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Is the Sky Really *Falling?*
A Review of Recent Global Warming Scare Stories

by Patrick J. Michaels

Executive Summary

In the last two years, a remarkable amount of disturbing news has been published concerning global warming, largely concentrating on melting of polar ice, tropical storms and hurricanes, and mass extinctions. The sheer volume of these stories appears to be moving the American political process toward some type of policy restricting emissions of carbon dioxide.

It is highly improbable, in a statistical sense, that new information added to any existing forecast is almost always "bad" or "good"; rather, each new finding has an equal probability of making a forecast worse or better. Consequently, the preponderance of bad news almost certainly means that something is missing, both in the process of science itself and in the reporting of science. This paper examines in detail both recent scientific reports on climate change and the communication of those reports.

Needless to say, the unreported information is usually counter to the bad news. Reports of rapid disintegration of Greenland's ice ignore the fact that the region was warmer than it is now for several decades in the early 20th century, before humans could have had much influence on climate. Similar stories concerning Antarctica neglect the fact that the net temperature trend in recent decades is negative, or that warming the surrounding ocean can serve only to enhance snowfall, resulting in a gain in ice. Global warming affects hurricanes in both positive and negative fashions, and there is no relationship between the severity of storms and ocean-surface temperature, once a commonly exceeded threshold temperature is reached. Reports of massive species extinction also turn out to be impressively flawed.

This constellation of half-truths and misstatements is a predictable consequence of the way that science is now conducted, where issues compete with each other for public support. Unfortunately, this creates a culture of negativity that is reflected in the recent spate of global warming reports.

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Introduction

For much of the last two years, the public has been barraged with global warming horror stories. Greenland is melting faster than ever thought. Antarctica is disappearing along with the Pacific island of Tuvalu. Frogs and toads are croaking in record numbers. Hurricanes are getting worse. Hurricanes will get worse.

Here I examine three climate-related issues that have received extensive coverage, deconstructing both the peer-reviewed literature and the reporting on that literature. Each of these topics is centrally important to global warming policy:

1. *Polar ice.* Melting of large areas of land ice will substantially raise sea level. Melting large areas of sea ice does not affect sea level but can have other important ecological impacts. Is Greenland gaining or losing ice? What about Antarctica?
2. *Hurricanes.* Since the fall of 2004, a number of papers have appeared in the scientific literature relating increasing hurricane severity to global warming. What are the strong points and what are the limitations of these studies? Are there other recent findings in the refereed literature that indicate otherwise? Have they been reported with the same prominence?
3. *Extinctions.* Some very disturbing research has recently been published linking global warming to massive extinctions of tropical amphibians and to large-scale migrations of entire classes of organisms. Do these studies stand up to further analyses? If not, why not?

Polar Ice

In a review of recent global warming science, it seems appropriate to start at the coldest place on earth.

Antarctica

Antarctica's ice sheets and glaciers are the largest mass of ice on the planet, comprising some 25.71×10^6 cubic kilometers, or 89.5 percent of total global ice.

Global warming theory predicts, in general, that warming is enhanced in cold, dry regions. That's because the response of temperature to a given "greenhouse" gas, such as carbon dioxide, is logarithmic. The response is similar if there are two greenhouse gases that absorb much of the same wavelengths of heat radiation emanating from the earth. Both water vapor and carbon dioxide have this property.

Suppose we had an atmosphere that initially contained a relatively constant concentration of carbon dioxide—at least since the recession of ice, some 11,000 years ago, from much of the North American land mass. (Technically, because the definition of an "ice age" is one with large areas of nonpolar land ice, we are still in one because of the massive Greenland ice cap.)

And also suppose we could find places where there were only tiny amounts of water vapor in the atmosphere. Those would be very cold land areas. The vapor pressure of water—a measure of how much is given off by a wet surface to the air—is about 1,000 times less at -40°C (-40°F) than it is at +40°C (105°F), which is the earth's nominal surface temperature range, depending on location. The atmosphere over cold land areas is exceedingly dry.

