

SETTING THE RECORD STRAIGHT

Responses To Common Challenges To Climate Science

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**Climate Leadership Initiative
Institute for a Sustainable Environment
University of Oregon
<http://climlead.uoregon.edu>**

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A good deal of misinformation has appeared in recent months challenging the reality, causes and trajectory of human-induced climate change. This document provides scientifically credible responses to some of the most commonly heard challenges.

Information Cited In This Document Is From:

- The 2007 *Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (<http://www.ipcc.ch/>). The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme to assess information regarding climate change. The 2007 Report is a consensus document produced by over 600 authors from 40 countries, and reviewed by over 620 experts and governments. It is considered the most extensively peer reviewed science document in history.
- *RealClimate*, a blog on climate science written by some of the nation's top climate scientists that provides timely responses to misinformation about climate science (<http://www.realclimate.org>). In 2005, *Scientific American* recognized *RealClimate* with a Science and Technology Web Award.
- The *Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest*, signed by 50 Northwest scientists in 2004. (<http://oregonstate.edu/sustainability/docs/oregonclimateconsensus.pdf>)
- The book *Global Warming* by Sir John Houghton, considered one of the most authoritative texts on climate change available today (Cambridge University Press, 2004).

Authors

This document was prepared by The UO Climate Leadership Initiative (CLI) a global climate change research program in the Institute for a Sustainable Environment at the University of Oregon, with assistance from Christopher Bretherton, PhD, Professor of Atmospheric Sciences and Applied Mathematics and Director, Program on Climate Change; Nathan Mantua, PhD, Research Associate Professor, Aquatic and Fishery Sciences and Associate Director, Climate Impacts Group; and Philip Mote, PhD, Research Scientist, Climate Impacts Group, and State Climatologist, at the University of Washington.

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A PRIMER ON GREENHOUSE GASES AND CLIMATE CHANGE

A natural "greenhouse effect" exists on Earth. Just as ceiling glass traps heat inside a vegetable greenhouse, quantities of certain gases, including carbon dioxide, water vapor, methane and others form a heat-trapping "glass ceiling" around the Earth. For most of Earth's history the ceiling has returned a part of the thermal radiation leaving the Earth's surface, keeping temperatures at levels that support life as we know it. This blanketing effect is called "natural" because the atmospheric gases existed long before human activities affected concentration levels.

From the beginning of civilization about 10,000 years ago to the beginning of the industrial revolution, levels of all atmospheric greenhouse gases held roughly constant at between 260 and 280 parts per million. Today, they are at 387 ppm and increasing at about 2 ppm annually. Climate scientists have determined that the increase is the result of human activities including the burning of fossil fuels and depletion of the Earth's natural capacity to sequester CO₂. The 38 percent increase in CO₂ equivalents creates an "enhanced greenhouse effect" that is causing the Earth's mean surface temperature to rise beyond the natural range of variability, causing disruptive and potentially perilous changes in climate conditions.

To further illustrate, even a half-degree rise in the body temperature of a human can cause discomfort. A 2-3° F temperature increase can produce serious health risks, and a 5° F or higher increase may cause death. A similar dynamic governs the Earth's surface temperatures. Even a small rise affects the climate globally, and a large increase would produce serious and dangerous changes in the Earth's climate.

THE SCIENTIFIC METHOD

Progress in science is achieved through the "scientific method". After observing phenomena such as climate change, scientists develop a hypothesis to explain what has been seen. The hypothesis is then proved or disproved through careful, disciplined laboratory and field observation and experimentation to determine if the explanation matches reality. Other scientists must be able to assess the validity of a finding through the peer review process. If further examination and peer-review challenges do not support a hypothesis, new ones are formed and the process begins anew. When the evidence in support of a hypothesis is sufficiently large, scientific findings are formed. The conclusions drawn by the IPCC are the result of the application of this process.

