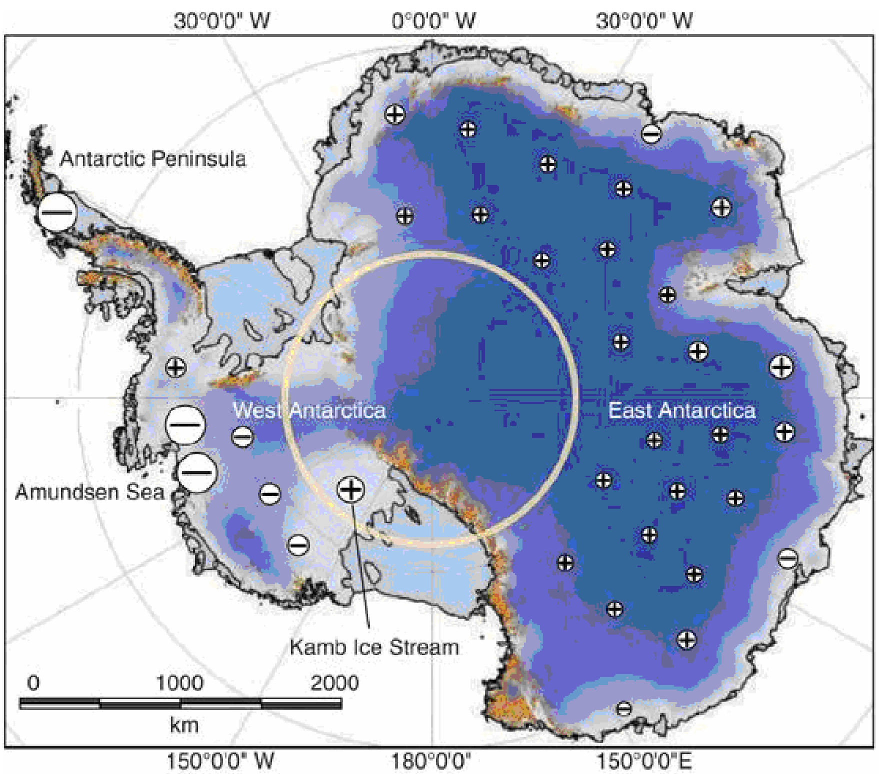
# Issues in the Current State of Climate Science

*A Guide for Policy Makers and Opinion Leaders*




In some parts of Antarctica, such as East Antarctica, the ice sheet is thickening (+ symbols), whereas in others, primarily in West Antarctica it is thinning (– symbols). (Source: Vaughn, 2005).

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"We only understand 10 percent of the climate issue. That is not enough to wreck the world economy with Kyoto-like measures".

--Henk Tennekes, former research director, Dutch Royal Meteorological Institute

"We understand public anxiety about climate change, but are concerned that many of these much publicized predictions are ill informed and misleading. We urge those involved to pay closer attention to the complexities of this challenging subject."

-- Reiter et al. (2004)

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# Issues in the Current State of Climate Science

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## Introduction

The science of climate and climate change is continually evolving and the balance between what we know and what we don't know changes constantly. Just when it seems like things are pretty certain, a new study comes along suggesting that our perception of the situation is too simplistic. More often than not what we *don't know* turns out to be more than we actually *do know* and the balance shifts.

For example, forecasts of the earth's future climate primarily are based upon output from complex computer models of the interactions between the earth's surface, its atmosphere, and outer space. However, combining several known limitations can make such forecasts less than reliable and much less than predictive.

## Limitations in Computer Modeling

**Limitation 1**: *Computer models are limited by man's current knowledge*

> Computer models only can be as good as the current level of scientific understanding of the processes they attempt to simulate.
>
> Take clouds as an example. While scientists have sound basic understanding concerning the conditions under which clouds form and dissipate, the finer points — such as how bright the clouds appear, how dense they are, and how big they become — are much less well understood. Because clouds play a major role in creating earth's climate — by reflecting the sun's energy back into space, trapping heat at the earth's surface, and producing precipitation — an accurate understanding of cloud behavior is essential in creating accurate climate models. Unfortunately, we lack that understanding.

**Limitation 2**: *Computer models aren't even able to "predict" past events.*

> Computer models are limited by the ability of the scientists who create them. Even feeding the current models everything they already know happened in the past, their models aren't able to replicate what we already know has happened. This is because, in many cases, the physics governing the real world is too complex to be replicated using current computing power. This denies today's climate models sufficient detail to replicate current conditions. Why then rely on them to "predict" the future?

**Limitation 3**: *Accurately modeling the future requires having information about what the future will bring.*

In addition to the limitations of computers to process what already is known and the incomplete scientific knowledge that besets current models, the scientists who put the models together must know something about the future if they are to accurately model it.

To study how earth's climate might be impacted by emissions of greenhouse gases (GHG) from human activity, a modeler must know what quantity of GHG will be emitted. This is impossible. Accurately gauging future emissions depends on the social, political, geopolitical and technological development to come. At best, one only can guess what the world's primary energy sources will be fifty or a hundred years from now. How can one even begin to predict demand for each energy source? At best, this is a highly speculative exercise.

Taken together, these three limitations impose severe constraints on how accurately scientists can predict changes in the earth's climate several decades (much less several centuries) from now. The best any climate scientist can do is rely on observations of the present and recent past to better understand how earth's climate already has changed in the time humans' alterations of earth's landscape and atmosphere have been greatest — a span of just over a century from the dawn of the Industrial Revolution in the late 19th century until now. Current observation is the only reliable guide of what to expect in coming decades.

## Global Temperatures: Past and Present

The earth's average temperature is the most fundamental measure of the climate as we know it. By combining temperature measurements made with thermometers at locations scattered around the globe during the past century-and-a-half, scientists possess a reasonable indication of how average temperature has varied over the years. This is depicted in *Figure 1*.

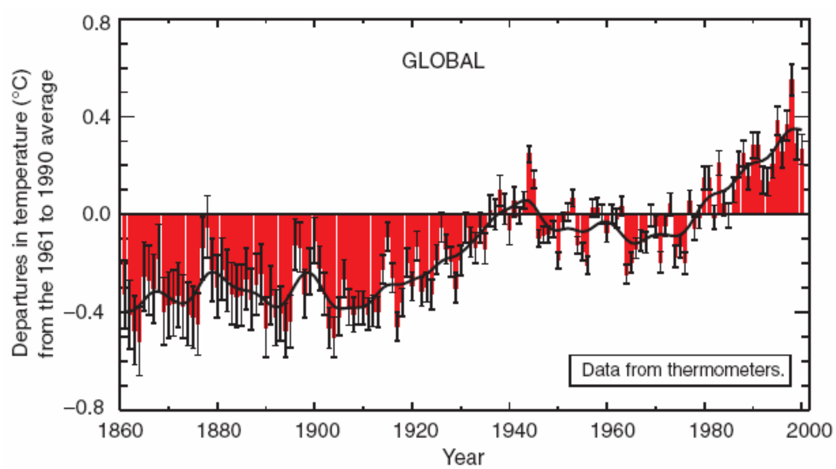



**Figure 1.** The observed history of variations in the earth's average temperature during the past 140 years. (Source: IPCC 2001)

(**Note:** *The standard international unit of temperature is a degree Celsius or º C. As all of the Figures in this report are reproduced from the primary scientific literature, they all use ºC. In order to convert the temperature anomalies, departures, or variations depicted in the Figures to the English unit degrees Fahrenheit, or ºF, simply multiply them by 1.8. For example, in* ***Figure 1*** *the y-axis depicting temperature departures ranges from -0.8ºC to +0.8ºC which is the same as -1.44ºF to +1.44ºF.)*

**Figure 1** makes obvious several facts:

1) The earth's average temperature is anything but steady; it changes from year-to-year and decade-to-decade. (It also changes over the course of centuries, millennia, and geologic time).
2) The earth's average temperature is higher now than it was 140 years ago. It has risen about 0.6°C (1.1°F) in 140 years.
3) The earth's average temperature has risen in the last thirty years
4) The earth's average temperature also rose during early in the 20th century.
5) The earth's average temperature cooled a bit between the mid-1940s and mid-1970s.

What **Figure 1** doesn't show is *why* these temperature changes happened.

Any number of things influence earth's temperature. The list includes volcanic eruptions, variations in the amount of energy received from the sun, El Niños, and La Niñas — all of which are natural. Human influences include changes in the landscape by cutting down or planting trees, plowing prairies to create cropland, building homes, expanding cities, damming rivers and streams, paving highways, and emitting gases into the atmosphere from factories, cars, trucks, airplanes, and power plants. Calculating the degree to which any of these or combinations of them have played a part in changing earth's average temperature during the past 150 years is anything but straightforward. The best current thinking is that the influences of volcanoes, El Niño, and La Niña tend only to last for a few years. Changes caused by solar activity and humans seem to extend over a longer term.

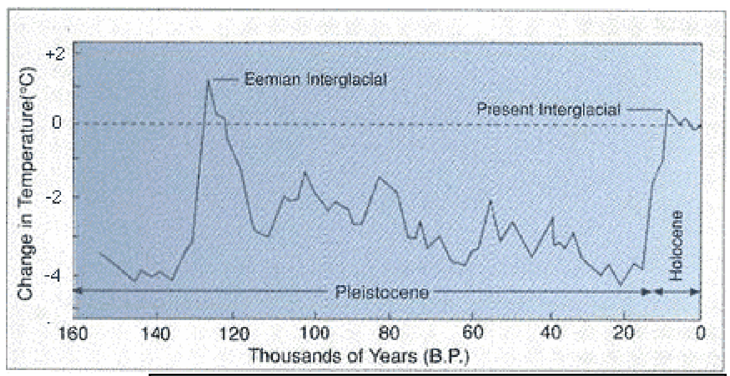



**Figure 2** - Variations in surface air temperature for the last 150,000 before the present (BP).

Scientists can fairly easily identify the short-lived temperature variations from volcanic eruptions and El Niño/La Niña events in the temperature record of the past 140 years. Over the longer term, it generally is believed that much of the warming in the early 20th century was dominated by changes in solar activity, while much of the warming that began in the last half of the 20th century likely was related to the vast array of human activities outlined above. But no quantitative confirmation can yet be assigned to such an idea.

But knowing that human activity is having an effect on climate in a broad quantitative sense is not particularly informative. It is more relevant for scientists to understand the *nature* of the impacts of human activities. Is it negative, positive, or neutral? How large or small is it? Will humans' impact on climate be negative, positive, neutral, large, or small in the future?

Finally, it is important to understand whether or not current average temperature is at all unusual from a longer perspective (**Figure 2**).

To answer these kinds of questions about temperature in the distant past, climatologists must calculate temperature using something other than thermometers. To ascertain temperature more than a couple of centuries ago, climatologists must rely on "proxy data" — information gleaned from tree rings, coral bands, lake sediments, and ice cores. All preserve a record of temperature over long periods of time because each "responds" to changes in temperature. These changes are reflected in the width of tree rings and coral bands, content of lake sediments, and atmospheric gases trapped in ice. How best to derive information on the earth's past climates from these proxies for temperature is hotly contested among climate scientists.

**The "Hockey Stick"**

The result of one prominent effort using climate proxies to reconstruct earth's temperature history back a thousand years is termed the "hockey stick" because of its gently sloping handle and dramatic blade (**Figure 3**).

