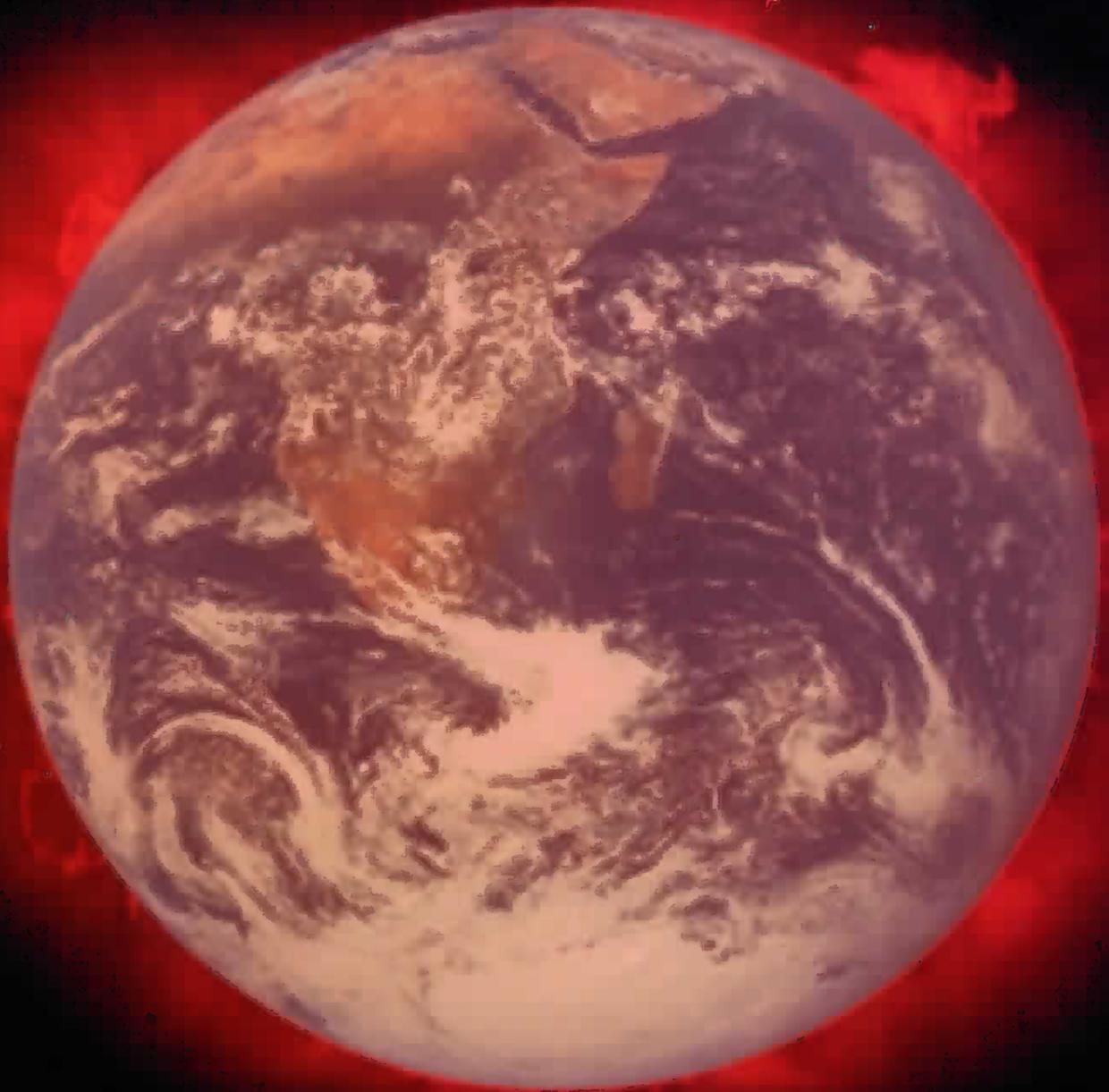


GLOBAL WARMING



Facts, Myths and Politics

It's hot outside.

