

Lyncean Group
Roger W. Cohen
July 21, 2010

Today I'm going to take a look at the global warming issue through a prism that focuses on the dynamics of the debate itself. There will be plenty of science, but it will all lead to a perspective on the debate.

[Slide 1] A remarkable feature of the dynamic is what happens when you ask the simple question, "What is the case for serious anthropogenic global warming?" Responses tend to fall into three categories:

1. Appeal to authority: "All scientific societies (or whole armies of scientists) agree that carbon dioxide emissions are causing (fill in the blanks)" Or, "Don't you know that the evidence is overwhelming?"
2. The "It doesn't matter" response: "Even if the science is wrong, it is still important to do something about it" (that "something" is always big and expensive). I'm going to call this the "Precautionary Principle" response – the idea that if there is any risk at all, we need to do something heroic to reduce it.
3. Out-and-out anger: "You denier, oil company shill (or some other ad hominem). How dare you try to tell me there won't be a catastrophe." This is a favorite of even otherwise dignified groups such as the National Academy of Sciences.

A Debate Dynamic

Question: "What is the case for significant anthropogenic global warming?"

Answer #1: *Appeal to Authority*, E.g.,

"Well, all scientific societies agree that carbon dioxide emissions are causing (*fill in the blank*)." Or... "Don't you know; the evidence is overwhelming."

Answer #2: *The "Precautionary Principle"*, E.g.,

"It doesn't matter. Even if the science is wrong, it is still important to do (*something big and expensive*) about it."

Answer #3: *Anger*, E.g.,

"You (*denier, tool of special interests, dogmatic #@\$%...*)!
How dare you tell me there will *not* be a climate catastrophe!"

SLIDE 1

Notably, what you *don't* get is an answer to the question.

So let's look at the case. It has nothing to do with the literally hundreds of alleged *effects* of global warming that have been claimed and reported in the media -- from shrinking ice caps to shrinking sheep. Those effects may or may not be happening – and many are not; and those that are happening may or may not be due to global warming – and many are not; and those that are due to past global warming

may or may not have been caused by human activity. Will Happer covers a broader sweep of science; I want to tell you about the case for what is called “attribution” – the assignment of past and future global warming primarily to human activities.

[Slide 2] The case boils down to two assertions. First is that the recorded 20th century warming was exceptional when compared with previous climate change. Therefore, we must have caused it, and it was mostly our CO2 emissions that did it. Second is the prediction that things will get much much worse in the future.

The Case for Attribution to Human Activity

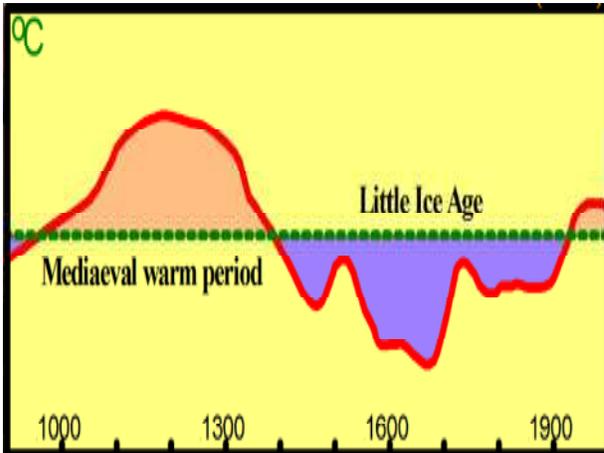
1. Evidence That Twentieth Century Warming Was Exceptional
2. Models Say Future Warming Will Be Much Worse

SLIDE 2

If 20th century warming was in fact exceptional, then previous warming episodes and all natural variations must have been smaller.

[Slide 3] Interestingly, in the first IPCC report of 1990, we saw this graphic of global average temperature since about the year 1000. The range of temperatures is about 2 degrees C across the millennium. There is a strong Medieval Warming Period, a deep Little Ice Age, and a sporadic warming trend since around 1700.

Early IPCC Report Found Current Temperatures Unexceptional



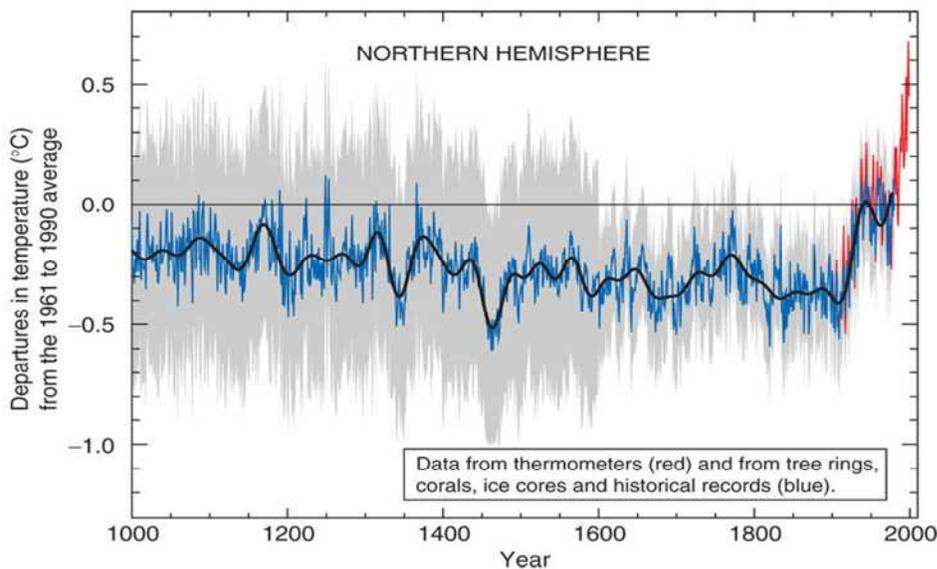
IPCC 1990
[After Hubert H. Lamb, first Director of CRU, University of East Anglia]

IPCC 1990 Fig 7c

SLIDE 3

[Slide 4] But when we get to the 2001 Report, we are presented with something much different--the Hockey Stick. It was based on various proxy “thermometers” such as tree rings. It seems to show that temperature purrs along merrily and constantly for a thousand years until the 20th century, when rapid warming takes off.

IPCC 2001: Hockey Stick as “Smoking Gun”
20th Century Warming Was Exceptional



IPCC 2001 SPM Fig. 1b

SLIDE 4

The hockey stick became the poster child of global warming, the most celebrated graph since Descartes invented the *idea* of graphs. We saw it in Gore's movie. It appeared over and over again in the IPCC report. Let me read from that report, "The rate and duration of warming of the 20th century has been much greater than in any of the previous nine centuries. Similarly, it is likely that the 1990s have been the warmest decade and 1998 the warmest year of the millennium." End of argument? Well no. We now know that this statement is baseless; it rests on work laden with technical errors and outright finagling.

