

**An Inconvenient Truth: The Scientific Argument**

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## **Abstract**

The movie *An Inconvenient Truth* is a powerful portrayal of global warming and its impacts. The main scientific argument presented in the movie is for the most part consistent with the weight of scientific evidence, but with some of the main points needing updating, correction, or qualification. The detailed argument relies almost entirely on past and current evidence and neglects almost all information that can be gained from computer models, perhaps because such information would be difficult for a lay audience to grasp, believe, or connect with emotionally. This places an undue weight on current events as signs of ongoing climate change: some such events are apparently not related at all to climate change, while for other specific events the role of global warming is difficult or impossible to establish.

### **1. Introduction**

*An Inconvenient Truth* (David et al. 2006) (henceforth AIT) is a documentary that features major portions of a “slideshow” by Al Gore interspersed with interviews and other vignettes. My discussion of the content of the movie is based upon repeated viewings and my own transcription of the movie.

The slideshow in AIT is quite engaging, and its choices of what to include and what to leave out are targeted to produce a much greater retention rate and paradigm shift than a typical college lecture. Gore’s knowledge of the science, including many of its subtleties, is impressive, and his ability to convey this information in a memorable way is also impressive.

The message of the slideshow and documentary is that global warming is a serious problem caused by man, and that we have the capacity and are morally obligated to fix it. In this essay, I will discuss the scientific basis of the first part of the argument, that global warming is a serious problem caused by man. The rest of the argument

touches on morality, sociology, economics, and politics and will not be considered here. Space does not permit a comprehensive analysis of every statement in the movie about global warming science, nor does it permit me to evaluate common criticisms of AIT. I will focus on the main scientific arguments and some common features of the evidence presented in support of those arguments.

## **2. The Main Argument**

The scientific argument in AIT consists of a series of main points, as follows:

(a) Despite Earth's size, it is possible for us to have a lasting, harmful impact on the Earth's environment (AIT 07:57)

(b) Global warming is caused by global warming pollution, which traps extra infrared radiation. (AIT 09:34)

(c) Carbon dioxide is going up relentlessly because of the larger changes in our civilization. (AIT 13:37)

(d) Impacts of the resulting global warming are visible worldwide in retreating glaciers. (AIT 16:23)

(e) Temperatures are unprecedented over past 1000 years, and the trend is intensifying. (AIT 20:21; AIT 28:20)

(f) Carbon dioxide concentrations are unprecedented over past 650,000 years and going higher, and the ice cores show that when there's more CO<sub>2</sub>, the temperature gets warmer. (AIT 23:20; AIT 22:03)

(g) Consequently, hurricanes, rainstorms, and droughts are getting stronger. (AIT 30:04; AIT 36:50; 37:55)

(h) Rapid warming is taking place in the Arctic, a clear sign of global warming. (AIT 45:08)

(i) Climate change can take place suddenly rather than gradually, for example with ocean currents. (AIT 46:13)

(j) Global warming is changing ecological niches, enhancing the spread of infectious diseases, and jeopardizing ocean ecosystems through coral bleaching. (AIT 52:09; AIT 53:08; AIT 53:55)

(k) The recent breakup of Antarctic ice sheets is another clear sign of global warming. (AIT 54:24)

(l) Greenland & West Antarctic ice sheets are endangered; their melting would cause catastrophic sea level rise. (AIT 57:13)

(m) Scientists agree that global warming is a serious problem. (AIT 72:18)

Slightly more than half of these points, as I have paraphrased them from AIT, are widely accepted and scientifically valid. In that category I would put points a, c, d, h, i, j, and k. Others require modification or qualification.

Point (b) is a simplification of the basic radiative processes behind an enhanced greenhouse effect, and the use of the phrase “global warming pollution” is political rather than scientific. Although the actual processes work somewhat differently than described by AIT and involve absorption, emission, and other heat transfer mechanisms, this description provides a nontechnical audience with an accessible understanding of the basic idea. However, elsewhere the term “global warming” is used as a synonym for “increasing global temperatures”, and attribution of the bulk of the recent increase of global temperatures to anthropogenic effects (of which greenhouse gas increase is easily the largest positive component) is “very likely” rather than certain, according to the IPCC (IPCC, 2007). More generally, the role of anthropogenic aerosols, volcanoes, top-of-atmosphere solar radiation, orbital variations, and other forcings of global temperatures are never mentioned in AIT, and the movie never corrects the impression that carbon dioxide variations are the only important cause of climate change.

While point (e) was supported by some published studies at the time, it is now understood to be too strong. The most up-to-date authoritative pronouncement on current temperatures relative to the past 1000 years is that of the North report (NRC 2006), which states, “Presently available proxy evidence indicates that temperatures at many, but not all, individual locations were higher during the past 25 years than during any period of comparable length since A.D. 900.” The accuracy of the statement that the temperature

trend is intensifying depends on how the trend is measured: if measured to the present day, shorter trends (less than 30 years) are larger than longer trends, but within the past 30 years global temperature estimates show no clear evidence of an accelerating trend.

Point (f) raises issues that I discuss in Section 3.