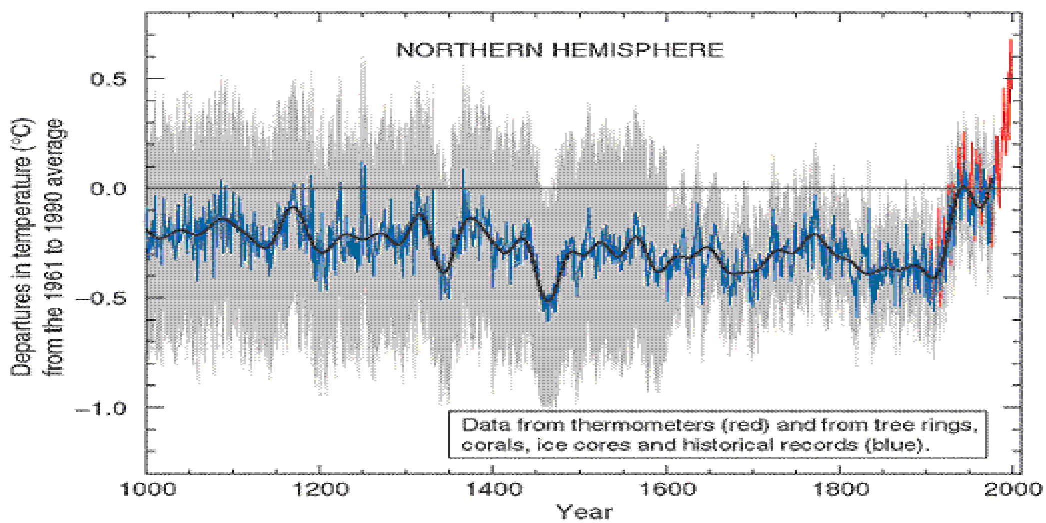



**Figure 3.** The "hockey stick" temperature reconstruction of the Northern Hemisphere for the past 1,000 years (the gray bands depict the range of confidence that the data in the other — blue lines — is "right"). The red line is temperature data from actual observations. (Source: Intergovernmental Panel on Climate Change, 2001)

This temperature reconstruction begins in 1,000 A.D. and seems to show that, over the course of 900 years, there was very little variation in temperature (the handle). Then suddenly, during the last century, temperature began to rise dramatically (the blade).

When first published, these results spurred a lot of publicity because they seemed to prove that current temperature is very unusual. It appeared to confirm a suspicion that human activity was forcing climate to change in ways never before experienced.

*Many climatologists were puzzled by the hockey stick reconstruction. It didn't appear to reflect well-documented climate anomalies such as the Little Ice Age (an extended cold period from the 16th and into the 19th century) and the Medieval Warm Period (a relatively warm couple of hundred years extending from about the 11th and into the*

*13th century). This caused them to question whether something was wrong with the methodology used to create the hockey stick graph from available climate proxies.*

Several analysts subsequently documented irregularities in the methodology that had been used to create the hockey stick. Other researchers employed different temperature reconstruction techniques and got different answers suggesting the level of natural variability in temperature over the last 1,000 years probably was much greater than reflected in the hockey stick. The upshot? Temperatures of the late 20th century are not all that unusual despite what the hockey stick first appeared to show. See figure below.

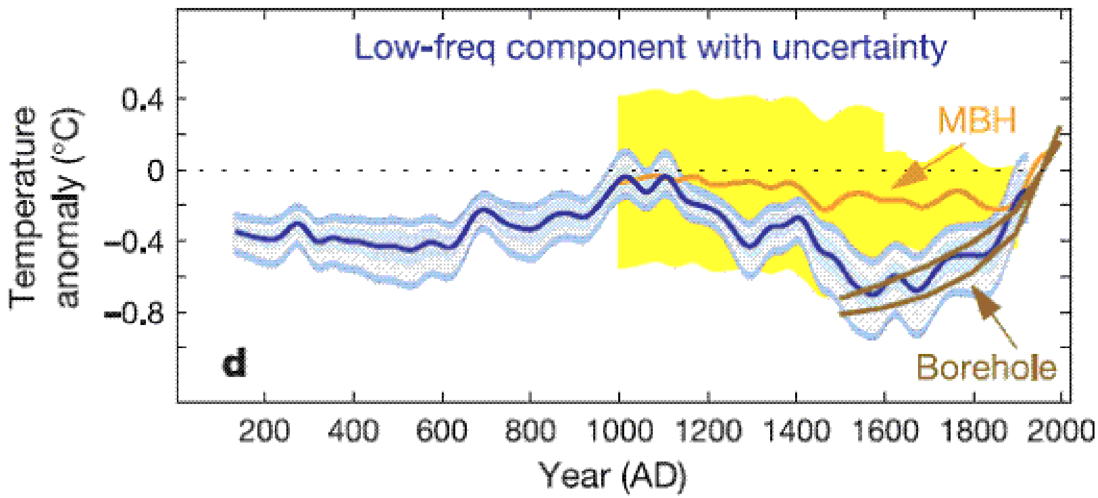



**Figure 4**. Research subsequent to the creation of the "hockey stick" has concluded that the variations of temperature during the past 1,000 to 2,000 years (blue line inside blue shaded region) likely exceeded the "hockey stick" (MBH) temperature reconstruction (orange line within yellow region) as originally indicated. Such past occurrences of natural variation indicate that current temperatures are not that unusual. Another source of past temperature variations come from borehole measurements (brown lines) which also indicate that past temperature variations were greater than indicated by the "hockey stick" model. (Source: Moberg et al., 2005)

## Climate Back Through Time: Both Hot and Cold

The natural variability of the earth's climate is further emphasized by longer-term climatic history. **Figure 5** depicts temperature as deduced using ice cores taken from Antarctica. The resulting data extends back more than 400,000 years. *Looking at* ***Figure 5****, it is evident that on several occasions in the past — and for periods lasting many thousands of years — temperatures were warmer than they are today.*

One cannot help but notice that during much of the past 400,000 years, temperatures were extremely colder than today. These were times when earth was in the grip of a series of ice ages. The last of the ice ages buried locations in North America as far south as Chicago under more than a mile of ice. When the glaciers receded they left behind the prairie potholes and gently rolling plains of North America, the Great Lakes, and other familiar topographic features.

Studies of past climate show that earth's climate can vary naturally, that past climates were as warm as (and even warmer than) that we experience today. It is worth noting that warm periods like the one in which we live have been relatively short-lived excursions from the ice-age conditions that dominate the past half-million years of earth's history.

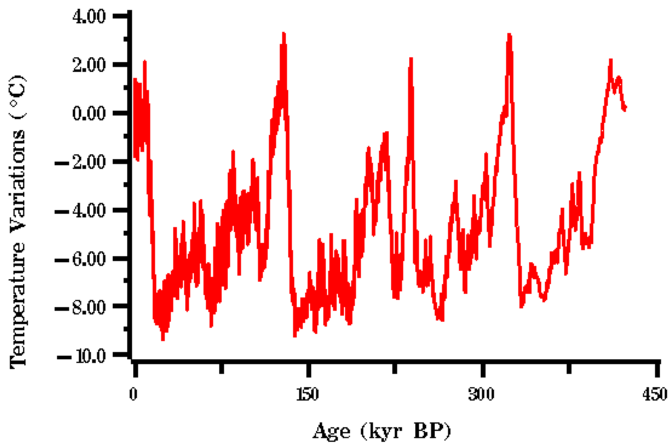



**Figure 5**. Temperatures as extracted from Antarctic ice cores for the past 400,000 years. The timescale (x-axis) is given in thousands of years before present, or kyr BP (source: U.S. Department of Energy, Carbon Dioxide Information Analysis Center).

Average temperature is but one measure of earth's climate — one that is not necessarily the most relevant to our daily experience. Climate change that takes place on regional-to-local scales has a more direct impact on our lives.

### Weather Extremes: They're not more extreme

If incidents of extreme weather such as thunderstorms, tornadoes, and hurricanes are increasing because of global warming brought about by human activities, there might be a reason for concern. But documented scientific observations demonstrate this is not the case.

*Hurricanes*:

In the wake of hurricanes Rita and Katrina there was a lot of talk about global warming and how it is increasing hurricane frequency and intensity. Some reports even went so far as to link the active 2004 and 2005 hurricane seasons to an enhanced greenhouse effect. Careful review of historic trends does not support this view.

Some of the world's leading hurricane experts, including Dr. Roger Pielke, Jr. (a researcher on risk and loss associated with severe storms and hurricanes), Dr. Christopher Landsea (a leading researcher on hurricanes and climate), Dr. Max Mayfield (head of the U. S. National Hurricane Center), Jim Laver (head of the U. S. Climate Prediction Center), and Dr. Richard Pasch (a hurricane specialist at the National Hurricane Center) recently conducted such a review.

According to Dr. Pielke, the team's lead scientist, the purpose of their project was "to provide a concise, largely non-technical, scientifically rigorous, globally inclusive, and interdisciplinary perspective on the state of current understandings of hurricanes and global warming that is explicitly discussed in the context of policy."

Their study concludes:

> Claims of linkages between global warming and hurricanes are premature for three reasons.
>
> First, *no connection has been established between greenhouse gas emissions and the observed behavior of hurricanes.* Emanuel (2005) is suggestive of such a connection, but is by no means definitive. In the future, such a connection may be established (e.g. in the case of observations of Emanuel (2005) or the projections of Knutson and Tuleya (2004)) or made in the context of other metrics of tropical cyclone intensity and duration that remain to be closely examined.
>
> Second, the peer-reviewed literature reflects a scientific consensus that *any future changes in hurricane intensities will likely be small in the context of observed variability*, while the scientific problem of tropical cyclogenesis [the process that initiates or intensifies cyclones in the atmosphere] is so far from being solved that little can be said about possible changes in frequency.
>
> And third, under the assumptions of the IPCC [the United Nations' Intergovernmental Panel on Climate Change], *expected future damages to society of its projected changes in the behavior of hurricanes are dwarfed by the influence of its own projections of growing wealth and population*. While future research or experience may yet overturn these conclusions, the state of knowledge today is such that there are good reasons to expect that *any conclusive connection between global warming and hurricanes or their impacts will not be made in the near term.*

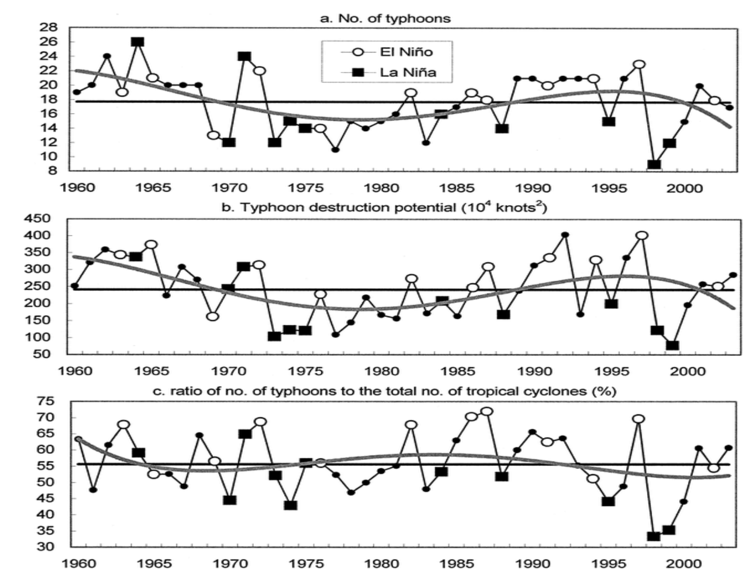



**Figure 6.** Real data shows *no sign* of sharply increasing trends in typhoon destructiveness or percent of typhoons with regard to total tropical storms in the Western North Pacific basins.

Additionally, Chan and Liu (2004) observed:

> "The [real-word] results emphasize the danger of drawing conclusions about future Tropical Cyclone intensity based on current climate model simulations that are not designed to make such predictions." (**Figure 6.**)

*Recent Hurricane Papers:*

The few scientists and the media outlets claiming hurricane intensity is increasing due to human-induced warming point to several recent studies. A closer look, though, reveals natural cycles are likely the primary cause, not human actions.