Beginning around 1850, the carbon dioxide concentration of the atmosphere began to rise, from a background of about 280 parts per million (ppm) to roughly 380 ppm today. Direct measurements, taken at Mauna Loa by Keeling et al.,[1] date back to 1957.

In fact, dry, cold land areas, such as Siberia or northwestern North America in winter indeed show more warming than do other places (Figure 1). As dispositive proof of that hypothesis, Michaels et al.[2] demonstrated that the more cold, dry air there is in these regions (as measured by barometric pressure, which is the weight of the air above a point), the greater the warming rate. As a control, regions that are moist show no such relationship.

Table 1
Areal Extent of Warming and Cooling in Antarctica, Showing the Biasing Effect of the Very Small Antarctic Peninsula, 1966–2000

Period	Antarctica	Antarctica without the Antarctic Peninsula
Annual	+41.4%, –58.3%	+33.8%, –65.9%
Winter (June–Aug.)	+62.5%, –37.3%	+56.3%, –43.4%
Spring (Sept.–Nov.)	+54.1%, –45.7%	+49.4%, –50.4%
Summer (Dec.–Feb.)	+31.7%, –67.4%	+22.8%, –76.3%
Autumn (Mar.–May)	+12.6%, –87.4	+0.3%, –99.7%

Plus signs indicate the proportion warming; minus signs indicate the proportion cooling. The Antarctic Peninsula is defined as the area north of 80°S and east of 80°W. From Doran et al., p. 518.

Antarctica is an exception. Over 15 years ago, Sansom[3] published a paper in the *Journal of Climate* that showed no net warming of Antarctica since the International Geophysical Year of 1957, which began the first systematic study of Antarctic temperature. Before then, records from transient expeditions are extremely sporadic. However, Sansom's study relied on only a handful of stations and did not form an areally weighted average, which is necessary because so many Antarctic weather stations are on the coast and very few inland.

Doran et al.[4] demonstrated a net cooling over Antarctica (Figure 1). Yet, on Earth Day, 2005, an AP Newswire headline said, "Study Shows Antarctic Glaciers Shrinking."[5] How does one square this seemingly contradictory result?

Table 1 gives the seasonal breakdown of Antarctic temperature change, from Doran et al. It is divided into Antarctica as a whole and Antarctica minus the Antarctic Peninsula—the narrow strip of land that points toward South America. It is clear from this table that warming of the peninsula, which makes up 2 percent of the continent, is quite anomalous compared to what is happening over the rest of the land area.

The AP story referred to work of Cook et al.,[6] which only examined glaciers in the northern portion of the peninsula, or about 1 percent of the Antarctic land area, and specifically the portion that has warmed the most.

The title of a scientific article is supposed to economically convey as much pertinent information as possible. But even our most respected journals occasionally publish misleading ones, which can help to generate misleading press stories.

In 2002 *Science* carried an article by Quayle et al. called "Extreme Responses to Climate Change in Antarctic Lakes."[7] Quayle et al. restricted their study to an area even smaller than the Antarctic Peninsula—nine lakes located on tiny Signey Island at the tip of the peninsula, which make up about 1/10,000,000 of Antarctica. The finding of note was that water in the lakes warmed at a rate about two to three times faster than the air temperatures and three to four times faster than global average temperature. (While the lakes are frozen for most of the year, liquid water remains below the ice.)

It is scientifically inappropriate to conflate global temperatures with what's happening on an isolated island, especially when the climate of that very small place is changing in a different direction than is that of the associated continent.