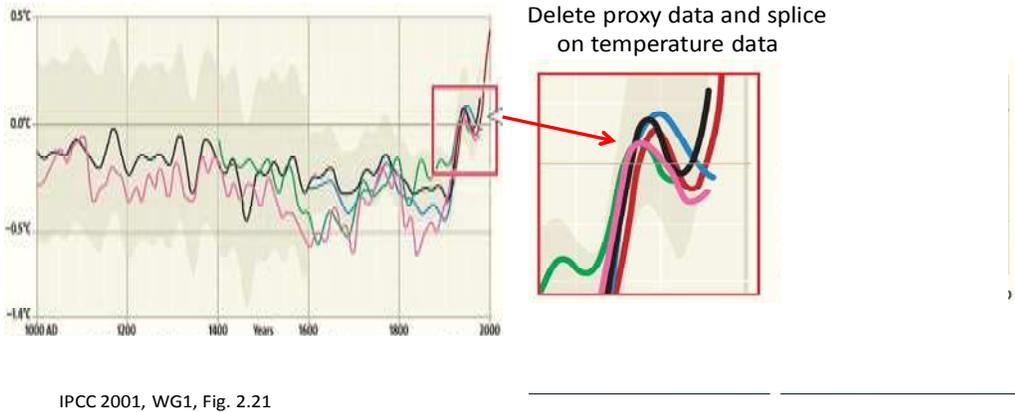
Climategate told us about the behind-the-scenes manipulations to promote and defend the stick, and to prevent opposing views from being published. But even before Climategate, the work of Steve McIntyre, Ross McKittrick, Hans Von Storch, and others had disposed of it from a science perspective. There are many documented serious problems with the stick. The early statistical methods were found to be flawed; they would produce an upward "blade" even from bogie proxies with no trend whatsoever. Other research found that the proxy method itself inherently underestimates past temperature changes by a factor of two or more. There is cherry-picking: the consistent and repeated inclusion of a small number of favorable proxies, while excluding many others from nearby locations that don't show stick behavior. There is the arbitrary upward adjustment of at least one 20th century tree ring density decline. There is even an example of contrary data entered upside down so as to contribute to rather than subtract from stick behavior.

The most notorious issue involves a widely publicized e-mail string that has scientists discussing a so-called "trick" to "hide the decline." They were talking about how to deal with a problem in showing how tree ring proxies stack up to the actual temperature record. The problem is that tree rings show a decline in their inferred temperature after 1960, while the actual temperature is believed to have increased. This is called the "divergence problem." At issue is whether tree rings can be trusted as proxy "thermometers" going back 1,000 years or more if they can't reproduce the last 40. The divergence problem was well known before the revelations. What is new is that we now know the details of an organized effort to cover up the discrepancies.

[Slide 5] So in this graph from IPCC 2001, you see four proxy reconstructions wiggling along pretty flat for centuries, then starting up, but if you look closely, they mysteriously end around 1960. The *actual* instrumental record is spliced on to create an upward sweeping blade. The proxy data are actually deleted.

“Hide the Decline”

Proxies Do Not Agree With Instruments Post 1960 – But Data Deleted in IPCC 2001

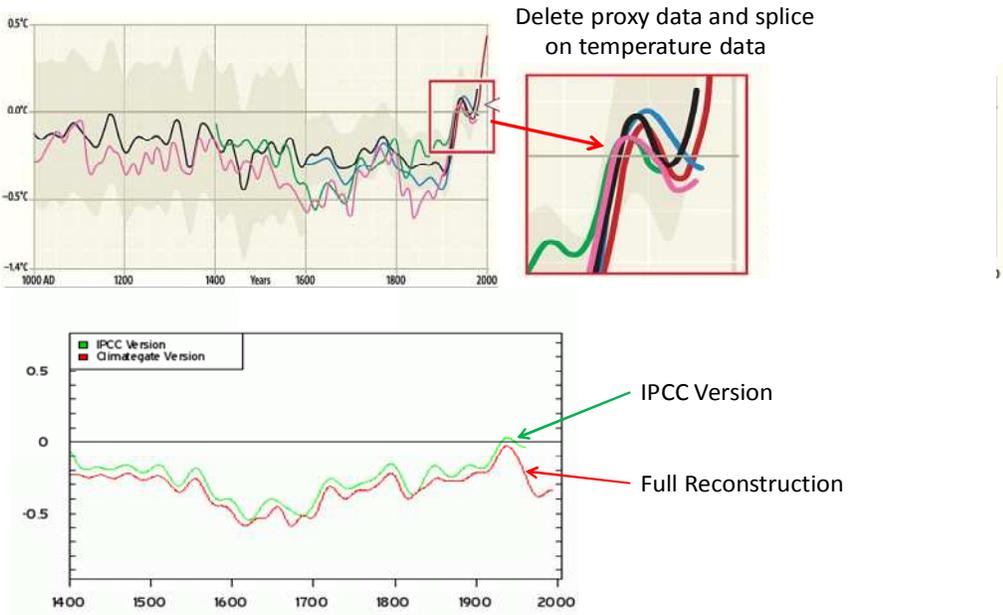


SLIDE 5

[Slide 6] Much later on we learn in the climategate emails what exactly was left out of the reconstructions. At the bottom of the slide we see that one tree ring reconstruction actually decreases, while the instrumental temperature goes up; in fact it drops all the way down to the baseline level of the last 400 years, giving no 20th century warming at all.

“Hide the Decline”