**Webster** and colleagues report that, globally, since 1970, the annual number of weak (category 1) hurricanes has declined a bit, the number of moderate (categories

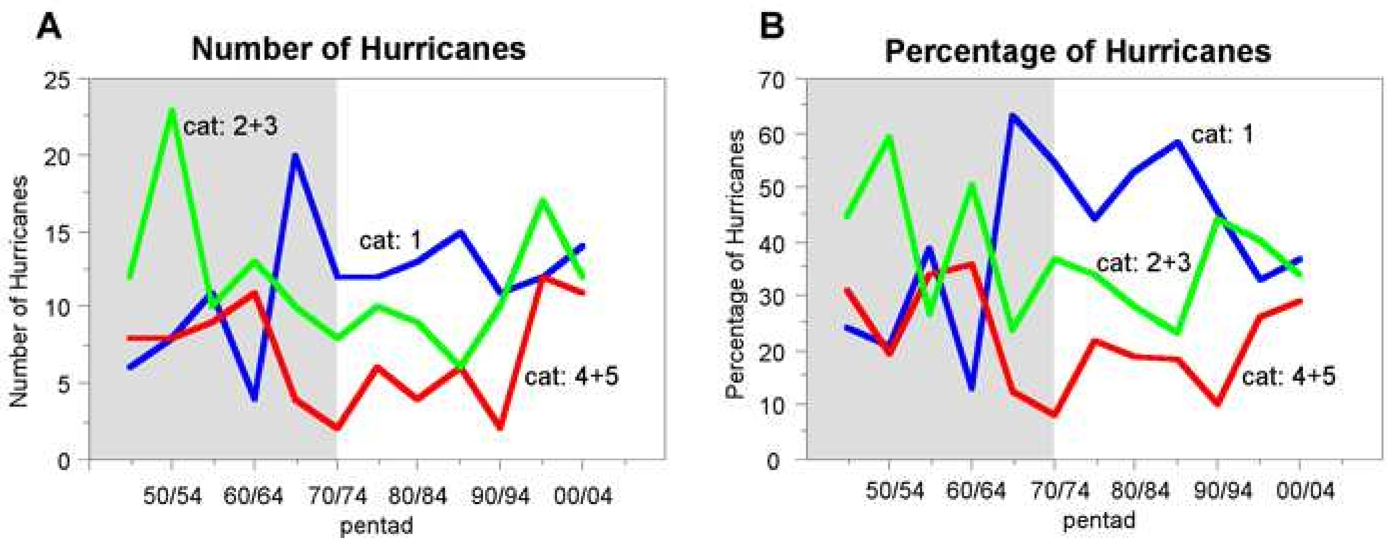



**Figure 7**. The region shaded in gray is the data from the period prior to that analyzed by Webster's group. Note that the behavior since 1970 (unshaded portion) is pretty much just as Webster et al. had found -- declines in the weaker category 1 storms and increases in the numbers and percentages of the strong category 4 and 5 storms. However, in the 25 years prior to 1970, just the opposite occurred -- the number and percentage of strong hurricanes declined while weak storms became more common.

2 and 3) hurricanes have fluctuated but the average has remained about the same, and the number of severe (categories 4 and 5) has increased. However, despite this apparent trend towards more intense hurricanes, they found that the highest wind speed observed in the most intense storms has remained remarkably constant. In other words, they found that the strongest storms are not getting stronger, but that there has been a tendency for more of them.

The problem is that Webster et al. choose to begin their analysis in 1970, instead of the mid- to late -1940s when hurricane hunter aircraft first were used -- a full 25 years before satellite monitoring became available (**Figure 7**). The longer term perspective reveals that just *the opposite of Webster occurred*: the number and percentage of strong hurricanes *declined* while weak storms became more common. When taken as a whole, the pattern appears better characterized as being dominated by active and inactive periods that oscillate through time, rather than having a temporal trend. This characterization is one that does not fit with the idea that hurricanes are becoming more intense because of increased atmospheric $CO_2$.

**Although 2004 was a high year for destructive potential (PDI), there has been no unusual or alarming trend for hurricanes land-falling on U.S. coastlines for 1900-2004.**

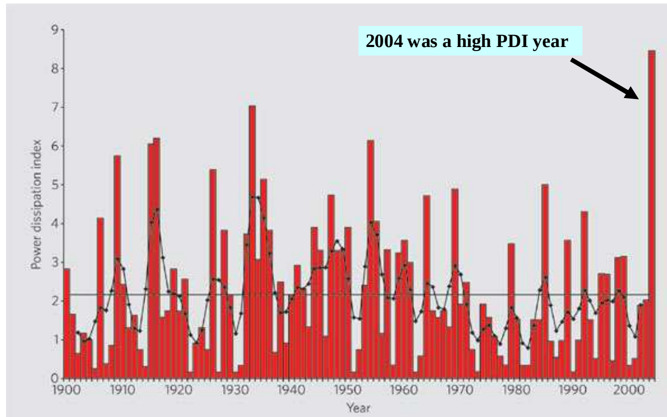



**Figure 8**

The strongest observed linkage between increases in global temperature and increases in tropical cyclone intensity was made recently by **Emanuel** (2005), who claimed to find "Increasing destructiveness of tropical cyclones over the past 30 years."

The empirical data do not yet support such a contention. Although 2004 was a year of great potential destructiveness (PDI), there has been no unusual or alarming trend for hurricanes land-falling on U.S. coastlines from 1900-2004 (**Figure 8**).

*Droughts*

The claim is explicitly made that global warming will increase the severity, extent and duration of droughts; and implicitly, beyond past natural variability.

In considering a large number of research findings, it would appear that the warming of the past century or so has tended to *reduce* the frequency and severity of drought throughout the United States.

Through careful studies of growth-rings of long-lived trees, a record of drought conditions in the American Southwest extending back to 1200 A.D. (deMenocal, 2001) shows that drought conditions in the southwest have not been especially worse in the last 40 years when the carbon dioxide forcing is purported to be the most dominant. Expectations to the contrary are derived from climate model "scenarios."

Are the more severe droughts of *past* centuries – when there was no man-made CO2 forcing –in line with modeled expectations of temperature-driven droughts? Not at all. In the words of deMenocal (2001): "Water availability, rather than temperature, is the key climatic determinant for life in semiarid expanses across the planet."

Drought conjures up images of the Dust Bowl of the 1930s, which lasted 6 years (1933-38) and resulted in one of the most devastating and well-documented agricultural, economic, and social disasters in the history of the United States. The drought was triggered by a large and widespread reduction in rainfall across the American West, particularly across the northern Great Plains. It displaced millions of people, cost over $1 billion (in 1930s U.S. dollars) in federal support, and contributed to a nascent economic collapse. A subsequent decadal-scale drought in the 1950s was severe but less widespread and mainly impacted the American Southwest, where improved land use practices and disaster relief programs mitigated its effects.

How did the 1930s and 1950s droughts compare with other historic and prehistoric droughts? In a comprehensive analysis of hundreds of tree-ring chronologies from across the United States, Cook and others established a network of summer drought reconstructions extending back to 1200 A.D. This reconstruction documents much more persistent droughts before the 1600s. These so-called "megadroughts" were extremely intense, persisted over many decades, and recurred across the American Southwest roughly once or twice every 500 years. Reconstructed conditions during the largest of these multi-decadal droughts far surpassed those during droughts recorded within the past 150 years (the period for which extensive instrumental data are available). Evidence for these and other megadroughts have been found in detailed lake sediment records. There is additional evidence for even longer, century-scale droughts in California before 1350 and 1110 A.D."

Additional drought insight is provided by:

Cronin et al. (2000), who studied the salinity gradient across sediment cores retrieved from the Chesapeake Bay, the largest estuary in the United States, in an effort to determine precipitation variability in the surrounding watershed over the past 1000 years. From this record, they learned that the region experienced several "megadroughts" of 60-70 years duration, some of which they describe as being "more severe than twentieth century droughts."

Fritz et al. (2000) used sediment cores from three North Dakota lakes to construct a 2000-year history of drought in the Northern Great Plains. Their data suggest that "droughts equal or greater in magnitude to those of the Dust Bowl period were a *common occurrence* during the last 2000 years."

Gray et al. (2003) report that "strong multidecadal phasing of moisture variation was present in all regions [of the central and southern Rocky Mountains] during the late 16th century megadrought."

Ni et al. (2002) developed a 1000-year history of cool-season (November-April) precipitation for each climate division in Arizona and New Mexico from a network of 19 tree-ring chronologies. They found, in their words, that "sustained dry periods comparable to the 1950s drought" occurred in "the late 1000s, the mid 1100s, 1570-97, 1664-70, the 1740s, the 1770s, and the late 1800s."

Benson et al. (2002) studied sediments from Pyramid Lake, Nevada. Over the most recent 2,740 years, drought durations were found to have ranged from 20 to 100 years. More recent droughts generally lasted less than a decade.

Tree-ring data were used by Hidalgo et al. (2000) to construct a history of stream flow in the Upper Colorado River Basin, where they found "a near-centennial return period of extreme drought events" that went all the way back to the early 1500s.

Tree rings also were used by Stahle et al. (2000) to develop a long-term history of drought over all of North America. The results of their study indicated that the 1930s Dust Bowl drought was the United States' most (1) severe, (2) sustained and (3) wide-spread drought of the past 300 years, but that it was eclipsed in all three categories by a 16th century "megadrought" that "far exceeded any drought of the 20th century." In fact, they say "the 16th century drought was the most extreme prolonged drought in the past 2000 years."

All this occurred long *before* the modern industrial age and the accelerated increase in the atmosphere's CO2 concentration.

Finally, Woodhouse and Overpeck (1998) concluded "twentieth-century droughts are not representative of the full range of drought variability that has occurred over the last 2000 years." Indeed, they say that the last hundred years have been characterized by droughts of "*moderate severity and comparatively short duration,* relative to the full range of past drought variability."

*Other types of severe weather*

Researchers investigating the behavior of thunderstorms, tornadoes and other types of weather extremes have reached similar conclusions. Because of increased media coverage, people assume such storms are getting worse and that the damage they cause is rising. However, when the data are carefully adjusted for changing population demographics (including income, inflation, property values, increased construction of beachfront property, etc.), what people believe to be true isn't supported by the weather record.

As the authors of an important study (Kunkel et al., 1999) summarize the situation:

> This paper reviews recent work on trends during this [20th] century in societal impacts (direct economic losses and fatalities) in the United States from extreme weather conditions [including hurricanes, thunderstorms, hailstorms, tornadoes, winter storms, heat waves] and compares those with trends of associated atmospheric phenomena. Most measures of the economic impacts of weather and climate extremes over the past several decades reveal increasing losses. But trends in most related weather and climate extremes do not show comparable increases with time. *This suggests that increasing losses are primarily due to increasing vulnerability arising from a variety of societal changes, including a growing population in higher risk coastal areas and large cities, more property subject to damage, and lifestyle and demographic changes subjecting lives and property to greater exposure.*[emphasis added]

***Simply put, there is little evidence that human activity related to the greenhouse effect is worsening extreme weather events.***

Peoples' belief that the weather is getting worse is based on the assumption that because weather-related damage is increasing, storms must be getting more severe. Instead, *the amount of damage related to storms is a result of rising property values and an increasing population placed at risk because of where they choose to live — areas prone to damage from hurricanes, for example.*

## Is Climate Change Forcing Species Migration and Extinction?

*Migration*

Why is it news that various plants and animals are being forced out of their natural habitat because climate is changing? As demonstrated by **Figure 1**, climate is changing. *It would be newsworthy if plants and animals weren't reacting to changes in their environment.* It would mean everything scientists have learned about biologic adaptation is wrong. It would mean that instead of changing behavior in response to environmental changes, life on earth is inflexible.