We hear in the news that temperature records are being broken everywhere in the World; that there have been more than 120 heat-related deaths in the USA to date (most in Texas), nearly total crop losses in south Georgia, gigantic wild fires in eastern Florida and the Okefenokee swamp, and a 122° temperature recorded in Arizona. Less well known is that massive ice chunks in Antarctica have been melting into the southern ocean, including one (about 80 square miles by a mile thick), which fell last March. Together with thermal expansion of ocean water, this is causing rising sea levels that are slowly encroaching on low-lying shore areas and islands. There are literally tens of thousands of cubic miles of ice remaining to fall into the ocean if all the Antarctic ice shelves break up. Also, not often mentioned in the popular press, is evidence that tropical diseases, such as dengue fevers, malaria and hantavirus, are spreading into new terrains which used to be too cool to support their animal vectors. Clearly, we have reason to be concerned about the climate.

We've also heard about scientific predictions of global warming and the political (usually conservative) doubts about the same. But, there is also a dose of skepticism about global warming in some quarters of the scientific community, which feeds the political doubters. Last year, the United States declined to sign the international treaty drafted by a United Nations committee on climate change in Kyoto, Japan (the so-called "Kyoto protocol"), because members of Congress quoted their chosen scientific opinions disputing the reality of "Global Warming," and were concerned about the economic impacts of the restrictions on greenhouse gases that the treaty required. Because we, the world's largest emitters of greenhouse gases, did not sign the accords, for practical purposes the Kyoto protocol is meaningless and there is nothing on a cooperative scale being done internationally to curb the emissions of "greenhouse gases." (Fortunately, scientists at the Kyoto meeting did make extensive international agreements to exchange data, which may ultimately be the most important outcome that could have occurred.) Many people, including political leaders, believe it is irrelevant whether or not we do curb these gases because they are convinced the greenhouse effect is nonexistent or insignificant to global weather. It's hot because it's hot. Some even argue it is beneficial (see the sidebar). From my discussions with students and others, and from news reports, I have come to realize that much of the public does not believe in the greenhouse effect, and that about as many believe global warming is due to "the Ozone Hole." Both impressions (no greenhouse effect, ozone heating) are factually wrong, but how is one to

know which of many related arguments are true facts and how much of the scientific information can be definitely related to our present weather situation?

Fact: It really is warm. The warmest three years on record have occurred in the 1990's, and most months of this year are the warmest ever observed by scientists. So, 1998 should break all previous records. Recent published analyses of data from Greenland ice cores, tree rings and ocean sediments confirm that this decade has included the warmest years since 1400 AD. This is especially interesting since the last "Ice Age" ended 10,000 years ago, and the immediate post-Ice Age climate was almost certainly not warmer than present. Therefore, although the older data are less certain, we have a very high probability that the present year and decade are the warmest since the beginning of the last Ice Age, more than 60,000 years ago!

Fact: The Greenhouse Effect is real. It's what makes greenhouses work. The basic concept is that certain gases (carbon dioxide, methane and water vapor, the major ones) allow sunlight to penetrate an atmosphere containing them, both indoors and outdoors, but they retard the emissions of heat rays (infrared) which bounce off surfaces and change their wavelengths by refraction. The net effect is that an environment containing these gases will heat up. In greenhouses, it keeps the air temperature many degrees above outside temperature without artificial heating. On the planet Venus, thick clouds of carbon dioxide keep the planet's surface at several hundred degrees centigrade. Most scientists assume the same is happening on Earth, to an increasing degree as greenhouse gases (mostly carbon dioxide) increase.

Fact: The Earth has an artificial build-up of greenhouse gases. Evidence from many sources (especially Greenland ice cores) shows that the background level of CO₂ was approximately 200 parts per million (ppm) for more than 10,000 years. This level remained fairly constant until the Eighteenth Century, when it began to climb slowly to 275 ppm due

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to release of carbon from industrial coal fires and from deforestation. Then in the early Twentieth Century, it climbed much faster as petroleum and hydrocarbon gases became used in all parts of civilian life, especially in automobiles. Present atmospheric CO₂ is approximately 365 ppm and climbing. Therefore, we have a 54% increase over a roughly 250 year span; however, at the present rate of increase, we will reach about 600 ppm by 2100. This is a pretty stark reality but, curiously, few people involved on either side of the global warming debate dispute these facts.

