A Skeptical Layman’s Guide to Anthropogenic Global Warming

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Forward: What Are My Goals For This Paper

The purpose of this paper is to provide a layman’s critique of the Anthropogenic Global Warming (AGW) theory, and in particular to challenge the fairly widespread notion that the science and projected consequences of AGW currently justify massive spending and government intervention into the world’s economies. This paper will show that despite good evidence that global temperatures are rising and that CO2 can act as a greenhouse gas and help to warm the Earth, we are a long way from attributing all or much of current warming to man-made CO2. We are even further away from being able to accurately project man’s impact on future climate, and it is a very debatable question whether interventions today to reduce CO2 emissions will substantially improve the world 50 or 100 years from now.

I am not a trained expert on the climate. I studied physics at Princeton University before switching my major to mechanical engineering, where I specialized in control theory and feedback loops, a topic that will be important when we get into the details of climate change modeling. For over ten years, my business specialty was market prediction and sales forecasting using modeling approaches similar to (if far less complex than) those used in climate.

My goal for this paper is not to materially advance climate science. However, I have found that the global warming skeptic’s case is seldom reported well or in any depth, and I wanted to have a try at producing a fair reporting of the skeptic’s position. I have been unhappy with several of the recent documentaries outlining the skeptic’s case, either because they skipped over a number of critical issues, or because they over-sold alternate warming hypotheses that are not yet well understood. To the inevitable charge that as a non-practitioner, I am not qualified to write this paper --I believe that I am able to present the current state of the science, with a particular emphasis on the skeptic’s case, at least as well as a good reporter might, and far better than most reporters actually portray the state of the science. Through this paper I will try to cite sources as often as possible and provide links for those who are reading this online, this report is best read as journalism, not as a scientific, meticulously footnoted paper.

Years ago, another man not trained in climate started a PowerPoint presentation of what he knew about Global Warming. Over time, he used it both as a vehicle for communication as well as a living document that would evolve over time to reflect his improving knowledge. A lot of people saw Al Gore’s PowerPoint presentation, and it became the backbone for the movie An Inconvenient Truth. I hope to use this paper the same way, as an evolving document to reflect my evolving knowledge. To this end, each version will get a software-like version number and date.

Before proceeding, I want to make one note on nomenclature. The terms global warming and climate change are often used interchangeably, and generally are used in a way that imply man-made causes. For example, when many people speak of global warming, they are actually talking about anthropogenic global warming, meaning warming of the Earth from man-made causes, generally the release of greenhouse gasses including CO2. Of course the climate can, and does, change without man’s help and the Earth can warm without man-made gasses. I will try to be precise in my terminology. I will use global warming to mean literally an increase in Earth’s surface temperatures, no matter what the cause. I will use anthropogenic global warming, or AGW, to mean the theory that man is causing some or all of the current warming.

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Chapter 1: Management Summary

We know the temperature of the Earth has increased over the last half of the 19th century and most of the 20th century as the world has exited a particularly cold period called the Little Ice Age. One of the odd coincidences that colors our judgment about climate trends is that man began systematically measuring temperatures in the early to mid-nineteenth century just as the world was beginning to exit what was perhaps the coldest period of the last millennia. Throughout their study of climate trends, scientists have to try to parse warming that is a natural result of exiting this cyclical cold period from warming that is perhaps due to man’s influence.

We know further, from laboratory work, that CO2, and more importantly water vapor, in the atmosphere serves to keep the Earth warmer than it would be in their absence. What we don’t know, in fact what we have no empirical proof for, is if rising CO2 levels over the last century (caused in part by man’s combustion of fossil fuels) has caused some or all of the 20th century warming. The fact that we have no empirical evidence for this man-made effect on climate doesn’t mean it is not true, but it is something we should not forget in all this debate. What we have instead are historical correlations in the data, far from perfect, that seem to show some relationship over history between CO2 and temperature. Some find this data to be compelling evidence of cause and effect, and others do not.

Before we start, since this paper is by definition somewhat in opposition to the core of Anthropogenic Global Warming (AGW) theory, it would be useful to state in simple terms just what that theory is. The strong AGW hypothesis is roughly as follows:

1. The world has been warming for a century, and this warming is beyond any cyclical variation we have seen over the last 1000 or more years, and beyond the range of what we might expect from natural climate variations.
2. Almost all of the warming in the second half of the 20th century, perhaps a half a degree Celsius, is due to man-made greenhouse gasses, particularly CO2.
3. In the next 100 years, CO2 produced by man will cause a lot more warming, from as low as three degrees C to as high as 8 or 10 degrees C.
4. Positive feedbacks in the climate, like increased humidity, will act to triple the warming from CO2, leading to these higher forecasts and perhaps even a tipping point into climactic disaster.
5. The bad effects of warming greatly outweigh the positive effects, and we are already seeing the front end of these bad effects today (polar bears dying, glaciers melting, etc).
6. These bad effects, or even a small risk of them, easily justify massive intervention today in reducing economic activity and greenhouse gas production.

In the rest of this paper, we will focus on potential weaknesses in this hypothesis. Specifically, I will argue that:

| There is no doubt that CO2 is a greenhouse gas, and it is pretty clear that CO2 produced by man has an incremental impact on warming the Earth’s surface. However, recent warming is the result of many natural and man-made factors, and it is extraordinarily difficult to assign all the blame for current warming to man. In turn, there are very good reasons to suspect that climate modelers may be greatly exaggerating future warming due to man. Poor economic forecasting, faulty assumptions about past and current conditions, and a belief that climate is driven by runaway positive feedback effects all contribute to this exaggeration. As a result, warming due to man’s impacts over the next 100 years may well be closer to one degree C than the forecasted eight. In either case, since AGW supporters tend to grossly underestimate the cost of CO2 abatement, particularly in lost wealth creation in poorer nations, there are good arguments that a warmer but richer world, where aggressive CO2 abatement is not pursued, may be the better end state than a poor but cooler world. |
In Chapter 2, we will address whether it is even appropriate to be a skeptic. Of late, several AGW supporters have declared the science “settled,” and skeptics the equivalent of tobacco lawyers or holocaust deniers. We will also look at the issue of bias, not just for skeptics but for AGW supporters as well.

In Chapter 3, we will cover a bit of background on Anthropogenic Global Warming (AGW) theory. We will learn some things about the CO2 greenhouse effect you have probably never heard in the media, such as the fact that warming from CO2 is actually a diminishing return phenomenon whose effect is asymptotic or essentially capped, making it hard to understand the prevalence of wild, open-ended temperature runaway scenarios.

In Chapter 4, we will review the historic empirical evidence for AGW theory. We will find that the science of historic climate reconstruction is still in its infancy, and a lot of uncertainty exists in the data. We will see that over the last several years, while correlations between CO2 and temperature exist in the data, much of the historical circumstantial evidence for AGW theory has gotten weaker, and we will cover “global dimming” and see if this effect makes the case for AGW stronger.

In Chapter 5 we will cover the absolutely fascinating topic of climate models. Most of what you have seen in the media is the output of complex climate models. We will find that there is a lot less here than meets the eye.

In Chapter 6 we will study several alternate explanations for recent warming that don’t involve man-made greenhouse gasses. Most prominent in these theories is the changing output of the sun.

In Chapter 7 we take on the scare stories – the lions and tigers and bears of climate reporting. In the movie An Inconvenient Truth, Al Gore caught the world’s attention with prophecies of seas rising twenty feet, hurricanes and tornados running rampant, and species dying. We will find that most of these claims are thought to be wild exaggerations even by scientists who support AGW theory.

In Chapter 8 we finally get to the Kyoto Treaty, explain its origins and shortcomings, and briefly discuss some policy alternatives. We’ll seriously consider whether a cooler but poorer world is really superior to a warmer but richer world.

Finally, in Chapter 9, we will consider AGW supporter’s rebuttals of some of these arguments. For this version, we will use the New Scientist’s recent 26 Global Warming Myths as a platform for this discussion.
Chapter 2: Is It OK to be a Skeptic?

For the first time since the Catholic Church dominated western man’s affairs, it has suddenly become a sin again to be labeled a “skeptic.” For most of my lifetime, “skepticism” was considered an essential element in the makeup of any good scientist (or journalist, for that matter). However, leading world figures are declaring skepticism to be immoral. Take one example, from this UPI story:

A former chief of the U.N. World Health Organization who also is a former prime minister of Norway and a medical doctor has declared an end to the climate-change debate.

Dr. Gro Harlem Brundtland, one of U.N. Secretary-General Ban Ki-moon's three new special envoys on climate change, also headed up the 1987 U.N. World Commission on Environment and Development where the concept of sustainable development was first floated.

"This discussion is behind us. It's over," she told reporters. "The diagnosis is clear, the science is unequivocal -- it's completely immoral, even, to question now, on the basis of what we know, the reports that are out, to question the issue and to question whether we need to move forward at a much stronger pace as humankind to address the issues."

In its most extreme form, this approach has AGW supporters labeling skeptics as equivalent to “holocaust deniers” and “tobacco lawyers.” Efforts have been made in several quarters to decertify climatologists or meteorologists who show any skepticism for AGW theory, making public adherence to the theory a minimum qualification for publication and professional standing. Enormous efforts are made to squelch skeptical speech. Just as one example, the BBC has run a zillion shows and specials sympathetic to AGW. When Channel 4 ran one single show (called the “Global Warming Swindle”) which outlined parts of the skeptics’ position, 37 scientists attempted to have it suppressed by the government.

This is all the more incredible given that AGW theory has only really been researched seriously and with any critical mass for about 20 years. Anyone who has studied the history of science will understand what incredible hubris it is to declare any new scientific theory, particularly one that concerns the unbelievably chaotic climate, as “done” after just 20 years work.

Let me give two quick examples of just how unsettled the science of climate change is. Both of these will be reviewed in more depth later in this paper, and both analyses figured prominently in the third IPCC report (2001) as well as Al Gore’s An Inconvenient Truth. The first is a 100,000 year temperature and CO2-level reconstruction from ice-core data. Anyone who saw Gore’s movie will remember the data in one of his Really Big Charts. And it looks compelling – in fact, when I first saw the chart five years ago, it was compelling to me. It shows CO2 levels and temperature moving in lock-step for 100,000 years. When CO2 is up, temperature is up and vice-versa, the clear implication being that CO2 seems to be a key, maybe the key, driver of climate. However, since that chart was first prepared, laboratory procedure has improved, and scientists have found (and there is very little disagreement about this, even among strong AGW supporters) that temperature increases occur on average 800 years before the CO2 starts to increase. Huh. There is a lot of debate about what this means, but in the last five years, this formerly definitive analysis is clearly no longer definitive, since it is hard to cause something after the fact.

The other example is the very famous Mann hockey stick chart, prominently featured in Gore’s movie and a key part of the IPCC report in 2001. I will go into the details later, but since 2001 this analysis has been effectively discredited, so much so it was almost entirely missing from the fourth IPCC report in 2007. In 2003 or so, Al Gore and many AGW supporters would have called the Mann hockey stick chart the single most important analysis “proving” AGW, and Gore treated it as such in his PowerPoint deck and his movie. Then, in 2007, it is repudiated and expunged from the record. Is this really what any reasonable person would call a “settled” science?
It is a true perversion of the scientific process to find that skepticism is no longer welcome or accepted in scientific debate. Which is one reason that AGW is sometimes called a secular religion. Because it is religion, not science, that burns skeptics at the stake. Climate Scientists Garth Paltridge wrote:

A colleague of mine put it rather well. The IPCC, he said, has developed a highly successful immune system. Its climate scientists have become the equivalent of white blood cells which rush in overwhelming numbers to repel infection by ideas and results which do not support the basic thesis that global warming is perhaps the greatest of the modern threats to mankind.

**Charges of Bias**

A funny thing has happened in climate science to scientific inquiry: the usual ethics of free discussion and fact-based criticism have been discarded in favor of ad hominem attacks on critics of AGW theory. The usual approach is to find some connection (even an imagined one) between any researcher who raises the smallest doubts about AGW theory and an oil or power company and then declare that the research is tainted by the bias of these companies that have a strong economic reliance on fossil fuel combustion (and thus the production of CO2). A good example can be found in a Boston Globe article on MIT's Alfred P. Sloan professor of meteorology Richard Lindzen. Mr. Lindzen has become the bete noir of AGW supporters, since his skepticism is harder to dismiss given his scientific pedigree and his co-lead author status on the first IPCC climate change report.

"We do not understand the natural internal variability of climate change" is one of Lindzen's many heresies, along with such zingers as "the Arctic was as warm or warmer in 1940," "the evidence so far suggests that the Greenland ice sheet is actually growing on average," and "Alpine glaciers have been retreating since the early 19th century, and were advancing for several centuries before that. Since about 1970, many of the glaciers have stopped retreating and some are now advancing again. And, frankly, we don't know why."

When Lindzen published similar views in The Wall Street Journal this spring, environmentalist Laurie David, the wife of comedian Larry David, immediately branded him a "shill." She resurrected a shopworn slur first directed against Lindzen by former Globe writer Ross Gelbspan, who called Lindzen a "hood ornament" for the fossil fuels industry in a 1995 article in Harper's Magazine....

For no apparent reason, the state of California, Environmental Defense, and the Natural Resources Defense Council have dragged Lindzen and about 15 other global-warming skeptics into a lawsuit over auto-emissions standards. California et al. have asked the auto companies to cough up any and all communications they have had with Lindzen and his colleagues, whose research has been cited in court documents.

"We know that General Motors has been paying for this fake science exactly as the tobacco companies did," says ED attorney Jim Marston. If Marston has a scintilla of evidence that Lindzen has been trafficking in fake science, he should present it to the MIT provost's office. Otherwise, he should shut up.

"This is the criminalization of opposition to global warming," says Lindzen, who adds he has never communicated with the auto companies involved in the lawsuit.

While I have no doubt that corporations are heavily influenced by their own economic interests, it is more of stretch to argue that anyone who has ever taken money from them or had any connection with them would purposely bias their research. When I learned to debate, I was taught that understanding biases was useful in knowing when to apply more or less skepticism, but one still has to refute the opposing position by meaningful critique of procedures or data. For example, one might say "given their strong desire to buttress the case for AGW, the researchers cherry-picked only the most extreme data, which I will
demonstrate by showing the data they included and the data they chose to exclude.” However, many modern AGW supporters believe that insinuating possible sources of bias is sufficient to exempt one from having to actually critique their opponents’ methods and findings.

This is particularly odd given that public funding for AGW projects absolutely dwarfs any funding coming from private sources whose incentive might be to disprove AGW. In fact, just this year, President Bush declared that the US Government alone spent more money on AGW research than on AIDS research, and the US is actually late in the climate funding game.

Recently, Greenpeace criticized ExxonMobil for exercising its free speech rights and giving about $2 million to global warming skeptics.

Still, the Greenpeace report is already receiving scrutiny in Washington, where Rep. Brad Miller, a North Carolina Democrat, has joined the environmentalist group in calling for Exxon to release its plans for contributions during the current year.

"The support of climate skeptics, many of whom have no real grounding in climate science, appears to be an effort to distort public discussion about global warming," Miller said. "So long as popular discussion could be about whether warming was occurring or not, so long as doubt was widespread, consensus for action could be postponed."

Incredibly, at these spending rates, skeptics are getting outspent by AGW supporters something like 1000:1 or more. It is astounding that AGW supporters, with such a huge funding and publication advantage, still feel threatened by critics.

Climate research, once a sleepy academic backwater, is now a multi-billion dollar industry. This boom in spending is because of fears of AGW, and should AGW theory be discredited, this funding will quickly dry up. So funding for climate researchers exists only as long as climate researchers beat the drum that AGW is a large threat. It strikes me that this is at least as large an incentive for bias as that of any Exxon-funded skeptic. Here’s another way to look at it: If AGW theory is proven correct, the likely political response might cut Shell’s revenues by 20-30%, at most. If AGW theory is proven incorrect, then university climate research funding might be cut by 100%. Directionally, all the incentives in academia are to inflate global warming projections. No one is going to make the news, or even continue to get funding, if they argue that warming will only be a degree or two in the next century. The guys that get the fame and the grants are those pushing the numbers higher and higher.

Certainly AGW supporters claim that academic researchers are only concerned about the science and are not concerned about the funding incentives. This may be true (though a bit naïve, for anyone who has been in a university environment and sought research funding), but if pro-AGW researchers are not swayed by the funding, then it should be equally true that AGW skeptics are not swayed by much smaller amounts of money flowing to them. Any argument that tries to claim that these situations are somehow different just ends up being circular, i.e. “it’s OK if our guys do it because our guys are right.”

One of the mistakes the IPCC process has systematically made is to make the lead author’s and reviewers of many of its report sections a scientist whose research is mostly in that area. While this makes a certain sense, as these people will be expert in their particular area of review, it presents them with a huge conflict of interest. For example, Michael Mann used his own historical temperature reconstructions as the lead analysis in the section of the third IPCC report for which he was lead author. Clearly, one wouldn’t expect him to be (nor was he) open to any research or issues or criticisms aimed at his own work. In the fourth report, the new lead author who replaced Mann on this section (Biffra) did the exact same thing Mann did – used his own work as centerpiece of the section, and has refused to even consider criticisms about that work.

Just to avoid future argument, I will outline my potential biases. I own a small recreation business which depends on people traveling to beautiful, natural settings. I lose business when the climate changes (e.g.
when lakes dry up next to my facilities, which has happened to me). I generally gain business when gas prices increase, as they might under various anti-global warming mandates, since my facilities tend to be short-drive weekend destinations rather than cross-country destinations. I grew up in Houston, Texas, so most of my family has worked in the oil industry at one time or another, and I worked for the Great Satan Exxon as my first job for three years out of college. I am a libertarian blogger at CoyoteBlog.com, and am suspicious of government interventions but have historically supported emissions limits where they make sense. No one has contributed any money to me for this paper or for the operation of my blog.

**The Climate Trojan Horse**

To fully understand the passionate, almost dogmatic dedication so many people have to AGW theory, it is a bit useful to look at a little history. After the fall of the Soviet Union in 1989, there were a lot of Marxists, socialists, anti-corporatists and anti-capitalists who were looking for a new way to package and reinvent themselves, given that the vast majority of people (at least in the West) considered socialism failed and no longer wanted to hear about it any more. For a while, many of these folks latched onto the anti-globalization cause. Every interview I ever saw of one of these anti-globalization guys was a real mess of disorganized beliefs, but one could tell the movement was the new home for anyone who wanted to stop the spread of capitalism and privately-owned business.

Then, along came anthropogenic global warming. Here was a theory and movement that united many disparate interests:

- Socialists, communists, and Marxists
- Anti-capitalists
- Anti-consumerists
- Those opposed to large corporations
- Those opposed to global free trade
- Those opposed to economic development and growth, longing for simplicity
- “Buy local” movements
- People who just hate oil companies

Suddenly, here was a big tent for all of these causes. I highly encourage you to view a global warming rally. Don’t just watch the snippets on the evening news, those usually highlight the most reasonable speakers at the rally. Actually go and watch the whole event. What you will see is far more anti-corporate, anti-oil company, anti-capitalist rhetoric than you will hear climate science and discussion. The two rallies I have seen with my own eyes were Marxist rallies under a climate banner. As an admittedly extreme example, I will refer you to the words of Paul Watson, Founder and President of Sea Shepherd Conservation Society, who offers his group’s vision. While this particular vision pre-dated most discussions of AGW, I hope you can see how AGW fear-mongering provides quite a useful vehicle for groups of this type:

"We need to radically and intelligently reduce human populations to fewer than one billion.... We need to stop burning fossil fuels and utilize only wind, water, and solar power with all generation of power coming from individual or small community units like windmills, waterwheels, and solar panels. Sea transportation should be by sail.... Air transportation should be by solar powered blimps when air transportation is necessary. All consumption should be local. No food products need to be transported over hundreds of miles to market. All commercial fishing should be abolished. If local communities need to fish the fish should be caught individually by hand. Preferably vegan and vegetarian diets can be adopted.... We need to remove and destroy all fences and barriers that bar wildlife from moving freely across the land.... We need to stop flying, stop driving cars, and jetting around on marine recreational vehicles.... Who should have children? Those who are responsible and completely dedicated to the responsibility which is actually a very small percentage of humans...."
Of course what he doesn’t say, but is an explicit outcome of this vision, is that we can all go back to being dirt poor and having a life expectancy of about 40 years.

The average person, say in America, wants little to do with any of this. But fear of AGW provides a way to engage everyone in the movement. Socialists of all stripes no longer have to spew Marxist notions that turn most people off; now, they can talk the science of global warming and hurricanes and massive floods and such, and, using fear, trample the average guy into their socialist goals of stifling capitalism, growth, and having the government take over the economy through this environmental back-door.