Proxies Do Not Agree With Instruments Post 1960 – But Data Deleted in IPCC 2001

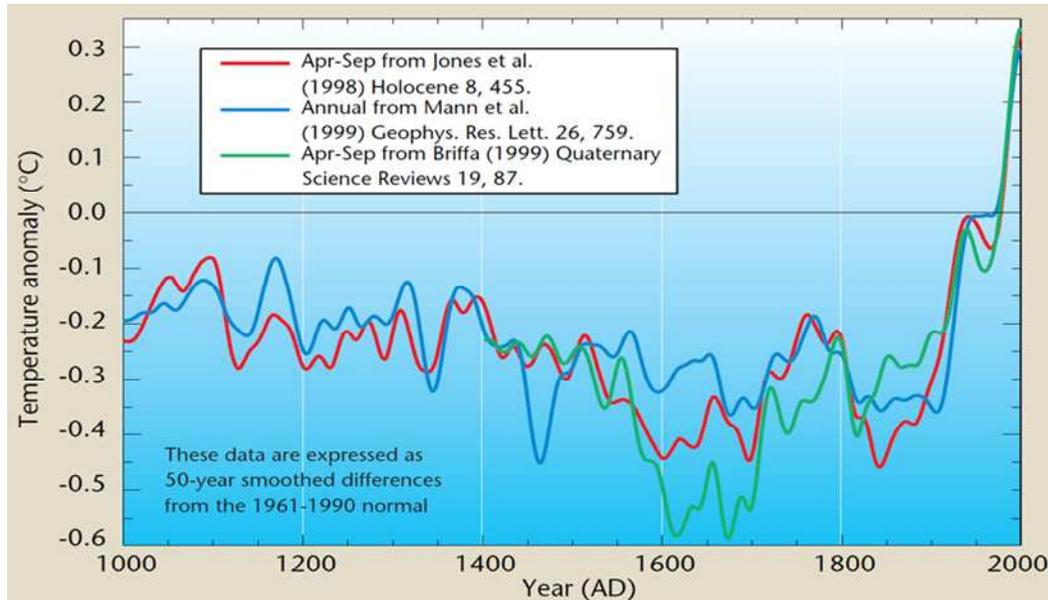


SLIDE 6

[Slide 7] In the UN WMO Anniversary Report, the trick is complete. We are shown what looks like continuous proxy curves throughout. No one can tell that the last forty years are really instrumental data spliced on because the proxies don't work. Instead we are given the impression that the proxies do

a great job of matching the instrumental record. As a touch of irony, the Forward to that report reads in part, “The WMO stands ready to maintain its role as the authoritative international scientific voice on weather and climate.”

World Meteorological Organization Report:
All Mention of Splicing of Proxy and Instrumental Record Is Gone



WMO Report 2000 Cover

SLIDE 7

It is symptomatic of the dynamic that some apologists have defended the “trick” as a clever and sophisticated way of dealing with a data problem. I am waiting for someone to explain what is clever and sophisticated about deleting data that oppose your basic conclusion.

Then there is the revelation that much raw data used to construct the instrumental temperature record itself from stations around the world have been lost or deleted. It means that basic calculations appearing to show a long-term rise in temperature over the past 150 years cannot be checked. This is scientifically unacceptable, made doubly damning because of the importance of the instrumental record and its role in climate modeling – more on this later.

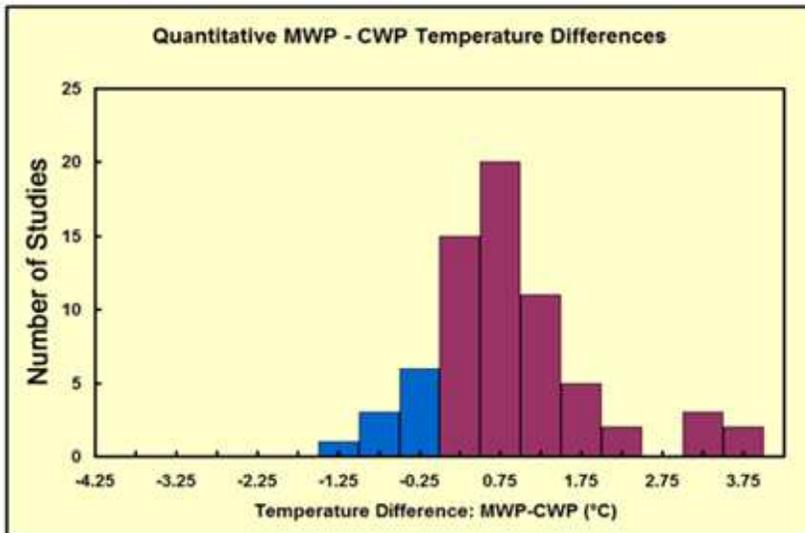
Apologists have also told us that these shenanigans don’t affect the science, which remains “overwhelming.” Not so fast. A small preindustrial climate variation and a rapid 20th century warming were essential to the IPCC case, and the focus of the climategate principals was to convince the world of this, engaging in manipulation and deception along the way, at the same time working to ensure that counterviews would not be published.

We may never know with certainty how 20th century warming stacks up against the Medieval. The 2006 Wegman Report to Congress concluded that the data just aren’t good enough, a conclusion reportedly confirmed by former Climate Research Unit head Phil Jones.

[Slide 8] But it is a fact that by latest count, 58 proxy studies – shown here in purple -- have the Medieval Period warmer than today, while 10 – shown here in blue -- have it cooler. And those 10 are not

independent. They are produced by the same researchers, reviewed by the same incestuous set of reviewers, who use a core of a few proxies again and again to get the hockey stick result. The weight of evidence from proxy studies is that the 20th century was not exceptionally warm at all.

Most Proxy Studies Show Medieval Warm Period Was Warmer than Today

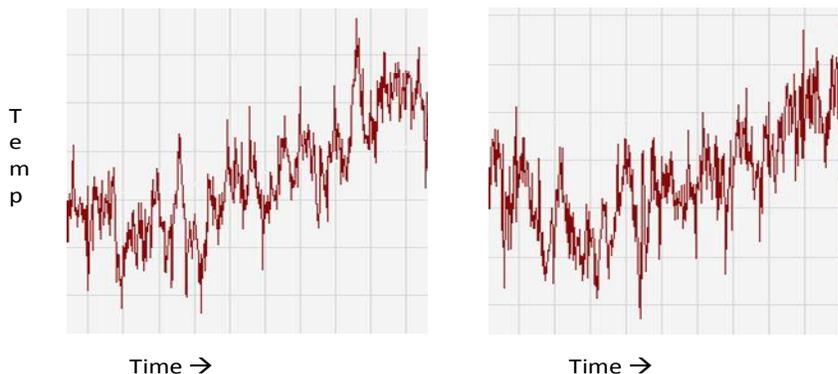


Center for the Study of Carbon Dioxide and Global Change

SLIDE 8

[Slide 9] There are other problems with the assertion that 20th century warming was exceptional. One stems from the fact that it actually occurred in two bursts. Those two bursts are shown here in separate graphs of global average temperature over a 50- year period – one covers 1895 through 1946; the other from 1957 through 2008. The scales are the same for both graphs; all I’ve done is displace them vertically to line them up. The earlier one is ascribed to natural causes, because human emissions then were insignificant compared to later in the century. The later one is blamed on us. The problem is that the first burst was just as fast as the second. Quiz: Which is which?

Global Average Temperature in Two Half Century Periods:
Which is 1895-1946 (Nature); Which is 1957-2008 (Us?)