Most of this man-made carbon dioxide comes from burning fossil carbon fuels (oil, gas, coal), but a large portion is caused by deforestation. Also, undetermined amounts of methane, another greenhouse gas, have been added to the atmosphere from several human activities, including waste dumps, landfills, and (the subject of many jokes) the digestive gases of cattle and other ruminant farm animals. Of course, huge natural sources and reservoirs of these greenhouse gases exist. The oceans and soil suck up vast quantities of CO₂ and methane, and plants build their tissues from carbon dioxide and water. Volcanoes spew out water vapor and a wide variety of other gases. These natural sources and sinks formed the background levels to which are added man-made contributions. Therefore, arguments about natural sources of greenhouse gases beg the point; they were already present and helped establish the world climate favorable for modern human and all other life. Manmade changes in greenhouse gases alter the quantities of those gases.

Fact: A cold year or two does not mean global warming is over or doesn't exist.

Weather patterns are affected by many factors, including minor fluctuations in the sun's output, El Niño and La Niña effects in the oceans, volcanic gases, ice crystals in the upper atmosphere and stratosphere, cloud patterns, and some randomness (also termed "chaos"). Some current studies show that the intensity of El Niño events may be affected by global warming, but that is not yet established well enough to be called "fact." A fairly recent volcanic event, the eruption of Pinatubo (Philippines, June 1991) released enormous volumes (estimated at 15 to 32 million tons) of sulfur dioxide, dust and water vapor into the stratosphere, forming high-altitude ice crystals and sulfur smog which lingered for several years. These stratospheric aerosols had a strong climatic cooling effect by simply reflecting sunlight back to space. The same effect was profoundly evident after Krakatau erupted in 1883, when there followed an infamous "year without a summer" around the World. It is not coincidental that the relatively coolest years of the present decade have been 1991 to 1994, when the effects of Pinatubo were most pronounced, and that it has been relatively warm

every year since the emissions from the volcano dissipated. These occasional volcanic and other modifiers of global climate may be considered part of the "background" and must be factored into calculations of global warming. Critics of the reality of global warming often cite the irregularities of climates and occasional cool years as evidence that there is not a measurable trend, but they are ignoring known short-term cooling effects.

Fact: The ozone hole is not related to the greenhouse effect.

The ozone hole is caused by chemical reactions related to the presence of breakdown products of chlorofluorocarbons (especially freons and halon) in the stratosphere. The "hole" occurs over Antarctica, and perhaps over the Arctic, and has the primary effect of allowing cosmic radiation to reach Earth at higher than normal intensities. If it is related at all to global warming, the relationship is uncertain and probably very small; but it has nothing directly to do with the greenhouse effect.

Fortunately, because the ozone hole problem is serious and very clear, there has been an international accord on dealing with the cause of ozone depletion. The USA signed the Montreal agreement on restricting the use and manufacture of certain chlorofluorocarbons, and the problem should not worsen beyond control and eventually may end. That is not at all the situation with global warming.

Debates: Is the Earth's climate really warming significantly, and are man-made greenhouse gases causing that warming, if it exists? Given the facts stated above, one might jump to the conclusion that, of course, both questions should be answered "yes." At present, that would reflect the majority of scientific opinion. But there is a sizeable dissenting scientific opinion that the cause-and-effect relationships between greenhouse gases and climate are not well enough established to make conclusions. A frequently cited problem is the complexity of climate modeling, given all the factors controlling weather (including the chaos component). For example, this year's powerful El Niño greatly perturbed weather patterns, yet we do not really know why the El Niño/La Niña cycle occurs. We cannot even be certain whether or not global warming influences El Niño and visa versa.