**The Need to Exaggerate**

One of the hardest parts of really trying to understand what is going on in the AGW scientific debate is separating the scientists doing real science from the political advocates, who sometimes carry quasi-scientific titles. A very, very small number of vocal climate scientists and a somewhat larger group of what I would call advocates and bureaucrats really determine what you hear in the media about AGW science. A great example is the UN IPCC reports. Unless you have gone online and dug into the detailed reports themselves, likely all you have seen from these reports is taken out of the management summaries “for policy-makers”. These summaries are written by bureaucrats and advocates, not so much by scientists, and tend to wildly mis-characterize the true state of the science. Careful language in the heart of the reports expressing uncertainty and low understanding of certain phenomena are cast aside in the summaries, in favor of a comforting certainty and absolutes. In earlier IPCC reports, this caused notable disconnects between the summaries and the detailed science. More recently, the UN has “fixed” this problem by having their non-scientists write the conclusions in the management summaries first, and then telling authors of the individual sections of the report to conform their writing, and their science, to the summary. So, for the Fourth IPCC report, the summary was published over a half year before the science!

As a result, while the IPCC reports claim to be the consensus of 5000 scientists, actually less than half would willingly sign their name to the management summaries of their work that you see in the press. The management summaries and related press releases have become more political advocacy than science, as UN bureaucrats use AGW-fear-mongering to increase their prestige and power. Generally, these summaries and press releases are taken more seriously by the press than they are climate scientists. You can get an insight on the IPCC process just by looking at how they select their co-lead authors on certain sections. A logical way to choose these authors would be to find scientists who bring a different scientific perspective – maybe a leading astronomer who studies the sun, maybe someone who studies hurricanes, or perhaps even, gasp, a skeptic or two. This is not how the IPCC makes the selection. Instead, they focus on including scientists, often with limited experience or expertise, who bring geographic or ethnic diversity to the panel. Nothing better demonstrates that the IPCC is first and foremost a political entity, and a scientific body second (at best).

If I seem too hard on the climate science community, then consider this quote from National Center for Atmospheric Research (NOAA) climate researcher and global warming action promoter, Steven Schneider:

> We have to offer up scary scenarios, make simplified, dramatic statements, and make little mention of any doubts we have. Each of us has to decide what the right balance is between being effective and being honest.

Is that how you learned science in high school – that lying about the science was OK if it makes you more politically effective? Der Spiegel, a magazine historically sympathetic to the AGW cause, published this analysis:

> This doesn't mean that Gore should necessarily be taken to task for his statements. He is a politician. But it is odd to hear IPCC Chairman Pachauri, when asked what he thinks about Gore's film, responding: "I liked it. It does emotionalize the debate, but it seems that it has to do that." And when Pachauri comments on the publication of the first SPM by saying, "I hope that this will..."
... shock the governments so much that they take action," this doesn't exactly allay doubts as to his objectivity. When Renate Christ, the secretary of the IPCC, is asked about her opinion of reporting on climate change, she refers to articles that mention "climate catastrophe" and calls them "rather refreshing." 

The problem is that the IPCC is not a political group whose goal is to exert pressure, but a scientific institution and panel of experts. Its members ought to present their results and analyses dispassionately, the way pathologists or psychiatrists do when serving as expert witnesses in court, no matter how horrible the victim's injuries and how deviant the perpetrator's psyche are.

I will end this section on an [admittedly extreme example](#) of a headline taken from the *Canadian*, a "progressive" magazine up in the Great White North. In the great race to one-up other media outlets in creating a panic, and not happy with just a few more hurricanes or some melted icebergs, the *Canadian* has taken the prize. Get ready for it…

"Over 4.5 Billion people could die from Global Warming-related causes by 2012"

In case you are struggling with the math, that means that they believe Global Warming could kill three quarters of the world's population in the next five years. And the media treats these people with total respect, and we skeptics are considered loony?
Chapter 3: The Basics of Anthropogenic Global Warming (AGW) Theory

I will not even try to do full justice here to the basic theory of AGW theory. I highly encourage you to check out RealClimate.org. This is probably the premier site of strong AGW believers and I really would hate to see AGW skeptics become like 9/11 conspiracists, spending their time only on like-minded sites in some weird echo chamber.

If you are reading this, you probably know that CO2 is what is called a greenhouse gas. This means that it can temporarily absorb radiation from the Earth, slowing its return to space and thereby heating the troposphere (the lower 10KM of the atmosphere) which in turn can heat up the Earth’s surface. You probably also know that CO2 is not the only greenhouse gas, and that water vapor, for example, is actually a much stronger and more prevalent greenhouse gas.

It is important to understand that the greenhouse gas effect is well-understood in the laboratory. No one really disagrees that, all other effects held constant in a laboratory, CO2 will absorb certain wavelengths of reflected sunlight. What may or may not be well-understood, depending on your point of view, is how this translates to the actual conditions in our chaotic climate. Does this effect dominate all other climate effects, or is it trivial compared to other forces at work? Does this greenhouse effect lead to runaway, accelerating change, or are there opposing forces that tend to bring the climate back in balance? These are hugely complex questions, and scientists are a long way from answering them empirically.

But wait, that can’t be right -- scientists seem so sure! Well, some scientists, particularly those close to microphones, seem sure. Their proof usually follows one or both of these paths:

1. Some scientists argue that they believe they have accounted for all the potential natural causes, or “forcings,” in the climate that might cause the warming we have observed over the last century, and they believe these natural forcings are not enough to explain recent temperature increases, so therefore the changes must be due to man. This seems logical, until I restate their logic this way: “the warming must be due to man because we can’t think of anything else it could be.”

2. Scientists have created complicated models to predict future climate behavior. They argue that their models show man-made CO2 causing most 20th century warming. Again this sounds good, until one understands that when these models were first run, they were terrible at explaining history. Since these first runs, scientists have tweaked the models until they match historical data better. So, in effect, they are saying that manmade CO2 is the cause of historical warming because the models they tweaked to match history… are very good at matching history; and because the models they programmed with CO2 as the major driver of climate show that…CO2 is the major driver of climate. We will see a lot of such circular analysis in later chapters.

The best evidence we could expect to find (lacking a second identical Earth we can use as a control in an experiment) is to find a historic correlation between temperature and CO2 that is stronger than the correlation between temperature and anything else (and of course, even this would not imply causation). There is a lot of argument whether we have that or not, a topic I will cover in the next chapter. Of course, the lack of unequivocal evidence at this point does not make the AGW theory wrong, just still… theoretical.

Before we get to the historical evidence, though, there may be a few other facts about CO2 and warming that you don’t know:

- CO2 is a really, really small part of the atmosphere. Currently CO2 makes up about 0.0378% of the atmosphere, up from an estimated 0.0280% before the industrial revolution. (Just to give an idea of scale, if you were flying from Los Angeles to New York City, traveling 0.0378% of the distance would not even get you off the runway at LAX. AGW advocates are arguing that a CO2 concentration increase of 0.009% has heated the world over a half a degree C.)
The maximum warming should, by greenhouse gas theories, occur in the troposphere (the first 10km or so of atmosphere). Global warming theory strongly predicts that the warming in the troposphere should be higher than warming at the ground. We will see later that the opposite is actually occurring.

The radiated energy returning to space consists of a wide spectrum of wavelengths. Only a few of these wavelengths are absorbed by CO2. Once these few wavelengths are fully absorbed, additional CO2 in the atmosphere has no effect whatsoever. Also, these absorbed frequencies overlap with the absorption of other gases, like water, which further lessens the incremental effect of extra CO2.

What does this mean? In effect, the warming effect of CO2 is a diminishing return relationship. The first increase of, say, 100 parts per million (ppm) in the atmosphere has a greater effect than the next 100 ppm, and so on until increased CO2 has essentially no effect at all.

I once bought a house that had fuchsia walls in the kitchen and family room (really). I spent all night painting the rooms with a coat of white paint, and when I was done, I found that some of the fuchsia still showed through the white paint, making it kind of light pink. A second coat of white
made the wall nearly perfectly white. The effects of CO2 in the atmosphere are similar, with the first “coat” making for the most warming and later “coats” having much less effect but still adding a bit. At some point, the wall is white and more coats have no effect.

This relationship of CO2 to warming is usually called sensitivity, and is often expressed as the number of degrees of global warming that would result from a doubling in global temperature.

There are lots of values floating around out there for sensitivity, but a preponderance (I won’t say consensus) seem to center on an increase of one degree C for a doubling of CO2 levels from the pre-industrial figure of about 280ppm. Note that you will see numbers much higher than this, but these generally include feedback loops, which we will get to later. Without feedbacks, 0.5 to maybe 1.5 degrees seems like a fairly well accepted number for sensitivity, though there are people on both side of this range.

Luboš Motl provides a handy approximation of the diminishing return effect from CO2 concentration on temperature. I have taken his approximation and graphed it below.

**Est. Climate Sensitivity to CO2**

This is a very crude approximation, but the shape of the curve is generally correct (if you exclude feedbacks, which we will discuss in MUCH more depth later). Other more sophisticated approximations generally show the initial curve less steep, and the asymptote less pronounced. Never-the-less, it is generally accepted by most all climate scientists that, in the absence of feedbacks, future increases in atmospheric CO2 will have less effect on world temperature than past increases, and that there is a cap (in this chart around 1.5 degrees C) on the total potential warming.

Note that this is much smaller than you will see in print. The key is in “feedbacks” or secondary effects that accelerate or slow warming. We will discuss these in more depth later, but typically AGW supporters believe these will triple the sensitivity numbers, so a non-feedback sensitivity of one degree would be tripled to three degrees. Remember, though, these two points:

- Warming from CO2 is a diminishing return, such that future CO2 increases has less effect than past CO2 increases
- In the absence of feedback, a doubling of CO2 might increase temperatures one degree C
• In the absence of feedback, the total temperature increase from future CO2 increases is capped, maybe as low as 1-1.5 degrees C.
Chapter 4: The historical evidence

I mentioned earlier that there is little or no empirical evidence linking increasing CO2 to the current temperature changes in the Earth, and even less, if that is possible, linking man’s contribution to CO2 levels to global warming. It is important to note that this lack of empirical data is not at all fatal to the theory. For example, there is a thriving portion of the physics community developing string theory in great detail, without any empirical evidence whatsoever that it is a correct representation of reality. Of course, it is a bit difficult to call a theory with no empirical proof “settled” and, again using the example of string theory, no one in the physics community would seriously call string theory a settled debate, despite the fact it has been raging at least twice as long as the AGW debate.

One problem is that AGW is a fairly difficult proposition to test. For example, we don’t have two Earths such that we could use one as the control and one as the experiment. Beyond laboratory tests, which have only limited usefulness in explaining the enormously complex global climate, most of the attempts to develop empirical evidence have involved trying to develop and correlate historical CO2 and temperature records. If such records could be developed, then temperatures could be tested against CO2 and other potential drivers to find correlations. While there is always a danger of finding false causation in correlations, a strong historical temperature-CO2 correlation would certainly increase our confidence in AGW theory.

Five to seven years ago, climate scientists thought they had found two such smoking guns: one in ice core data going back 650,000 years, and one in Mann’s hockey stick using temperature proxy data going back 1,000 years. In the last several years, substantial issues have arisen with both of these analyses, though this did not stop Al Gore from using both in his 2006 film.

Remember what we said early on. The basic “proof” of anthropogenic global warming theory outside the laboratory is that CO2 rises have at least a loose correlation with warming, and that scientists “can’t think of anything else” that might be causing warming other than CO2.

The long view (650,000 years)

When I first saw it years ago, I thought one of the more compelling charts from Al Gore's PowerPoint deck, which was made into the movie *An Inconvenient Truth*, was the six-hundred thousand year close relationship between atmospheric CO2 levels and global temperature, as discovered in ice core analysis. Here is Al Gore with one of those great Really Big Charts.

If you are connected to the internet, you can watch this segment of Gore’s movie at YouTube. I will confess that this segment is incredibly powerful -- I mean, what kind of Luddite could argue with this Really Big Chart?
Because it is hard to read in the movie, here is the data set that Mr. Gore is drawing from, taken from page 24 of the recent fourth IPCC report.

Unfortunately, things are a bit more complicated than presented by Mr. Gore and the IPCC. In fact, Gore is really, really careful how he narrates this piece. That is because, by the time this movie was made, scientists had been able to study the ice core data a bit more carefully. When they first measured the data, their time resolution was pretty course, so the two lines looked to move together. However, with better laboratory procedure, the ice core analysts began to find something funny. It turns out that for any time they looked at in the ice core record, temperatures actually increased on average 800 years before CO2 started to increase. When event B occurs after event A, it is really hard to argue that B caused A.

So what is really going on? Well, it turns out that most of the world’s CO2 is actually not in the atmosphere, it is dissolved in the oceans. When global temperatures increase, the oceans give up some of their CO2, outgassing it into the atmosphere and increasing atmospheric concentrations. Most climate scientists today (including AGW supporters) agree that some external force (the sun, changes in the Earth’s tilt and rotation, etc) caused an initial temperature increase at the beginning of the temperature spikes above, which was then followed by an increase in atmospheric CO2 as the oceans heat up.

What scientists don’t agree on is what happens next. Skeptics tend to argue that whatever caused the initial temperature increase drives the whole cycle. So, for example, if the sun caused the initial temperature increase, it also drove the rest of the increase in that cycle. Strong AGW supporters on the other hand argue that while the sun may have caused the initial temperature spike and outgassing of CO2 from the oceans, further temperature increases were caused by the increases in CO2.

The AGW supporters may or may not be right about this two-step approach. However, as you can see, the 800-year lag substantially undercuts the ice core data as empirical proof that CO2 is the main driver of global temperatures, and completely disproves the hypothesis that CO2 is the only key driver of global temperatures. We will return to this 800-year lag and these two competing explanations later when we discuss feedback loops.
**The medium view (1000 years)**

Until about 2000, the dominant reconstruction of the last 1000 years of global temperatures was similar to that shown in this chart from the 1990 IPCC report:

![Chart showing temperature reconstruction over 1000 years.](chart.png)

There are two particularly noticeable features on this chart. The first is what is called the “Medieval Warm Period”, peaking in the 13th century, and thought (at least 10 years ago) to be warmer than our climate today. The second is the “Little Ice Age” which ended at about the beginning of the industrial revolution. Climate scientists built this reconstruction with a series of “proxies”, including tree rings and ice core samples, which (they hope) exhibit properties that are strongly correlated with historical temperatures.

However, unlike the 650,000 year construction, scientists have another confirmatory source for this period: written history. Historical records (at least in Europe) clearly show that the Middle Ages was unusually warm, with long growing seasons and generally rich harvests (someone apparently forgot to tell Medieval farmers that they should have smaller crops in warmer weather). In Greenland, we know that Viking farmers settled in what was a much warmer period in Greenland than we have today (thus the oddly inappropriate name for the island) and were eventually driven out by falling temperatures. There are even clearer historical records for the Little Ice Age, including accounts of the Thames in London and the canals in Amsterdam freezing on an annual basis, something that happened seldom before or since.

Of course, these historical records are imperfect. For example, our written history for this period only covers a small percentage of the world’s land mass, and land only covers a small percentage of the world’s surface. Proxies, however have similar problems. For example, tree rings only can come from a few trees that cover only a small part of the Earth’s surface. After all, it is not every day you bump into a tree that is a thousand years old (and that anyone will let you cut down to look at the rings). In addition, tree ring growth can be covariant with more than just temperature (e.g. precipitation); in fact, as we continue to study tree rings, we actually find tree ring growth diverging from values we might expect given current temperatures (more on this in a bit).

Strong AGW supporters found the 1990 IPCC temperature reconstruction shown above awkward for their cause. First, it seemed to indicate that current higher temperatures were not unprecedented, and even coincided with times of relative prosperity. Further, it seems to show that global temperatures fluctuate widely and frequently, thus begging the question whether current warming is just a natural variation, an expected increase emerging from the Little Ice Age.

So along comes strong AGW proponent (and RealClimate.org founder) Michael Mann of the University of Massachusetts. Mann electrified the climate world, and really the world as a whole, with his revised temperature reconstruction, shown below, and called “the Hockey Stick.”
Gone was the Little Ice Age. Gone was the Medieval Warm Period. His new reconstruction shows a remarkably stable, slightly downward trending temperature record that leaps upward in 1900. Looking at this chart, who could but doubt that our current global climate experience was something unusual and unprecedented. It is easy to look at this chart and say – wow, that must be man-made!

In fact, the hockey stick chart was used by AGW supporters in just this way. Surely, after a period of stable temperatures, the 20th century jump is an anomaly that seems to point its finger at man (though if one stops the chart at 1950, before the period of AGW, the chart, interestingly, is still a hockey stick, though with only natural causes).

Based on this analysis, Mann famously declared that the 1990's were the warmest decade in a millennia and that "there is a 95 to 99% certainty that 1998 was the hottest year in the last one thousand years." (By the way, Mann now denies he ever made this claim, though you can watch him say these exact words in the CBC documentary Global Warming: Doomsday Called Off). If this is not hubris enough, the USAToday published a graphic, based on Mann’s analysis and which is still online as of this writing, which purports to show the world’s temperature within .0001 degree for every year going back two thousand years!

To reconcile historical written records with this new view of climate history, AGW supporters argue that the Medieval Warm Period (MWP) was limited only to Europe and the North Atlantic (e.g. Greenland) and in fact the rest of the world may not have been warmer. Ice core analyses have in fact verified a MWP in Greenland, but show no MWP in Antarctica (though, as I will show later, Antarctica is not warming yet in the current warm period, so perhaps Antarctic ice samples are not such good evidence of global warming). AGW supporters, then, argue that our prior belief in a MWP was based on written records that are by necessity geographically narrowly focused. Of course, climate proxy records are not necessarily much better. For example, from the fourth IPCC report, page 55, here are the locations of proxies used to reconstruct temperatures in AD1000:
As seems to be usual in these reconstructions, there were a lot of arguments among scientists about the proxies Mann used, and, just as important, chose not to use. I won’t get into all that except to say that many other climate archeologists did not and do not agree with his choice of proxies and still support the existence of a Little Ice Age and a Medieval Warm Period. There also may be systematic errors in the use of these proxies which I will get to in a minute.

But some of Mann’s worst failings were in the realm of statistical methodology. Even as a layman, I was immediately able to see a problem with the hockey stick: it shows a severe discontinuity or inflection point at the exact same point that the data source switches between two different data sets (i.e. from proxies to direct measurement). This is quite problematic. Syun-Ichi Akasofu makes the observation that when you don’t try to splice these two data sets together, and just look at one (in this case, proxies from Arctic ice core data as well as actual Arctic temperature measurements) the result is that the 20th century warming in fact appears to be part of a 250 year linear trend, a natural recovery from the little ice age (the scaling for the ice core data at top is a chemical composition variable thought to be proportional to temperature).

![Graph showing temperature changes over time with annotations](image)

*Figure 3a: Late Holocene ice core record from Akademii Nauk Ice Cap, Severnaya Zemlya, Russian Arctic, together with temperature records at Vardo, Norway, and along the arctic coast stations (Polyakov et al., 2002), the last one is the same as the blue curve in Figure 2 (D. Frizsche et al., 2006).*

However, the real bombshell was dropped on Mann’s work by a couple of Canadian scientists named Stephen McIntyre and Ross McKitrick (M&M). M&M had to fight an uphill battle, because Mann resisted their third party review of his analysis at every turn, and tried to deny them access to his data and methodology, an absolutely unconscionable violation of the principles of science (particularly publicly funded science). M&M got very good at filing Freedom of Information Act Requests (or the Canadian equivalent)
Eventually, M&M found massive flaws with Mann’s statistical approach, flaws that have since been confirmed by many experts, such that there are few people today that treat Mann’s analysis seriously (At best, his supporters defend his work with a mantra roughly akin to “fake but accurate.”) I’ll quote the MIT Technology Review for M&M’s key finding:

But now a shock: Canadian scientists Stephen McIntyre and Ross McKitrick have uncovered a fundamental mathematical flaw in the computer program that was used to produce the hockey stick. …

[Mann’s] improper normalization procedure tends to emphasize any data that do have the hockey stick shape, and to suppress all data that do not. To demonstrate this effect, McIntyre and McKitrick created some meaningless test data that had, on average, no trends. This method of generating random data is called Monte Carlo analysis, after the famous casino, and it is widely used in statistical analysis to test procedures. **When McIntyre and McKitrick fed these random data into the Mann procedure, out popped a hockey stick shape!**

A more complete description of problems with Mann hockey stick can be found at this link. Recently, a US Congressional Committee asked a group of independent statisticians led by Dr. Edward Wegman, Chair of the National Science Foundation's Statistical Sciences Committee, to evaluate the Mann methodology. Wegman et. al. savaged the Mann methodology as well as the peer review process within the climate community. From their findings:

It is important to note the isolation of the paleoclimate community; even though they rely heavily on statistical methods they do not seem to be interacting with the statistical community. Additionally, we judge that the sharing of research materials, data and results was haphazardly and grudgingly done. In this case we judge that there was too much reliance on peer review, which was not necessarily independent. Moreover, the work has been sufficiently politicized that this community can hardly reassess their public positions without losing credibility. Overall, our committee believes that Dr. Mann’s assessments that the decade of the 1990s was the hottest decade of the millennium and that 1998 was the hottest year of the millennium cannot be supported by his analysis.