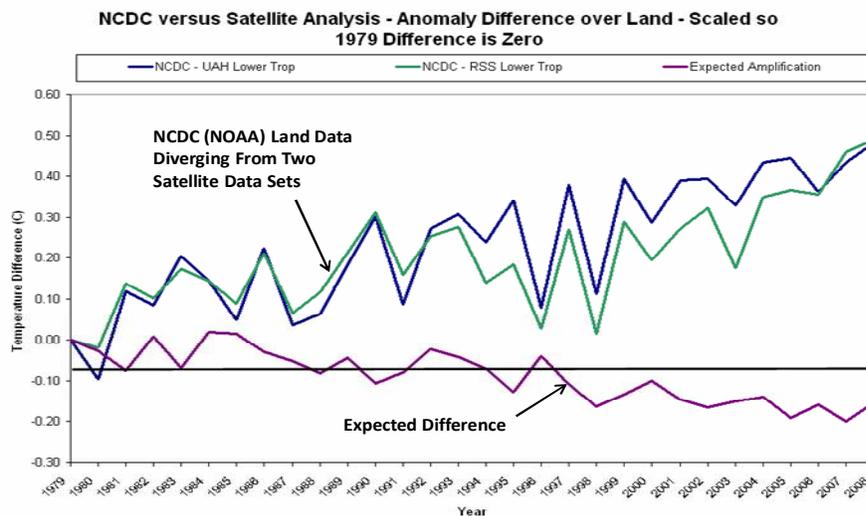
Global average temperature and time scales are identical

Hadley CRUT3 global average temperature record

Answer: The one blamed on us is on the left. But the real question is: If the first was natural, why is the second unnatural

[Slide 10] Another problem is the surface instrumental data themselves. For example, we observe a steady divergence of satellite data from land-based data since the satellite measurement era began in 1979. This graph from a recent publication plots the difference between land data from the National Climate Data Center and the satellite data sets from the University of Alabama at Huntsville and the Remote Sensing Systems Company. We expect the track indicated by the purple. This expanding difference points to highly exaggerated warming trends in land-based data, by about 1½ degrees C per century. This instrumental difference is itself more than the entire 20th century warming trend. Quiz Number 2: Which data streams are *not* highlighted in IPCC reports?

Satellite Measurements Show Much Less Warming Than Land-Based Data



P. J. Klotzbach et al, *An alternative explanation for differential temperature trends at the surface and in the lower troposphere*, Journal of Geophysical Research 2009

SLIDE 10

Published land temperature trends are indeed biased upward. We know this because the trends are highly correlated with local and regional socioeconomic variables such as urban development, land use, and preferential measurement station drop out in cooler, rural areas. The effect is so large that the published warming trend may be exaggerated by a factor of two.

And then there is the troubling back-correcting of past trends. These corrections consistently make the past look cooler, whereas unbiased corrections should equally favor warming and cooling. When you see a NASA published graph of temperature trend, the odds are good that it is steeper than it was a few years ago – not because we have become warmer but because the past has become cooler -- past data have been adjusted, making the trend look steeper. It seems that it is even harder to predict the past than the future.

The real backbone of the case is the climate models. These very complex computer models are calibrated against the observed warming of the 20th century and then used to forecast climate for future emissions scenarios. This calibrating or “hindcasting” is where the exaggeration of past trends becomes important. The steeper the warming, the harder to account for it with natural variations. Indeed, models cannot reproduce past warming with just natural variations, so it must have been

caused mostly by greenhouse gases, mainly CO₂.

Using the models, the IPCC says that doubling of atmospheric CO₂ relative to the preindustrial era – the mid 1800s -- will warm the earth on average by 2 to 4 ½ degrees C, with a most likely value of 3 degrees. That doubling should occur sometime in the second half of the century. But the whole edifice rests on whether those natural variations and the so called “feedbacks” in the climate system are modeled correctly. Feedbacks are physical and chemical changes to the climate that are caused by the radiative warming effect of CO₂. They are very hard to get right, and it is not a matter of raw computing power; it is a matter of physics. Without feedbacks, the effect of doubling atmospheric CO₂ is only a modest 1 degree. To get serious global warming, there must be large amplifying feedbacks to supercharge the warming.

[Slide 11] My one equation says that the global warming we get for doubling of atmospheric CO₂ is that naked one degree, divided by (1-f), where f is the so-called feedback factor. If all the feedbacks add up to zero, global warming is 1.1 degrees C. Extreme positive reinforcing feedback occurs when f approaches 1. Then climate becomes unstable: adding a single molecule of CO₂ would theoretically set off runaway warming. But f could also be less than zero, giving negative feedback. Then global warming would be *less than 1 degree* for doubling. The climate models on which the IPCC relies say that feedback is strongly positive; That range of 2 to 4 ½ degrees means that f is between about 0.5 and 0.8, implying the serious warming they warn us about.

“It’s the Feedbacks, Stupid”

Global Warming From Doubling of CO₂ = $1.1\text{ }^{\circ}\text{C} / (1 - f)$
where f is the net “Feedback Factor”

- No Feedback: $f = 0 \rightarrow$ Global Warming = 1.1 °C
- Strongest Possible Feedback: $f = 1 \rightarrow$ Climate is unstable
- Negative Feedback: $f < 0 \rightarrow$ Global Warming < 1.1 °C

IPCC Models: Global Warming is 2 - 4.5 °C; “Most likely:” 3 °C,
Corresponding to $0.5 \leq f \leq 0.8$ with f most likely $\approx 2/3$

SLIDE 11

The most important feedback is the cloud-water vapor feedback. Add a little more CO₂ to the air, and the earth will warm slightly. Surface evaporation will increase, giving more water vapor – the daddy of all greenhouse gases. More water vapor will tend to form more clouds, and much depends on the clouds. There are well documented problems with the way the climate models deal with clouds.

[Slide 12] Colorado State Distinguished Professor of Atmospheric Science Graeme Stephens writes in an extensive review of the cloud feedback issue that, “Different assumptions ... produce very different

conclusions about the *magnitude and sign* of feedbacks.” That is a dignified way of saying that you can get any answer you want. And further, “The lack of maturity of feedback analysis methods also suggests that progress in understanding climate feedback will require development of *alternative methods of analysis*.” You can read that as, “new ideas are needed.”

*Clouds Are the Key Feedback Lever:
Models’ Reliability Questioned*

Graeme L. Stephens (Colorado State University,
Distinguished Professor of Atmospheric Science):

“...different assumptions about the [cloud] system produce very different conclusions about the magnitude and sign of feedbacks.”

“The lack of maturity of feedback analysis methods also suggests that progress in understanding climate feedback will require development of alternative methods of analysis.”