Studies of global climate and weather patterns are done by computer models which try to incorporate all possible effectors and data into their predictions. As with all computer models (or statistics of any kind), the results are only as good as the data one puts into the model. Much of the past criticism by "global-warming-skeptics" has addressed the quality of data and the inherent complexity (and limitations) of computer climate modeling. This criticism was partly justified

GLOBAL WARMING



SUMMIT

Kyoto, Japan

Signs of change

■ Average global surface temperature has risen 1° F in the past 100 yrs.

■ Hottest 12 years ever recorded have all occurred since 1980

■ Sea levels have risen 4-10 inches over the past century

■ Summers are longer; winters are milder though there is much year to year variation

■ Human activities that contribute to global warming are on the rise - cutting trees; burning coal, oil and gas; driving cars

THE THREAT FROM CLIMATE CHANGE

Why Earth's heating up

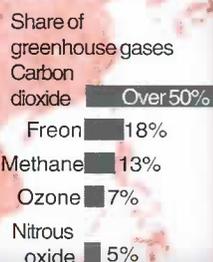
Most climate scientists say human activity has contributed to global warming.

How it happens

2 Heat reflected off Earth back into space, but greenhouse gases trap some heat in atmosphere.

1 Sun's rays penetrate Earth's Atmosphere

3 More greenhouse gases trap more heat raising global temperature



The culprits

Gases that play a part in warming and where they come from:

CARBON DIOXIDE

Source: Burning oil, gas, coal

■ Levels have increased 25% in past 100 yrs.

FREON

Source: Air conditioners

■ Newly outlawed in U.S., EU countries

METHANE

Sources: Agriculture; oil, gas pipelines, wells

OZONE

Source: Car exhaust

NITROUS OXIDE

Source: Car exhaust

KRT

SOURCES: White House, Friends of the Earth, news reports; research by JUDY TREIBLE

opinions are based on the older studies and I have seen no recent published scientific studies in the mainstream literature that contradict the reality of global warming.

Whether human effects are causing global warming is still a matter of applying logic and inference rather than reading out data. The newer climate models show that the oceans and atmosphere have warmed about 0.8° C above the last century average. But may this not be a natural Earth event? Here's one view: since it is indisputable that man-made greenhouse gases are building up globally, and that greenhouse gases undoubtedly can cause warming, they must be contributing to global warming. Here's another view: so many factors influence climate, the greenhouse effect, whatever it may be, is almost certainly only a small component of our overall climate. If one volcano, for example, can cool the earth for years, how can we know what causes long-term changes?

The interactions of global-warming-science and politics are unavoidable. Scientists have political views and influences just as do the general population. Politicians seem to embrace whichever pole of science opinion on this global warming debate fits their chosen outlook. Al Gore embraces warming scenarios; Trent Lott rejects them. Liberals tend to embrace and bemoan the human responsibility for excess greenhouse gases, whereas conservatives tend to reject it or dismiss it as unimportant. It is clear that if America is to take leadership in responding to the release of greenhouse gases (which we most definitely have not done yet), it will require much self-control and some self-sacrifice (e.g., smaller cars, more energy-efficient lighting). This does not sit well with conservative viewpoints. Nor does the inherently international nature

because older computer climate models took considerable liberties with weak data. As of the past two years, the data quality and the reliability and sophistication of computer climate models have improved tremendously, and coincidentally, the results of those models have been consistently more positive in predicting serious future warming trends. In other words, we really know better now than we did only two years ago and the outlook is worse. Most anti-warming scientific

of the scientific protocols (such as the Kyoto accords) appeal to conservative politicians, especially since the conferences were held under United Nations aegis. Liberal politicians tend to embrace both international and UN endeavors and are more willing to accept cooperative efforts over America-first initiatives.