In 2007, the IPCC released its new climate report, and the hockey stick, which was the centerpiece bombshell of the 2001 report, and which was the “consensus” reconstruction of this “settled” science, can hardly be found. There is nothing wrong with errors in science; in fact, science is sometimes advanced the most when mistakes are realized. What is worrying is the unwillingness by the IPCC to acknowledge a mistake was made, and to try to learn from that mistake. Certainly the issues raised with the hockey stick are not mentioned in the most recent IPCC report, and an opportunity to be a bit introspective on methodology is missed. M&M, who were ripped to shreds by the global warming community for daring to question the hockey stick, are never explicitly vindicated in the report. The climate community slunk away rather than acknowledging error.

In response to the problems with the Mann analysis, the IPCC has worked to rebuild confidence in its original conclusion (i.e. that recent years are the hottest in a millennium) using the same approach it often does: When one line on the graph does not work, use twelve:
As you can see, most of these newer analyses actually outdo Mann by showing current warming to be even more pronounced than in the past (Mann is the green line near the top). This is not an unusual phenomenon in global warming, as new teams try to outdo each other (for fame and funding) in the AGW sales sweepstakes. Just as you can tell the newest climate models by which ones forecast the most warming, one can find the most recent historical reconstructions by which ones show the coldest past.

Where to start? Well, first, we have the same problem here that we have in Mann: Recent data from an entirely different data set (the black line) has been grafted onto the end of proxy data. Always be suspicious of inflection points in graphs that occur exactly where the data source has changed. Notice also a little trick, by the way – observe how far the “direct measurement” line has been extended. Compare this to the actual temperatures in the charts above. The authors have taken the liberty to extend the line at least 0.2 degrees past where it actually should be to make the chart look more dramatic.

There are, however, some skeptics conclusions that can be teased out of this data, and which the IPCC completely ignores. For example, as more recent studies have deepened the little ice age around 1600-1700, the concurrent temperature recovery is steeper (e.g. Hegerl 2007 and Moberg 2005) such that without the graft of the black line, these proxies make the 20th century look like part of the fairly linear temperature increase since 1700 or at least 1800.

But wait, without that black line grafted on, it looks like the proxies actually level off in the 20th century! In fact, from the proxy data alone, it looks like the 20th century is nearly flat. In fact, this effect would have been even more dramatic if lead author Biffra hadn’t taken extraordinary liberties with the data in his study. Biffra (who replaced Mann as the lead author on this section for the Fourth Report) in 2001 initially showed proxy-based temperatures falling in the last half of the 20th century until he dropped out a bunch of data points by truncating the line around 1950. Steve McIntyre has reconstructed the original Biffra analysis below without the truncation (pink line is measured temperatures, green line is Biffra’s proxy data). Oops.
Note that this ability to just drop out data that does not fit is NOT a luxury studies have in the era before the temperature record existed. By the way, if you are wondering if I am being fair to Biffra, here is his explanation for why he truncated:

In the absence of a substantiated explanation for the decline, we make the assumption that it is likely to be a response to some kind of recent anthropogenic forcing. On the basis of this assumption, the pre-twentieth century part of the reconstructions can be considered to be free from similar events and thus accurately represent past temperature variability.

Did you get that? “Likely to be a response to some kind of recent anthropogenic forcing.” Of course, he does not know what that forcing on his tree rings is and can’t prove this statement, but he throws the data out none-the-less. This is the editor and lead author for the historical section of the IPCC report, who clearly has anthropogenic effects on the brain. Later studies avoided Biffra’s problem by cherry-picking data sets to avoid the same result.

We’ll get back to this issue of the proxies diverging from measured temperatures in the moment. But let’s take a step back and ask “So should 12 studies telling the same story (at least once they are truncated and “corrected”) make us more confident in the answer?” It is at this point that it is worth making a brief mention of the concept of “systematic error.” Imagine the problem of timing a race. If one feared that any individual might make a mistake in timing the race, he could get say three people to time the race simultaneously, and average the results. Then, if in a given race, one person was a bit slow or fast on the button, his error might be averaged out with the other two for a result hopefully closer to the correct number. However, let’s say that all three are using the same type of watch and this type watch always runs slow. In this case, no amount of extra observers are going to make the answer any better – all the times will be too low. This latter type of error is called systematic error, and is an error that, due to some aspect of a shared approach or equipment or data set, multiple people studying the same problem can end up with the same error.

There are a couple of basic approaches that all of these studies share. For example, they all rely heavily on the same tree ring proxies (in fact the same fifty or sixty trees), most of which are of one species (bristlecone pine). Scientists look at a proxy, such as tree rings, and measure some dimension for each year. In this case, they look at the tree growth. They compile this growth over hundreds of years, and get a data set that looks like 1999-.016mm, 1998, .018mm etc. But how does that correlate to temperature? What they do is pick a period, something like 1960-1990, and look at the data and say “we know temperatures average X from 1980 to 1990. Since the tree rings grew Y, then we will use a scaling factor of X/Y to convert our 1000 years of tree ring data to temperatures.

I can think of about a million problems with this. First and foremost, you have to assume that temperature is the ONLY driver for the variation in tree rings. Drought, changes in the sun, changing soil composition or chemistry, and even CO2 concentration substantially affect the growth of trees, making it virtually impossible to separate out temperature from other environmental effects in the proxy.

Second, one is forced to assume that the scaling of the proxy is both linear and constant. For example, one has to assume a change from, say, 25 to 26 degrees has the same relative effect on the proxy as a change from 30 to 31 degrees. And one has to assume that this scaling is unchanged over a millennium. And if one doesn’t assume the scaling is linear, then one has the order-of-magnitude harder problem of deriving the long-term shape of the curve from only a decade or two of data. For a thousand years, one is forced to extrapolate this scaling factor from just one or two percent of the period.

But here is the problem, and a potential source for systematic error affecting all of these studies: Current proxy data is wildly undershooting prediction of temperatures over the last 10-20 years. In fact, as we learned above, the proxy data actually shows little or no 20th century warming. Scientists call this “divergence” of the proxy data. If Biffra had hadn’t artificially truncated his data at 1950, the effect would be even more dramatic. Below is a magnification of the spaghetti chart from above – remember the black line is “actual,” the other lines are the proxy studies.
In my mind, divergence is quite damning. It implies that scaling derived from 1960-1980 can’t even hold up for the next decade, much less going back 1000 years! And if proxy data today can be undershooting actual temperatures (by a wide margin) then it implies it could certainly be undershooting reality 700 years ago. And recognize that I am not saying one of these studies is undershooting – they almost ALL are undershooting, meaning they may share the same systematic error. (It could also mean that measured surface temperatures are biased high, which we will address a bit later)

**The short view (100 years)**

The IPCC reports that since 1900, the world’s surface has warmed about 0.6°C, a figure most folks will accept (with some provisos I’ll get to in a minute about temperature measurement biases). [From the NOAA Global Time Series](#):
This is actually about the same data in the Mann hockey stick chart -- it only looks less frightening here (or more frightening in Mann) due to the miracle of scaling. The folks at JunkScience.com have helpfully overlaid atmospheric CO2 concentrations on this same data (CO2 is blue and gray line with the X’s, temperature is in purple).

This chart is a real head-scratcher for scientists trying to prove a causal relationship between CO2 and global temperatures. By theory, temperature increases from CO2 should be immediate, though the oceans provide a big thermal sink that to this day is not fully understood. However, from 1880 to 1910, temperatures declined despite a 15ppm increase in CO2. Then, from 1910 to 1940 there was another 15ppm increase in CO2 and temperatures rose about 0.3 degrees. Then, from 1940-1979, CO2 increased by 30 ppm while temperatures declined again. Then, from 1980 to present, CO2 increased by 40 ppm and temperatures rose substantially. By grossly dividing these 125 years into these four periods, we see two long periods totaling 70 years where CO2 increases but temperature declines and two long periods totaling 55 years of both CO2 and temperature increases.

By no means does this variation disprove a causal relation between CO2 concentrations and global temperature. However, it also can be said that this chart is by no means a slam dunk testament to such a relationship. Here is how strong AGW supporters explain this data: Strong AGW supporters will assign most, but not all, of the temperature increase before 1950 to “natural” or non-anthropogenic causes. The current IPCC report in turn assigns a high probability that much or all of the warming after 1950 is due to anthropogenic sources, i.e. man-made CO2. Which still leaves the cooling between 1940 and 1979 to explain, which we will cover shortly.

Take this chart from the fourth IPCC report (the blue band is what the IPCC thinks would have happened without anthropogenic effects, the pink band is their models’ output with man’s influence, and the black line is actual temperatures (greatly smoothed).
Scientists know that “something” caused the pre-1950 warming, and that something probably was natural, but they are not sure exactly what it was, except perhaps a recovery from the little ice age. This is of course really no answer at all, meaning that this is just something we don’t yet know. Which raises the dilemma: if whatever natural effects were driving temperatures up until 1950 cannot be explained, then how can anyone say with confidence that this mystery effect just stops after 1950, conveniently at the exact same time anthropogenic warming “takes over”? As you see here, it is assumed that without anthropogenic effects, the IPCC thinks the world would have cooled after 1950. Why? They can’t say. In fact, I will show later that this assumption is really just a necessary plug to prevent their models from overestimating historic warming. There is good evidence that the sun has been increasing its output and would have warmed the world, man or no man, after 1950.

But for now, I leave you with the question – If we don’t know what natural forcing caused the early century warming, then how can we say with confidence it stopped after 1950? (By the way, for those of you who already know about global cooling/dimming and aerosols, I will just say for now that these effects cannot be making the blue line go down because the IPCC considers these anthropogenic effects, and therefore in the pink band. For those who have no idea what I am talking about, more in a bit).

Climate scientist Syun-Ichi Akasofu of the International Arctic Research Center at University of Alaska Fairbanks makes a similar point, and highlights the early 20th century temperature rise:

![Graph showing temperature changes from 1880 to 2000](image)

**Figure 2: Red – global average change (IPCC Reports), Blue – data from stations along the coastline of the Arctic Ocean (Polyakov et al., 2002). The figure shows also the amount of various sources of energy used during the last century; gas, oil, and coal all release CO₂.**

Again, what drove the Arctic warming up through 1940? And what confidence do we have that this forcing magically went away and has nothing to do with recent temperature rises?

### Sulfates, Aerosols, and Dimming

Strong AGW advocates are not content to say that CO2 is one factor among many driving climate change. They want to be able to say CO2 is THE factor. To do so with the historical record over the last 100 years means they need to explain why the world cooled rather than warmed from 1940-1979.

Strong AGW supporters would prefer to forget the global cooling hysteria in the 1970s. During that time, the media played up scientific concerns that the world was actually cooling, potentially re-entering an ice age, and that crop failures and starvation would ensue. (It is interesting that AGW proponents also predict agricultural disasters due to warming. I guess this means that we are, by great coincidence, currently at the
exact perfect world temperature for maximizing agricultural output, since either cooling or warming would hurt production). But even if they want to forget the all-too-familiar hysteria, they still need to explain the cooling.

What AGW supporters need is some kind of climate effect that served to reduce temperatures starting in 1940 and that went away around 1980. Such an effect may actually exist.

There is a simple experiment that meteorologists have run for years in many places around the world. They take a pan of water of known volume and surface area and put it outside, and observe how long it takes for the water to evaporate. If one correctly adjusts the figures to reflect changes in temperature and humidity, the resulting evaporation rate should be related to the amount of solar irradiance reaching the pan. In running these experiments, there does seem to be a reduction of solar irradiance reaching the Earth, perhaps by as much as 4% since 1950. The leading hypothesis is that this dimming is from combustion products including sulfates and particulate matter, though at this point this is more of a hypothesis than demonstrated cause and effect. The effect is often called “global dimming.”

The aerosol hypothesis is that sulfate aerosols are the main cause of global dimming, as they tend to act to cool the Earth by reflecting and scattering sunlight before it reaches the ground. In addition, it is hypothesized that these aerosols as well as particulates from combustion may act to seed cloud formation in a way that makes clouds more reflective. The nations of the world are taking on sulfate and particulate production, and will likely substantially reduce this production long before CO2 production is reduced (mainly because it is possible with current technology to burn fossil fuels with greatly reduced sulfate output, but it is not possible to burn fossil fuels with greatly reduced CO2 output). If so, we might actually see an upward acceleration in temperatures if aerosols are really the cause of dimming, since their removal would allow a sort-of warming catch-up.

Sulfates do seem to be a pretty good fit with the cooling period, but a couple of things cause the fit to be well short of perfect. First, according to Stern, production of these aerosols worldwide (right) did not peak until 1990, at level almost 20% higher than they were in the late 1970’s when the global cooling phenomena ended.

One can also observe that sulfate production has not fallen that much, due to new contributions from China and India and other developing nations (interestingly, early drafts of the fourth IPCC report hypothesized that sulfate production may not have decreased at all from its peak, due to uncertainties in Asian production). Even today, sulfate levels have not fallen much below where they were in the late 1960’s, at the height of the global cooling phenomena, and higher than most of the period from 1940 to 1979 where their production is used to explain the lack of warming.

Further, these sulfate dimming effects really only can be expected to operate over land, limiting their effect on global temperatures since they effect only a quarter or so of the globe. In fact, research has shown that dimming is three times greater in urban areas close to where the sulfates are produced (and where most university evaporation experiments are conducted) than in rural areas, and that in fact when you get out of the northern latitudes where industrial society dominates, the effect may actually reverse in the tropics.

There are, though, other potential explanations for dimming. For example, dimming may be an effect of global warming itself. As I will discuss in the section on feedback processes later, most well-regulated
natural systems have feedback mechanisms that tend to keep trends in key variables from “running away.” In this case, warming may be causing cloud formation due to increased evaporation from warmer oceans.

It is also not a done deal that test evaporation from pans necessarily represents the rate of terrestrial evaporation. In fact, research has shown that pan evaporation can decrease because surrounding evaporation increases, making the pan evaporation more an effect of atmospheric water budgets and contents than irradiance.

This is a very important area for research, but as with other areas where promoters of AGW want something to be true, beware what you hear in the media about the science. The IPCC’s fourth report continues to say that scientific understanding of many of these dimming issues is “low.” Note also that global dimming does not “prove” AGW by any means, it merely makes the temperature-CO2 correlation better in the last half of the 20th century. All the other issues we have discussed remain.

The Troposphere Dilemma and Urban heat islands

While global dimming may be causing us to under-estimate the amount of global warming, other effects may be causing us to over-estimate it. One of the mysteries in climate science today has to do with different rates of warming on the Earth’s surface and in the troposphere (the first 10km or so of atmosphere above the ground). AGW theory is pretty clear – the additional heat that is absorbed by CO2 is added to the troposphere, so the troposphere should experience the most warming from greenhouse gasses. Some but not all of this warming will transfer to the surface, such that we should expect temperature increases from AGW to be larger in the troposphere than at the surface.

Well, it turns out that we have two ways to measure temperature in the troposphere. For decades, weather balloons have been sent aloft to take temperature readings at various heights in the atmosphere. Since the early 70’s, we have also had satellites capable of mapping temperatures in the troposphere. From Spencer and Christy, who have done the hard work stitching the satellite data into a global picture, comes this chart of satellite-measured temperatures in the troposphere. The top chart is Global, the middle is the Northern Hemisphere, the bottom is the Southern Hemisphere.
You will probably note a couple of interesting things. The first is that while the Northern hemisphere has apparently warmed about a half degree over the last 20 years, the Southern hemisphere has not warmed at all, at least in the troposphere. You might assume this is because the Northern Hemisphere produces most of the man-made CO2, but scientists have found that there is very good global mixing in the atmosphere, and CO2 concentrations are about the same wherever you measure them. Part of the explanation is probably due to the fact that temperatures are more stable in the Southern hemisphere (since land heats and cools faster than ocean, and there is much more ocean in the southern half of the globe), but the surface temperature records do not show such a north-south differential. At the end of the day, nothing in AGW adequately explains this phenomenon. (As an aside, remember that AGW supporters write off the Medieval Warm Period because it was merely a local phenomena in the Northern Hemisphere not observed in the south – can’t we apply the same logic to the late 20th century based on this satellite data?)

An even more important problem is that the global temperature increases shown here in the troposphere over the last several decades have been lower than on the ground, exactly opposite of predictions by AGW theory,

In 2006, David Pratt put together a combined chart of temperature anomalies, comparing satellite measurements of the troposphere with ground temperature measurements. He found, as shown in the chart below, but as you can see for yourself visually in the satellite data, that surface warming is substantially higher over the last 25 years than warming of the troposphere. In fact, the measured anomaly by
satellite (and by balloon, as we will see in a minute) is half or less than the measured anomaly at the surface.

There are a couple of possible explanations for this inconsistency. One, of course, is that there is something other than CO2-driven AGW that is at least partially driving recent global temperature increases. We will cover several such possibilities in a later chapter on alternative theories. One theory that probably does not explain this differential is global dimming. If anything, global dimming should work the other way, cooling the ground vs. the troposphere. Also, since CO2 works globally but SO2 dims locally, one would expect more cooling effect in the northern vs. the southern hemisphere, while actually the opposite is observed.

Another possible explanation, of course, is that one or the other of these data sets has a measurement problem. Take the satellite data. The measurement of global temperatures from space is a relatively new art, and the scientists who compile the data set have been through a number of iterations to their model for rolling the measurements into a reliable global temperature (Christy just released version 6). Changes over the past years have actually increased some of the satellite measurements (the difference between ground and surface used to be even greater). However, it is unlikely that the quality of satellite measurement is the entire reason for the difference for the simple reason that troposphere measurement by radiosonde weather balloons, a much older art, has reached very consistent findings (if anything, they show even less temperature increase since 1979).

A more likely explanation than troposphere measurement problems is a measurement problem in the surface data. Surface data is measured at thousands of points, with instruments of varying types managed by different authorities with varying standards. For years, temperature measurements have necessarily been located on land and usually near urban areas in the northern hemisphere. We have greatly increased this network over time, but the changing mix of reporting stations adds its own complexity.

The most serious problem with land temperature data is from urban heat islands. Cities tend to heat their environment. Black asphalt absorbs heat, concrete covers vegetation, cars and power sources produce heat. The net effect is that a city is several degrees
hotter than its surroundings, an effect entirely different from AGW, and this effect tends to increase over time as the city gets larger. (Graphic courtesy of Bruce Hall)

Climate scientists sometimes (GISS – yes, NOAA -- no) attempt to correct measurements in urban areas for this effect, but this can be chancy since the correction factors need to change over time, and no one really knows exactly how large the factors need to be. Some argue that the land-based temperature set is biased too high, and some of the global warming shown is in fact a result of the UHI effect.

Anthony Watts has done some great work surveying the problems with long-term temperature measurement (some of which was obtained for this paper via Steve McIntyre’s Climate Audit blog). He has been collecting pictures of California measurement sites near his home, and trying to correlate urban building around the measurement point with past temperature trends. More importantly, he has created an online database at SurfaceStations.org where these photos are being put online for all researchers to access.

The tennis courts and nearby condos were built in 1980, just as temperature measurement here began going up. Here is another, in Marysville, CA, surrounded by asphalt and right next to where cars park with hot radiators. Air conditioners vent hot air right near the thermometer, and you can see reflective glass and a cell tower that reflect heat on the unit. Oh, and the BBQ the firemen here use 3 times a week.
So how much of this warming is from the addition of air conditioning exhaust, asphalt paving, a nearby building, and car radiators, and how much is due to CO2. No one knows. The more amazing thing is that AGW supporters haven’t even tried to answer this question for each station, and don’t even seem to care.

As of June 28, 2007, The SurfaceStations.org documentation effort received a setback when the NOAA, upon learning of this effort, removed surface station location information from their web site. The only conclusion is that the NOAA did not want the shameful condition of some of these sites to be publicized.

I have seen sites like RealClimate arguing in their myth busting segments that the global temperature models are based only on rural measurements. First, this can’t be, because most rural areas did not have measurement in the early 20th century, and many once-rural areas are now urban. Also, this would leave out huge swaths of the northern hemisphere. And while scientists do try to do this in the US and Europe (with questionable success, as evidenced by the pictures above of sites that are supposedly “rural”), it is a hopeless and impossible task in the rest of the world. There just was not any rural temperature measurement in China in 1910.

Intriguingly, Gavin Schmidt, a lead researcher at NASA’s GISS, wrote Anthony Watts that criticism of the quality of these individual temperature station measurements was irrelevant because GISS climate data does not relay on individual station data, it relies on grid cell data. Just as background, the GISS has divided the world into grid cells, like a matrix (example at right).

Unless I am missing something fundamental, this is an incredibly disingenuous answer. OK, the GISS data and climate models use grid cell data, but this grid cell data is derived from ground measurement stations. So just because there is a statistical processing step between “station data” and “grid cell data” does not mean that at its core, all the climate models don’t rely on station data. All of these issues would be easier to check of course if NASA’s GISS, a publicly funded research organization, would publicly release the actual temperature data it uses and the specific details of the algorithms it uses to generate and smooth and correct grid cell data. But, like most all of climate science, they don’t. Because they don’t want people poking into it and criticizing it. Just incredible.