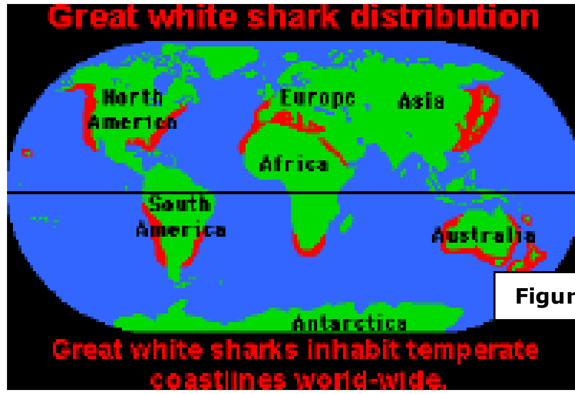


Figure 9

One recent example of false claims (presented to viewers of FOX cable news) is that the warming of north Atlantic waters is responsible for the appearance of a Great White Shark off the coast of Alaska. The truth is that Great Whites (*Carcharadon carcharias*) are endothermic – able to elevate their body temperature above that of the surrounding water. They can tolerate a broad temperature range, providing them access to prey (primarily coastal pinnipeds) over a wide ecological niche -- including sub-artic Alaskan waters. They have long been observed along the U.S. coastline from California to Alaska (**Figure 9**).

As for earth's plant life, atmospheric CO2 enrichment tends to ease the potentially negative effects of rising temperatures. Studies indicate that more CO2 in the air enables plants to grow better at nearly all temperatures, but especially at higher temperatures. Elevated CO2 boosts the optimum temperature at which plants grow best and it raises the upper-limiting temperature above which plants die. Elevated CO2 makes them much more resistant to heat stress.

It appears that if the atmosphere's temperature and CO2 concentration rise together, plants are able to adapt to the rising temperature and experience *no* ill effects. Under such conditions, plants living near the heat-limited boundaries of their ranges *do not* migrate poleward or upward towards cooler regions of the globe.

At the other end of the temperature spectrum, plants living near the cold-limited boundaries of their ranges *extend their ranges* into areas where the temperature was previously too low for them to survive. They actually *expand* their ranges and overlap the similarly-expanding ranges of other plants, thereby *increasing local plant biodiversity*, which in turn supports *increased* wildlife diversity.

Amazingly, the bulk of the scientific studies that prompts media scare stories, such as those that filed the April 3, 2006 issue of TIME magazine, actually support the *opposite* of what often is claimed. Rather than suggesting earth's biosphere is about to suffer irreparable damage as a result of past natural warming and future predicted warming, research substantiates nearly everything known about the beneficial effects of atmospheric CO2 enrichment on plant physiology. These studies portray a biosphere of *increased species richness almost everywhere on earth* in response to global warming and the increase in atmospheric CO2 concentration of the past century and a half that has promoted an expansion of species' ranges throughout the entire world.

*Extinction*

It is important to recognize that if recent changes in earth's climate are stressing flora and fauna to the point of extinction, then natural changes in climate from year-to-year and decade-to-decade already should have killed them. Annual and decadal fluctuations are much more dramatic than the changes in average temperature observed to date. For example, if annual or decadal climate variations threaten life forms, then the huge temperature swings that occurred multiple times during the past 400,000 years (**Figure 5**) should already have killed off all life on earth. Obviously, such is not the case.

Nature responds differently than do models of nature's response, as Drs. Sherwood and Craig Idso report:

> Of course plants *could* migrate poleward and upward at the poleward and upper bounds of their ranges, as new territories that were too cold for them in the past became more hospitable; but their warm-edge boundaries would not need to change. Likewise, there would be no need for changes in the warm-edge bounds of the ranges of animals that depend upon specific species of plants for their sustenance. And, in fact, this is precisely what scientists are discovering where there has been regional warming over the past several decades.
>
> In a study of shifts in the ranges of more than half a hundred European butterfly species over the past century, for example, Parmesan et al. (1999) found that most of them extended the northern boundaries of their ranges further north in response to a regional warming of approximately 0.8°C; but the southern boundaries of their ranges remained unchanged. Likewise, Thomas and Lennon (1999) studied an equally large number of British bird species from 1970 to 1990, finding that the northern boundaries of species residing in the southern part of Britain shifted northward by an average of 19 km, while the southern boundaries of species residing in the northern part of the country shifted not at all. Hence, rather than being forced to migrate and being nudged closer to extinction in response to a local increase in temperature during a period of increasing atmospheric CO2 concentration, these many butterfly and bird species actually *increased* their ranges and became even *more protected* from the possibility of extinction.
>
> Similar phenomena have been observed in the sea. In a detailed analysis of benthic foraminifera (amoeba-like seal-dwelling organisms) in the Northeast Pacific, Cannariato *et al*. (1999) evaluated a sediment core to determine the effects of a number of rapid climatic changes over the course of its 60,000-year record. They found many periods of rapid temperature change, but no extinctions. In fact, they determined that the benthic ecosystems they studied "appear to be both resilient and robust in response to rapid and often extreme environmental conditions," concluding that "broad segments of the biosphere are well adapted to rapid climate change."

Nowhere can there be found a listing of all the species imagined to have gone extinct during warming over the last two centuries. On the other hand, a richness of new species continues being discovered, such as the recent find reported in the mountain rainforests of New Guinea. New species of birds, frogs, butterflies and palms were cataloged and include:

* Twenty new species of frogs
* Four new butterflies
* Five new species of palms
* The world's largest rhododendron flower
* New birds such as the wattled honeyeater; breeding grounds of the golden-fronted bowerbird and Berlepsch's six-wired bird of paradise which were thought extinct.
* A new species of tree kangaroo as well as six species of others that are rare elsewhere.

The current issue of TIME magazine ominously tells its readers to be "very worried" about polar bear extinction. Their source is likely the World Wildlife Fund. The problem is, reports like these have one intended conclusion: Climate change is bad (especially for polar bears). Thus, any observed associations – as apposed to model scenarios -- between polar bears and climate change are typically ignored if they don't show the intended patterns. That is precisely the case in this instance.

Case in point, in the Baffin Bay region (the area between North America and Greenland), the temperature has been *decreasing* and the polar bear populations there have been in *decline*. In the region with the greatest temperature *increase* – the Pacific region between Siberia and Alaska – nearby bear populations in the North and South Beaufort Sea (just north of Alaska) have *risen*. Bear population and temperature have been relatively stable throughout the remaining areas. In other words, the observed relationship between temperature and bear population is the *opposite* of what the WWF and Time magazine reports would lead readers to believe.

Truth is that the diversity of life on earth is mute but dramatic testimony that plants and animals are readily adaptable to variations in climate. Life forms on earth actively respond to climate fluctuations with changes in their behavior and location. To paraphrase Mark Twain, "rumors of their demise are greatly exaggerated!"

For a full-length paper on the question of warming and species extinction, see (http://www.co2science.org/scripts/Template/0_CO2ScienceB2C/pdf/extinction.pdf).

## Is There a World-wide Loss of Coral Reefs?

This appears to be another exaggeration. As one might expect, the subject is much more complicated than simplistic concern about coral "bleaching".

Corals enjoy a symbiotic relationship with certain photosynthetic algae of the genus *Symbiodinium*. The algae get their nutrients from the coral and the coral acquire photosynthetic products from the algae.

There are different groups (or clades) of *Symbiodinium* that vary genetically and benefit corals in different ways. Bleaching is evidence corals have rejected the *Symbiodinium*. They lose their color and when bleaching occurs, large numbers of corals die. But some corals manage to survive bleaching events. They acquire new *Symbiodinium* potentially better adapted to the new environment.

In a paper that appeared in Nature, Andrew Baker (2001) proposes that bleaching may be an excellent strategy employed by corals to sacrifice short-term benefits for longer-term gains. This line of thinking accounts for corals' ability to survive over millions of years and through much harsher climate changes than those experienced over the last few decades.

Two more recent investigations into the health of the Great Barrier Reef (GRB) have been presented in Australia by the Queensland Chief Scientist and the Productivity Commission. Despite an exhaustive listing in the literature, neither of these reports was able to find a single convincing example of substantive damage to the GBR related to human activity. The Productivity Commission report (2003) concludes there is "no conclusive evidence" of water quality decline within the GBR lagoon or of "any resulting damage to ecosystems..." But even more important, there is *abundant evidence that the GBR remains in excellent health* within the bounds of the variations which occur within its natural environment. In this context, coral bleaching outbreaks are entirely natural. *Natural* bleaching outbreaks probably have been occurring on the GBR for thousands of years and will continue.

More recently, two marine biologists (Precht and Aronson, 2004) concluded that from 10,000 to 6,000 years ago, extratropical North Atlantic sea surface temperatures (SSTs) were 2-3°C *warmer* than at present and coral reefs flourished. They report that the fossil record clearly demonstrates the ability of corals to *expand* their ranges poleward in response to global warming and to "reconstitute reef communities in the face of rapid environmental change." In fact, they report that coral range expansions are occurring *today* and note "there is mounting evidence that coral species are responding to recent patterns of increased SSTs by *expanding* their latitudinal ranges."

**Melting Polar Ice Caps?**

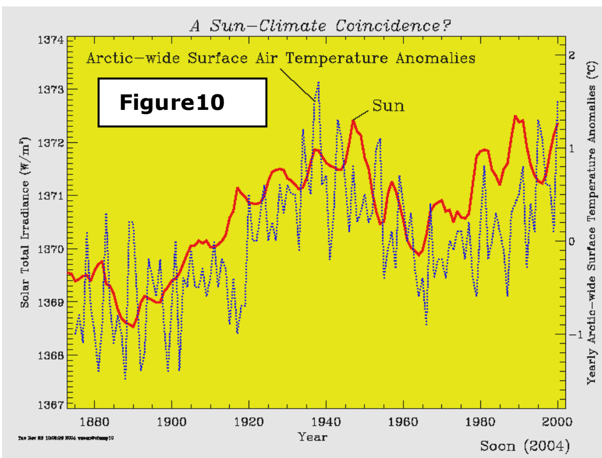
There seem to be signs in the Arctic and Antarctic that climate change is underway. But remember: talk about life at the North and South Poles concerns the most remote and inhospitable places on earth. While data seem to indicate that temperatures over much of the Arctic have increased over the past several decades (to levels last experienced in the 1930s), data from Antarctica suggests just the opposite. Not only have temperatures cooled a bit over Antarctica, but snow and ice accumulation is increasing.

Most news stories about Antarctica don't report that the continent as a whole is not behaving like its northern counterpart. Instead, one hears reports on conditions along the Antarctic *Peninsula* — a relatively small piece of the continent that juts northward toward South America.

Antarctic *Peninsula* temperatures have been warming. In this way, conditions there are similar to those in the Arctic. Ice on the peninsula has been melting over the past couple of decades. The once-frozen spit of land is becoming more hospitable to life; plant and animal species are beginning to colonize locations where they had not been previously.

What is taking place on the Antarctic Peninsula comprises *less than two percent of the total area of Antarctica*. Conditions at the Peninsula no more reflect what is occurring over the entire continent than those in Florida reflect what is happening all across North America.

Regarding **Arctic temperature changes**, the *key question* is whether man-made CO2 is responsible. Recent research suggests it is highly premature to conclude that anthropogenic CO2 is largely responsible for the observed changes and variations within the Arctic climatic and eco-systems. Instead, solar variations appear to be an important explanation for the observed Arctic surface air temperature change over the past 130 years or so. [See **Figs. 10 and 11**] The power of solar forcing was shown to be far more consistent and dominant than the commonly proposed factor of climate change from increasing atmospheric carbon dioxide. In other words, anthropogenic CO2 probably plays a far smaller role in observed and future changes in the Arctic than is commonly assumed.