Point (g) notes, following the IPCC (Trenberth et al, 2007) that hurricanes, rainstorms, and droughts have been observed to have become more intense in recent decades. An increase in intensity is consistent with expectations derived from physical arguments or global climate model projections. However, predictions regarding the magnitude of changes that would be caused by global warming are presently uncertain or in disagreement with observed change magnitudes, so anthropogenic climate change cannot conclusively be established as the primary cause of these changes, and the IPCC (Trenberth et al., 2007) does not draw such a conclusion.

Point (l) is misleading because AIT does not give a sense of the likely time scale of substantial sea level rise, and the extent to which such sea level changes are catastrophic depends sensitively on the rate of those changes. As far as we know, it is physically impossible for the Greenland Ice Sheet to “break up and melt”, as postulated in the movie, because the Greenland Ice Sheet is not floating. Mechanisms for possible accelerated loss of the Greenland Ice Sheet involve surface melting and acceleration of the outward flow of the ice sheet to the sea (Lemke et al. 2007, p. 367); this involves a continual thinning of the ice sheet rather than a breaking up into pieces, until the ice sheet has mostly melted away.

With respect to point (m), AIT mischaracterizes Oreskes (2004). Oreskes investigated whether published papers agreed with the consensus explanation for global warming. She did not investigate whether such papers considered global warming to be a serious problem. In any case, such value judgments are rarely found in scientific articles. Policy statements by leading professional organizations also do not tend to describe global warming as a “serious problem”, per se. The American Meteorological Society (AMS 2007), for example, refers to global warming as having “important impacts”, some of which are then listed, and the American Geophysical Union (AGU 2008) refers to “disruptions”, with the possibility of “dramatic disruptions”. While I personally believe

that global warming is a serious problem, it is not known to what extent this opinion is held by relevant scientists.

### **3. Global Warming in the Present Tense**

The argument in AIT outlined in Section 2 is far from the strongest scientific argument that could be made in support of the proposition that global warming is a serious problem caused by man. Notably missing from the argument is any mention of global climate models and their role in developing our present understanding of recent climate change. It seems plausible that Gore determined that the concept of computer models was too abstract, intangible, and complex for a lay audience, that the effort required to convince the audience that computer models were trustworthy in certain aspects would require too much time and detract from the rest of the message.

Instead, the movie relies almost exclusively on events that have already taken place to make its case. Notice that all of the statements in the main argument are in the present tense. This has the cumulative effect of making global warming immediate for the audience.

A search of all occurrences of the word “will” in AIT reveals only five references to the future predicted state of any aspects of the climate system. One manages to be immediate anyway: a statement that maps will need to be redrawn based on what’s happening in Greenland right now (AIT 59:06). Two others refer to disappearing glaciers (AIT 16:46, AIT 16:59), and are presented as extrapolations of present-day trends. One is a mention of published predictions of when the summertime Arctic ice cap will vanish, but without saying how these predictions were made (AIT 44:16). Finally, one is a prediction of atmospheric carbon dioxide levels within the next fifty years (AIT 23:54). With this prediction, Gore illustrates the high level of suspicion that predictions in general engender in his audience, because this is the only point in the movie he feels compelled to state, “There’s not a single fact, or date, or number that’s been used to make this up that’s in any controversy.” (AIT 23:58)

The avoidance of climate projections, particularly those that are model-based, leaves a gap in the argument that climate change is a serious problem. Somehow, the

audience must be convinced that temperatures are going to continue to rise dramatically. Graphs of past temperatures convey that message to some extent, but to drive the point home, Gore uses the rhetorical device of encouraging his audience to make its own climate projection. The device is very effective and is one of the most dramatic moments in AIT, but it is also deeply misleading.

Follow along carefully with the movie. First, Gore shows the Vostok temperature and carbon dioxide graphs over the past 650,000 years (AIT 20:40). The graphs are scaled so that the variability of the two graphs is similar. He notes that the two graphs appear to change simultaneously, and states that the most important aspect of the relationship between temperature and carbon dioxide is that “when there is more carbon dioxide, the temperature gets warmer, because it traps more heat from the Sun inside.” (AIT 22:01) This statement is nearly true, notwithstanding issues of “trapping” versus the true nature of the energy budget, and would be exactly true if Gore had said “...the temperature is warmer...” rather than “...the temperature gets warmer...” His actual wording implies that the observed temperature changes were caused by the carbon dioxide changes. Instead carbon dioxide is understood to be a positive feedback on temperature rather than a causal mechanism over the period shown.

Gore then states that the current global temperature represents a nice day in the northern United States, while the ice age global temperature corresponds to a mile-thick ice layer in the same location. (AIT 22:17) After showing the current and projected future carbon dioxide levels, he then says, “Again, if, on the temperature side, if this much on the cold side is a mile of ice over our head, what would that much on the warm side be?” (AIT 24:22) In context, the only possible meaning of “that much on the warm side” is a temperature as far above natural ice-age variability as the change of carbon dioxide concentrations will be above natural ice-age variability. There is no temperature scale provided in the graphic (except for the qualitative nice day vs. a mile of ice), but based on the magnitude of Vostok temperature variations, the warming above pre-industrial times would be 18C. The audience is being invited to infer that global temperatures ought to rise 18C if carbon dioxide concentrations double, but the currently-accepted value for climate sensitivity to doubled carbon dioxide concentrations is about 2.5-4C. Among the reasons for the smaller number: causation rather than feedback, the

logarithmic dependence of temperature on carbon dioxide, and changes in other feedbacks such as snow cover.