As a final note, for those that think something as seemingly simple as consistent temperature measurement is easy, check out this theory courtesy of Anthony Watts.

It seems that weather stations shelters known as Stevenson Screens (the white chicken coop like boxes on stilts housing thermometers outdoors) were originally painted with whitewash, which is a lime based paint, and reflective of infra-red radiation, but its no longer available, and newer paints have been used that [have] much different IR characteristics.
Why is this important? Well, paints that appear "white" and reflective in visible light have different properties in infrared. Some paints can even appear nearly "black" and absorb a LOT of infrared, and thus bias the thermometer. So the repainting of thousands of Stevenson screens worldwide with paints of uncertain infrared characteristics was another bias that has crept into the instrumental temperature records.

After running this test, Watts actually ran an experiment comparing wood that had been whitewashed vs. using modern white latex paint. The whitewashed wood was 5 degrees cooler than the modern latex painted wood.

**Using Computer Models to Explain the Past**

It is often argued by AGW supporters that because the historic warming is so close to what the current global warming models say historic temperatures should look like, and because the models are driven by CO2 forcings, then CO2 must be causing the historic temperature increase. We are going to spend a lot of time with models in the next chapter, but here are a few thoughts to tide us over on this issue.

The implication here is that scientists carefully crafted the models based on scientific theory and then ran the models, which nearly precisely duplicated history. Wrong. In fact, when the models were first built, scientists did exactly this. And what they got looked nothing like history.

So they tweaked and tuned, changing a constant here, adding an effect (like sulfates) there, changing assumptions about natural forcings, until the models matched history. The models match history because they were fiddled with until they matched history. The models say CO2 caused warming because they were built on the assumption that CO2 causes warming. So, unless one wants to make an incredibly circular argument, the models are useless in determining how much CO2 affects history. But we’ll get to a lot more on models in the next chapter.
Chapter 5: The computer models and predicting the future

We have gotten well into this paper, and we still have not discussed what is perhaps the most problematic aspect of AGW research: the computer models.

If an economist came up with a computer model that he claimed could predict the market value of every house in the world in the year 2106 within $1,000, would you believe him? No, you would say he was nuts -- there is way too much uncertainty and complexity. Climate, of course, is not the same as housing prices. It is in fact, much, much more complex and more difficult to predict. There is nothing wrong with trying to predict the complex and chaotic. But there is a certain sense of hubris in believing that one has succeeded with the kind of 95% certainty figures used by the IPCC.

All climate forecasting models are created by a pretty insular and incestuous climate science community that seems to compete to see who can come up with the most dire forecast. Certainly there are financial incentives to be as aggressive as possible in forecasting climate change, since funding dollars tend to get channeled to those who are the most dramatic. The global warming community spends a lot of time with ad hominem attacks on skeptics, usually accusing them of being in the pay of oil and power companies, but they all know that their own funding in turn would dry up rapidly if they were to show any bit of skepticism in their own work.

The details of these models is beyond the scope of this paper. However, it is important to understand how they work in broad outlines.

The modelers begin with certain assumptions about climate that they build into the model. For example, the computers themselves don’t somehow decide if CO2 is a more important forcing on the climate than solar activity – the modelers, by the assumptions they feed into the model, decide these things. The models return the result that CO2 is the most important driver of climate in the coming century because their programmers built them with that assumption, not because the model somehow sorts through different inputs and comes up with the key drivers on its own.

Because the models have been built to test man’s possible impact on the climate via greenhouse gas emissions, they begin with an econometric forecast of world economic growth, and, based upon assumptions about fuel sources and efficiencies, they convert this economic growth into emissions forecasts. The models generally contain subroutines that calculate, again based upon a variety of assumptions, how man-made CO2 plus other inputs will change the atmospheric CO2 concentration. Then, via assumptions about climate sensitivity to CO2 and various feedback loops programmed in, the models will create forecasts of temperatures, precipitation, etc. These models, depending on their complexity, will show regional variations in many of these variables. Finally, the models are tuned so that they better match history, in theory making them more accurate for the future.

One should note that while the IPCC asked modelers to look at a series of different cases, the only substantial difference between these cases is the volume of CO2 and other greenhouse gasses produced. In other words, the only sensitivity the IPCC seriously modeled was on levels of CO2. No other contingency – e.g. potential variations in global temperature sensitivity to CO2, solar output, land use – were considered. This should give you an idea of how hard-wired the anthropogenic causation is in the IPCC process.

In this section, I will begin by discussing the models’ basic assumptions about the climate. I will then discuss the econometric forecasts they are founded on, the assumptions about CO2 sensitivity and feedback processes, and finally model tuning and their ability to match history.
The Dangers in Modeling Complex Systems

At any one time, thousands of people are being paid literally millions of dollars on Wall Street to try to model the behavior of various stock indices and commodity prices. The total brain power and money power thrown over the last 50 years at trying to build an accurate predictive model for financial markets literally dwarfs, by a factor of 100 or more, the cumulative resources spent to date on long-term climate modeling. Financial markets are incredibly complex, and they are driven by hundreds of variables. Interest rates, corporate profits, loan default rates, mortgage refinance rates, real estate prices, GDP growth, exchange rates, etc. all tend to drive the behavior of financial markets. And no one has cracked the code. Sure, some people have built successful short-term trading models, but people have mostly lost their shirts when they have tried to make long-term bets based on computer financial models that beautifully matched history but failed to accurately predict the future.

How is it possible that a model that accurately represents the past fails to accurately predict the future? Financial modelers, like climate modelers, look to history in building their models. Again, like climate modelers, they rely both on theory (e.g. higher interest rates should generally mean lower stock prices) as well as observed correlations in the historic data set. The problem they meet, the problem that every modeler meets but most especially the climate modeler, is that while it is easy to use various analysis tools to find correlations in the data, there is often nothing that will tell you if there is really a causal relationship, and which way the causality runs. For example, one might observe that interest rates and exchange rates move together. Are interest rate changes leading to exchange rate adjustments, or vice versa? Or, in fact, are they both caused by a third variable? Or is their observed correlation merely coincidence?

It was once observed that if an old AFL football team wins the Superbowl, a bear market will ensue on Wall Street in the next year, while an NFL team victory presaged a bull market. As of 1997, this correlation held for 28 of the last 31 years, a far better prediction record than that of any Wall Street analyst. But of course this correlation was spurious, and in the next 4 years it was wrong every time. Had someone built a financial model on this indicator, it would have looked great when he ran it against history, but he would have lost his shirt using it.

Want a better prediction record? For seventeen straight US presidential election cycles, from 1936 to 2000, the winner of the election was accurately predicted by...the Washington Redskins. In particular, if the Redskins won their last home game before the election, the party that occupies the White House holds it in the election. Otherwise, if the Redskins lose, the opposition party wins. Seventeen in a row! R-squared of one! Success against odds of 131,072:1 of guessing all 17 right. But of course, the input was spurious, and in 2004, soon after this relationship made the rounds of the Internet, the algorithm failed.

This is why we spent so much time in the previous chapter on evaluating historic correlations between CO2 and temperature. Because the models are built on an assumption that not only is temperature strongly correlated with CO2, but that temperature is historically highly stable without this outside anthropogenic forcing. If there are problems with this assumed causation, which we saw there are, then there in turn are major inherent problems with the models themselves. As climate scientist Syun-Ichi Akasofu of the International Arctic Research Center at University of Alaska Fairbanks wrote:

> The computers are “taught” that the temperature rise during the last hundred years is due mostly to the greenhouse effect. If the truth is that only about 10% of the present warming is caused by the greenhouse effect, the computer code must be rewritten.

Do Model Outputs Constitute Scientific Proof?

Remember what I said earlier: The models produce the result that there will be a lot of anthropogenic global warming in the future because they are programmed to reach this result. In the media, the models are used as a sort of scientific money laundering scheme. In money laundering, cash from illegal origins
(such as smuggling narcotics) is fed into a business that then repays the money back to the criminal as a salary or consulting fee or some other type of seemingly legitimate transaction. The money he gets back is exactly the same money, but instead of just appearing out of nowhere, it now has a paper-trail and appears more legitimate. The money has been laundered.

In the same way, assumptions of dubious quality or certainty that presuppose AGW beyond the bounds of anything we have see historically are plugged into the models, and, shazam, the models say that there will be a lot of anthropogenic global warming. These dubious assumptions, which are pulled out of thin air, are laundered by being passed through these complex black boxes we call climate models and suddenly the results are somehow scientific proof of AGW. The quality hasn’t changed, but the paper trail looks better, at least in the press. The assumptions begin as guesses of dubious quality and come out laundered at “settled science.” Climate Scientists Garth Paltridge wrote:

It needs to be understood that any reasonable simulation even of present climate requires computer models to be tuned. They contain parameters (that is, pieces of input information) whose numerical values are selected primarily to give the right answer about today's climate rather than because of some actual measurement. This was particularly so in the mid-eighties. The problem with tuning is that it makes any prediction of conditions different from those of the present far less believable. Even today the disease of "tuneable parameters" is still rampant in climate models, although fairly well hidden and not much spoken of in polite society. The scientifically-inclined reader might try sometime asking a climate researcher just how many such parameters there are in his or her latest model. The reader will find there are apparently lots of reasons why such a question is ridiculous, or if not ridiculous then irrelevant, and if not irrelevant then unimportant. Certainly the enquirer will come away having been made to feel foolish.

**Econometrics and CO2 Forecasts**

The IPCC has never been able to choose a particular climate model it thinks is best. Instead, it aggregates ten or twelve of them and averages their results, hoping that if there are errors in the climate models, they will average out somehow (forgetting that systematic errors don’t average out, as we discussed earlier in the context of historic temperature reconstructions). The one thing the IPCC does do to bring some order to all this is to establish baseline econometric and emissions scenarios for all the teams to feed into the front end of their models. That way, for a given forecast case, they know variation in model output is due to differing climate-related assumptions rather than differing economic assumptions.

But a funny thing happens when one tries to make an economic growth forecast for 100-year periods, as the IPCC has: Very small changes in assumptions make enormous differences. Here is a simple example. An economy that grows by 3% per year will be 19x larger in 100 years. However, if that economy were to grow instead by 4% rather than 3%, it will be 51x larger in 100 years. So a change in the growth rate by one percentage point yields a final size nearly 2.7 times larger. The same is true with forecasting CO2 growth – a very small change in assumptions can lead to very large differences in absolute production.

After release of the 3rd IPCC report in 2001, researchers Ian Castles, formerly the head of Australia's national office of statistics, and David Henderson of the Westminster Business School and formerly the chief economist of the OECD, decided to scrutinize the IPCC’s economic assumptions. They found that the IPCC had made a fundamental mistake in crafting their econometrics, one that caused all of their economic growth estimates (and therefore estimates of CO2 production) to be grossly overestimated. Based on the IPCC assumptions, South Africa ends up with a GDP per capita far in excess of the United States by the year 2100. Incredibly, the IPCC numbers imply that Algeria, Argentina, Libya, Turkey, and North Korea will all pass the US in per capita income by the end of the century.

Beyond making it clear that there is an element of the absurd in the IPCC’s economic forecasting approach, these errors tend to inflate CO2 forecasts in two ways. First, CO2 forecasts are raised because, in the models, larger economies produce more CO2. Second, though, the models assume different rates for CO2
production per unit of GDP for each country. Most of the countries the IPCC shows growing so fast – Algeria, South Africa, Libya, North Korea, etc. – have lower than average CO2 efficiencies (i.e. higher than average CO2 production per unit of GDP), so excess growth assumptions in these countries has a disproportionate impact on projected CO2 emissions. By the way, it would be interesting to see if the IPCC is using marginal rather than average rates. For example, France has a very low average rate of CO2 per unit of GDP because of its nukes, but its marginal growth is met mostly with fossil fuels.

I can’t say whether these same mistakes exist in the 2007 4th Assessment. However, since the IPCC flatly rejected Castles and Henderson’s critique, it is likely the same methodology was used in 2007 as in 2001. For example, here are the CO2 emissions forecasts from the 4th assessment – notice most all of them have a step-change increase in slope between history and the future. Just look at the jump across the dotted line in lead case A1B, and several are even steeper.

So what does this mean? Remember, small changes in growth rate make big differences in end values. For example, below are the IPCC fourth assessment results for CO2 concentration. If CO2 concentrations were to increase at about the same rate as they are today, we would expect an end value in 2100 of between 520 and 570 ppm, as opposed to the IPCC numbers below where the projection mean is over 800 in 2100. The difference is in large part in the economic growth forecasts.

Since it is not at all clear that the IPCC has improved its forecasting methodology over the past years, it is instructive as one final exercise to go back to the 1995 emissions scenarios in the 2nd assessment. Though the scale is hard to read, one thing is clear – only 10 years later we are well below most of the forecasts, including the lead forecast is92a (this over-forecasting has nothing to do with Kyoto, the treaty’s impact has been negligible, as will be discussed later). One can be assured that if the forecasts are already overstated after 10 years, they will be grossly overstated in 100.
Climate Sensitivity and the Role of Positive Feedbacks

As discussed earlier, climate sensitivity generally refers to the expected reaction of global temperatures to an arbitrary change in atmospheric CO2 concentration. In normal usage, it is usually stated as degrees Celsius of global warming from a doubling in CO2 concentrations from pre-industrial levels (approx 280 ppm to 560 ppm). The IPCC and most AGW supporters put this number at about 3.5 to 4.0 degrees C.

But wait – earlier I said the number was probably more like 1.0C, and that it was a diminishing return. Why the difference? Well, it has to do with something called feedback effects.

Before I get into these, let’s think about a climate sensitivity of 4 degrees C, just from a historical standpoint. According to the IPCC, CO2 has increased by about 100ppm since 1880, which is about 36% of the way to a doubling. Over this same time period, global temperatures have increased about 0.7C. Since not even the most aggressive AGW supporter will attribute all of this rise to CO2 levels, let’s be generous and credit CO2 with 0.5C. So if we are 36% of the way to a doubling, and giving CO2 credit for 0.5 degrees, this implies that the sensitivity is probably not more than 1.4 degrees C. And we only get a number this high if we assume a linear relationship – remember that CO2 and temperature are a diminishing return relation (chart at right), so future CO2 has less impact on temperature than past CO2, so 1.4 would be at the high end. In fact, using the logarithmic relationship we saw before, 0.5 degrees over 36% of the doubling would imply a sensitivity around 1.0. So, based on history, we might expect at worst another 0.5C from warming over the next century.

Most AGW supporters would argue that the observed sensitivity over the last 30 years has been suppressed by dimming/sulfate aerosols. However, to get a sensitivity of 4.0, one would have to assume that without dimming, actual warming would have been about 2.0C. This means that for the number 4.0 to be right,

1. Absolutely nothing else other than CO2 has been causing warming in the last 50 years AND
2. Sulfate aerosols had to have suppressed 75% of the warming, or about 1.5°C, numbers far larger than I have seen anyone suggest. Remember that the IPCC classifies our understanding of this cooling effect, if any, as “low”

But in fact, even the IPCC itself admits that its models assume higher sensitivity than the historically observed sensitivity. According to the fourth IPCC report, a number of studies have tried to get at the sensitivity historically (going back to periods where SO2 does not cloud the picture). Basically, their methodology is not much different in concept than the back of the envelope calculations I made above.

These are shown in a) below, which shows a probability distribution of what sensitivity is (IPCC4 p. 798). Note many of the highest probability values of these studies are between 1 and 2. Also note that since CO2 content is, as the IPCC has argued, higher than it has been in recorded history, any sensitivities calculated on historical data should be high vs. the sensitivity going forward. Now, note that graph c) shows how a number of the climate models calculate sensitivity. You can see that their most likely values are consistently higher than any of the historical studies from actual data. This means that the climate models are essentially throwing out historical experience and assuming that sensitivity is 1.5 to 2 times higher going forward, despite the fact a diminishing return relationship says it should be lower.

So how do these models get to such high sensitivities? The answer, as I have mentioned, is positive feedback.
Let me take a minute to discuss positive feedbacks. This is something I know a fair amount about, since my specialization at school in mechanical engineering was in control theory and feedback processes.

Negative feedback means that when you disturb an object or system in some way, forces tend to counteract this disturbance. Positive feedback means that the forces at work tend to reinforce or magnify a disturbance.

You can think of negative feedback as a ball sitting in the bottom of a bowl. Flick the ball in any direction, and the sides of the bowl, gravity, and friction will tend to bring the ball back to rest in the center of the bowl. Positive feedback is a ball balanced on the pointy tip of a mountain. Flick the ball, and it will start rolling faster and faster down the mountain, and end up a long way away from where it started with only a small initial flick.

Almost every process you can think of in nature operates by negative feedback. Roll a ball, and eventually friction and wind resistance bring it to a stop. There is a good reason for this. Positive feedback breeds instability, and processes that operate by positive feedback are dangerous, and usually end up in extreme states. These processes tend to "run away." I can illustrate this with an example: Nuclear fission is a positive feedback process. A high energy neutron causes the fission reaction, which produces multiple high energy neutrons that can cause more fission. It is a runaway process, and it is dangerous and unstable. We should be happy there are not more positive feedback processes on our planet.

Since negative feedback processes are much more common, and since positive feedback processes almost never yield a stable system, scientists assume that processes they meet are negative feedback until proven otherwise. Except in climate, it seems, where everyone assumes positive feedback is common.

In global warming models, water vapor plays a key role as both a positive and a negative feedback loop to climate change. Water vapor is a far more powerful greenhouse gas than CO2, so its potential strength as a feedback mechanism is high. Water comes into play because CO2 driven warming will put more water vapor in the atmosphere, because greater heat will vaporize more water. If this extra vapor shows up as more humid clear air, then this in turn will cause more warming as the extra water vapor absorbs more energy and accelerates warming. However, if this extra water vapor shows up as clouds, the cloud cover will tend to reflect energy back into space and retard temperature growth.

Which will happen? Well, nobody knows. The IPCC4 report admits to not even knowing the sign of water’s impact (e.g. whether water is a net positive or negative feedback) in these processes. And this is just one example of the many, many feedback loops that scientists are able to posit but not prove. And climate scientists are coming up with numerous other positive feedback loops. As one author put it:

Regardless, climate models are made interesting by the inclusion of "positive feedbacks" (multiplier effects) so that a small temperature increment expected from increasing atmospheric carbon dioxide invokes large increases in water vapor, which seem to produce exponential rather than logarithmic temperature response in the models. It appears to have become something of a game to see who can add in the most creative feedback mechanisms to produce the scariest warming scenarios from their models but there remains no evidence the planet includes any such effects or behaves in a similar manner.

Note that the majority of the warming in these models appears to be from these feedback processes. Though it is hard to pick it out exactly, section 8.6 of the fourth IPCC report seems to imply these positive feedback processes increase temperature 2 degrees for every one degree from CO2. This explains how these models get from a sensitivity of CO2 alone of about 1.0 to 1.5 degrees to a sensitivity of 3.5 or more degrees – it’s all in the positive feedback.
So, is it reasonable to assume these feedback loops? First, none have really been proven empirically, which does not of course necessarily make them wrong. In our daily lives, we generally deal with negative feedback: inertia, wind resistance, friction are all negative feedback processes. If one knew nothing else, and had to guess if a natural process was governed by negative or positive feedback, Occam’s razor would say bet on negative. Also, we will observe in the next section that when the models with these feedbacks were first run against history, they produced far more warming than we have actually seen (remember the analysis we started this section with – post-industrial warming implies 1-1.5 degrees sensitivity, not four).

Perhaps most damning is to ask, if this really is such a heavily positive feedback process, what stops it? Remember the chart from earlier (show again at the right), showing the long-term relationship of CO2 and warming. Also remember that the data shows, and even AGW supporters acknowledge, that temperature rises led CO2 rises by about 800 years. Their explanation is that “something” caused the temperature to start upwards. This higher temperature, as it warmed the oceans, caused CO2 to outgas from the oceans to the atmosphere. Then, this new CO2 caused the warming to increase further. In other words, outgassing CO2 from the oceans was a positive feedback to the initial temperature perturbation. In turn, the IPCC argues there are various other positive feedbacks that multiply the effect of the additional warming from the CO2. This is positive feedback layered on positive feedback. It would be like barely touching the accelerator and having the car start speeding out of control.

So the question is, if global temperature is built on top of so many positive feedbacks and multipliers, what stops temperature from rising once it starts? Why didn’t the Earth become Venus in any of these events? Because, for whatever else it means, the chart above is strong evidence that temperature does not run away.

I have seen two suggestions, neither of which is compelling. The first is that the oceans ran out of CO2 at some point. But that makes no sense. We know that the oceans have far more CO2 than could ever be liberated entirely to the atmosphere today, and besides, the record above seems to claim that CO2 in the atmosphere never really got above where it was say in 1880.