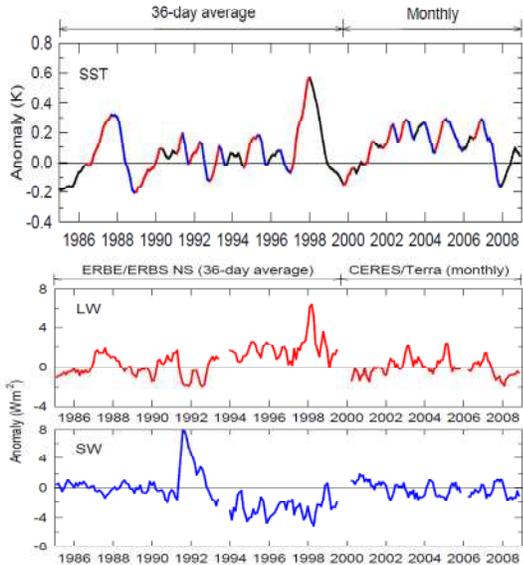
G. L. Stephens, *Cloud Feedbacks in the Climate System: A Critical Review*, J. Climate (2005)

SLIDE 12

In addition to *theoretical* problems with the models, there are major *empirical* issues. Recent experimental studies by Dick Lindzen of MIT, Roy Spencer of the University of Alabama, Stephen Schwartz of Brookhaven, Dave Douglass of the University of Rochester, Nir Shaviv of the Hebrew University and others – all using different approaches -- provide evidence that the feedback factor is in fact small and may even be net negative so as to dampen global warming. Indeed, the weight of recent *empirical* evidence points to a global temperature rise of only *about* 1 degree C for doubling of CO₂, with an uncertainty of perhaps plus or minus a half degree, with nearly half of it already in the bank because of past emissions.

[Slide 13] Let me briefly touch on one study as an example of the kind of research being done. It is one of several that get a handle on feedback by correlating natural temperature fluctuations with outgoing terrestrial radiation. These graphics are from a forthcoming paper by Dick Lindzen and Yong-Sang Choi at MIT. At the top of the slide is the record of tropical sea surface temperatures from 1985 through 2008. You can see El Niño events as prominent peaks and La Ninas as troughs. Concurrently we have satellite measurements at the top of the atmosphere of both outgoing infrared radiation (in red) and reflected sunlight (in blue). The infrared measurements record changes in the earth’s thermal radiation into space. This is how the earth cools itself off. Short term changes in reflected sunlight are thought to arise mainly from changes in clouds.

Using Satellite Outgoing Radiation Data to Estimate Feedback



Natural Fluctuations in Sea Surface Temperatures...

... Produce Discernable Warming and Cooling Events...

... That Can Be Correlated With Changes in Outgoing Infrared Radiation...

... and Reflected Sunlight...

... to Estimate the Feedback Factor f

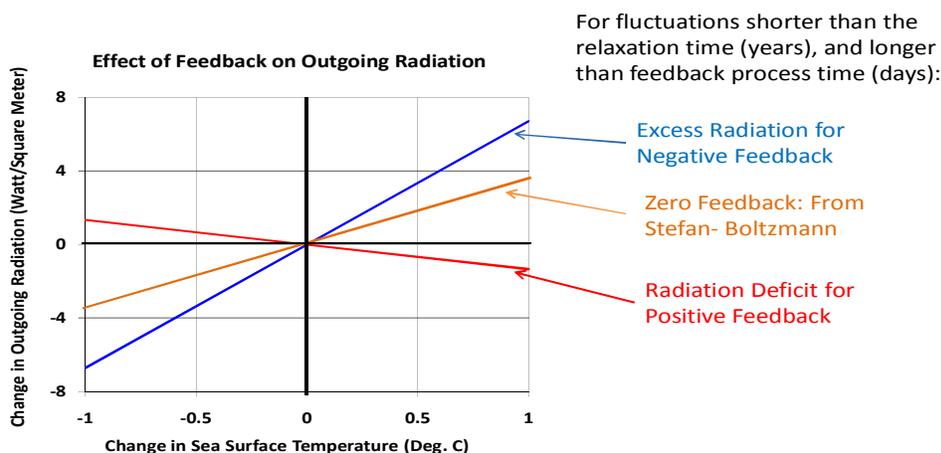
R. S. Lindzen and Y.-S. Choi, *On the observational determination of climate sensitivity and its implications*, Submitted to J. Geophys. Res. 2010

SLIDE 13

The point is that natural fluctuations occasionally produce discernible heating and cooling events that can be identified with changes in the earth's radiation budget, both infrared and sunlight. The feedback factor f can be estimated from an analysis of these correlations.

[Slide 14] How? Suppose for example there is a warming event. Without feedbacks, we expect outgoing radiation to increase linearly with temperature according to the orange line, whose slope is known from radiation physics. Now suppose feedback is positive so that a warming of the sea surface generates yet more warming. This can happen only if outgoing radiation *decreases* relative to the zero-feedback case, as shown for example by the red line. Negative feedback occurs if radiation is *larger* than expected, as shown by the example of the blue line. The earth is then doing a better job of cooling itself off than predicted by Mr. Stefan and Mr. Boltzmann.

Estimating Feedback By Relating Changes in Outgoing Radiation To Sea Surface Temperature Excursions

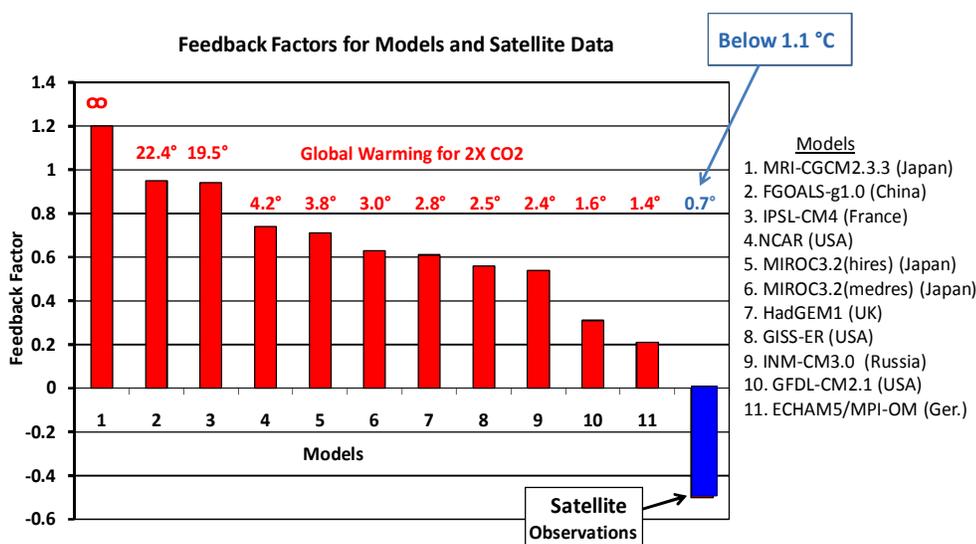


SLIDE 14

So analyzing the correlations between temperature change and outgoing radiation can give information on feedback. But one has to be careful to deal with noise properly and to make sure that the causal arrow is right – that it is temperature causing changes in outgoing radiation and not some exogenous change that alters outgoing radiation that then changes temperature. And very importantly, one can also run climate models to get their predicted radiation response to these same sea surface temperature fluctuations. These runs give their apparent feedback factors as well. The results are shown here.