Challenges and debates are a core element of the scientific method because they are fundamental to correcting and strengthening scientific understanding. While the method thrives on continual challenges, such challenges must be based on new data or interpretations that better explain the observed phenomena to the satisfaction of qualified peer reviewers. Arguments, petitions and belief statements that do not stand up to peer review, or are unwilling to submit to this disciplined process, however large the numbers of signers, are not scientifically credible.

RESPONSES TO COMMON CHALLENGES TO CLIMATE SCIENCE

Challenge: Despite what computer models say, there is no evidence of global warming.

Response: Computer models are not the only source of information that confirms global warming. The IPCC cited several lines of evidence in concluding that warming is “unequivocal” including: Direct measurement of surface temperatures; Satellite measurements of the upper and lower troposphere; Ice sheet borehole analysis; Sea ice melt; Sea level rise measurements; Permafrost melt; Glacial melt observations.

Objection: There was some warming earlier in the last century but it stopped in 1998 and there is now evidence that the globe is cooling.

Response: This statement is at best an artful manipulation of the truth. An extremely strong El Nino occurred in 1997-98 that contributed to exceptional global warmth in addition to greenhouse gases. After the El Nino ended, temperatures dropped from the exceptional high. Even with this, numerous measures show that warming has continued since 1998.

Objection: Recent winters have been exceptionally cold and snowy which shows that average U.S. temperatures are going down, not up.

Response: Recent winters have been exceptionally cold in some places and exceptionally warm in others. Scientists discern the role of rising greenhouse gases in climate by looking at variations over large areas and long periods of time. Local extreme events, like a cold snowy winter, are exciting but tell us little about climate change

Challenge: Annual mean temperature in the U.S. has fluctuated for decades and the primary cause is changing solar activity levels and ocean temperatures, not CO₂.

Response: The mean temperature over the U.S. or any other region does fluctuate from year to year. Some continents, and some portions of different continents, will be warmer or cooler at any given time than other regions. Nevertheless, the average temperature over all major continents and oceans has warmed too much over the past century to attribute purely to random fluctuations. There is no evidence for significant fluctuations in solar radiation over the recent past when temperatures have rapidly risen. There are natural variations in ocean temperature such as El Nino, but again these do not explain why the ocean surface has warmed as much as we have measured. On the other hand, increased greenhouse gases cause the ocean surface to warm, just like the land.

Challenge: The current warming is just a natural cycle.

Response: The global climate does experience some natural cycles and variations. But, climate scientists have rigorously examined this issue and determined that natural causes such as solar variability, volcanic activity, and the urban heat island affect are not the cause of today's warming.

Challenge: There is no proof that rising CO₂ causes global warming.

Response: Very strong evidence - laboratory, satellite, and ground measurements - shows that higher levels of CO₂ by themselves would cause warming. The long-term geological record shows that temperature and the abundance of CO₂ are closely correlated throughout time. Analysis of ice taken from the Greenland and Antarctic ice sheets provides a continuous record going back over 600,000 years [IPCC chapter 6]. The air trapped in the ice of cores drilled into the glaciers provides samples of past atmospheric conditions. A vast data bank of oxygen, nitrogen, CO₂, and methane levels is thus now available to scientists. The date of the air can be credibly analyzed and this information shows that when atmospheric CO₂ concentrations were high so were temperatures, and ice ages occurred when CO₂ was very low. This data gives climate scientists great confidence that temperature and the abundance of CO₂ are closely correlated. Further, there is no theory of climate where rising atmospheric CO₂ levels does *not* increase global mean temperatures. There is no dispute about the reality of the “greenhouse effect.” Certain gases, including CO₂, methane and others, absorb heat in the atmosphere and re-radiate it downward to the Earth. This process helps to regulate the earth’s temperature.

Challenge: CO₂ traditionally follows temperature, not the other way around.