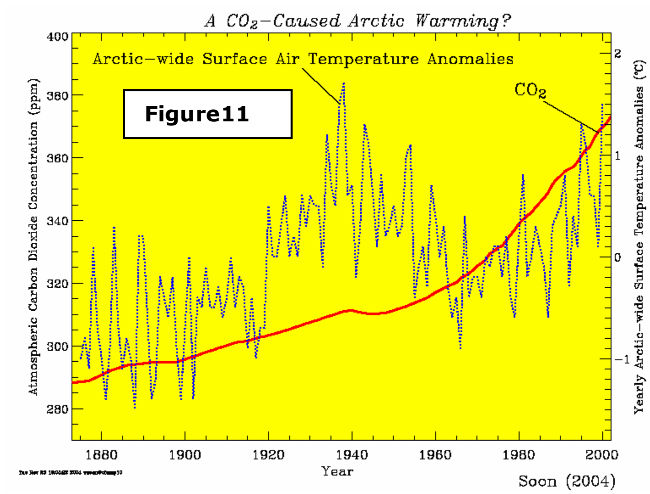



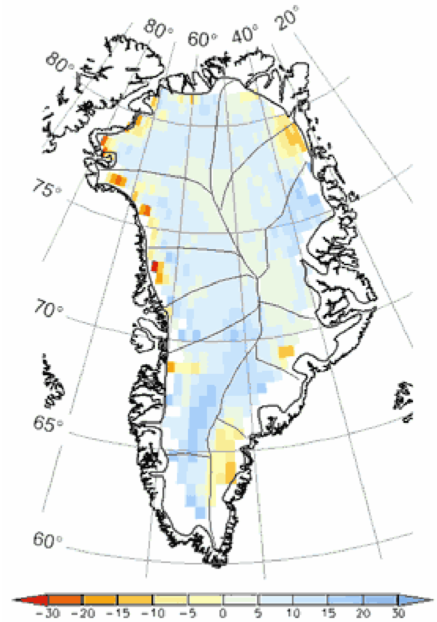

**Figure 10** summarizes the current understanding regarding factors that are responsible for the observed Arctic surface temperatures. Soon (2005) identifies both the multidecadal variation in total solar irradiance (i.e., all wavelengths of integrated sunlight) and the 11-year solar UV irradiance forgings to be important in explaining the observed Arctic surface air temperature change over the past 130 years or so. **Figure 11** shows a weaker correlation with CO2.

The Arctic and Antarctica paint contrasting pictures of how climate is changing.

Reports are also incomplete regarding claims that Greenland's ice sheets are melting and raising sea levels.

Worry tends to focus on the melting and thinning of ice in the *coastal areas* of Greenland. However, *opposite* changes are occurring in the *much larger interior* ice sheet. A Norwegian-led team of scientists studying an 11-year period (1992-2003) of Greenland ice sheet activity reported that "below 1500 meters, the elevation-change rate is -2.0 ± 0.9 cm/year, in qualitative agreement with reported thinning in the ice-sheet margins," *but* that "an *increase* of 6.4 ± 0.2 cm/year is found in the *vast interior areas* above 1500 meters." Spatially averaged over the bulk of the ice sheet, the *net* result is a mean *increase* of 5.4 ± 0.2 cm/year, "or ~6.0 cm over 11 years. *The Greenland Ice Sheet has not been wasting away, but has been growing at a very respectable rate*. This increase, like the one in Antarctic, is *removing* water from the oceans.

## Are Glaciers In Retreat?




Greenland ice-sheet elevation change in cm/year (see color scale) derived from 11 years of ERS-1/ERS-2 satellite altimeter data, 1992-2003. Result: 5.4 cm/year *increase*.

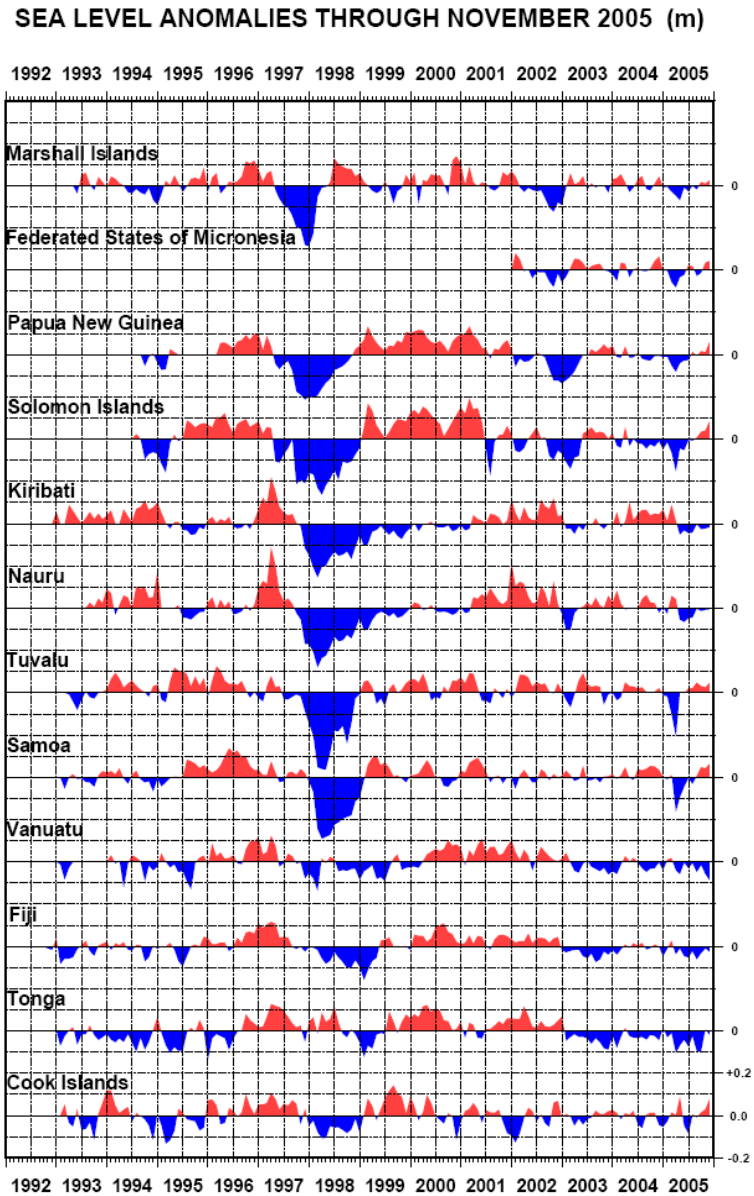
The full story begins with a clear recognition of just how little is known about glaciers. Of the 160,000 glaciers presently in existence, only 67,000 (42%) have been inventoried to any degree (Kieffer et al.,2000). There are only a tad over 200 glaciers for which mass balance data exist for but a single year (Braithwaite, R.J. and Zhang, Y. 2000). "Relationships between interannual variability of glacier mass balance and climate." *Journal of Glaciology* 45: 456-462). When the length of record increases to five years, this number drops to 115. If both winter and summer mass balances are required, the number drops to 79. Furthermore, if ten years of record is used as a cutoff, only 42 glaciers qualify. This lack of data concerning glaciers, in the words of Braithwaite and Zhang, highlights "one of the most important problems for mass-balance glaciology" and demonstrates the "sad fact that many glacierized regions of the world remain unsampled, or only poorly sampled." This suggests that we really know very little about the true state of most of the world's glaciers.

During the 15th through 19th centuries, widespread and major glacier advances occurred during a period of colder global temperature known as the **Little Ice Age** (Broecker, 2001; Grove, 2001). Following the peak of Little Ice Age, it should come as no surprise that many records indicate widespread glacial retreat once temperatures began to warm in the mid- to late-1800s, a time when many glaciers returned to positions characteristic of those before the Little Ice Age. In many instances the rate of glacier retreat has not increased over the past 70 years. In some cases glacier mass balance actually has increased during a time when the atmosphere experienced the bulk of the increase in its $CO_2$ content.

Herbert Glacier

Concern for ice melt often focuses on Montana's Glacier National Park and Alaska's Herbert Glacier. However, natural processes are evident in both.

A recent 300-year study of Glacier National Park found its glaciers have advanced and retreated repeatedly, and *not* in sync with variable greenhouse gas levels. Another study found Alaskan glaciers have had periods of advance and retreat for at least 700 years. A researcher at the University of Alaska-Southeast reports that some 800 years ago Herbert Glacier retreated miles back into its valley. A forest grew. Then the glacier again advanced, then receded, advanced, and is again receding.




## Is Sea Level Rise Accelerating?

An accelerated rise in sea level rise is far from scientifically established. Several studies in fact conclude that the rate of global sea level rise has been rather *stable* over the past century or more at a mean value of approximately 1.8 ± 0.3 mm yr-1.

Recently, White *et al*. (2005) conducted an analysis of the available data in an attempt to find the elusive *predicted* increase in the sea level's rate of rise (acceleration). They compared estimates of coastal and global averaged sea level between 1950 and 2000 and concluded their results confirm earlier findings of "*no significant increase* in the rate of sea level rise during this 51-year period" (the last half of the 20th century which includes two decades of a supposedly "unprecedented" rate of temperature increase.)

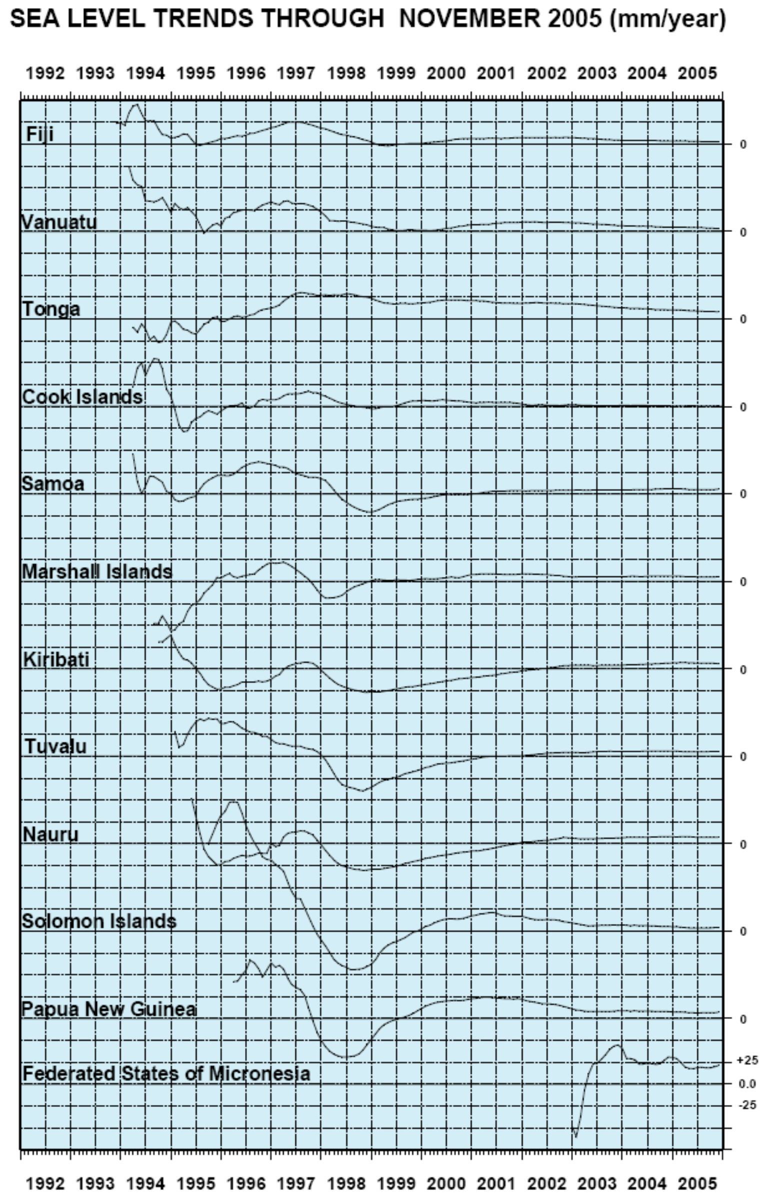
In addition to computer-based simulation models – often the source of alarmist predictions – it is also essential to collect information on what *actually* is happening to the coasts of atoll islands. This requires accurate monitoring of sea-level change and coastal change.