[Slide 15] The bottom line is that the satellite observations indicate negative feedback and therefore small global warming, in contradiction to climate models. Over on the left are results from 11 models from institutions around the world. All of them give positive feedback, ranging from about 0.2 to a marginally unstable climate. But the satellite measurements give a feedback factor of about minus a half. The contrast could not be more striking. Using our little equation we can translate the feedback factors into values of global warming for doubling of CO₂. You see the models get a result ranging from a low of 1.4 degrees up to infinity. (Does anyone recall being told how the models agree with each other?) However, the satellite observations suggest a value of only 0.7 degrees, a factor of 4 lower than the IPCC's most likely number and far short of catastrophic.

Satellite Observations Indicate Negative Feedback
 → Small Global Warming, Contradicting Climate Models



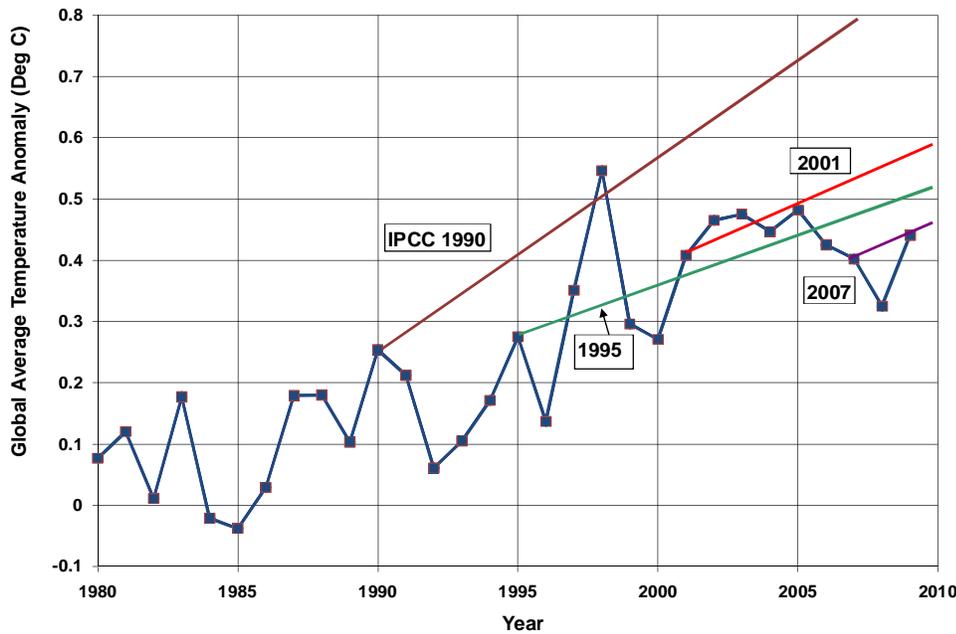
R. S. Lindzen and Y.-S. Choi, *On the observational determination of climate sensitivity and its implications*, Submitted to J. Geophys. Res. 2010

SLIDE 15

While empirical studies like this can tell us something about the nature and size of feedbacks and point to problems with the climate models, they do not provide insight on the physical mechanisms involved, so much remains to be done. But when it's all said and done, real science predicts real things that really happen. The most fundamental tenet of science is the notion that it must be tested by prediction. If it is successful, we keep it around tentatively; if not, we show it the door. The climate models have failed to predict the course of global temperature or to identify an observed greenhouse gas fingerprint. Indeed the temperature projections in IPCC reports have generally greatly overstated subsequent measured temperature trends.

[Slide 16] This slide compares the central projections of global average temperature from each of the four IPCC reports to the actual temperature trend, starting in the year of the report. These are projections – no hindcasting here. They represent the IPCC’s best estimate of how global warming was supposed to unfold. Notice though that the projections look like simple extrapolations from the recent past at the time of the respective reports. But the projections themselves keep calling for a warming rate that just doesn’t happen. Indeed, counter to model predictions and despite steady increases in atmospheric CO2, there has been no statistically significant global warming since around 1995, and the oceans down to a depth of 700 meters have actually cooled slightly since 2004 when the Project Argo deep diving buoys were deployed.

Surface Global Temperature And IPCC Projections
Compared (HadCRUT3 Data Set)



SLIDE 16

You have just heard the case for attribution of global warming to human emissions. It rests on the climate models and the hockey stick. Neither one holds up to hardnosed scientific scrutiny. So what does cause most climate change? There is a very large body of work that strongly implicates natural variations such as solar variability and unforced changes in ocean cycles in 20th century warming. But that’s fodder for another talk.

Now what about that appeal to authority, “All scientific societies agree...” It is the show stopper to engaging a layperson on the issue. Indeed the societies have become more important as IPCC credibility has declined, and National Academy of Sciences leadership has announced its intention to provide science advocacy for what it considers needed societal change. So a group of physicists set out in early 2009 to try to moderate the Policy Statement of the American Physical Society.

[Slide 17] The point of concern has been this excerpt from the Statement. The passage is laden with problems: *Nothing* in science is incontrovertible; Global warming is *not* occurring, at least for ten or fifteen years; but worst of all is the simple fact that none of this is based on a scientific assessment undertaken by the Society itself. It simply parrots the posture of the IPCC and its derivatives. It has angered many members. Even those unfamiliar with the science disliked its definitiveness, its successive non sequiturs, and its alarmist nature.

American Physical Society Statement on Climate Change (2007)

“The evidence is incontrovertible: Global warming is occurring. If no mitigating actions are taken, significant disruptions in the Earth's physical and ecological systems, social systems, security and human health are likely to occur. We must reduce emissions of greenhouse gases beginning now.”

SLIDE 17

[Slide 18] With Climategate and subsequent disclosures casting doubt over the integrity of climate science and eroding public trust invested in science itself, we petitioned the Society to conduct an independent and objective study of the global warming issue. Some 266 physicists have endorsed the call for a new look at the science, and as you can see from this sample, some highly experienced and distinguished physicists think we need that look. They come from diverse academic, government, and industrial backgrounds.

**Regarding the National Policy Statement on Climate Change of the American Physical Society Council:
A Petition to the Council of the American Physical Society.....**

As current and past members of the American Physical Society, we the undersigned petition the APS Council to commission an independent, objective study and assessment of the science relating to the question of anthropogenic global warming. The assessment should consider findings representing the full scope of available scientific sources.