Although there was obviously no global significance, the Associated Press said this finding "could have very important implications for global climate change."[8] In reality, Signey Island is a pretty special case. It is on

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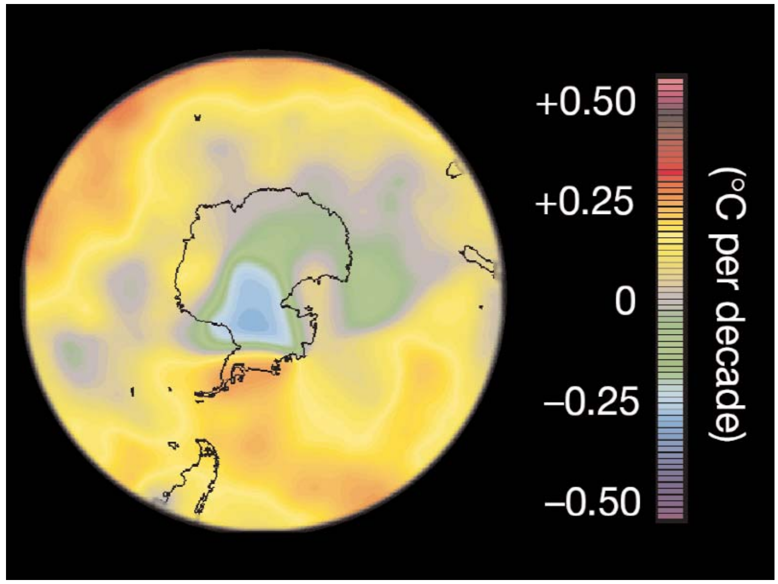
Figure 1
Antarctic Temperature Trends, 1966–2000



From Doran et al., p. 519.

the edge of a lot of ice, and small changes in wind patterns will dramatically change the local temperature. What really was being observed was a local ecological response to variations in local climate; in fact, it was a response to a variation that was atypical for the region as a whole.

There actually is a reasonable explanation for Antarctic cooling resulting from a general global warming. Antarctica is surrounded by water—the Southern Ocean—which has warmed an average of roughly 0.3°C in the last four decades. Although that might not seem like much (and it isn't much), it results in an increased amount of water vapor in the air surrounding Antarctica. When this air is forced to ascend the continent by any number of meteorological mechanisms, the increased moisture will give rise to increased low-level cloudiness and snow. The increase in Antarctic snow was documented by Davis et al.,[9] who wrote that the accumulation of snow was sufficient to make Antarctica as a whole a net "sink" for sea-level rise, just as is projected by all recent climate models.[10]

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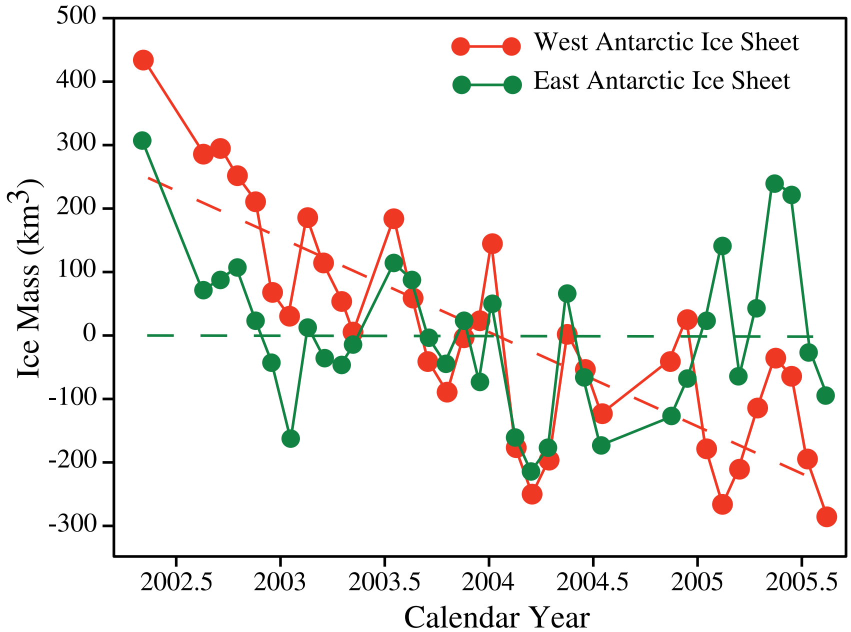
The low-level clouds responsible for snowfall are known to have a net cooling effect on surface temperatures. Consequently, it is most likely that the growth in Antarctic ice documented by Davis et al.[11] is a result of oceanic warming, which is why this growth is anticipated in the models cited above.