The second suggestion is based on the diminishing return relationship of CO2 to temperature. At some point, as I have emphasized many times, CO2’s ability to absorb infrared energy is saturated, and incremental quantities have little effect. But note in the IPCC chart above, CO2 on the long time scale never gets as high as it is today. If you argue that CO2’s absorption ability was saturated in earlier events, then you have to argue that it is saturated today, and that incremental CO2 will have no further warming effect, which AGW supporters are certainly NOT arguing. Any theory based on some unknown negative feedback has to deal with the same problem: If one argues that this negative feedback took over at the temperature peaks (in black) doesn’t one also have to argue that it should be taking over now at our current temperature peak? The pro-AGW argument seems to depend on an assumption of negative feedbacks in the past that for some reason can’t be expected to operate now or in the future. Why?

In fact, we really have not seen any evidence historically of these positive feedback multipliers. As I demonstrated at the beginning of this chapter, even assigning as much as 0.5C of the 20th century temperature increase to CO2 only implies a sensitivity just over 1.0, which is about what we would expect from CO2 alone with no feedbacks. This is at the heart of problems with AGW theory – There is no evidence that climate sensitivity to CO2 is anywhere near large enough to justify the scary scenarios spun by AGW supporters nor to justify the draconian abatement policies they advocate.
My tendency is to conclude that in fact, positive feedbacks do not dominate climate, just as they do not dominate any long-term stable system. Yes, certain effects can reasonably be said to amplify warming (ice albedo is probably one of them) but there must exist negative feedbacks that tend to damp out temperature movements. Climate models will never be credible, and will always overshoot, until they start building in these offsetting forcings.

**Climate Models had to be aggressively tweaked to match history**

A funny thing happened when they first started running climate models with high CO2 sensitivities in them against history: The models grossly over-predicted historic warming. Again, remember our previous analysis – historical warming implies a climate sensitivity between 1 and 1.5. It is hard to make a model based on a 3.5 or higher sensitivity fit that history. So it is no surprise that one can see in the IPCC chart below that the main model cases are already diverging in the first five years of the forecast period from reality, just like the Superbowl predictors of the stock market failed four years in a row. If the models are already high by 0.05 degree after five years, how much will they overshoot reality over 100 years?

In a large sense, this is why the global climate community has latched onto the global dimming / aerosols hypothesis so quickly and so strongly. The possible presence of a man-made cooling element in the last half of the 20th century, even one that the IPCC fourth report ranks our understanding of as “low,” gives modelers a valuable way to explain why their models are overstating history. The aerosols hypothesis is valuable for two reasons:

- Since SO2 is prevalent today, but is expected to go down in the future, it allows modelers to forecast much higher warming and climate sensitivity in the future than has been observed in the past.
• Our very lack of understanding of the amount, if any, of such aerosol cooling is actually an
advantage, because it allows modelers to set the value of such cooling at whatever value they need
to make their models work

I know the last statement seems unfair, but in reading the IPCC and other reports, it appears to me that
aerosol cooling values are set in exactly this way – as what we used to call a “plug” figure between actual
temperatures and model output. While this may seem a chancy and fairly circular reasoning, it makes sense
for scientists because they trust their models. They really believe the outputs are correct, such that any
deviation is not attributed to their assumptions about CO2 or climate sensitivity, but to other man-made
effects.

But sulfates are not the only plug being used to try to make high sensitivity models match a lower
sensitivity past. You can see this in the diagram below from the fourth IPCC report. This is their summary
of how their refined and tweaked models match history.

![Diagram of temperature anomalies with blue and pink bands](image)

The blue band is without anthropogenic effects. The pink band is with anthropogenic effects, including
warming CO2 and cooling aerosols. The black line is measured temperatures (smoothed out of course).

You can see the pink band which represents the models with anthropogenic effects really seems to be a
lovely fit, which should make us all nervous. Climate is way too chaotic a beast to be able to model this
tightly. In fact, given uncertainties and error bars on our historical temperature measurements, climate
scientists are probably trumpeting a perfect fit here to the wrong data. I am reminded again of a beautiful
model for presidential election results with a perfect multi-decadal fit based on the outcome of NFL
football games.

But ignoring this suspiciously nice fit, take a look at the blue bar. This is what the IPCC models think the
climate would be doing without anthropogenic effects (both warming CO2 and cooling sulfates, for
example). With the peaked shape (which should actually be even more pronounced if they had followed
the mid-century temperature peak to its max) they are saying there is some natural effect that is warming
things until 1950 and then turns off and starts cooling, coincidently in the exact same year that
anthropogenic effects start taking off. I challenge you to read the IPCC assessment, all thousand or so
pages, and find anywhere in that paper where someone dares to say exactly what this natural effect was, or
why it turned off exactly in 1950.

The reality is that this natural effect is another plug. There is no actual empirical data to back up the blue
line (in fact, as we will see in the alternate theories section, there is good empirical data that this blue band
is wrong). Basically, climate scientists ran their models against history, and found that even with their SO2
plug, they still didn’t match well – they were underestimating early century warming and over-estimating
late century warming. Remember that the scientists believe their models and their assumptions about a
strong CO2 effect, so they have modeled the non-anthropogenic effect by running their models, tuning them to historical actuals, and then backing out the anthropogenic forcings to see what is left. What is left, the plug figure, is the blue line.

Already, the models used by the IPCC tend to overestimate past warming even if all past warming is attributable to anthropogenic causes. If anthropogenic effects explain only a fraction of past warming, then the current models are vastly overstated, good for stampeding the populous into otherwise unpopular political control over the economy, but of diminished scientific value.

The note I will leave you with is this: Do not gain false confidence in the global climate models when they show you charts that their outputs run backwards closely match history. This is an entirely circular argument, because the models have been built, indeed forced, to match history, with substantial plug figures added like SO2 effects and non-anthropogenic climate trends, effects for which there are no empirical numbers.
Chapter 6: Alternate explanations and models

Solar Irradiance

If you walked into a room and found that it was too hot, would you, as a first step:

1. Measure the air to find anomalies in the mix of gasses
2. Count the number of people in the room, to assess the effect of body heat on the room’s temperature
3. Check the thermostat on the furnace

If you answered #3, sorry, but you can’t join the IPCC. If you really want to irritate an AGW supporter, ask about the sun. To AGW supporters, only a Luddite would check the sun’s output when they could instead be obsessing over the increase in CO2 by 0.009% of the atmosphere.

When they looked at the problem, the IPCC decided that over the last 50 years, the sun has been irrelevant to warming. Note that the blue band in this chart (described in more detail in the last section), the IPCC thinks that without man, the world would have cooled over the last 50 years:

Further, when they detailed different climate forcings, the forcing from changing solar irradiance was a trivial rounding error (though they had the good grace to mark their understanding of this as “low”) meaning the sun has very little effect vs. what the sun had in 1850 (in the Little Ice Age!)
But it turns out, interestingly, that solar irradiance may be close to its highest point in centuries. Al Gore says that current global temperatures are the highest they have been in 1000 years. A new study by the Institute of Astronomy in Zurich says that the "sun is more active now than it has been at anytime in the previous 1,000 years." Related?

Sunspots have been monitored on the Sun since 1610, shortly after the invention of the telescope. They provide the longest-running direct measurement of our star's activity.

The variation in sunspot numbers has revealed the Sun's 11-year cycle of activity as well as other, longer-term changes.

In particular, it has been noted that between about 1645 and 1715, few sunspots were seen on the Sun's surface.

This period is called the Maunder Minimum after the English astronomer who studied it.

It coincided with a spell of prolonged cold weather often referred to as the "Little Ice Age". Solar scientists strongly suspect there is a link between the two events - but the exact mechanism remains elusive....

But the most striking feature, he says, is that looking at the past 1,150 years the Sun has never been as active as it has been during the past 60 years.

Over the past few hundred years, there has been a steady increase in the numbers of sunspots, a trend that has accelerated in the past century, just at the time when the Earth has been getting warmer.

The data suggests that changing solar activity is influencing in some way the global climate causing the world to get warmer.

We can look at solar output over large time frames by looking at the production of carbon-14 (less is produced in years of high solar activity, and vice versa). The analysis below used the ratio of oxygen isotopes in the stalagmites to estimate the water temperature at the time they were formed. The result is an interesting correlation between solar activity and a global temperature proxy over a long time-scale (Graph from Neff et al., 2001):
Over the last 1000 years, we see that (again using a reversed scale of C14 as a proxy) solar activity is highly correlated with long term temperature trends (I have used the pre-Mann chart, because while it may over-emphasize the Medieval Warm Period, I still think such a period existed).

Solar Output Anomaly

Temperature Anomaly

Look at the following reconstruction data by Judith Lean of the Naval Research Library and charted from her data at NOAA by Junkscience.com shows that interestingly, the sun's output does appear to be higher today than they have been in many, perhaps hundreds of years.

Would such increased activity be expected to result in higher Earth temperatures? I don't know, and there are some issues one has to be careful with on this chart. Most importantly the scaling: While the shape of the curve looks a lot like the temperature trend over the last 400 years, note that the entire variation from the low to the high point is only about 0.25% – the scaling makes it look more dramatic. Of course, the same could be said for global temperature, where a half degree C temperature increase on an absolute Kelvin scale would only be about 0.17%, so an argument can be made that on a percentage basis, this change in irradiance is about the same order of magnitude as our change in temperature. A more sophisticated comparison might say that since black body radiation is related to absolute temperature to the fourth power, .25% increase in irradiance would be expected to heat the Earth by .06%.
The chart on the above left compares the recent temperature anomaly to solar irradiance, while the chart on the right compares it to CO2 concentrations. Neither is a beautiful fit (and one may have to include aerosols in either scenario to account for 1970’s cooling) but solar irradiance seems at least as good as that of CO2. Remember, the IPCC shows the world cooling due to solar effects during the same time the red solar irradiance line is peaking.

Recently Alexander et. al. have done some very comprehensive work relating solar irradiance and rainfall. The study posits that one of the reasons for less than perfect fit of sunspot and irradiance data with temperature is that the Sun actually works on a 21 year cycle when the sunspot cycle is combined with the cyclical wobble of the Sun's motion through space. The study concluded:

The Intergovernmental Panel on Climate Change (IPCC) (2001) dismisses the view that solar activity has a meaningful influence on global climate. The basis for this view is that variations in the receipt of solar activity are too small to account for variations in the climatic responses. These variations were determined from satellite and other observations. What the IPCC scientists failed to appreciate is that changes in the level of solar radiation received on earth are amenable to precise calculation. The variations are well in excess of the IPCC value of +0.3 Wm^–2 quoted earlier.

One of the interesting things about solar output is that, if it is really higher, we should see effects on other planets, not just on Earth. And, in fact, a lot of evidence has been pouring in over the last 5 years from astronomers (not climate guys) that the rest of the solar system has been warming dramatically.

Take Mars, for example. Mar’s ice caps have been melting and diminishing since NASA’s Mars Global Surveyor and Odyssey started to measure them around 2002.

Changes in the red spot on Jupiter seem to be a sign of warming temperatures. And Neptune’s moon Triton is warming. We have to be careful with how we draw conclusions on these outer planets, since their “year” is so long, seasonal changes can last decades.

And on Neptune:

As seen in Figure 1, Neptune has been getting brighter since around 1980; furthermore, infrared measurements of the planet since 1980 show that the planet has been warming steadily from 1980 to 2004. As they say on Neptune, global warming has become an inconvenient truth. But with no one to blame, Hammel and Lockwood explored how variations in the output of the Sun might control variations in the brightness of Neptune.
What would seem so simple statistically is complicated by the degrees of freedom in the various time series which is related to the serial correlation in the data (e.g., next year’s value is highly dependent on this year’s value). Nonetheless, they find that the correlation coefficient between solar irradiance and Neptune’s brightness is near 0.90 (1.00 is perfect). The same relationship is found between the Earth’s temperature anomalies and the solar output. Hammel and Lockwood note “In other words, the Earth temperature values are as well correlated with solar irradiance (r = 0.89) as they are with Neptune’s blue brightness (|r| > 0.90), assuming a 10-year lag of the Neptune values.” The temporal lag is needed to account for the large mass of Neptune that would require years to adjust to any changes in solar output.
Hammel and Lockwood conclude that “In summary, if Neptune’s atmosphere is indeed responding to some variation in solar activity in a manner similar to that of the Earth albeit with a temporal lag” then “Neptune may provide an independent (and extraterrestrial) locale for studies of solar effects on planetary atmospheres.”

More on the sun's variance and climate change here.

**Cosmic Rays**

One of the problems with irradiance as a driver for climate change is that though the changes seem to be fairly well correlated with the temperature anomaly, many scientists think the magnitude is too small to totally account for temperature changes. It is ironic that AGW supporters use this as a refutation of the sun’s effect, since they have exactly the same problem with CO2, and must posit huge positive feedback loops to justify their forecasts.

A second, newer theory has emerged as to a potential second warming effect of solar output. To understand it, we have to start with clouds. For those that don’t live in a hot climate like I do here in Phoenix, I will give everyone a bit of background – clouds cool things off. Ok, as with everything in climate, things are actually far more complicated – high clouds can sometimes cause warming, and nighttime clouds can actually slow cooling. Never-the-less, in general, cloudcover cools things off by blocking out and reflecting the sun’s energy.

Clouds are in fact such a strong cooling force that has been estimated by several sources (Theodor Landscheidt, 1998) that having clouds cover 1% more of the Earth’s surface would cancel the heating effect of a doubling of CO2. In fact, it was one of my criticisms earlier that AGW theory seems overly intent on finding positive feedback loops, while not considering negative feedbacks seriously enough – one such potential negative feedback is that on a warmer Earth, more water is evaporated into clouds, in turn cooling things back off.

But recently, an interesting new theory on cloud formation has emerged. In short, it holds that cosmic rays, which are the high energy particles that arrive at Earth from supernovas, spur cloud formation by ionizing air molecules that act as seeds for water condensation and cloud formation. This sounds wild, but really no wilder than warming by a gas (CO2) that makes up a near trivial portion of the atmosphere. Like CO2 warming, this effect has been observed in various laboratory chambers. But is it really a measurable driver of climate?

*Henrik Svensmark and Eigil Fris-Christensen* looked at historic data on cloud cover and cosmic ray incidence, from various measuring points. Their data was extended and refined by Shiva in 2005.
Cosmic rays vs. CO2 detailed

So what changes cosmic ray flux to the Earth? The biggest influence is the sun. When the sun’s output is high, cosmic rays are prevented from hitting the Earth, and vice versa. So high solar activity corresponds to low cosmic ray flux and therefore lower cloud formation and higher temperatures.

While the link between solar irradiance levels and warming is pretty straight forward, the cosmic ray cloud formation proposition is still in its infancy. Those of us who criticize AGW supporters for running past the evidence on CO2 should not make the same mistake on cosmic rays, and movies such as The Global Warming Swindle have gone too far in portraying this alternate theory as fact.

Man’s Land Use

Recently, Roger Pielke has done a substantial amount of research on a different type of anthropogenic forcing. Specifically, he has hypothesized that man’s changing patterns of land use can be a substantial driver of regional climate, including temperature and even more particularly, precipitation. For example, clearing relatively dry land and replacing it with irrigated agriculture substantially changes to the local heat balance, not the least by increasing humidity. Dr. Pielke explains summarizes the consequences on his web site:

Humans are significantly altering the global climate, but in a variety of diverse ways beyond the radiative effect of carbon dioxide. The IPCC assessments have been too conservative in recognizing the importance of these human climate forcings as they alter regional and global climate. These assessments have also not communicated the inability of the models to accurately forecast the spread of possibilities of future climate. The forecasts, therefore, do not provide any skill in quantifying the impact of different mitigation strategies on the actual climate response that would occur.
Chapter 7: The effects of global warming

There is no area in global warming discussions where AGW advocates have done more to shoot down their own credibility than in the absolutely egregious science and absurd claims that have been made about the potential negative effects of global warming. If AGW advocates are frustrated that skeptics question their science and their credibility, they need to look no further than their own claims on global warming effects, which are so easy to prove wrong that it causes people like me to question everything else they say.

Why only bad stuff?

Whenever global warming is discussed in the press, the consequences are all universally bad. Floods, famine, drought, pestilence, disease – they are all commonly predicted results of global warming. But it is worth noting that in the 1970’s, when climate scientists and the press were in a panic over global cooling, the predicted results were… floods, famine, drought, pestilence, disease. The implication is that we currently happen to be balanced on the knife edge of exactly the optimum world temperature for mankind. Any change warmer or cooler results in net negative consequences.

This, of course, seems an odd coincidence. Since man evolved into homo sapiens, he has experienced a wide range of cooler and warmer temperatures than we experience today. It seems frankly amazing that in the mid 20th century we happened to be sitting at the absolute ideal temperature for modern technological society and agriculture. Now, I guess you can argue that our society has made enormous investments based on the locations of the best crop lands, the height of the oceans, the typical paths of storms, etc., and that shifts in any of these would force an expensive restructuring of these investments. However, it is also worth noting that from the bottom of the Little Ice Age to say 1980, the world warmed at least a degree, and no one really noticed! Everyone was still talking about cooling!

So I think that any honest analysis of the effects of global warming would have to acknowledge that there are likely both positive and negative effects. While some areas may experience heat-induced droughts, other will be wetter as more moisture from the oceans is evaporated. While some crops will struggle, others, particularly in northern latitudes, will thrive due to longer growing seasons. For each crop of vegetables that wilt in a heat wave there will be a crop of citrus that didn’t freeze. While more may die from the heat, fewer will die from the cold. These may still net to a negative sum, but that net sum will be substantially less negative than a one-sided look at only the downsides of warming would arrive at.

One reason that warming impact analysis is hard is because while we may talk about the world warming a degree or two, the world does not warm evenly. Most climate models show the most warming on dry winter nights (Siberian winters, for example, get a disproportionate share of the warming). An extra summer degree in Arizona would suck; an extra winter degree in Siberia would probably be welcomed, and would likely extend growing seasons.

In the rest of this chapter, I will spend some time with a number of the most common “scary results” from global warming.

Ice melting / ocean rising

In An Inconvenient Truth, Al Gore claims that oceans will rise twenty feet due to global warming. Helpfully, a number of websites have been created to show what parts of the world (including much of Florida) would sink beneath the oceans like Atlantis with a 20-foot rise in sea level.

Fortunately, even most AGW supporters believe that Gore is wildly exaggerating, at least for any time period less than a couple of centuries. The Fourth IPCC report (see chart below) predicts sea level rise by
the year 2100 of ... 12-15 inches. And remember that this is based on forecasts of both CO2 production and climate sensitivity to CO2 that are arguably high by a factor of two or more. From the fourth IPCC report (different columns are for different starting CO2 forecasts):

![Sea Level Rise Chart](image)

**Figure 10.33.** Projections and uncertainties (5 to 95% ranges) of global average sea level rise and its components in 2080 to 2099 (relative to 1980 to 1999) for the six SRES marker scenarios. The projected sea level rise assumes that the net of the present-day ice sheet mass imbalance that is due to recent ice flow acceleration will persist unchanged. It does not include the contribution shown from scaled-up ice sheet discharge, which is an alternative possibility. It is also possible that the present imbalance might be transient, in which case the projected sea level rise is reduced by 0.02 m. It must be emphasized that we cannot assess the likelihood of any of these three alternatives, which are presented as illustrative. The state of understanding prevents a best estimate from being made.

By the way, to give a sense of scale, the IPCC estimates that the oceans have already risen about 0.2 meters in the last 130 years or so:

![Global Mean Sea Level](image)

**Figure E5.1E.** Annual average of the global mean sea level based on reconstructed sea level trends since 1970 and tide gauge measurements since 1920 (blue) and satellite altimetry since 1992 (black). Units are in mm relative to the average for 1951 to 1990. Error bars are 90% confidence intervals. (Figure 5.15)

One other interesting thing you can see from the sea level forecast chart is that even the IPCC considers ice melting virtually irrelevant. That is because most of the surface level increase is from thermal expansion of
the water as the oceans warm. In the A1B case, for example, net worldwide ice melt raises oceans by about 4 inches in the next hundred years.

This last conclusion may seem crazy to anyone who has watched the media of late or seen Mr. Gore’s movie. Images of ice crashing into the ocean and sea ice retreating are common fodder for global warming visuals. But the fact is that ice, like everything else in climate, is complicated.

- **North Pole:** Arctic sea ice melting is totally irrelevant to ocean surface levels. Since the ice floats, even a 100% melting of the Arctic ice will not change sea level one bit, just as ice melting in your glass of water does not cause your glass to overflow.