Response: It actually makes no difference whether CO₂ follows or leads. During the ice ages, ice cores suggest that that CO₂ increased almost simultaneously with global mean temperature. It is hard to interpret the ice core record exactly enough to tell whether CO₂ rose precisely at the same time as global mean temperature. In fact, scientists would not expect this, because the climate also interacted with the slow growth and meltback of icesheets. Our present climate change is simpler to understand, because we are increasing CO₂ so quickly. The warming effects of CO₂ have been known for *more than 100 years*. CO₂ has not risen above about 290 ppm any time in the last 650,000 years until now and it is *unequivocal* that human activities are the cause of this increase.

Challenge: Global warming is happening on Mars and Pluto as well. Since there are no humans there burning fossil fuels, CO₂ can't be the cause of Global Warming.

Response: There is very little evidence of warming on Mars and even if there was, it has nothing to do with warming on Earth. The only factor that the Earth and Mars share is the sun, so if the warming on Mars were real and related it would have to be due to the sun. Solar variability on Earth has been measured very carefully and scientists have affirmed that it is *not* the primary cause of the warming of the past 60 years.

Challenge: Over 30,000 scientists have signed the "Oregon petition" that states that human impacts on the climate can't be reasonably proven.

Response: The so-called “Oregon petition” is a sham, as Scientific American reported in 2001. The science it claims is blatantly false and misleading. A simple analysis of the people listed on the petition shows that veterinarians, physicians, business executives and many other non-climate scientists supposedly have signed it. This document is a scientifically irresponsible charade.

Challenge: Global warming is a hoax committed by environmental extremists/liberals/those who want to control others (or regulate industry, create big government, undermine economic growth, redistribute wealth etc.).

Response: The Fourth Assessment Report by the Intergovernmental Panel on Climate Change was produced by over 600 authors from 47 countries, and reviewed by over 600 experts and governments. In addition, every major international scientific institution dealing with climate, ocean, and/or atmosphere agrees that the climate is warming rapidly beyond natural variability and the primary cause is human-induced CO₂ emissions. The different social cultures and political systems these organizations operate within make it hard to see how they would all be environmental extremists. The organizations include:

<p style="text-align: center;"><u>U.S. Science Organizations</u></p> <ul style="list-style-type: none"> • NASA's Goddard Institute of Space Studies • U.S. National Oceanic and Atmospheric Administration • U.S. National Academy of Sciences • U.S. Environmental Protection Agency • American Geophysical Union • American Meteorological Society • American Institute of Physics • National Center for Atmospheric Research <p style="text-align: center;"><u>European and Canadian Science Organizations</u></p> <ul style="list-style-type: none"> • Accademia dei Lincei (Italy) • Academie des Sciences (France) • The Royal Society of the UK • Deutsche Akademie der Naturforscher Leopoldina (Germany) • Royal Irish Academy 	<ul style="list-style-type: none"> • Flemish Academy of Belgium for Sciences and the Arts • Royal Swedish Academy of Sciences • Royal Society of Canada • Canadian Meteorological and Oceanographic Society Royal <p style="text-align: center;"><u>Asia, Australia and Other Science Organizations</u></p> <ul style="list-style-type: none"> • Academia Brasileira de Ciencias (Brazil) • Indian National Science Academy • Science Council of Japan • Russian Academy of Sciences • Australian Academy of Sciences • Caribbean Academy of Sciences • Indonesian Academy of Sciences • Academy of Sciences Malaysia • Academy Council of New Zealand • Chinese Academy of Sciences
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A Note on Challenges to the IPCC Report

Some climate scientists have criticized the IPCC Report for being too conservative. For example, scientists have said it did not factor in the risk of "abrupt" climate change and attendant changes driven, for instance, by rapid glacial drainage and melting of the Greenland and Antarctic ice sheets. On the other hand, while few climate scientists deny the reality of climate change, some have said that the IPCC report overemphasized the risk of climate change because no data supports the view that a dangerous tipping point is close at hand. Both of these criticisms may have merit. However, it is important to note that the IPCC report describes a *range* of possible scenarios ranging from high risk to low risk, not a single scenario.