Harold M. Agnew
President, General Atomics Corporation (1979 -1984)
White House Science Councilor (1982 -1989)
Director, Los Alamos National Laboratory (1970 -1979)
E.O. Lawrence Award 1966, Enrico Fermi Award 1978, Los Alamos Medal (with H.A. Bethe) 2001
Member National Academy of Sciences, National Academy of Engineering; Fellow APS, Fellow AAAS

Ralph B. Alexander
Former Associate Professor of Physics
Wayne State University
President, R.B. Alexander & Associates
Technology and market analysis in environmentally friendly materials and coatings
Author, *Global Warming False Alarm (Canterbury)*

Louis J. Allamandola
Director, Astrochemistry Laboratory
NASA Ames Research Center
Fellow APS, Fellow AAAS
Member American Chemical Society, American Astronomical Society, International Astronomical Union

Arthur G. Anderson
Vice President and former Director of Research
IBM (retired)
Fellow APS, Fellow IEEE, Member National Academy of Engineering

SLIDE 18

[Slide 19] There are 100 Fellows and members of the National Academies of Sciences and Engineering. Many have authored important books on various physics topics, and many have won significant prizes and awards, including two Nobels. A number have published major research on the global warming issue, authored books on it, or worked in contiguous areas of meteorology and climate. Nearly all have backgrounds in key science areas that underlie the global warming issue, such as radiation physics and fluid dynamics.

Kenneth A. Jackson
President, Materials Research Society (1976-1977)
President, American Association for Crystal Growth (1970-1976)
Chalmers Award (Materials Society of the AIME) 2003
Award of the American Association for Crystal Growth 1993; Matthewson Gold Medal (AIME) 1966
Member National Academy of Engineering; Fellow APS, AAAS, The Metallurgical Society

H. Richard Johnson
Co-Founder and Former CEO
Watkins-Johnson Company (retired)
Life Fellow IEEE, Member National Academy of Engineering

James R. Johnson
3M Company (retired)
Member Carlton Society (3M Hall of Fame)
Member National Academy of Engineering

Alexander E. Kaplan
Professor, Department of Electrical and Computer Engineering
The Johns Hopkins University
Max Born Award (Optical Society of America) 2005
Alexander von Humboldt Award (von Humboldt Foundation) 1996
Fellow Optical Society of America

Thomas J. Karr
Director, DARPA & Strategic Projects, Advanced Concepts & Technology Division
Northrop Grumman Electronic Systems
Lawrence Livermore National Laboratory (1984-1996)
Editor, Applied Optics (1991-1994)
Member Optical Society of America, AAAS; Senior Member IEEE

SLIDE 19

But backing off does not come easily or happily to large organizations that are invested in a position, especially a position conducive to continued research funding. To date, the APS Statement remains intact, but a long explanatory note has been added; the original 157 word Statement is retained but appended with 827 words of explanation. There is a problem when you need a group of physics monks to expend more than 5 times the number of words to explain what those original words meant. But grudging progress is being made. The Society is still pondering a study. But while that snail crawls along, we will be launching a topical group on Climate Physics within the APS, under terms specified in the Society Constitution. It will be a way for physicists with all points of view to meet, learn about and debate the science, and present research insights, independent of the posturing of the physics monks. Every scientist, climate expert or no, has a dog in this fight that is literally to preserve the scientific method, so painfully assembled over the past 400 years.

We come now to the, "It doesn't matter," response. The Precautionary Principle warns that no matter how small the environmental risk, we should drive it as close to zero as we can. But we need to include economic risk in the equation as well as risk of environmental damage. And when we do, things get more complicated. Here I will put on my strategic planning hat. I spent a good part of my career sorting out the economic benefits, costs, and risks of various technology policies and specific technologies.

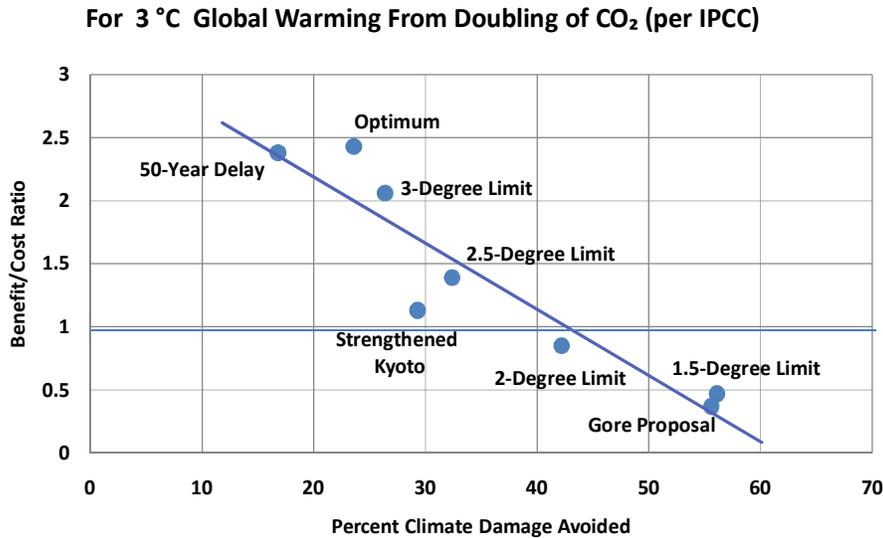
First, it is absolutely critical to understand that in any serious emissions reduction scenario, we are talking about diverting huge amounts of capital from the economy. I have found that many people have little appreciation of the size of the energy industry and even less appreciation of the capital needed and economic impact associated with imposed major changes. Every year the world uses the equivalent of 3 cubic miles of oil to supply its energy. Let's see what's involved in transforming the industry to greatly reduce CO2 emissions.

Marty Hoffert of NYU and colleagues and Tom Wigley of NCAR and his colleagues have independently calculated how much new emissionless energy the world will need to deploy in order to stabilize the atmosphere at various levels of CO2. They estimated that by 2050, 10 to 30 trillion watts of emissionless primary energy production would be needed to stabilize at double the pre-industrial level. With current renewables costing about \$5-10 per average watt above and beyond hydrocarbon- or nuclear-based energy, the additional capital could easily exceed \$50 trillion over 40 years. Even in this era of mega spending and hyper deficits, this is real money. Such a capital investment would be equivalent to devoting the entire current U.S. private nonresidential capital investment over 40 years to the extra cost of emissionless energy. It would suck this capital from all other investments that would normally go to advancing the quality of life for everyone on earth, creating jobs for manufacturing, services, and trade. And the most severe impact would be on the poorest people in the less developed world.