But some may argue that this ducks the question. Does current, well-documented retreat of artic ice sheets provide independent confirmation of the magnitude of AGW? In fact, though ice sheets are retreating, this seems to be part of a two hundred year trend that began long before man was burning fossil fuels in any quantity:

![Figure 9a: Upper, retreat of sea ice in the Norwegian Sea (T. Vinje, 2001). Lower, satellite data responding to the period between 1970 and 1998 are shown.](image)

- **Alpine Glaciers:** We know that many Alpine glaciers around the world are retreating. Some of this is surely from global warming, but some is also from fluctuations in precipitation. In many cases, we have documented evidence that these glaciers have been retreating since the 19th century, and that they have been less extensive in the past.
Reid A. Bryson is Emeritus Professor and founding chairman of the University of Wisconsin Department of Meteorology—now the Department of Oceanic and Atmospheric Sciences and a member of the United Nations Global 500 Roll of Honor. When asked about the retreat of Alpine glaciers, he says, “What do they find when the ice sheets retreat, in the Alps? A silver mine! The guys had stacked up their tools because they were going to be back the next spring to mine more silver, only the snow never went,” he says. “There used to be less ice than now. It’s just getting back to normal.”

Alaska Geographic published a chart of the retreat of the glaciers at Glacier Bay, Alaska, showing most of the retreat occurred before the 2nd half of the 20th century:

One special note should be made of the glaciers on Kilimanjaro, because their retreat over the last 125 years has been well-documented and played a starring role in An Inconvenient Truth. Analysis has shown that most the glacial retreat at Kilimanjaro occurred before 1953 (and therefore before most recent warming) and that the retreat has more to do with moisture in the air than with global warming. One wonders why the movie, with glacial retreats around the world that are provably due to warming, would focus on one that is probably not due to warming.

- **Greenland:** Greenland has a lot of ice, and there is not much doubt that if it all melted, the oceans would rise a lot. However, we know that in the middle ages, Greenland was much warmer and had less extensive ice coverage (thus the name Greenland and the successful attempt to farm it for over a century)

While there is a lot of discussion about whether the Medieval Warm Period extended worldwide, most accept that it did cover the North Atlantic, including Greenland. Boreholes, such as the Dahl-Jensen below, seem to prove out our historical information, showing a temperature peak around the year 1000.

- **Antarctica:** Something like 80-85% of the world’s ice is in Antarctica. And no one really thinks it is melting or going to melt. In fact, if you look at the marks on the IPCC chart above for the contribution of Antarctic ice to ocean levels, it has a net negative impact, which means the IPCC actually expects the Antarctic ice sheet to grow, not melt.

Whoa, that can’t be right! Mr. Gore showed those videos of ice retreating in Antarctica. Well, yes, sort of. Scientists expect that global warming will make the sea currents that circle Antarctica
a bit warmer, leading to more precipitation and more snowfall on the continent. Besides, Antarctica is so damn cold that raising temperatures a few degrees is not going to melt anything.

The one exception is the Antarctic Peninsula, which sticks out into the warmer oceans. This land area, representing about 2% of the Antarctic land mass and even less of its total ice sheet, is expected to warm and lose ice while the other 98% gains ice.

Guess what? Mr. Gore chose that little 2% to illustrate his movie. Was he ignorant of the choice he was making, or did he know exactly what he was doing, telling the literal truth (that the peninsula is melting) but leading viewers to the wrong conclusion overall about Antarctic ice?

By the way, one last interesting fact that frankly, scientists don’t fully understand is the fact that the South Pole is really not experiencing any warming. While the warming at the north pole exceeds the global average, the south pole shows little or no anomaly.

**Hurricanes & Tornados**

Alter Hurricane Katrina, the media storyline focused strongly on the role global warming may have played in increasing hurricane power and activity. Lost in the rush to blame global warming was the fact that Katrina, when it made landfall, was not even a category 5 hurricane, and its devastation was due more to a city sited below sea-level that did a poor job of managing its storm protection.

In fact, many hurricane experts do not agree with the argument that warming oceans can lead to more and stronger hurricanes. In fact, hurricane activity is more related to the difference in temperatures between the cold and warmer waters, a difference AGW theory says should decrease rather than increase. So is there reason to believe hurricanes are on the rise as global temperatures warm? The answer, as shown below, seems to be no:
But what about storm damage? It certainly seems like recent hurricanes have resulted in far more economic damage. And they have, but for the simple reason that over the last several decades, Americans have put billions of dollars of expensive homes and other facilities in vulnerable Gulf and Atlantic coast locations. Several years ago, Dr. RA Pielke and CW Landsea (that can’t really be the name of a scientist studying coastal strikes by hurricanes) attempted to correct hurricane damage numbers for the density and value of coastal real estate:

**Annual Hurricane Damage: 1925-1995**
Normalized to 1995 values

*Figure 4.* Time series of United States hurricane-related losses (direct damages in millions of 1995 U.S. Dollars) from 1925 to 1995 in normalized 1995 damage amounts (utilizing inflation, coastal county population changes and changes in wealth).
By this reckoning, it is hard to see any trend.

Another claim Mr. Gore makes in *An Inconvenient Truth* is that 2004 was the most active year for tornadoes ever in the United States, and that there has been a steady trend in increasing tornadoes as the globe has warmed.

And certainly if you look at the raw numbers, you might be worried:

![Tornado Chart](chart.png)

But there is a little something Mr. Gore fails to mention. During this time period, from 1950 to 2000, the technology and network for detecting tornadoes has improved vastly. From the NOAA

With increased national doppler radar coverage, increasing population, and greater attention to tornado reporting, there has been an increase in the number of tornado reports over the past several decades. This can create a misleading appearance of an increasing trend in tornado frequency. To better understand the true variability and trend in tornado frequency in the US, the total number of strong to violent tornadoes (F3 to F5 category on the Fujita scale) can be analyzed. These are the tornadoes that would have likely been reported even during the decades before Doppler radar use became widespread and practices resulted in increasing tornado reports. The bar chart below indicates there has been little trend in the strongest tornadoes over the past 55 years.
Oops! In fact, tornado frequency seems to be falling as temperatures warm. Do you think this was another honest mistake, like with Antarctica, or did Mr. Gore purposefully obfuscate the real story?

**Temperature Extremes**

Another argument is that global warming will lead to more temperature extremes, particularly record sweltering highs. That seems logical enough, but Bruce Hall actually compiled the data and found something interesting. He created a data base for each state which shows in what year that state's monthly temperature records were set. So for each state, he has the years when the twelve monthly high temperature records were set (e.g. year of highest Arizona Jan temp, year of highest Arizona Feb temp, etc.) and the years when the twelve monthly low temperature records were set. Here, for example, is his data for Arizona:

**Arizona: Temperature Extremes**

<table>
<thead>
<tr>
<th>Month</th>
<th>Maximum °F</th>
<th>Year</th>
<th>Place</th>
<th>Minimum °F</th>
<th>Year</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>90</td>
<td>2000</td>
<td>Organ Pipe National Monument*</td>
<td>−40</td>
<td>1971</td>
<td>Hawley Lake</td>
</tr>
<tr>
<td>Feb.</td>
<td>97</td>
<td>1988</td>
<td>Yuma*</td>
<td>−37</td>
<td>1985</td>
<td>Flagstaff</td>
</tr>
<tr>
<td>March</td>
<td>103</td>
<td>1985</td>
<td>Fort Mohave</td>
<td>−26</td>
<td>1968</td>
<td>Maverick</td>
</tr>
<tr>
<td>April</td>
<td>113</td>
<td>1988</td>
<td>Parker</td>
<td>−16</td>
<td>1980</td>
<td>Hawley Lake</td>
</tr>
<tr>
<td>May</td>
<td>121</td>
<td>1910</td>
<td>Gila Bend</td>
<td>4</td>
<td>1964</td>
<td>Pinion</td>
</tr>
<tr>
<td>June</td>
<td>128</td>
<td>1994</td>
<td>Lake Havasu City</td>
<td>13</td>
<td>1971</td>
<td>Alpine</td>
</tr>
<tr>
<td>July</td>
<td>127</td>
<td>1905</td>
<td>Parker</td>
<td>25</td>
<td>1997</td>
<td>Flagstaff</td>
</tr>
<tr>
<td>Aug.</td>
<td>124</td>
<td>1933</td>
<td>Parker*</td>
<td>20</td>
<td>1968</td>
<td>Fort Valley</td>
</tr>
<tr>
<td>Sept.</td>
<td>123</td>
<td>1950</td>
<td>Yuma</td>
<td>11</td>
<td>1934</td>
<td>Williams</td>
</tr>
<tr>
<td>Oct.</td>
<td>116</td>
<td>1917</td>
<td>Sentinel</td>
<td>−9</td>
<td>1949</td>
<td>Fort Valley</td>
</tr>
<tr>
<td>Nov.</td>
<td>100</td>
<td>1931</td>
<td>Granite Reef Dam</td>
<td>−30</td>
<td>1931</td>
<td>Fort Defiance</td>
</tr>
<tr>
<td>Dec.</td>
<td>92</td>
<td>1958</td>
<td>Bouse</td>
<td>−36</td>
<td>1990</td>
<td>Flagstaff</td>
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So, for example, the record for the highest July temperature was set in 1905 at Parker, Arizona with a scorching 127 degrees. The entry in his database would then be Arizona-July: 1905. He notes that there is
a bias in the data toward more recent years, since if the record was set in 1905 and tied in 1983, only the newer 1983 date will show in the data. I would also observe that this data is uncorrected for urban heat island effects (as cities urbanize they get hotter, and effect that is different than CO2-cause global warming and is usually corrected for in global warming studies). There is also a bias towards the present in having more measurement points today than 100 years ago: More measurement points means that, over a state, one is more likely to pick up the true high (or low).

Though I have other problems with the anthropogenic global warming hypothesis, I have never really doubted that the world has warmed up over the last century. So even I, a skeptic, would expect a disproportionate number of the all-time high temperatures to be in the last decade, particularly without UHI correction and with the bias discussed above. The global warming folks would argue that the effect should be doubly pronounced, since they claim that we are seeing not just a general heating, but an increase in volatility (ie more extreme variation around the mean).

But Hall doesn't find this when he graphs the data. Take the 600 state monthly high temperature records that exist on the books today (50 states times 12 months) and graph the distribution of years in which these records were set:

Assuming about 120 years of data, you should expect to see a high temperature record on average in a database of 600 records at 5 per year, which is precisely where we have been of late and well below the record years in the thirties (remember the dust bowl?) and the fifties. It seems to actually show a reduction in temperatures or volatility or both.

This may seem impossible – how can the mean increase without causing a lot more new highs? But remember what we discussed earlier – global warming is expected to be seen disproportionately in nighttime and winter temperatures. This means that the mean can increase even as daytime summer highs don’t increase much. In a sense, is the lows, not the highs, that are getting higher.
Vincent et al in 2005 did a study of temperature trends in South America from 1960-2000. What they observed is exactly what we discussed here: The number of warm days and cold days did not really change. The warming trend showed up as a decrease in cold nights and an increase in warm nights, meaning effectively that the diurnal (across 24 hours) temperature variation is narrowed.

It's a little hard to be scared by this.

**Extinction and Disease**

Biologist Josef Reichholf was interviewed recently in *der Spiegel*. He is a strong conservationist, and certainly has his axe to grind with industrial society. In fact he blames industrial agriculture and modern development for problems that species face.
Many species are certainly threatened, but not by climate change….Many species have already fled from the countryside to the cities, which have been transformed into havens of biodiversity. We are also seeing another interesting phenomenon: Major cities, like Hamburg, Berlin and Munich, have formed heat islands where the climate has been two or three degrees warmer than in the surrounding countryside for decades. If higher temperatures are truly so bad, why do more and more animals and plants feel so comfortable in our cities?

On the contrary, there is much to be said for the argument that warming temperatures promote biodiversity. There is a clear relationship between biodiversity and temperature. The number of species increases exponentially from the regions near the poles across the moderate latitudes and to the equator. To put it succinctly, the warmer a region is, the more diverse are its species.

OK, but what about those polar bears? We have all seen the media pictures of bears stranded on blocks of ice, as if all the arctic has melted out from under them. Well, it turns out that polar bears have survived much warmer conditions. We know polar bears existed as a separate species at least 125,000 years ago, and in the intervening years, there have been periods where Arctic sea ice melted completely during the summer months. And yet polar bears still exist today. Polar bears may be threatened by man’s hunting and encroachment on its hunting grounds, but not likely by our fossil fuel combustion.

AGW fear-mongering also extends to breathless predictions of increases in “tropical” diseases. Reichhoff also takes on this canard:

Many people truly believe that malaria will spread as temperatures rise. But malaria isn't even a true tropical disease. In the 19th century, thousands of people in Europe, including Germany, the Netherlands and even Scandinavia, died of malaria, even though they had never gone abroad. That's because this disease was still prevalent in northern and central Europe in previous centuries. We only managed to eliminate malaria in Europe by quarantining the sick, improving hygiene and draining swamps. That's why I consider it virtually impossible that malaria would return to us purely because of climate change. If it does appear, it'll be because it has been brought in somewhere.

Most of the world’s leading tropical disease experts tend to agree with Reichhoff. In fact, I would argue that diseases like Malaria are not diseases of the tropics but diseases of poverty and under-development. Malaria is prevalent in Africa not because Africa is hot but because Africa is poor. Asian tropical countries that have developed substantially over the last several decades have also greatly reduced malaria. In fact, as I will discuss in later sections, by reducing world economic growth and slowing development in the third world in the name of CO2 reduction, we will actually increase rather than reduce these diseases.

**Collapse of the Gulf Stream and Freezing of Europe**

One of the recent hysteria’s has been that global warming will cause the Gulf Stream to collapse as Atlantic circulation patterns are radically altered, thus leading to the freezing of Europe. More sober scientists have since essentially said “nevermind.” The Gulf Stream and Atlantic circulation patterns are far more robust than this theory assumed, and, even if the Gulf Stream changes, proponents of the theory were overestimating the dependence of Europe on Gulf Stream warming.

**Non-warming Effects of CO2**

Interestingly, we may eventually decide that other non-climate effects of CO2 production actually present more tangible environmental threats. In particular, recent studies have shown that more atmospheric CO2 is causing the PH of ocean surface layers to drop (ie become more acidic) leading potentially to coral kills and substantial changes in sea life. At the same time, physicist Freeman Dyson argues that stratospheric
cooling from man-made CO2 is much more a problem than surface warming, and is much more measurable and provable. These topics are beyond my scope at this point, but something we may see more of in the future.
Chapter 8: Kyoto and Policy Alternatives

**Kyoto**

In the mid-1990’s, a number of western nations crafted a CO2-reduction treaty named Kyoto for the city in which the key conference was held. The treaty called for signatory nations to roll back their CO2 emissions to below 1990 levels by a target date of 2012. Japan, Russia, and many European nations signed the treaty; the United States did not. In fact, the pact was ratified by 141 nations, but only calls for CO2 limits in 35 of these (so the other 106 were really going out on a limb signing it). China, India, Brazil and most of the third world are exempt from its limits.

We will discuss the costs and benefits of CO2 reduction a bit later. However, it is instructive to look at why Kyoto was crafted the way it was, and why the United States refused to sign, even when Al Gore was vice-president.

The most obvious flaw is that the entire developing world, including China, SE Asia, and India, are exempt. These countries account for 80% of the world's population and the great majority of growth in CO2 emissions over the next few decades, and they are not even included. If you doubt this at all, just look at what the economic recovery in China over the past months has done to oil prices. China's growth in hydrocarbon consumption will skyrocket over the coming years, and China is predicted to have higher CO2 production than the United States by 2009.

The second major flaw with the treaty is that European nations cleverly crafted the treaty so that the targets were relatively easy for them to make, and very difficult for the United States to meet. Rather than freezing emissions at current levels at the time of the treaty, or limiting carbon emission growth rates, the treaty called for emissions to be rolled back to below 1990 levels. Why 1990? Well, a couple of important things have happened since 1990, including:

a. European (and Japanese) economic growth has stagnated since 1990, while the US economy has grown like crazy. By setting the target date back to 1990, rather than just starting from day the treaty was signed, the treaty effectively called for a roll-back of economic growth in the US that other major world economies did not enjoy.

b. In 1990, Germany was reunified, and Germany inherited a whole country full of polluting inefficient factories from the old Soviet days. Most of the dirty and inefficient Soviet-era factories have been closed since 1990, giving Germany an instant one-time leg up in meeting the treaty targets, but only if the date was set back to 1990, rather than starting at the time of treaty signing.

c. Since 1990, the British have had a similar effect from the closing of a number of old dirty Midlands coal mines and switching fuels from very dirty coal burned inefficiently to more modern gas and oil furnaces and nuclear power.

d. Since 1990, the Russians have an even greater such effect, given low economic growth and the closure of thousands of atrociously inefficient communist-era industries.

It is flabbergasting that US representatives could allow the US to get so thoroughly out-manuevered in these negotiations. Does anyone in the US really want to roll back the economic gains of the nineties, while giving the rest of the world a free pass? Anyway, as a result of these flaws, and again having little to do with the global warming argument itself, the Senate voted 95-0 in 1997 not to sign or ratify the treaty unless these flaws (which still exist in the treaty) were fixed. Then-Vice-President Al Gore agreed that the treaty should not be signed without modifications, which were never made and which Europeans were never going to make.
By the way, enough time has elapsed that we have data on the progress of various countries in meeting these targets. And if you leave out various accounting games with offsets of dubious value, most all the European nations, despite all the advantages described above, are still missing their targets. The political will simply does not exist to hamstring their economies to the extent necessary to roll back CO2 growth. Actual growth rates for CO2 emissions have been (source UN):

<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>European Union</th>
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</thead>
<tbody>
<tr>
<td>1990-1995</td>
<td>6.4%</td>
<td>-2.2%</td>
</tr>
<tr>
<td>1996-2000</td>
<td>10.1%</td>
<td>2.2%</td>
</tr>
<tr>
<td>2001-2004</td>
<td>2.1%</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

You can see that the Europeans positioned themselves well in the 1990’s to make their targets. Realize that as the treaty was negotiated, they already had a good idea of these numbers for 1990-1995 and even a few years beyond. They knew that by selecting a 1990 baseline, they were already on target to meet the goals and the US would be far behind. Again, realize that the 1990-2000 EU performance on CO2 production had nothing to do with post-Kyoto regulatory responses and everything to do with the economic fundamentals we outlined above that would have existed with or without the treaty.

Since 2000, however, it has been a different story. European emissions have increased as their economies have recovered, at the same time the US experienced a post-9/11 slowdown.

By the way, the US is generally the great Satan in AGW circles because its per capita CO2 production is the highest in the world. But this is in part because our economic output per capita is close to the highest in the world. The US is about in the middle of the pack in efficiency, though behind many European countries which have much higher fuel taxes and heavier nuclear investments.

As an interesting side note, the US per capita CO2 emissions, as show below, have actually been flat to down since the early 1970’s. To the extent that Europe is doing better at CO2 reduction than the US, it may actually be more of an artifact of their declining populations vs. America’s continued growth.

![U.S. Per Capita Energy Use and Carbon Dioxide Emissions](Image)


Finally, if you get really tired of the US-bashing, you can take some comfort that though the US is the #1 per capita producer of CO2, of which we are uncertain is even harmful, we have done a fabulous job
reducing many other pollutants we are much more certain are harmful. For example, the US has much lower SO2 production than most European nations and the water quality is better. One could argue that the US has spent its abatement dollars on things that really matter.

Cost of the Solutions vs. the Benefits: Why Warmer but Richer may be Better than Colder and Poorer

If you get beyond the hard core of near religious believers in the massive warming scenarios, the average global warming supporter would answer this paper by saying: "Yes there is a lot of uncertainty, but though the doomsday warming scenarios via runaway positive feedback in the climate can't be proven, they are so bad that we need to cut back on CO2 production just to be on the safe side."

This would be a perfectly reasonable approach if cutting back on CO2 production was nearly cost-free. But it is not. The burning of hydrocarbons that create CO2 is an entrenched part of our lives and our economies. Forty years ago we might have had an easier time of it, as we were on a path to dramatically cut back on CO2 production via what is still the only viable technology to massively replace fossil fuel consumption -- nuclear power. Ironically, it was environmentalists that shut down this effort, and power industries around the world replaced capacity that would have gone nuclear mostly with coal, the worst fossil fuel in terms of CO2 production (per BTU of power, Nuclear and hydrogen produce no CO2, natural gas produces some, gasoline produces more, and coal produces the most).

Just halting CO2 production at current levels (not even rolling it back) would knock several points off of world economic growth. Every point of economic growth you knock off guarantees you that you will get more poverty, more disease, more early death. If you could, politically, even make such a freeze stick, you would lock China and India, nearly 2 billion people, into continued poverty just when they were about to escape it. You would in the process make the world less secure, because growing wealth is always the best way to maintain peace. Right now, China can become wealthier from peaceful internal growth than it can from trying to loot its neighbors. But in a zero sum world created by a CO2 freeze, countries like China would have much more incentive to create trouble outside its borders. This tradeoff is often referred to as a cooler but poorer world vs. a richer but warmer world. Its not at all clear which is better.

What impact, warming?

We've already discussed just how much the popular media has overblown the effect of warming. Sea levels may rise, but only by 15 inches in one hundred years, and even that based on arguably over-inflated IPCC models. There is no evidence that weather patterns will be more severe, or that diseases will spread, or that species will be threatened by warming. And, since most of the warming has been and will be concentrated in winter and nights, we will see rising temperatures more in a narrowing of temperature variability rather than a drastic increase in summer high temperatures. Growing seasons, in turn, will be longer and deaths from cold, which tend to outnumber heat-related deaths, will decline.