Some people and organizations have claimed the IPCC is biased because it refused to acknowledge information that disproves or downplays the significance of global warming. After reviewing thousands of peer-reviewed scientific papers, some of which supported human-induced global warming and others that didn't, the IPCC concluded through its consensus peer-review process that the preponderance of evidence “unequivocally” supported the conclusion that the earth is warming beyond natural variability and that humans are the primary cause.

Challenge: Climate models can't explain periods when it was even warmer than today, let alone predict the weather next week, so why should we believe what they say about 50 or 100 years from now.

Response: This challenge mixes weather, which describes daily and monthly patterns, and climate change, which is about weather averaged over 30 years or more. Daily and annual weather predictions are very difficult because of the chaotic nature of weather systems. But this is not true with climate. Future climates are much more predictable than future weather. The challenge also confuses regional and global trends. For example, there may have been some temperatures in the same range roughly 6,000 years ago, but they were limited to the northern hemisphere and the summer months only. In addition, scientists know that warming was caused by changes in the earth's orbit similar to what controlled the Ice Ages. We know without a doubt this is not a factor today. This does not mean that predicting climate change is easy. But climate modeling has dramatically improved in recent years.

Challenge: There are many competing theories and unknowns about climate change. It is therefore impossible to claim that a consensus exists. Until a true consensus exists, no significant action should be taken.

Response: There is little debate in the climate science community about whether changes in atmospheric CO₂ concentrations alter the earth's greenhouse effect. There *are* debates about how high temperatures will go and how quickly they will rise. The consensus among scientists on climate change includes the following:

- The climate is warming beyond the range of natural variability.
- The major cause of most of the observed warming are rising levels of the greenhouse gases including CO₂, methane, and others.
- The rise in CO₂ is the result of burning fossil fuels and land use changes that have eroded the earth's ability to breakdown and dissipate emissions.
- Today's 387 ppm of CO₂ equivalent concentrations in the atmosphere (more than 30% above the historic levels) signifies that temperatures will continue to rise for the next half century even if greenhouse gas emissions are rapidly reduced.
- If CO₂ and other greenhouse gas emissions continue to rise over this century, the warming will continue and likely accelerate; and
- The high-end temperature increase projected by the IPCC (more than 11.5° F by century's end) will pose significant danger to civilization. Even the IPCC's 'low scenario' of increased warming of 3.2 F with a likely range of 2.0 to 5.2° F will produce very serious economic, social, ecological and political consequences.

Although a few climate scientists disagree with some of these points, complete unanimity should never be expected. For example, a small group of scientists (including some of those that dispute the link between CO₂ and atmospheric warming) continue to claim that no relationship exists between smoking and cancer. However, the overwhelming majority of scientists do see a link. Policymakers therefore have acted to protect the public.

Objection: The Hockey Stick graph, which is the basis of global warming theory, has been debunked many times.

The so-called 'Hockey Stick' graph shows relatively constant global temperatures from AD 1000 to AD 1900, and then a dramatic increase from 1900 to 2000 when emissions from the industrial revolution and land use changes accelerated (thus the graph looks like a hockey stick lying flat with the blade pointing upwards). The conclusion is that human burning of fossil fuels and land use changes have disrupted the climate over the past 100 years. Evidence of rising global temperatures over the past 100 years does not depend on this reconstruction of temperature change. To the contrary, the Hockey Stick is just one of many independent lines of study confirming rising temperatures in the past 100 years.

The second reason the objection is false is that although there were some methodological problems with the original paper (by Mann et al) describing the past 1000 years of temperature, they were examined by other climate scientists and found to be minor. The subsequent technical changes made to the methodology did not change the study results. Further, a dozen model-based and proxy-based reconstructions of northern hemisphere temperature change by different organizations *all* show similar patterns: the 20th century is the warmest of the entire record and warming was most dramatic after 1920.