Bill Mitchell, Acting Director of the National Tidal Facility, Adelaide, South Australia recently observed:

> Although there has been a lot of discussion and debate linking the vulnerability of atoll islands to the impacts of global change, this has suffered for several reasons.

There is scientific uncertainty about sea-level rise predictions. Problems exist with interpretations of sea-level trends from tidal data for the last century. There is a poor understanding of change and dynamics in atoll environments. Erosion is often quoted as an impact of sea-level rise but there are very few studies giving accurate assessments of how much erosion will occur and how the low-lying reef island will respond. Not enough is known about the natural variability of atoll islands in order to identify global change-induced effects.

The result has been that many assessments are, to a large extent, based on speculation. This has not helped the small-island states of the atoll countries, particularly when discussing the impacts of global change in international fora.




A sophisticated SEAFRAME (Sea level Fine Resolution Acoustic Measuring Equipment) tide-gauge array has now been deployed at 12 sites to monitor sea level in the region.

Though existing for a short period, the SEAFRAME gauges already have provided useful information on regional changes. The 14-year record of sea-level anomalies shows a dramatic *drop* in sea level associated with the 1997/98 El Niño. Some countries such as Tuvalu experienced a *drop* in sea level of almost 40 cm during that event. Other countries such as Nauru experienced a sea-level rise in the year preceding this event, resulting in a total sea-level variation of over 50 cm from one year to the next.

Tuvalu has been a poster-child example of concern about sea-level rise attributed to warming. The island's government led the cry about small nations being swamped beneath the waves of rising seas, sought international compensation and guarantees from Australia and New Zealand to provide "residency" to 12,000 islanders in the event of inundation.

The National Tidal Facility, based in Adelaide, Australia, has dismissed Tuvalu's claims as unfounded. The facility has maintained accurate monitoring of sea level at Tuvalu and reports, "The historical record shows no visual evidence of any acceleration in sea level trends."

It appears likely that beach erosion and construction on the island intended to attract tourists have caused the sea flooding of areas over the last decade. But this is a *local* problem, one that will not be solved by massive cuts in carbon dioxide emissions around the world.

Within the past month, however, a research paper purported to have detected an acceleration in the rate of sea level rise. While long-term records from tide gauges do not show acceleration over the 20th century and short-term records from satellites do not show any acceleration during the past few decades, the satellites do appear to show a greater rate of rise than the tide gauges. While no one really knows how to tie the two datasets together Church et al. recently attempted to combine both datasets and, in doing so, reported a *slight* acceleration in sea level rise. However, their result has not yet been subject to much scrutiny and hasn't been confirmed by other datasets and analyses. While the scientific community is not yet ready to climb aboard, various advocacy groups eagerly have done so.

Referring to real data, one is hard-pressed to find alarming trends in sea-level rise, as monthly trends for the south Pacific atolls below indicate.

## Mosquito-borne Diseases

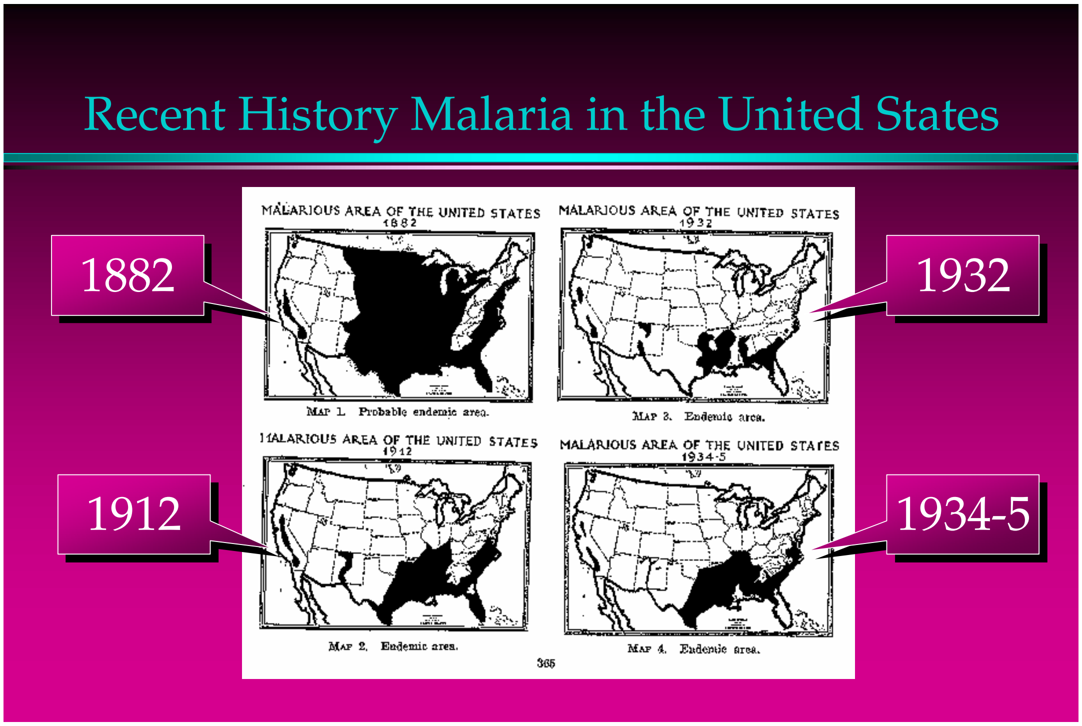
Frequently, the specter is raised of **mosquito-borne diseases** gaining a new toehold in Europe, North America and high latitudes in Africa. This is not supported by science. Simplistic popular writings and models assume that mosquito-borne diseases like malaria are uniquely tropical and that warmer temperatures are what determine their incidence and distribution in northern latitudes.

Malaria take-home points:

- Malaria is not a tropical disease
- In the past, dengue and yellow fever as far north as Boston
- Proponents of climate-based change ignore basic principles
- Climate is only one of many factors in transmission
- Current models cannot 'predict' future transmission
- No evidence of changes in transmission due to climate
- Public conceptions are manipulated by special interest groups
- The public and their decision makers are vulnerable to abuse

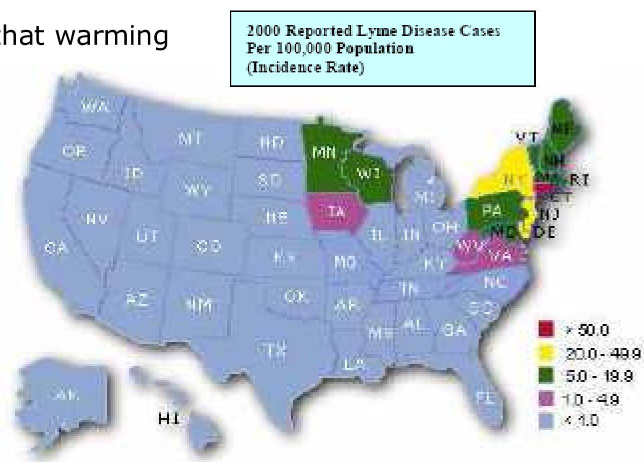
Dr. Paul Reiter, formerly with the U.S. Centers for Disease Control and Prevention, refutes these claims in the journal, *Emerging Infectious Diseases*. Dr. Reiter points out that "until the second half of the 20th century, malaria was endemic and widespread in many temperate regions, with major epidemics as far north as the Arctic Circle. From 1564 to the 1730s, the coldest period of the Little Ice Age, malaria was a prominent cause of illness and death in several parts of England. Transmission began to decline only in the 19th century, when the present warming trend was well under way. The history of the disease in England underscores the role of factors other than temperature in malaria transmission."

According to Dr. Reiter and many other specialists, these "other factors" also apply to diseases such as yellow fever and dengue.




Reiter et al. (2004) caution that the link between global warming and the spread of **malaria** is not straightforward, and cite numerous examples. They conclude, "We understand public anxiety about climate change, but are concerned that many of these much publicized predictions are ill informed and misleading. We urge those involved to pay closer attention to the complexities of this challenging subject."

A more recent claim has been made that warming is responsible for the increased incidents of **Lyme disease**. Leading specialists have found the *opposite* to be true: "Mean temperatures show weak and inconsistent correlations with incidence."[i] Incidents are instead related to New England farmlands returning to forests near homes. This creates new "edge habitat" and an explosion in deer populations which carry the blackleg tick. Lyme disease is not a problem in the warmer Southern states.



## What the Future May Bring

As to what the future holds, the distant past offers only a little guidance.

It suggests that at some time in the not-too-distant future (at least on a geologic timescale), we can expect the world to begin its plunge toward another ice age. One can only hope that when that day comes, humans will have acquired the know-how to adapt or even prevent it from occurring. But this is not a concern for the near future (on a human timescale).

*Adaptation Strategies*

However, near-term adaptation strategies are of immediate concern, and the dangers of ignoring them have long been recognized. As to the importance of adaptation, Robert Matthews of Aston University, Birmingham, England has recent commented:

> When the effects of adaptation are taken into account, the results are frequently revelatory. A team led by Robert Mendelsohn of Yale University has examined the economic impact of predicted climate change when adaptation is included. They find that a warmer world can actually produce *net economic gain* - at least for the richest nations. In contrast, the poorest nations look set to suffer disproportionately, essentially because they have hot climates already.
>
> This has important implications for policies for dealing with the impact of climate change. Because if rich nations actually thrive on a warmer planet, they will be in a position to assist more vulnerable nations to deal with the effects - *without jeopardising* their own economic growth.
>
> Many questions have still to be addressed: what is the optimal mix of mitigation and adaptation, and how should rich nations assist those worst affected by global warming? But the *biggest question* of all is why [some] climate scientists still seem so reluctant to accept that humans are more resourceful than the average turkey.

For at least the next several decades — and perhaps even longer — earth’s climate record suggests we will likely face a period of rising temperatures. Use of fossil fuels accompanied by their greenhouse gas emissions may contribute to that warming (as may the other human activities mentioned above, such as changing practices of land-use). But scientists don’t know how much and how fast the energy mix will change. That, in turn, will have a bearing on how much and how fast the anticipated warming will occur.

As previously discussed, much of the guidance we seek on these questions derives from projections made by current less-than-perfect climate models and the energy consumption and emissions scenarios that are fed into the models.

The IPCC believes that during the 21$^{st}$ century, temperatures will rise between 1.4 and 5.8°C (2.5° to 10.4°F). This is a wide range and is not particularly useful in predicting what will happen.

A temperature change at the lower end of the range likely can be readily adapted to both by humans and the natural environment. It may even be beneficial because it would extend growing seasons for plants and agricultural crops. This impact already has been observed during the past twenty to thirty years.

If future temperature change is more near the high end of the IPCC estimated range, then the impact can be expected to be greater and more disruptive to natural and human communities. Greater ability and resources to adapt would be required.

Another scientifically plausible way of anticipating what the future might be like is to examine trends that have been established over the recent past. For example, if the rate of temperature rise established during the past thirty years (depicted in **Figure 1**) represents the time of the greatest impact from human activity on earth's atmosphere, then extending that trend into the future suggests that during the next hundred years, temperature will rise about another 1.8°C (3.6°F), near the low end of the IPCC range.

*Future Warming Scenarios*

NASA scientist and climate modeler Dr. James Hansen has said that "future global warming can be predicted much more accurately than is generally realized" because he considers observations and trends to be more precise and reliable than climate model results. This, he says, is "because [the observations] include all the processes operating in the real world, even those we have not yet been smart enough to include in the models." Hansen predicts an additional warming during the next fifty years of about 0.75°C (give or take 0.25°C). In Fahrenheit equivalents this is a change of 0.9 to 1.8°F — again, warming close to the lower end of IPCC projections.