In essence, the audience is being encouraged to overestimate the absolute magnitude of future anthropogenic climate change beyond currently-accepted science by a factor of five. This, to me, is the most serious flaw in AIT.

#### **4. Signs and Portents**

Another consequence of the emphasis in AIT on present-day climate change rather than future projections of climate change is the need to assert that catastrophic weather events associated with global warming are already happening. The present-day weather events are to be interpreted as signs and portents of what is to come in a warmer world. In the movie, Gore compares the current weather events to the Book of Revelation (AIT 37:29), and in the supplementary materials on the DVD, Gore compares changes in ecosystems to the plagues of Egypt.

As discussed in Section 2, the increasing observed intensity of hurricanes, floods, and droughts is plausibly but not unambiguously attributable to global warming. Much less attributable are individual weather events. Yet in AIT it seems that every significant weather event other than a cold snap is another sign of global warming. Trends in unusual weather events are only detectable over decades, and if an argument is built on the basis of weather during the past year being not nice, what happens to the argument when weather the next year is nice? A rigorous scientific argument based on statistics has been put aside in favor of soliciting a visceral response from the audience.

In many cases, the presumed link to rising global temperatures is absent. For example, Gore mentions that Japan set an all-time record for typhoon frequency in 2004 (AIT 30:25). Yet there is presently no detectable trend in typhoon frequency either globally or in the northwest Pacific (Webster et al. 2005), and with global warming, the current scientific consensus is that typhoon frequency would probably stay about the same or decrease (Meehl et al. 2007, p. 788). In another example, Gore associates the spread of the West Nile Virus across the United States with global warming (AIT 53:40), when in reality it was simply the introduction of an exotic virus into North America that



was then spread through a large number of mosquito species indigenous to both temperate and tropical latitudes (Hayes et al. 2005). Attributing the spread of West Nile to global warming is akin to attributing the spread of smallpox among Native Americans to the Little Ice Age.

In many other cases, the relationship of weather events to rising global temperatures is real but exaggerated. Insurance losses from floods and other disasters are dramatically increasing (AIT 37:07), but the relative importance of climate change and increased vulnerability is difficult to determine (Pielke et al. 2005; Epstein and McCarthy 2005). Hurricane Katrina is almost literally the poster child of global warming. But nobody can say what Katrina would have been in the absence of recent climate change. Numerous recent books such as van Heerden and Bryan (2006) make a convincing case that the Katrina disaster was a direct consequence of poor levee design and construction and poor evacuation planning, and that had the infrastructure performed as it was supposed to, Katrina would not have been a disaster for New Orleans. Gore, by not distinguishing between spatial sea surface temperature variations and long-term temperature changes, leads the audience to believe that Katrina itself was a global warming prediction come true (AIT 31:23). Instead, New Orleans had long been identified as a man-made disaster waiting to happen.

It is human nature to seek explanations and causes for natural disasters rather than accept that they are a product largely of chance. It is also human nature to imagine that things are getting worse. Arguing that a statistically significant trend in extreme events is present has much less rhetorical power to the lay audience than does arguing that specific extreme events are predictions of global warming come true. Relating global warming to specific current events does make the expected effects of global warming much more concrete and tangible. Gore has substituted an emotionally powerful argument for a scientifically valid one.

## **5. Conclusion**

An Inconvenient Truth is a powerful movie. Most of the major elements of the scientific argument presented in AIT are consistent, in whole or in part, with the existing

scientific consensus. Many parts very effectively address common misconceptions about climate change. Other elements leave out important facts or essential estimates of uncertainty, thereby creating new misconceptions about climate change. The evidence used in support of the scientific argument is often event-specific, but individual events are rarely attributable directly to climate change.

Gore makes the apparently tactical decision to avoid mention of climate models and projections of future climate in favor of emphasizing present signs of global warming. This maximizes the emotional impact of AIT, but also results in a scientific argument many of whose details do not stand up to scrutiny.

While I have contended above that the evidence of present signs of global warming is exaggerated in AIT, it does not follow that AIT necessarily exaggerates the overall threat of global warming. AIT is in many ways analogous to the mother who tells her child, “Wear clean underwear. What if you get in an accident and go to the hospital unconscious and they have to take your clothes off?” The details of the argument are incorrect (nobody will pay attention to underwear in the emergency room), but the broad argument is correct (clean underwear should be worn, for a variety of reasons) and the details are effective (kids are more inclined to wear clean underwear).

AIT likewise is both effective and annoyingly misleading. For each statement in AIT that goes too far, there are perhaps ten other scientifically valid statements that could have been made but were left out in the interest of time or persuasiveness for a lay audience. The IPCC reports remain the best available comprehensive summary of the scientific basis of global warming causes and effects.

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