climate has been influenced by other factors other than greenhouse gases. These climate fluctuations are shown in the frozen ice.

Global mean temperatures have been collected via satellite. This data has proven over the years to be faulty. As a result, reports have been made regarding the sea-level rise that is to be expected. This draws more attention to data collected from radiosondes.

In addition to the flaws associated with satellite data, there is also much skepticism associated with the projections of computer models. Mainly, the role of water vapor in the atmosphere is not getting adequate attention. This makes it difficult to be certain about areas of the earth that will flood due to the rise of sea-level.

Private and public organizations have been conducting extensive research in an effort to reduce emissions. Programs are mainly focused on combining energy efficiency with pollution prevention.

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