My opinion, for what it's worth, is that we should apply basic logic and some elementary principles of science to this set of data and arguments, and see

where the results lead. If we ask whether there is positive evidence for global warming, we must answer "yes," given the increasing average temperatures, the fact of the greenhouse effect, and the fact of the increase in atmospheric carbon dioxide and methane. Is there positive evidence against global warming? No, there are just suggestions that it may not be happening. The weight of argument goes strongly toward the reality of global warming. Likewise, we may ask the same questions about human contributions to global warming, and, by the same arguments, we have positive evidence for (the greenhouse gases) and nothing positive against. May other factors be involved? Certainly, but they do not diminish the problem of human enhancement of atmospheric carbon.

Finally, I suggest we apply the concept of evaluating "Type I" vs. "Type II" errors. These are engineering risk assessment strategies where a Type I error is an overreaction to a problem: doing something unnecessary that may be costly. A Type II error is an underreaction: failing to do what is necessary to prevent a problem. In the case of serious environmental disturbances which may have terminal consequences (such as global warming), the Type II error is by far the more serious. Given the present state of scientific knowledge, it seems to me foolish to chance the Type II error of enhancing future global warming by doing nothing significant to stop the generation of excess greenhouse gases from the USA. Indeed, we should be the world's leader in combating this problem, rather than the world's most egregious source of the gases and the leading stumbling block in reaching international agreements to limit their output.

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Sidebar:

An insight into bad science and politics

Thousands of environmental scientists, including me, received an impressive mailing last winter. It contained a cover letter and an 8-page paper entitled "Environmental Effects of Increased Atmospheric Carbon Dioxide," written by four authors from two small research institutes. The article appeared to be reprinted from a technical journal and was formatted very much like articles in the journal *Science*, the most prestigious and widely read American science journal. The conclusions of the article were startling: the Earth's atmosphere is indeed piling up carbon dioxide gas, but that's good! To quote the abstract of the article: "What mankind is doing is liberating carbon from beneath the Earth's surface and putting it into the atmosphere, where it is available for conversion into living organisms." The body of the paper contains many graphs showing

that CO₂ buildup is just as much as the most pessimistic liberal view would hold, but that since plant life thrives in CO₂, this is to our benefit because we will enjoy lush future crop and forest growth.

To say the least, this article startled me and seemed bizarre. The premise (that if a little CO₂ is good, a whole lot more is better) is absurd. It's equivalent to saying that since fertilizer helps plants grow, we should just dump tons of it everywhere and watch the plants go wild. (In fact, we do that with our croplands and streams, and we have massive algae buildups, unusable soils and clogged waterways because of excess fertilizers from farm runoff, phosphate detergents and hog and chicken farms.) I was curious to understand how a science journal could publish a paper with such transparently insupportable ideas, and then I discovered this wasn't a scientific journal reprint! It was made to look like one but was, in fact, a self-published article, basically a pseudo-scientific infomercial.

For a while I thought little more of this article, except that the substance of it would fit nicely into negative political views on global warming, and I wondered who else saw it. A month later, I received an Internet correspondence from the American Physical Society (APS) about this mailing. Apparently, they report, it was sent to a wide variety of specialists; that it was indeed a phony article; and that there was an interesting connection between the authorship of the article and some political affiliations. This gets a bit complex, but here it is: two of the authors listed "the Oregon Institute of Science and Medicine" as their locations, and two were from the "George Marshall Institute" in Washington, DC. According to the APS memo, the George Marshall Institute is headed by Fred Seitz, who has been a fanatical supporter of anti-global warming political opinions, and was previously a strong spokesman for the "Star Wars" initiative, also a conservative political strongpoint. The Oregon Institute is headed by Arthur Robinson, also a strong supporter of conservative issues such as home schooling and the building of nuclear bomb shelters.

The letter enclosed with the mailing had no letterhead and was mailed from a post office box in La Jolla, California. This mailing must have cost hundreds of thousands of dollars, and was certainly not an idle moment's work. I believe it provides some insight into the nature of the anti-global-warming camp, or at least their most extreme spokespersons. That scientists who have influence on national political processes could be associated with this scientific misrepresentation is worrisome and suggests there is less than meets the eye to their arguments. Certainly there is a well-funded anti-warming political agenda.