What impact, Intervention?

While the Kyoto treaty was a massively-flawed document, with current technologies a Kyoto type cap and trade approach is about the only way we have available to slow or halt CO2 emissions. And, unlike the impact of warming on the world, the impact of such a intervention is very well understood by the world's economists and seldom in fact disputed by global warming advocates. Capping world CO2 production would by definition cap world economic growth at the rate of energy efficiency growth, a number at least two points below projected real economic growth. In addition, investment would shift from microprocessors and consumer products and new drug research and even other types of pollution control to energy. The effects of two points or more lower economic growth over 50-100 years can be devastating:
• Remember the power of compounded growth rates we discussed earlier. A world real economic growth rate of 4% yields income fifty times higher in a hundred years. A world real economic growth rate two points lower yields income only 7 times higher in 100 years. So a two point reduction in growth rates reduces incomes in 100 years by a factor of seven! This is enormous. It means, literally, that on average everyone in a cooler world would make 1/7 what they would make in a warmer world.

• Currently, there are perhaps a billion people, mostly in Asia, poised to exit millennia of subsistence poverty and reach the middle class. Global warming intervention will likely consign these folks to continued poverty. Does anyone remember that old ethics problem, the one about having a button that every time you pushed it, you got a thousand dollars but someone in China died. Global warming intervention strikes me as a similar issue - intellectuals in the west feel better about man being in harmony with the Earth but a billion Asians get locked into poverty.

• Lower world economic growth will in turn considerably shorten the lives of billions of the world's poor

• A poorer world is more vulnerable to natural disasters. While AGW advocates worry (needlessly) about hurricanes and tornados in a warmer world, what we can be certain of is that these storms will be more devastating and kill more people in a poorer world than a richer one.

• The unprecedented progress the world is experiencing in slowing birth rates, due entirely to rising wealth, will likely be reversed. A cooler world will not only be poorer, but likely more populous as well. It will also be a hungrier world, particularly if a cooler world does indeed result in lower food production than a warmer world.

• A transformation to a prosperous middle class in Asia will make the world a much safer and more stable place, particularly vs. a cooler world with a billion Asian poor people who know that their march to progress was halted by western meddling.

• A cooler world would ironically likely be an environmentally messier world. While anti-growth folks blame all environmental messes on progress, the fact is that environmental impact is a sort of inverted parabola when plotted against growth. Early industrial growth tends to pollute things up, but further growth and wealth provides the resources and technology to clean things up. The US was a cleaner place in 1970 than in 1900, and a cleaner place today than in 1970. Stopping or drastically slowing worldwide growth would lock much of the developing world, countries like Brazil and China and Indonesia, into the top end of the parabola. Is Brazil, for example, more likely to burn up its rain forest if it is poor or rich?

The Commons Blog links to this study by Indur Goklany on just this topic:

If global warming is real and its effects will one day be as devastating as some believe is likely, then greater economic growth would, by increasing greenhouse gas (GHG) emissions, sooner or later lead to greater damages from climate change. On the other hand, by increasing wealth, technological development and human capital, economic growth would broadly increase human well-being, and society’s capacity to reduce climate change damages via adaptation or mitigation. Hence, the conundrum: at what point in the future would the benefits of a richer and more technologically advanced world be canceled out by the costs of a warmer world?

Indur Goklany attempted to shed light on this conundrum in a recent paper presented at the 25th Annual North American Conference of the US Association for Energy Economics, in Denver (Sept. 21, 2005). His paper — “Is a richer-but-warmer world better than poorer-but-cooler worlds?” — which can be found here, draws upon the results of a series of UK Government-sponsored studies which employed the IPCC’s emissions scenarios to project future climate change between 1990 and 2100 and its global impacts on various climate-sensitive determinants of human and environmental well-being (such as malaria, hunger, water shortage, coastal flooding, and habitat loss). The results indicate that notwithstanding climate change, through much of this century, human well-being is likely to be highest in the richest-but-warmest world and lower in poorer-but-cooler worlds. With respect to environmental well-being, matters may be best under the former world for some critical environmental indicators through 2085-2100, but not necessarily for others.
This conclusion casts doubt on a key premise implicit in all calls to take actions now that would go beyond “no-regret” policies in order to reduce GHG emissions in the near term, namely, a richer-but-warmer world will, before too long, necessarily be worse for the globe than a poorer-but-cooler world. But the above analysis suggests this is unlikely to happen, at least until after the 2085-2100 period.

Policy Alternatives

Above, we looked at the effect of a cap and trade scheme, which would have about the same effect as some type of carbon tax. This is the best possible approach, if an interventionist approach is taken. Any other is worse.

The primary other alternative bandied about by scientists is some type of alternative energy Manhattan project. This can only be a disaster. Many scientists are technocratic fascists at heart, and are convinced that if only they could run the economy or some part of it, instead of relying on this messy bottom-up spontaneous order we call the marketplace, things, well, would be better. The problem is that scientists, no matter how smart they are, miss with their bets because the economy, and thus the lowest cost approach to less CO2 production, is too complicated for anyone to understand or manage. And even if the scientists stumbled on the right approaches, the political process would just screw the solution up. Probably the number one alternative energy program in the US is ethanol subsidies, which are scientifically insane since ethanol actually increases rather than reduces fossil fuel consumption. Political subsidies almost always lead to investments tailored just to capture the subsidy, that do little to solve the underlying problem. In Arizona, we have thousands of cars with subsidized conversions to engines that burn multiple fuels but never burn anything but gasoline. In California, there are hundreds of massive windmills that never turn, having already served their purpose to capture a subsidy. In California, the state bent over backwards to encourage electric cars, but in fact a different technology, the hybrid, has taken off.

Besides, when has this government led technology revolution approach ever worked? I would say twice - once for the Atomic bomb and the second time to get to the moon. And what did either get us? The first got us something I am not sure we even should want, with very little carryover into the civilian world. The second got us a big scientific dead end, and probably set back our space efforts by getting us to the moon 30 years or so before we were really ready to do something about it or follow up the efforts.

If we must intervene to limit CO2, we should jack up the price of fossil fuels with taxes, or institute a cap and trade scheme which will result in about the same price increase, and the market through millions of individual efforts will find the lowest cost net way to reach whatever energy consumption level you want with the least possible cost. (The only real current alternative that is rapidly deploy-able to reduce CO2 emissions anyway is nuclear power, which could be a solution but was killed by...the very people now wailing about global warming.)
Chapter 9: Rebuttals by AGW Supporters

As stated in the introduction, the purpose of this paper is not to provide a balanced portrayal of AGW theory; its purpose instead is to provide a comprehensive overview of skeptic’s concerns with AGW theory. However, the issues raised here are not necessarily new, and AGW supporters have attempted to address many of them.

The New Scientist, a fairly strong and reliable voice for advocacy of anthropogenic global warming theory, recently published its response to what it calls 26 myths about global warming, many of these “myths” being correlated loosely with skeptics concerns about AGW theory as outlined in this paper. Walking through their points seems a reasonable way to entertain a rebuttal to the skeptic’s position. Each of these has a link to the New Scientist article in question. I have tried to summarize the position with a quote, shown in italics. My response to each then follows.

Before I get into these 20 myths, note that many of the key skeptic’s questions are neatly avoided. While the magazine gives itself certain softball questions, it does not attempt to take on skeptics questions such as:

- Isn’t warming from CO2 a diminishing return, such that each 10ppm of CO2 has less warming effect than the last 10 ppm?
- Isn’t warming from CO2 asymptotic, such that total warming from CO2 is capped?
- Isn’t 2/3 or more of the future warming in IPCC forecasts due to positive feedback effects that tend to be rare in stable systems and that even the IPCC admits are poorly understood?
- Aren’t there a lot of problems with ground-based temperature measurements?
- Aren’t the historical proxies for temperature diverging from measurements, such that the IPCC actually dropped many of the recent proxy measurements to hide this result?

There are many others, but we can get at them tangentially through dealing with the 20 “myths” below

• **Human CO2 emissions are too tiny to matter**

  So what's going on? It is true that human emissions of CO2 are small compared with natural sources. But the fact that CO2 levels have remained steady until very recently shows that natural emissions are usually balanced by natural absorptions. Now slightly more CO2 must be entering the atmosphere than is being soaked up by carbon "sinks".

  Though I do know that some skeptics will claim that man can’t be changing world CO2 levels, I don’t believe I even tried to make that claim in this paper.

  **The more salient point in asking whether human CO2 emissions are too tiny to matter is to ask whether the change in composition of the atmosphere of 0.009% by human activities is substantial enough to affect world climate in any important way, particularly when the portion being increased, CO2, is a relatively weak greenhouse gas vs. other portions.**

  • **We can't do anything about climate change**

  It is true that the action taken so far, such as the Kyoto Protocol, will only have a marginal effect. The protocol’s authors have always described it as a first step. But even before it came into effect in 2005, the protocol has triggered some profound thinking among governments, corporations and citizens about their carbon footprint and how to reduce it. Industrialized countries such as the UK are planning for emissions reductions of 60% or more by mid-century.
This is a bit of a straw man. Certainly to the extent that man is causing climate change, men with enough will can do something about it. The question is whether the costs justify the avoided change – this is a question that I have addressed sufficiently and won’t revisit here. However, I would like to comment on this:

*We may find that once the process has begun, the world loses its addiction to carbon fuels surprisingly quickly. Natural scientists fear “tipping points” in the climate system. But there are also tipping points in social, economic and political systems. Once under way, things can happen fast...*

This is a statement to which I both agree and disagree. I am a technological optimist, and so generally accept that world-changing technologies will continue to spring from man’s mind, and that the introduction of these changes can be fast and their impact dramatic. The only reason that I am a tad skeptical about this statement is that the vast majority of strong AGW adherents are technology pessimists, so it would be uncharacteristic for them to take such a position. Absent unimagined new technologies, change of the type AGW supporters are hoping for is actually *not* a positive feedback process as implied in this statement. Why is it that climate scientists see so many positive feedback processes, when these are actually so rare? In fact, most investment decisions, for example investments to reduce CO2 emissions, follow a diminishing return relationship. Early investors capture the low-hanging fruit, while each successive wave of investment offers a lower return (here, in CO2 reduction) for each incremental dollar invested.

- **The ‘hockey stick’ graph has been proven wrong**

  *Most researchers would agree that while the original hockey stick can – and has – been improved in a number of ways, it was not far off the mark. Most later temperature reconstructions fall within the error bars of the original hockey stick. Some show far more variability leading up to the 20th century than the hockey stick, but none suggest that it has been warmer at any time in the past 1000 years than in the last part of the 20th century.*

No one statement by AGW supporters would do more to build my confidence in their findings than to actually have someone say “the Mann hockey stick was a deeply flawed analysis, and we have taken great pains to make sure the flaws identified in Mann are not present in other historical reconstructions.” However, when I see the statement above, I am left to wonder if any of the flaws in Mann have actually been corrected in other works, or if systematic errors still exist. Since AGW supporters refuse to acknowledge flaws in Mann, it is almost certain that these flaws still exist in the other analyses (therefore making it unsurprising that new analyses show roughly the same results). Remember that Mann was replaced by Biffra as lead author of this section of the Fourth IPCC report, and it was Biffra who dropped 20-30 years of recent data from his historical reconstruction when it did not show the result that he wanted it to.

- **Chaotic systems are not predictable**

  *Getting reasonably accurate predictions is a matter of choosing the right timescale: days in the case of weather, decades in the case of climate.*

  *Climate scientists sometimes refer to the effects of chaos as intrinsic or unforced variability: the unpredictable changes that arise from the dynamic interactions between the oceans and atmosphere rather than being a result of "forcings" such as changes in solar irradiance or greenhouse gases.*

  *The crucial point is that unforced variability occurs within a relatively narrow range. It is constrained by the major factors influencing climate: it might make some winters bit a warmer, for instance, but it cannot make winters warmer than summers*
There are systems people who would both agree and disagree with this statement. The real study of chaotic systems is barely older than the study of global warming, and most mathematicians would say that the issue of long-term predictability of macro trends in chaotic systems is not settled science.

However, one issue the statement overlooks is that even if chaotic systems have some long-term order, at least when “viewed from a distance,” this does not mean that the drivers of those long-term trends can be discerned by those of us standing in the chaos. So while it may be theoretically possible to predict long-scale climate changes, it may still be impossible to discern the true drivers of these climate systems amidst the chaos, making the long-term prediction problem moot.

Remember, no one has a thermometer that provides two readings – temperature due to “natural” causes and temperature due to man-made forcings. The only argument one can make outside of a laboratory is to try to correlate temperature changes to certain other variables, like CO2 level. But in a chaotic system, when thousands of variables may matter, and there are all kinds of cross-dependencies between variables, definitively showing direct correlation, much less causation, is very hard, possibly impossible. Remember, outside lab experiments, climate scientists main argument that CO2 is causing current warming is “We have checked everything else it possibly could be, and it wasn’t those things, so it must be CO2.” In a chaotic system, such a statement borders on hubris.

- We can't trust computer models of climate

> Climate is average weather, and it can vary unpredictably only within the limits set by major influences like the Sun and levels of greenhouse gases in the atmosphere. We might not be able to say whether it will rain at noon in a week's time, but we can be confident that the summers will be hotter than winters for as long as the Earth's axis remains tilted.

> The validity of models can be tested against climate history. If they can predict the past (which the best models are pretty good at) they are probably on the right track for predicting the future – and indeed have successfully done so.

I hope that if you have learned anything from this paper, you already know how to refute the statement above. Climate models match history because they have been tuned and tweaked and overridden to do so. The fact that they then can reproduce history is meaningless. Even more, you should run away quickly from anyone who makes this statement, because they are either ignorant of what they are talking about or they are trying to sell you the Brooklyn Bridge.

> Finally, the claim is sometimes made that if computer models were any good, people would be using them to predict the stock market. Well, they are!

> A lot of trading in the financial markets is already carried out by computers. Many base their decisions on fairly simple algorithms designed to exploit tiny profit margins, but others rely on more sophisticated long-term models.

Sorry, but this is a facile and ignorant mis-interpretation of what financial models are doing. Yes, people are running long-term financial models as part of a trading strategy, but these models feed into very short-term trading decisions. If you looked at the output from these long-term models, you would see that they are changing constantly as new data flows in. There is an old joke about two campers who see a bear growling at them. One of them starts putting his tennis shoes on. The other one says to him “Why are you putting your shoes on? You can’t outrun that bear.” His friend replied “I don’t have to outrun the bear. I just have to outrun you.” Traders’ long-term models work the same. They don’t actually expect them to be right, they just want them to be better, based on current conditions, than other traders’ models, then they can make money.
• They predicted global cooling in the 1970s

Indeed they did…. However, Schneider soon realised he had overestimated the cooling effect of aerosol pollution and underestimated the effect of CO₂, meaning warming was more likely than cooling in the long run….

The calls for action to prevent further human-induced global warming, by contrast, are based on an enormous body of research by thousands of scientists over more than a century that has been subjected to intense – and sometimes ferocious – scrutiny. According to the latest IPCC report, it is more than 90% certain that the world is already warming as a result of human activity.

We have already dealt with aerosols, and unlike many skeptics I have not really held the 1970’s global cooling panic against the climate community. The last paragraph is just circular. Saying the IPCC is 90% sure does not answer the arguments about what skeptics feel the IPCC is ignoring.

• It's been far warmer in the past, what's the big deal?

First of all, it is worth bearing in mind that any data on global temperatures before about 150 years ago is an estimate, a reconstruction based on second-hand evidence such as ice cores and isotopic ratios. The evidence becomes sparser the further back we look, and its interpretation often involves a set of assumptions. In other words, a fair amount of guesswork.

This is hilarious. What happened to their confidence in Mann and 1000-year temperature reconstructions just a few myths back? But to continue, the answer is basically yes, but:

The important question is what is causing the current, rapid warming? We cannot dismiss it as natural variation just because the planet has been warmer at various times in the past. Many studies suggest it can only be explained by taking into account human activity.

Nor does the fact that it has been warmer in the past mean that future warming is nothing to worry about. The sea level has been tens of metres higher during past warm periods, enough to submerge most major cities around the world.

Here is why it matters – beyond the laboratory evidence of the greenhouse effect, which tells us merely that there is an affect and not how strong it is, the main evidence cited by AGW supporters for current warming being man-made is to try to show that current warming is somehow unprecedented, and therefore unlikely to be natural. So it is odd here that AGW supporters simply shrug their shoulders here and say that it is not important that current warming be unprecedented.

• It's too cold where I live - warming will be great

This does not sound too bad, and for many people it won't be. Wealthy individuals and countries will be able to adapt to most short-term changes, whether it means buying an air conditioner or switching to crops better suited to the changing climate. Rainfall will fall in mid-latitudes but rise in high latitudes, and initially agricultural yields will probably. Some regions will suffer, though. Africa could be hardest hit, with yields predicted to halve in some countries as early as 2020.

As global temperature climbs to 3°C above present levels - which is likely to happen before the end of this century if greenhouse emissions continue unabated - the consequences will become increasingly severe. More than a third of species face extinction. Agricultural yields will start to fall in many parts of the world. Millions of people will be at risk from coastal flooding. Heatwaves, droughts, floods and wildfires will take an ever greater toll.
I hope readers will accept that I am not exaggerating or constructing straw men when I talk about the dire predictions by AGW supporters. There is nothing here that we have not dealt with earlier, except perhaps the rainfall. Of late, AGW supporters seem to have shifted to rainfall (rather than sea level rise) as their lead scary topic. Note, however, that even the IPCC admits that it and all of its modelers really do not understand (even a little bit) the effect of global warming on rainfall and drought. Logic says that with more water evaporated, while global warming may cause now local draughts, overall rainfall should increase. I would bet any amount of money that lower economic growth due to aggressive CO2 abatement will have a far more deleterious effect on worldwide agricultural yields than global warming.

• **Global warming is down to the Sun, not humans**

  So what role, if any, have solar fluctuations had in recent temperature changes? While we can work out how Earth's orbit has changed going back many millions of years, we have no first-hand record of the changes in solar output associated with sunspots before the 20th century.

  It is true that sunspot records go back to the 17th century, but sunspots actually block the Sun's radiation. It is the smaller bright spots (faculae) that increase the Sun's output and these were not recorded until more recently. The correlation between sunspots and bright faculae is not perfect, so estimates of solar activity based on sunspot records may be out by as much as 30%.

  The other method of working out past solar activity is to measure levels of carbon-14 and beryllium-10 in tree rings and ice cores. These isotopes are formed when cosmic rays hit the atmosphere, and higher sunspot activity is associated with increases in the solar wind that deflect more galactic cosmic rays away from Earth. Yet again, though, the correlation is not perfect. What is more, recent evidence suggests that the deposition of beryllium-10 can be affected by climate changes, making it even less reliable as a measure of past solar activity.

  This is again a pretty hilarious statement. One could easily argue that temperature and CO2 proxies have at least as much uncertainty. One wonders why AGW advocates do not seem as concerned about the errors in the proxies they hold dear. But anyway, to continue:

  But even if solar forcing in the past was more important than this estimate suggests, as some scientists think, there is no correlation between solar activity and the strong warming during the past 40 years. Claims that this is the case have not stood up to scrutiny (pdf document).

  Direct measurements of solar output since 1978 show a steady rise and fall over the 11-year sunspot cycle, but no upwards or downward trend.

  Similarly, there is no trend in direct measurements of the Sun's ultraviolet output and in cosmic rays. So for the period for which we have direct, reliable records, the Earth has warmed dramatically even though there has been no corresponding rise in any kind of solar activity.

  This is another you-study-my-study pissing match. I am happy to admit that our knowledge of the sun’s changing impact on climate is poor, and that it is hard to separate out this one effect in a chaotic system. I refuse to fall into the same scientific hubris as AGW supporters. However, those who think the sun has some contribution to warming are buttressed by the knowledge that they are working with the main driver of climate, rather than a secondary variable.

• **It’s all down to cosmic rays**

  There is no convincing evidence that cosmic rays are a major factor determining cloud cover. The ionising of air by cosmic rays will impart an electric charge to aerosols, which in theory could
encourage them to clump together to form particles large enough for cloud droplets to form around, called "cloud condensation nuclei".

But cloud physicists say it has yet to be shown that such clumping occurs. And even if it does, it seems far-fetched to expect any great effect on the amount of clouds in the atmosphere. Most of the atmosphere, even relatively clean marine air, has plenty of cloud condensation nuclei already.

A series of attempts by Svensmark to show an effect have come unstuck. Initially, Svensmark claimed there was a correlation between cosmic ray intensity and satellite measurements of total cloud cover since the 1980s – yet a correlation does not prove cause and effect. It could equally well reflect changes in solar irradiance, which inversely correlate with cosmic ray intensity.