In 2006 Velicogna and Wahr[12] claimed that Antarctica recently lost enough ice to raise sea level at a rate of 0.02 inch per year. This is noteworthy because of the universe of climate model results, noted above, that say Antarctica should gain ice.

Velicogna and Wahr used 34 months of data recorded by a new NASA satellite that measures the force of gravity. Although there are a lot of complicated calculations required to determine how this relates to ice, the resulting changes are shown in Figure 2.

Figure 2
Ice Mass Variations in Antarctic Ice Sheets



Ice mass variations over the West Antarctic Ice Sheet (red) and the East Antarctic Ice Sheet (green) as measured by a gravity-sensing satellite. Note that there are only 34 months of data. From Velicogna and Wahr, p. 1755.

The record begins in mid-2002. Note that the observations are all rather regularly spaced over time *with the exception of two points*, including the first one, which is the highest point. Scientists are trained to beware of the effect of extreme single points at the end or beginning of a time series, but no mention of the biasing effect was made in the paper.

Perhaps of more concern is that this record begins near the high point of Antarctic ice depth, as shown in Davis et al. (Figure 3).[13]

Recently, Overpeck et al.[14] projected a massive melting of Greenland and Antarctica's ice sheets, resulting in a sea-level rise of 12–18 feet. This is the same sea level that occurred in the last interglacial, about 130,000 years ago. Overpeck et al. made this projection because their model for 2100 gives higher arctic temperatures than in the last interglacial; sea levels rose that much during the interglacial.

Nowhere do Overpeck et al. mention that all the available models require thousands of years of warming to melt most of Greenland's ice[15] and that it must take even longer in Antarctica. A run of three emissions scenarios used for the next 100 years with 18 climate models yields a mean sea-level rise from Greenland of .06 inch per year[16] around 2100. As noted above, all models project that Antarctica gains ice in a warming world.

Shindell and Schmidt[17] of the National Aeronautic and Space Administration wrote that the 30-year cooling trend in Antarctica was caused by a combination of stratospheric ozone depletion and a change in atmospheric circulation caused by global warming. This pattern is called the Southern Annular Mode (SAM) and is an out-of-phase oscillation in temperature between the south polar region and the Southern Ocean at lower latitudes. Shindell and Schmidt predicted that global warming will cause the SAM to become neutral, or effectively disappear. It is presently enhanced by the polar cooling effects of stratospheric ozone depletion.

NASA produced a lurid press release about Shindell and Smith's modeling results, promising certain disaster for the region because of "ice sheets melting and sliding into the ocean" leading to "greatly increasing sea levels."

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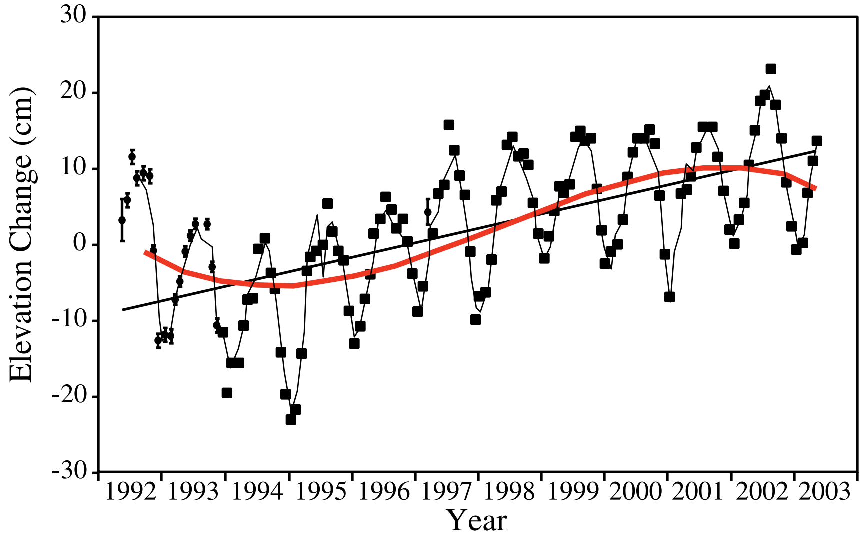
Figure 3
Ice Mass Change (elevation change) Observed over the East Antarctic Ice Sheet