It is important to bear in mind investigations such as Dr. Hansen's when considering potential actions to reduce carbon dioxide emissions from human activities. His findings are based upon real-world observations. Sometimes the fact that, by all appearances, future climate change will be *modes*t-- is *not* well represented in the global warming stories in the popular media. In most stories, worst-case scenarios are played up, while more realistic or likely scenarios are barely mentioned at all.

A statement of climate change was jointly issued by the national science academies representing eleven of the world's leading industrial nations in association with the July 2005 G8 economic summit. G8 nations include the United Kingdom, France, Germany, Italy, Russia, Canada, Japan, and the United States. The national science academies of China, India and Brazil also participated in crafting the statement, which was an attempt to draw the United States into discussions with the European Union concerning mandatory limits on carbon dioxide emissions. It emphasized two primary points: 1) that climate change (as caused by human-induced alterations of the composition of the atmosphere) is real, and 2) something needs to be done about it.

The second point simply does not follow from the first.

Simply stating that climate change is a real thing and following that with the statement, "The scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action," is akin to saying, "After years of careful study we have compiled sufficient scientific evidence to conclude the sky appears to be blue. Now let's do something about it."

*What is missing is a scientific assessment of the potential threat posed by climate change balanced against its potential benefits. Without a science-based benefit/risk analysis, a simple scientific finding on its own doesn't merit specific action no matter how scientifically ground-breaking it might be.*

*Thinking About It*

How is daily life changed by what is arguably the greatest scientific breakthrough in history: Einstein's Theory of General Relativity? Not at all. Unless a scientific finding has an implication that impacts human life in some direct way, it is unlikely that human behavior will change.

*The reason there is no threat assessment accompanying the science academies' statement is that there is no scientific consensus on what level of threat climate change poses — at least not one the eleven signatories could agree upon.* The best that they could do was to identify evidence of a smattering of climate change. Even they would have to admit it either could be beneficial or detrimental, depending on the degree of change, its timing, and location.

"The projected changes in climate will have both beneficial and adverse effects at the regional level, for example on water resources, agriculture, natural ecosystems and human health. The larger and faster the changes in climate, the more likely it is that adverse effects will dominate," the academies wrote.

Yet, as has been demonstrated, "larger and faster" hardly is likely. The academies acknowledged the large range estimated by the IPCC: "The average global surface temperatures will continue to increase to between 1.4 centigrade degrees [2.5ºF] and 5.8 centigrade degrees [10.4ºF] above 1990 levels, by 2100." Recall how the low end of this range represents a change that is likely to be more beneficial than adverse, while the upper end represents a situation which could be more adverse than beneficial. *Without scientific guidance — guidance that is absent from the joint academies' statement — a finding that "climate change is real" does not justify "taking prompt action."*

There is ample (and mounting) evidence that climate change in the coming decades will be modest and will proceed at a rate that is somewhere near the low-end of the IPCC-projected temperature range. Interestingly, the NASA graph of the U.S. temperature history documents that average temperature has cooled 0.7 degress C since 1998 (National Aeronautics and Space administration, 2005).

Therefore, according to the national science academies joint statement, it is logical to assume that the impacts will less likely be adverse and might even be beneficial. If so, why should nations push for corrective action? What if such action *reverses* some the potential benefits?

In the United States, the 20th century received ten percent *more* precipitation. In a world where water resources are recognized to be increasingly precious, should the U.S. take action to reverse the benefit of increased precipitation? Obviously, the justification for action is far from clear.

*Kyoto and CO2 Mitigation*

Even if world-wide action were taken to mitigate CO2 emissions, would it matter? Would there be measurable, net benefits?

The Kyoto Protocol calls for mandatory carbon dioxide reductions by developed countries like the U.S. of about 30% from where they otherwise would be in the year 2010. Reducing man-made CO2 emissions this much would have an *undetectable* effect on climate while having a *devastating* effect on the U.S. and other national economies.

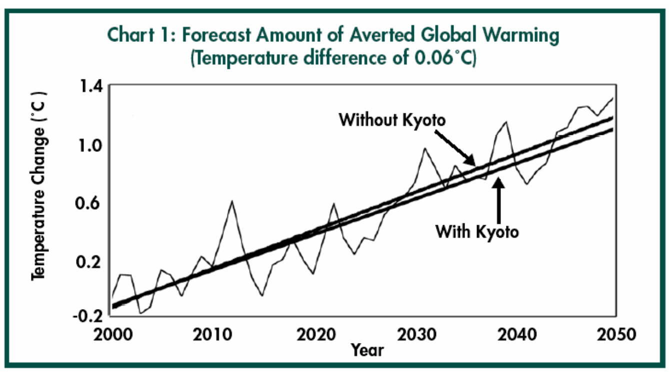
Major U.S. reductions in energy consumption under Kyoto would result in a decline of living standards. Meeting Kyoto would require a carbon tax of approximately $43.50/bbl of oil consumed (Energy Information Agency), plus similar additional tax on use of natural gas and coal.

Can Americans drive their cars 30% less; reduce their winter heating 30%; pay 20-50% more for everything from automobiles to zippers? And that would be just a down payment, with multiple more such reductions and "sacrifices" advocated thereafter - some advocacy groups are calling for "forty Kyotos."

What's more, increases in fossil energy consumption by growing economies, such as China and India, will more than offset any reduction in emissions that have been demanded from other industrialized countries, particularly the U.S.

Such drastic measures, even if imposed equally on all countries around the world, would reduce total human greenhouse contributions from CO2 by about 3.5%.

An analysis by NCAR scientist Tom Wigley showed that the global adherence to the terms of the Kyoto Protocol would result in a temperature "savings" (i.e. a slowdown of the warming rate) of only 0.06 to 0.07ºC by 2050 and 0.15ºC by 2100—an amount that is virtually undetectable by modern scientific methodology and an amount that would have no impact on natural systems.




While the greenhouse reductions would exact a high human price, in terms of sacrifices to our standard of living and freedoms, they would yield statistically negligible results in terms of measurable impacts to climate change. There is no expectation that any statistically significant global warming reductions would come from the Kyoto Protocol. And if an enforced (it actually is unenforceable, see: http://ff.org/centers/csspp/pdf/20060126_horner.pdf) international agreement yields no promised results, then independent State or local mandatory mitigation programs appear facile, wasteful and irresponsible.

# Appendix I

**Lindzen Climate Testimony before the UK House of Lords**

Memorandum by Professor Richard S Lindzen, Massachusetts Institute of Technology

UK Parliament, Select Committee on Economic Affairs Minutes of Evidence

http://www.publications.parliament.uk/pa/ld200506/ldselect/ldeconaf/12/5012506.htm

I am honoured to be able to share my impressions of the global warming issue with the members of this esteemed body. For the past 45 years I have been conducting research into various aspects of the physics of climate. I currently hold the Alfred P Sloan Professorship in Atmospheric Physics at the Massachusetts Institute of Technology, and have previously held professorships at Harvard University and the University of Chicago.

It goes without saying that few laymen understand what global warming is really about. However, most of you have been assured that it is a very serious problem, and that almost all scientists agree. For example, your Prime Minister has written that it was quite wrong "to suggest that scientific opinion is equally split", and he went on to claim "The overwhelming view of experts is that climate change, to a greater or lesser extent, is man-made, and, without action, will get worse". The Prime Minister is certainly aware that there are many sources of climate change, and that profound climate change occurred frequently long before man appeared on earth. Moreover, given the ubiquity of climate change, it is implausible that all change is for the worse. Nevertheless, on the whole I do not disagree with the Prime Minister. Indeed, I know of no split whatever, and suspect that the Prime Minister is simply setting up a straw man in claiming that there is opposing opinion. Where the Prime Minister is, in my view, leading you astray is in suggesting that this agreement constitutes support for alarm.

Indeed, when we analyse the nature of the scientific agreement we will see that it provides no support for alarm. However, given the proclivity of governments to respond to alarm with substantial support for science, we can understand the reluctance of the scientific community, such as it is, to object to the alarmist interpretation of their agreement.

**WHAT IS TRULY AGREED**

In order to analyse the meaning of the Prime Minister's claim, it is helpful to break the claim into its component parts. I won't suggest that there is no controversy over details, but there are few that would fundamentally disagree with the following.

1. The global mean surface temperature is always changing. Over the past 60 years, it has both decreased and increased. For the past century, it has probably increased by about 0.6 degrees Centigrade (C). That is to say, we have had some global mean warming.

2. $CO_2$ is a greenhouse gas and its increase should contribute to warming. It is, in fact, increasing, and a doubling would increase the radiative forcing of the earth (mainly due to water vapour and clouds) by about 2 per cent.

3. There is good evidence that man has been responsible for the recent increase in $CO_2$, though climate itself (as well as other natural phenomena) can also cause changes in $CO_2$.

I will refer to this as the *basic agreement*. To this extent, and no further, it is legitimate to speak of a scientific consensus.

## BEYOND THE BASIC CONSENSUS

Various bodies have been unable to resist making claims that items 1 and 2 are causally connected. This is referred to as the attribution question. I will show that attribution is by no means widely accepted or even plausible. However, as we will see, the alleged attribution, itself, also provides little or no support for alarm. The reason why the *basic agreement* (even when supplemented by the claim of attribution) does not support alarm hinges on other points of widespread agreement, which the Prime Minister failed to mention (and very likely was unaware of).

4. In terms of climate forcing, greenhouse gases added to the atmosphere through mans activities since the late 19th Century have already produced three-quarters of the radiative forcing that we expect from a doubling of $CO_2$. The main reasons for this are (1) $CO_2$ is not the only anthropogenic greenhouse gas—others like methane also contribute; and (2) the impact of $CO_2$ is nonlinear in the sense that each added unit contributes less than its predecessor. For example, if doubling $CO_2$ from its value in the late 19th Century (about 290 parts per million by volume or ppmv) to double this (ie, 580 ppmv) causes a 2 per cent increase in radiative forcing, then to obtain another 2 per cent increase in radiative forcing we must increase $CO_2$ by an additional 580 ppmv rather than by another 290 ppmv. At present, the concentration of $CO_2$ is about 370 ppmv.

5. A doubling of $CO_2$ should lead (if the major greenhouse substances, water vapour and clouds remain fixed), on the basis of straightforward physics, to a globally averaged warming of about 1C. The current increase in forcing relative to the late 19th Century due to mans activities should lead to a warming of about 0.76C, which is already more than has been observed, but is nonetheless much less than current climate models predict.

## CLIMATE MODELS AND BASELESS ALARMISM

This brings us, finally, to the issue of climate models. Essential to alarm is the fact that most current climate models predict a response to a doubling of $CO_2$ of about 4C. The reason for this is that in these models, the most important greenhouse substances, water vapour and clouds, act in such a way as to greatly amplify the response to anthropogenic greenhouse gases alone (ie, they act as what are called large positive feedbacks). However, as all assessments of the Intergovernmental Panel on Climate Change (IPCC) have stated (at least in the text—though not in the Summaries for Policymakers), the models simply fail to get clouds and water vapour right. We know this because in official model intercomparisons, all models fail miserably to replicate observed distributions of cloud cover. Thus, the model predictions are critically dependent on features that we know must be wrong.

If we nonetheless assume that these model predictions are correct (after all stopped watches are right twice a day), then man's greenhouse emissions have accounted for about six times the observed warming over the past century with some unknown processes cancelling the difference. This is distinctly less compelling than the statement that characterised the IPCC Second Assessment and served as the smoking gun for the Kyoto agreement: *The balance of evidence suggests a discernible human influence on global climate*. This is simply a short restatement of the *basic agreement* with the addition of a small measure of attribution. While one could question the use of the word "discernible", *there is no question that human influence should exist, albeit at a level that may be so small as to actually be indiscernible*. As we have already noted, however, even if all the change in global mean temperature over the past century were due to man, it would still imply low and relatively unimportant influence compared to the predictions of the models that are drawn on in IPCC reports.