Ah, but those trillions would head off the economic threat posed by climate catastrophe. But would it? Using integrated assessment models, environmental economists have explored the benefits and costs of various policy options. Think of an integrated assessment model as a carbon cycle model, climate model, and economic model ganged together. A leading practitioner is Economics Professor William Nordhaus of Yale University. He is a Fellow of the American Academy of Arts and Sciences and serves on the Congressional Budget Office Panel of Economic Experts. In 2005, the Association of Environmental and Resource Economists presented him with the Publication of Enduring Quality Award. This is considered the "Nobel" of environmental economics, and Nordhaus is generally believed to be on the short list for the actual Nobel.

[Slide 20] Here is an extract of results from his 2008 book. The graph plots the discounted benefit-to-cost ratio for a variety of policy options against the percentage of climate damage avoided, *assuming* the IPCC's most likely value of 3 degrees C for doubling of CO2. There are some interesting things here. First, the optimum policy under this scenario is a gradually implemented carbon tax. It returns a benefit of about 2.4 times costs. But a 50-year delay before implementing any tax is very close to optimal. It affords time for economies to grow so they can better afford the costs I just described. A strengthened Kyoto – which stresses cap-and-trade – just about breaks even. A policy that limits total global warming to 2 degrees C, a favorite for EU flag waving, gets us into negative return territory. And the truly draconian Gore proposal returns only 50 cents on the dollar. Interestingly, this says that if the IPCC is right, we are going to endure a large percentage of damage no matter what we do, and this sharp negative slope says that the more aggressively we try to avoid it, the less attractive the mitigation investment becomes. But now the real punch line: From what we know, the IPCC's value of 3 degrees C for doubling is almost certainly much too high, so these benefit-to-cost ratios and the climate damage are also too high.

Abatement Costs Skyrocket and Benefit/Cost Ratios Plummet As Policies Become More Aggressive



W. D. Nordhaus, *A Question of Balance: Weighing the Options on Global Warming Policies* (2008)

SLIDE 20

[Slide 21] I ran the Nordhaus model for the far more likely 1 degree temperature rise for doubling and got a very different picture. For example, in the year 2055, if the IPCC were right, temperature would have risen another 1.2 degrees C, assuming natural variations cancel out. As we've seen, benefits under the optimum policy run 2.4 times costs. But for a 1 degree warming for doubling, temperature is up less than 0.4 degree, and almost all of the climate damage never happens. The return for the optimum policy is then well into negative territory. We are paying for an insurance policy whose premium is much larger than the risk. And since none of us can recall implementing an optimum global economic policy, the economic results would actually be much worse than this. Unit economic costs go up rapidly when policies are enacted only by specific regions or states, or part of the economy is excluded for political or

But the IPCC Is Much Too High...
Science Impacts Economics

If Global Warming for Doubled CO ₂ Is:	BAU Temperature Rise For 2005-2055 Is:	Benefit/Cost Ratio For Optimal Policy Is:
3 °C	1.2 °C	2.4
1 °C	0.4 °C	0.5

SLIDE 21

other reasons. The fact is that enacting any abatement policy would unnecessarily throw away future wealth and well being.

So the Precautionary Principle is hazardous to our future economic health. The science and the economics are coupled, and it makes a great deal of difference whether we follow the IPCC or the body of empirical evidence. And following the Precautionary Principle would logically lead us to spend trillions on other improbable events such as the next large asteroid collision, and we *know that* will happen someday.

And think about this: One purpose of science is to *reduce* uncertainty so as to facilitate wise decisions to promote human progress. The Precautionary Principle claims that one special brand of uncertainty *is itself* a reason to make decisive economic sacrifices. But the science does not support such economic interventions. Beware of the “It doesn’t matter” response. It does matter, and it matters a great deal.

To wrap up, I want to talk a little about the anger response: “You denier...paid agent of oil or tobacco or whatever. How dare you tell me there won’t be a catastrophe.” Here I rely largely on son Geoff, the academic social psychologist in the family. As contrary evidence has accumulated, proponents of global warming have shown signs of cognitive dissonance. More than a half century ago, Leon Festinger developed the concept of cognitive dissonance and conducted early studies referred to even today. The idea is that when presented with information that is dissonant from strong beliefs that people have invested in, the easiest way to deal with it is to ignore it, refuse to accept it, or simply avoid that type of information. This helps explain why people can be resistant to new information which, on a rational basis, should be good news. Why would you get angry if someone tells you, “There won’t be a climate catastrophe.”

But how can a belief be held so strongly when most people do not have the training or the inclination to make a scientific assessment. Well, it is easy for people to fold their global warming cognitive into their political cognitive or their too-many-people cognitive. There it becomes hardly resistant to new information.

[Slide 22] Then, as Climategate shows, all kinds of strategies are invented to defend the cognitive, and

Dealing with Cognitive Dissonance...The Global Warming Trick



the reward system condones and supports these strategies.

Past social psychology studies give us insight into today's debate dynamics. One study followed people who bought bomb shelters during the Cold War. It found that they tended to exaggerate the threat of nuclear war and to discount peace proposals, almost as if they were invested in nuclear war. Also, Festinger's book, *When Prophecy Fails*, tells of a doomsday cult that predicted the end of the world on a particular date. When the day came and went, paradoxically the believers became even more determined they were right. They became louder and proselytized even more aggressively.

So we can expect ever more strident, bizarre, and opaque defenses from proponents. Here is a sad example...an excerpt from a May letter signed only by National Academy of Sciences members: "Many recent assaults on climate science and, more disturbingly, on climate scientists by climate change deniers, are typically driven by special interests or dogma, not by an honest effort to provide an alternative theory that credibly satisfies the evidence." Most of these signatories have no background in the sciences underlying the issue but are willing to go on public record to stamp out scientific opposition.

A recent publication in the PNAS seeks to persuade us that serious anthropogenic global warming must be real because "relative climate expertise and scientific prominence of the researchers unconvinced of [it] are substantially below that of the convinced researchers."

We are told that warming is accelerating when there has been none. Wild speculations about imminent "tipping points" abound without even a definition of what this means. We are told that even cooling is consistent with global warming, and indeed global warming has morphed into *Climate Change*, allowing it to embrace anything that happens – hot or cold, wet or dry, storms or no storms -- much like astrology.

So what do we really know? We know that climate is far too complex and too insensitive to greenhouse gases to pretend that we can "stabilize" it by marginal changes in CO2 emissions, whether it is California's AB32, or the many incarnations of national legislation or global proposals. We know that government policies offer great economic pain and no environmental gain. We also know that the global warming issue has produced intellectual deception and the subversion of the scientific process, widespread corporate rent seeking, and the gross waste of resources that could have gone to improve our environment. But we still have it within our grasp to restore integrity to the science process and to avert unnecessary economic hardship, especially for the world's poorest who might otherwise aspire to make great strides this century.