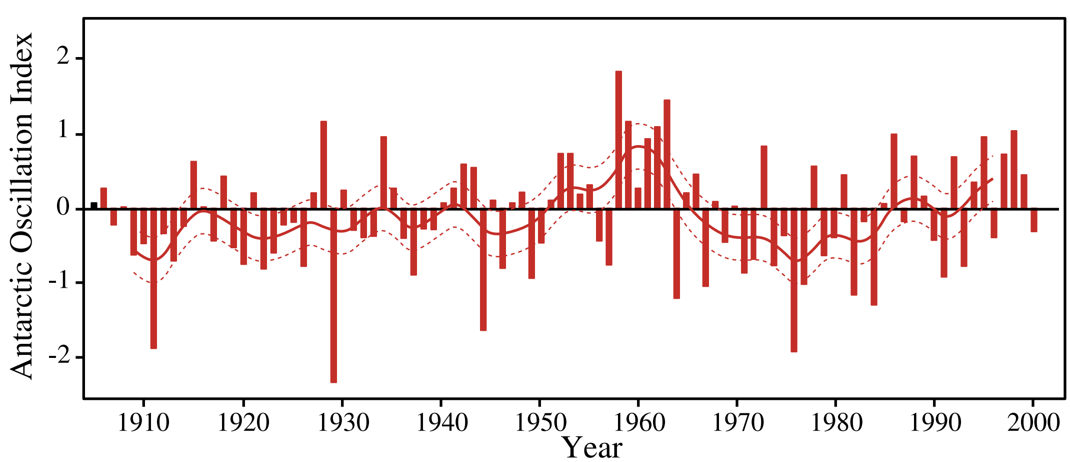


From Davis et al., p. 1799, who attributed the rise to increasing snowfall, which is a logical consequence of warming the ocean surrounding Antarctica.

The current pattern is similar to that observed over 40 years ago.

Shindell and Schmidt did not cite a concurrent 100-year reconstruction of the SAM by Jones and Widmann[18] (Figure 4), which shows that the current pattern is similar to that observed over 40 years ago and that the pattern was negative (implying a warmer Antarctica and a cooler ocean) virtually the entire first half of the 20th century. Forty years ago there was no ozone depletion in the Antarctic stratosphere. Consequently, the

Figure 4
Reconstructed Variability of the SAM



Reconstructed history of the Southern Anular Mode, 1905–2000. From Jones and Widmann, p. 291.

cold SAM pattern can arise without that effect.

In summary, the balance of internally consistent evidence is that Antarctica will gain ice in the next century because of increased snowfall caused by a slightly warming Southern Ocean. That increased snowfall must be associated with an increase in low-level cloudiness, which has the net effect of cooling the underlying surface. Although ozone depletion may be an additional cause of Antarctic cooling, as that is remediated, the Southern Ocean will continue to warm, causing further increases in cloudiness and snowfall.

Greenland

Greenland's ice sheets and glaciers make up the largest ice mass in the Northern Hemisphere, some 2.85×10^6 cubic kilometers, or 9.9 percent of total global ice volume. Together, Greenland and Antarctica hold 99.4 percent of the world's ice. The remaining non-polar ice volume, including the vast Himalayan Ice Cap, is a mere 0.6 percent.