Another example of the misuse of the *basic agreement* to promote alarm consists in the opening lines of the executive summary of the US National Research Council (NRC) 2001 report: *Climate Change Science: An Analysis of Some Key Questions*. This hurried report was prepared at the specific request of the White House. The brief and carefully drafted report of 15 pages was preceded by a totally unnecessary 10 page executive summary. The opening lines were appended at the last moment without committee approval. Here they are:

*Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising.*

*The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes is also a reflection of natural variability.*

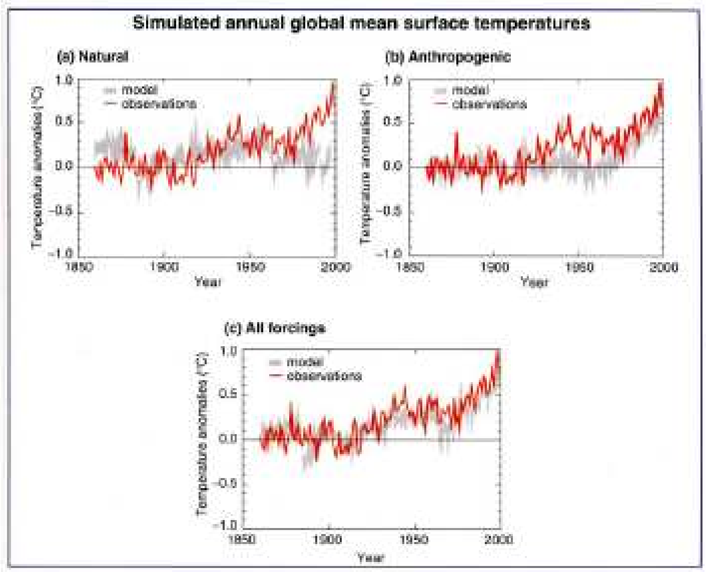
To be sure, this statement is leaning over backwards to encourage the alarmists. Nevertheless, the two sentences in the first claim serve to distinguish observed temperature change from human causality. The presence of the word "likely" in the second statement is grossly exaggerated, but still indicates the lack of certainty, while the fact that we have not emerged from the level of natural variability is, in fact, mentioned albeit obliquely. What, as usual, goes unmentioned is that the observed changes are much smaller than expected.

The response from many commentators was typical and restricted to the opening lines. CNN's Michelle Mitchell characteristically declared that the report represented "a unanimous decision that global warming is real, is getting worse, and is due to man. There is no wiggle room". Mitchell's response has, in fact, become the standard take on the NRC report. Such claims, though widely made in your country as well as mine, have no basis: they are nonsensical.

**MISLEADING INFERENCES**

How is it that model based alarm has been "justified" despite the fact that the observed warming over the past century is much less than was anticipated by the models? As usual, the argument involves obscuring this latter fact. The argument also ignores the fact that the climate is capable of unforced internal variability. That is to say, the climate can vary without any external forcing at all. El Niño is an example but there are many others besides. Reference to any temperature history of the earth shows fluctuations that are not connected to any known forcing, and these fluctuations amount to as much as half a degree Centigrade.

The most common defense is based on studies from the UK's Hadley Centre, and appears in Chapter 12 of the IPCC's Third Scientific Assessment. I would like to comment on this line of argument.




In these studies, we are shown three diagrams. In the first, we are shown an observed temperature record (without error bars), and the results of four model runs with so-called natural forcing for the period 1860-2000. There is a small spread in the model runs (which presumably displays model uncertainty—it most assuredly does not represent internal variability). In any event, the models look roughly like the observations until the last 30 years. We are then shown a second diagram where the observed curve is reproduced, and the four models are run with anthropogenic forcing. Here we see rough agreement over the last 30 years, and poorer agreement in the earlier period. Finally, we are shown the observations and the model runs with both natural and anthropogenic forcing, and, voila, there is rough agreement over the whole record. It should be noted that the models used had a relatively low sensitivity to a doubling of CO2 of about 2.5C. In order to know what to make of this exercise, one must know exactly what was done. The natural forcing consisted in volcanoes and solar variability. Prior to the Pinatubo eruption in 1991, the radiative impact of volcanoes was not well measured, and estimates vary by about a factor of 3. Solar forcing is essentially unknown. Thus, natural forcing is, in essence, adjustable. Anthropogenic forcing includes not only anthropogenic greenhouse gases, but also aerosols that act to cancel warming *(in the Hadley Centre results, aerosols and other factors cancelled two thirds of the greenhouse forcing)*. Unfortunately, the properties of aerosols are largely unknown. This was remarked upon in a recent paper in *Science*, wherein it was noted that the uncertainty was so great that estimating aerosol properties by tuning them to optimise agreement between models and observations (referred to as an inverse method) was probably as good as any other method, but that the use of such estimates to then test the models constituted a circular procedure. In the present instance, therefore, aerosols constitute simply another adjustable parameter (indeed, both its magnitude and its time history are adjustable). However, the choice of models with relatively low sensitivity, allowed adjustments that were not so extreme.

What we have is essentially an exercise in curve fitting. I suppose that the implication is that it is possible that the model is correct, but the likelihood that all the adjustments are what actually occur is rather small. The authors of Chapter 12 of the IPCC Third Scientific Assessment provided the following for the draft statement of the Policymakers Summary: *From the body of evidence since IPCC (1996), we conclude that there has been a discernible human influence on global climate. Studies are beginning to separate the contributions to observed climate change attributable to individual external influences, both anthropogenic and natural. This work suggests that anthropogenic greenhouse gases are a substantial contributor to the observed warming, especially over the past 30 years. However, the accuracy of these estimates continues to be limited by uncertainties in estimates of internal variability, natural and anthropogenic forcing, and the climate response to external forcing*.

This statement is not too bad—especially the last sentence. To be sure, the model dependence of the results is not emphasised, but the statement is vastly more honest than what the Summary for Policymakers in the IPCC's Third Assessment Report ultimately presented: *In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations*. In truth, nothing of the sort can be concluded. The methodology, by omitting any true treatment of internal variability, misses a crucial point. One can represent the presence of internal variability simply by plotting an horizontal line with the average value of the temperature for the period 1850-2000, and broadening this line to have a thickness of about 0.4C to represent the random internal variability of climate (in nature if not in the models). One can then plot the observations with a thickness of about 0.3C (corresponding to an observational uncertainty of about +/-0.15C). The two appropriately broadened lines will now overlap almost everywhere (a certain percentage of non-overlap is statistically expected) leaving no evident need for forcing at all.

Thus, the impact of man remains indiscernible simply because the signal is too small compared to the natural noise. *Claims that the current temperatures are "record breaking" or "unprecedented", however questionable or misleading, simply serve to obscure the fact that the observed warming is too small compared to what models suggest. Even the fact that the oceans' heat capacity leads to a delay in the response of the surface does not alter this conclusion.*

## FROM ALARMISM TO FANTASY

We still have not really addressed the interesting question of how modest warming has come to be associated with alarm. Here we must leave the realm where fudging and obfuscation are the major tools to a realm of almost pure fantasy. A simple example will illustrate the situation.

According to any textbook on dynamic meteorology, one may reasonably conclude that in a warmer world, extratropical storminess and weather variability will actually decrease. The reasoning is as follows. Judging by historical climate change, changes are greater in high latitudes than in the tropics. Thus, in a warmer world, we would expect that the temperature difference between high and low latitudes would diminish. However, it is precisely this difference that gives rise to extratropical large-scale weather disturbances. Moreover, when in Boston on a winter day we experience unusual warmth, it is because the wind is blowing from the south. Similarly, when we experience unusual cold, it is generally because the wind is blowing from the north. The possible extent of these extremes is, not surprisingly, determined by how warm low latitudes are and how cold high latitudes are. Given that we expect that high latitudes will warm much more than low latitudes in a warmer climate, the difference is expected to diminish, leading to less variance. Nevertheless, we are told by advocates and the media that exactly the opposite is the case, and that, moreover, the models predict this (which, to their credit, they do not) and that the basic agreement discussed earlier signifies scientific agreement on this matter as well. Clearly more storms and greater extremes are regarded as more alarming than the opposite. Thus, the opposite of our current understanding is invoked in order to promote public concern. *The crucial point here is that once the principle of consensus is accepted, agreement on anything is taken to infer agreement on everything advocates wish to claim*.

Again, scientists are not entirely blameless in this matter. Sir John Houghton (the first editor of the IPCC scientific assessments) made the casual claim that a warmer world would have more evaporation and the latent heat (the heat released when evapourated water vapour condenses into rain) would provide more energy for disturbances. This claim is based on a number of obvious mistakes (though the claim continues to be repeated by those who presumably don't know better).

For starters, extratropical storms are not primarily forced by the latent heat released in convection. However, even in the tropics, where latent heat plays a major role, the forcing of disturbances depends not on the evaporation, but on the evaporation scaled by the specific humidity at the surface. It turns out that this is almost invariant with temperature unless the relative humidity decreases in a warmer world. Incidentally, this would suggest that the feedbacks that cause models to display high climate sensitivity are incorrect. The particularly important issue of whether warming will impact hurricanes, is a matter of debate. As the IPCC has noted, there is no empirical evidence for such an impact. State of the art modeling suggests a negative impact, while there are theoretical arguments that suggest a slight positive impact on hurricane intensity. This is all of significant intellectual interest, but it is not the material out of which to legitimately build alarm.

Perhaps the most reprehensible attempt to generate alarm over global warming has been seen in connection with the recent tragic tsunamis in South Asia, where statements were made attempting to link this essentially geological event to global warming. However specious such links are, they follow what has become an almost self-parodying habit of those proclaiming alarm of attaching any severe, unusual or even common but not well known event to global warming while suggesting rather dishonestly that the event had indeed been predicted by models.

**SUMMING UP**

*So where does all this leave us?*

First, I would emphasise that the *basic agreement* frequently described as representing scientific unanimity concerning global warming is entirely consistent with there being virtually no problem at all. Indeed, the observations most simply suggest that the sensitivity of the real climate is much less than found in models whose sensitivity depends on processes which are clearly misrepresented (through both ignorance and computational limitations). Attempts to assess climate sensitivity by direct observation of cloud processes, and other means, which avoid dependence on models, support the conclusion that the sensitivity is low. More precisely, what is known points to the conclusion that a doubling of CO2 would lead to about 0.5C warming, and a quadrupling (should it ever occur) to about 1C. Neither would constitute a particular societal challenge. Nor would such (or even greater) warming be associated with more storminess, greater extremes, etc.

Second, a significant part of the scientific community appears committed to the maintenance of the notion that alarm may be warranted. Alarm is felt to be essential to the maintenance of funding. The argument is no longer over whether the models are correct (they are not), but rather whether their results are at all possible. Alas, it is impossible to prove something is impossible.

As you can see, the global warming issue parts company with normative science at a pretty early stage. A very good indicator of this disconnect is the fact that there is widespread and even rigorous scientific agreement that complete adherence to the Kyoto Agreement would have no discernible impact on climate. This clearly is of no importance to the thousands of negotiators, diplomats, regulators, general purpose bureaucrats and advocates attached to this issue.

At the heart of this issue there is one last matter: namely, the misuse of language. George Orwell wrote that language "becomes ugly and inaccurate because our thoughts are foolish, but the slovenliness of our language makes it easier for us to have foolish thoughts". There can be little doubt that the language used to convey alarm has been sloppy at best. Unfortunately, much of the sloppiness seems to be intentional. The difficulties of discourse in the absence of a shared vocabulary are, I fear, rather evident.

*25 January 2005*

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