I am starting to notice a trend here of making statements about competing that could be applied equally well to AGW theory. And what about all those points they made above, reminding us over and over that CO2 greenhouse theory works in the lab. Now the lab is not good enough?

However, I would accept that the cosmic ray theory is pretty undeveloped and not acceptably proven. It has had a number of fits and starts. Just like CO2 greenhouse theory, the cosmic ray effect on climate can be reproduced in the lab, but it is really hard to parse out its effects in the chaotic climate.

• CO2 isn't the most important greenhouse gas

At some of these overlaps, the atmosphere already absorbs 100% of radiation, meaning that adding more greenhouse gases cannot increase absorption at these specific frequencies. For other frequencies, only a small proportion is currently absorbed, so higher levels of greenhouse gases do make a difference.

This means that when it comes to the greenhouse effect, two plus two does not equal four.

Wow! An AGW supporter actually said this in public. This is to our point that there is a diminishing return from incremental CO2 in the atmosphere. Of course, they say this in the context of trying to show why water isn’t as important as it might seem, but still, it’s there

But the overall quantities of these other gases are tiny. Even allowing for the relative strength of the effects, CO2 is still responsible for two-thirds of the additional warming caused by all the greenhouse gases emitted as a result of human activity.

Water vapour will play a huge role in the centuries to come, though. Climate models, backed by satellite measurements, suggest that the amount of water vapour in the upper troposphere (about 5 to 10 kilometres up) will double by the end of this century as temperatures rise.

This will result in roughly twice as much warming than if water vapour remained constant. Changes in clouds could lead to even greater amplification of the warming or reduce it – there is great uncertainty about this. What is certain is that, in the jargon of climate science, water vapour is a feedback, but not a forcing.

Again, I am not getting into this, we covered it plenty in the paper. When they say “CO2 is still responsible for two-thirds of the additional warming” (and remember this is an output of their models, not any other analysis) what they really mean is that “our models that were programmed to have CO2 drive the climate show that CO2 drives the climate.” Note that in a three paragraph answer about the effect of water vapor as a climate feedback, only three words – “or reduce it” – acknowledge that it might actually have a negative feedback effect, despite the fact that even the IPCC includes cloud cover as a negative feedback. They just don’t want to admit a negative feedback might even exist.
• **The lower atmosphere is cooling, not warming**

  *One study in Science* revealed errors in the way satellite data had been collected and interpreted. For instance, the orbit of satellites gradually slows, which has to be taken into account because it affects the time of day at which temperature recording are taken. This problem was always recognised, but the corrections were given the wrong sign (negative instead positive and vice versa).

  *A second study, also in Science*, looked at the weather balloon data. Measurements of the air temperature during the day can be skewed if the instruments are heated by sunlight. Over the years the makers of weather balloons had come up with better methods of preventing or correcting for this effect, but because no one had taken these improvements into account, the more accurate measurements appeared to show daytime temperatures getting cooler.

  The corrected temperature records show that tropospheric temperatures are indeed rising at roughly the same rate as surface temperatures. Or, as a [2006 report by the US Climate Change Science Program (pdf)](http://www.climatescience.gov/) puts it: “For recent decades, all current atmospheric data sets now show global-average warming that is similar to the surface warming.” This one appears settled.

  There is still some ambiguity in the tropics, where most measurements show the surface warming faster than the upper troposphere, whereas the models predict faster warming of the atmosphere. However, this is a minor discrepancy compared with cooling of the entire troposphere and could just be due to the errors of margin inherent in both the observations and the models.

  First, observe absolutely ruthless efforts to apply corrections and adjustments to any measurement that does not fit their theory, while blithely accepting the surface temperature measurements that we showed can be really unreliable. Given the choice of focusing on managing satellite temperatures up or surface temperature down, you can see which they chose. Second, note that this is another narrow one study conclusion. AGW supporters frequently cite single studies (conducted by AGW supporters) that overturn skeptics arguments as having “settled” the issue. There are still many reasons to think that troposphere temperature increases are less than surface increases. Finally, even temperature increases that were the same between the surface and the troposphere would be a real problem for AGW theory. The authors here act like this surface-troposphere issue is a minor deal, but in fact if AGW theory is right, the troposphere has to warm more, because that is where the extra heat is being absorbed. This is not at all settled.

• **Antarctica is getting cooler, not warmer, disproving global warming**

  It is clear that the Antarctic Peninsula, which juts out from the mainland of Antarctica towards South America, has warmed significantly. The continent’s interior was thought to have warmed too, but in 2002 a [new analysis of records](http://www.climatescience.gov/) from 1966 to 2000 concluded that it has cooled overall....

  Climate models do not predict an evenly spread warming of the whole planet: changes in wind patterns and ocean currents can change the distribution of heat, leading to some parts warming much faster than average, while others cool at first.

  Agreed

• **The oceans are cooling**

  Now the authors of the 2006 study have [submitted a correction (pdf format)](http://www.climatescience.gov/). It turns out that a fault in the software on some of the floats led to some temperature measurements being associated with the wrong depth.
Meanwhile, work by other teams suggests that the past warmth of the oceans has been overestimated. The problem was due to expendable sensors that are thrown overboard and take measurements as they sink.

I never had heard the claim that the oceans were cooling, so it does not surprise me that they are not. However, it is again interesting the amount of due diligence that AGW supporter put in to the correction of any temperature measurement the might refute global warming, while blithely accepting the atrocious condition and biases in ground-based temperature measurement because, well, because these instruments are telling the story they want to hear.

• The cooling after 1940 shows CO₂ does not cause warming

The mid-century cooling appears to have been largely due to a high concentration of sulphate aerosols in the atmosphere, emitted by industrial activities and volcanic eruptions. Sulphate aerosols have a cooling effect on the climate because they scatter light from the Sun, reflecting its energy back out into space.

The rise in sulphate aerosols was largely due to the increase in industrial activities at the end of the second world war. In addition, the large eruption of Mount Agung in 1963 produced aerosols which cooled the lower atmosphere by about 0.5°C, while solar activity levelled off after increasing at the beginning of the century.

I think I was pretty fair in discussing the aerosol cooling hypothesis in this paper, though many would disagree with the above statement’s certainty.

Climate models that take into account only natural factors, such as solar activity and volcanic eruptions, do not reproduce 20th century temperatures very well. If, however, the models include human emissions, including greenhouse gases and aerosols, they accurately reproduce the 1940 to 1970 dip in temperatures.

I hope readers who have made it this far can supply the refutation of this point: Wrong, wrong, wrong. Climate models initially matched history poorly. Today they match well because they have been tweaked and adjusted and forced to match. They match because they are programmed to match. And, as we discussed, they match only because they make ridiculously low assumptions for natural forcings, and assume all natural forcings causing temperatures to rise in the first half of the century magically reversed in 1950, though there is no good evidence for it.

• It was warmer during the Medieval period, with vineyards in England

In the southern hemisphere, the picture is even more mixed, with evidence of both warm and cool periods around this time. The Medieval Warm Period may have been partly a regional phenomenon, with the extremes reflecting a redistribution of heat around the planet rather than a big overall rise in the average global temperature.

What is clear, both from the temperature reconstructions and from independent evidence – such as the extent of the recent melting of mountain glaciers – is that the planet has been warmer in the past few decades than at any time during the medieval period. In fact, the world may not have been so warm for 6000 or even 125,000 years (see Climate myths: It has been warmer in the past, what's the big deal?).

What really matters, though, is not how warm it is now, but how warm it is going to get in the future. Even the temperature reconstructions that show the greatest variations in the past 1000 years suggest up until the 1980s, average temperature changes remained within a narrow band.
spanning 1°C at most. Now we are climbing out of that band, and the latest IPCC report (pdf format) predicts a further rise of 0.5°C by 2030 and a whopping 6.4°C by 2100 in the worst case scenario.

We have covered this pretty well in this paper, so again I won’t go back into it, except to highlight a couple of things we can learn from this statement. First, note the hubris again – it is warmer today than in the last 125,000 years. I sure wish there was a way to bet on this – I would have only a one in 125,000 chance of being wrong in betting against this statement. Second, note the use of the worst case scenarios. For 2100, we don’t get the best case or even the average case, we get the worst case. Can you name another branch of science where people do this? Can you imagine, say, a group out to measure the speed of light. They are going to get some middle figure with an error band of some range. Wouldn’t you expect them to day that they found the speed of light to be so-and-so, plus or minus an error of such-and-such size? If they were climate scientists, they would instead announce that they have found the speed of light could be as large as Z, that being the highest possible figure in their error band.

• **We are simply recovering from the Little Ice Age**

Yet while there is some evidence of cold intervals in parts of the southern hemisphere during this time, they do not appear to coincide with those in the northern hemisphere. Such findings suggest the Little Ice Age may have been more of a regional phenomenon than a global one.

Solar radiation was probably lower at times during this period, especially during a dip in solar activity called the Maunder minimum around 1700, but models and temperature reconstructions suggest this would have reduced average global temperatures by 0.4°C at most.

The larger falls in temperature in Europe and North America may have been due to changes in atmospheric circulation over the North Atlantic, or in the Gulf Stream, or both, reducing heat transport from the tropics (see Climate change sceptics lose vital argument).

The warming after the so-called Little Ice Age may reflect both an increase in solar activity and a redistribution of heat around the planet. In particular, the increase in global temperature in the first half of the 20th century may have been largely due to an increase in solar activity. The continued warming in recent decades, however, cannot be explained by increases in solar radiation alone.

Remember the graphs we showed earlier – the arctic proxies look like the current warming is a straight linear increase from the 1700s to today. In fact, in the IPCC spaghetti graph showing all those historic reconstructions, they all show a natural warming from the 18th and 19th century through the 20th. Again, AGW supporters really need to explain why they are so confident that this natural warming trend stopped in 1945 or so, exactly and coincidently at the exact same moment that man-made forcings caused the world to continue to warm, coincidently at about the same rate it was warming naturally earlier in the century.

• **Warming will cause an ice age in Europe**

Few scientists think there will be a rapid shutdown of circulation. Most ocean models predict no more than a slowdown, probably towards the end of the century. This could slow or even reverse some of the warming due to human emissions of greenhouse gases, which might even be welcome in an overheated Europe, but the continent is not likely to get colder than it is at present.

A slowdown in circulation would affect many parts of the world by disrupting global rainfall patterns. But these effects will be insignificant compared with the much greater changes global warming will cause.
I already mentioned that this had been refuted pretty well

- **Ice cores show CO₂ increases lag behind temperature rises, disproving the link to global warming**

  *It takes about 5000 years for an ice age to end and, after the initial 800 year lag, temperature and CO₂ concentrations in the atmosphere rise together for a further 4200 years.*

  *What seems to have happened at the end of the recent ice ages is that some factor – most probably orbital changes – caused a rise in temperature. This led to an increase in CO₂, resulting in further warming that caused more CO₂ to be released and so on: a positive feedback that amplified a small change in temperature. At some point, the shrinking of the ice sheets further amplified the warming.*

  *Models suggest that rising greenhouse gases, including CO₂, explains about 40% of the warming as the ice ages ended. The figure is uncertain because it depends on how the extent of ice coverage changed over time, and there is no way to pin this down precisely.*

I was extremely happy to see that they at least tried to address the issue I raised, ie is it really realistic to have a process dominated by positive feedback, and if so, why doesn’t it run away. Their answer:

  *Finally, if higher temperatures lead to more CO₂ and more CO₂ leads to higher temperatures, why doesn’t this positive feedback lead to a runaway greenhouse effect? There are various limiting factors that kick in, the most important being that infrared radiation emitted by Earth increases exponentially with temperature, so as long as some infrared can escape from the atmosphere, at some point heat loss catches up with heat retention.*

Which might make sense EXCEPT that they are claiming that today’s temperature and level of CO₂ are higher than these historical levels, so we are already higher than the level where they claim “heat loss catches up with heat retention.” So either their answer is right, and there is a strong compensating process which is not built into their models, or they are wrong and they still need to explain what keeps a positive feedback dominated process from running away.

- **Ice cores show CO₂ rising as temperatures fell**

  *There are some mismatches though. Besides lags at the end of ice ages, cores taken from the ice overlying the famous lake below Vostok in Antarctica seemed to show that about 120,000 years ago, the temperature plummeted sharply while CO₂ levels remained high for many thousands of years.*

  *The question is whether this is real or just a reflection of the problems with working out the age of the trapped air and with deuterium as a temperature indicator. Many researchers are working on ways to independently date the air and the ice, and to improve temperature reconstructions based on relative deuterium content. One involves working out what is called the deuterium excess by comparing the relative amounts of deuterium and oxygen-18 in the ice.*

  *The deuterium excess reflects the temperature at the sea surface where the water that later fell as snow evaporated, rather than the surface temperature where the snow fell. It helps to reveal whether variations in the relative deuterium content of the ice are a result of water coming from a different source region rather than changes in local temperature.*

  *In 2001, researchers used the deuterium excess to correct for some of the problems with the temperature record of the Vostok ice core. Their results produce a much closer fit between.....*
temperature and CO₂ levels and reduces the mismatch around 120,000 years ago to a few thousand years.

I did not really raise this issue, as even the most enthusiastic AGW supporter does not tend to claim that CO₂ drives all historic temperature changes. However, again, note the pattern – any historic data that does not fit with AGW data typically is scrutinized and “corrected.” Articles discussing flaws in methodology in gathering such data are quickly published. Contrast this with the difficulty scientists have in questioning any data that supports AGW theory. As we saw earlier, the New Scientist still can’t bring itself to utter the words “the Mann hockey stick was flawed.” Neither could the IPCC, they just sort of dropped it, or buried it in the midst of 12 others, without even saying why the analysis that was the centerpiece of their last report was strangely missing.

- Mars and Pluto are warming too

The Sun’s energy output has not increased since direct measurements began in 1978. If increased solar output really was responsible, we should be seeing warming on all the planets and their moons, not just Mars and Pluto.

Our solar system has eight planets, three dwarf planets and quite a few moons with at least a rudimentary atmosphere, and thus a climate of sorts. Their climates will be affected by local factors such as orbital variations, changes in reflectance (albedo) and even volcanic eruptions, so it would not be surprising if several planets and moons turn out to be warming at any one time.

I agree we have a lot to learn about this, and nothing at all is settled. However, we now have evidence from at least 5 other terrestrial bodies that are warming at the same time the Earth is warming. Why do AGW supporters resist at least investigating further?

- Many leading scientists question climate change

Climate change sceptics sometimes claim that many leading scientists question climate change. Well, it all depends on what you mean by "many" and "leading". For instance, in April 2006, 60 "leading scientists" signed a letter urging Canada’s new prime minister to review his country’s commitment to the Kyoto protocol.

This appears to be the biggest recent list of sceptics. Yet many, if not most, of the 60 signatories are not actively engaged in studying climate change: some are not scientists at all and at least 15 are retired.

Compare that with the dozens of statements on climate change from various scientific organisations around the world representing tens of thousands of scientists, the consensus position represented by the IPCC reports and the 11,000 signatories to a petition condemning the Bush administration’s stance on climate science.

I have carefully avoided the game of dueling scientific numbers. As to the claim that the skeptic list “are not actively engaged in studying climate change: some are not scientists at all and at least 15 are retired” I would be thrilled if AGW supporters held to this standard in making their own numbers. But, they manage to abandon this standard by the next paragraph, when they claim the pro-AGW numbers, like the 11,000, are open to the same criticism (since there are only 500-600 true climate scientists in the world, vs. physicist, meteorologists, etc).

- It’s all a conspiracy
Now that there is a consensus, those whose findings challenge the orthodoxy are always going have a tougher time convincing their peers, as in any field of science. For this reason, there will inevitably be pressure on scientists who challenge the consensus. But findings or ideas that clash with the idea of human-induced global warming have not been suppressed or ignored – far from it.

Journalists do have an interest in promoting themselves (and their books), while their employers want to boost their audience and sell advertising. Publicity helps with all these aims, but you get far more publicity by challenging the mainstream view than by promoting it. Which helps explain why so many sections of the media continue to publish or broadcast the claims of deniers, regardless of their merit.

The notion of a “conspiracy” of course, is a useful straw man, implying devious villains in the SPECTRE conference room planning the overthrow of the world. I won’t argue the point again, except to encourage you to watch the news with a critical eye, and decide for yourself. However, just to get you started, ask yourself if these events are signs of healthy, unbiased science:

- A group of AGW supporters are trying to get the British government to use force to block the publication of a skeptical movie (the Global Warming Swindle)
- AGW supporters in California have included skeptical scientists such as MIT’s Dr. Richard Lindzen as defendants in a law suit, asking that damages be paid by people and companies whose public speech doesn’t conform to AGW theory
- Many AGW skeptics have been unable to get scientists who have published publicly funded research to reveal their data and methodology for critique. Freedom of Information Act (FOIA) requests have become a necessary tool of climate skeptics.
- When a group began photographing temperature measurement points to document the shortcomings in historical surface temperature measurements, the NOAA pulled the locations of its measurement stations off the Internet so that these US citizens could no longer take pictures of and critique US government installations.
- Scientists who question AGW theory are equated by AGW supporters with Holocaust deniers.

• Hurricane Katrina was caused by global warming

More data is needed settle the issue. Some are looking to natural records of past hurricane activity in stalagmites, lake deposits and coral rubble. Others are re-analysing existing databases. In February 2007, one such re-analysis concluded that over the past two decades, hurricane intensity has increased in the Atlantic but not in other parts of the world (pdf format).

Yet another complicating factor is that changes in climate can also change the paths that tropical cyclones tend to take, determining whether they remain over oceans or strike land.

What every one agrees on is that over the past few decades there has been a huge rise in the number of people being killed or injured by hurricanes, and in damage to infrastructure, and this trend looks set to continue. The main reason for this, however, is that more and more people are living and building in hurricane zones.

Most of these three paragraphs is entirely correct – there is no evidence that hurricane numbers or intensity are effected by global warming, and if they are, whether they are increased or decreased. However, Hurricane Katrina was most certainly NOT caused by global warming. Why can’t they just say that? It may have been made stronger or weaker. Its course may have been altered. But it was not created by warming. By the way, the year after Katrina saw a much smaller than average Atlantic hurricane season.

• Higher CO₂ levels will boost plant growth and food production
But it is extremely difficult to generalise about the overall impact on plant growth. Numerous groups around the world have been conducting experiments in which plots of land are supplied with enhanced CO$_2$, while comparable nearby plots remain at normal levels.

While these experiments typically have found initial elevations in the rate of plant growth, these have tended to level off within a few years. In most cases this has been found to be the result of some other limiting factor, such as the availability of nitrogen or water.

So the answer is yes, but there is a diminishing return at some point. Isn’t that the same as can be said for the CO$_2$ greenhouse effect?

Predicting the world's overall changes in food production in response to elevated CO$_2$ is virtually impossible. Global production is expected to rise until the increase in local average temperatures exceeds 3°C, but then start to fall. In tropical and dry regions increases of just 1 to 2°C are expected to lead to falls in production. In marginal lands where water is the greatest constraint, which includes much of the developing world but also regions such as the western US, the losses may greatly exceed the gains.

Have you noticed yet that things that might hurt the AGW-interventionist’s case always seem “impossible to predict” while the climate is well within our prediction capabilities?

As for food crops, the factors are more complex. The crops most widely used in the world for food in many cases depend on particular combinations of soil type, climate, moisture, weather patterns and the infrastructure of equipment, experience and distribution systems. If the climate warms so much that crops no longer thrive in their traditional settings, farming of some crops may be able to shift to adjacent areas, but others may not. Rich farmers and countries will be able to adapt more easily than poorer ones.

I love the rich-poor language. The leftish New Scientist simply can’t help itself. But I will accept this statement, and go further: This is the reason that aggressive actions to reduce CO$_2$ that reduce economic growth, particularly in the developing world, may not make sense. To the extent that some climate change will occur no matter what, or is already programmed by our past actions, then a richer world can deal with it better than a poorer one.

- Polar bear numbers are increasing

Yet recently there have been claims that polar bear populations are increasing. So what's going on? There are thought to be between 20,000 and 25,000 polar bears in 19 population groups around the Arctic. While polar bear numbers are increasing in two of these populations, two others are definitely in decline. We don't really know how the rest of the populations are faring, so the truth is that no one can say for sure how overall numbers are changing.

Again, I love this. We can know the global temperature increase over a century to a tenth of a degree but it is impossible to count polar bears.

A comprehensive review (pdf) by the US Fish and Wildlife Service concluded that shrinking sea ice is the primary cause for the decline seen in these populations, and it recently proposed listing polar bears as threatened (pdf) under the Endangered Species Act. The International Conservation Union projects the bears' numbers will drop by 30% by 2050 (pdf) due to continued loss of Arctic sea ice.

Note that down 30% (which coming from an environmental advocacy ground has got to be considered the most extreme possible estimate) is not “extinct.” The article fails to address at all the issue that polar bears have survived through eras when Arctic sea ice melted completely in the summers. And there are many
reasons for threats to polar bear numbers – most experts would say that hunting and threats to habitat are much more important factors than global temperatures.