A recent *Science* paper by Eric Rignot and Pannir Kanagaratnam[19] received a tremendous amount of publicity when it claimed that there has been a widespread and accelerating loss of Greenland's peripheral glaciers during the past 10 years, and increasing runoff from the main ice sheet. The rate given was 224 ± 41 cubic kilometers per year for 2005. For comparative purposes, the Greenland ice mass given above, in standard numerical notation, is 2,850,000 cubic kilometers, yielding a loss of eight-thousandths of a percent per year. This translates into a sea-level rise of two-hundredths of an inch per year.

Amazingly, there was no reference in this paper to Johannessen et al.'s 2005 publication, in the same journal, which showed that the Greenland ice cap is *accumulating* at a rate of 5.4 ± 0.2 centimeters per year.[20] This is the increase in elevation of the ice cap, measured by the very same satellites that Rignot and Kanagaratnam used![21]

What's the difference? Rignot and Kanagaratam combined observations of ice loss from the coastal glaciers with models of changes over the inland ice cap, whereas Johannessen et al. observed changes in the ice cap directly. Johannessen et al. found that the rise in ice-cap elevation converts to about 75 cubic kilometers

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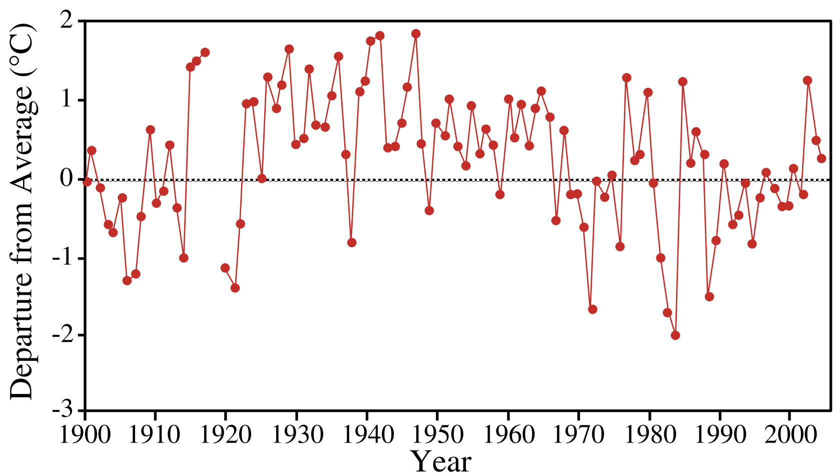
Figure 5
Temperature History from Southern Greenland, 1900–2005



From U.S. Department of Commerce, National Climatic Data Center.

According to Krabill, "If present-day thinning is attributable to warmer temperatures, thinning must have been even higher earlier this century."

per year. Had Rignot and Kanagaratam used *real data* as opposed to a *computer simulation*, they would have found that any loss of Greenland ice had occurred in only the last five years (it was gaining ice before then, even accounting for the loss from the glaciers), and the total loss would be around 93 cubic kilometers, which is slightly over 40 percent of the already-tiny loss Rignot and Kanagaratam originally claimed.

Figure 5 is the temperature history for southern Greenland from the U.S. National Climatic Data Center, from 1900 through 2005. This is the area with the greatest glacial retreat. Note that temperatures from 1920 through the late 1940s were generally higher than they are today. Writing about the mass-balance of Greenland ice in *Science* in 2000, Krabill et al. said:

> Greenland temperature records from 1900–1995 [note: Figure 5 is through 2005] show the highest summer temperatures in the 1930s, followed by a steady decline until the early 1970s and a slow increase since. The 1980s and 1990s were about half a degree colder than the 96 year mean. Consequently, if present-day thinning is attributable to warmer temperatures, thinning must have been even higher earlier this century.[22]

In 2004 Chylek et al. wrote:

> Since 1940, however, the Greenland coastal stations have undergone predominantly a cooling trend. At the summit of the Greenland ice sheet, the summer average temperature has decreased at the rate of 2.2°C per decade since the beginning of measurements in 1987. This suggests that the Greenland ice sheet and coastal regions are not following the current global warming trend.[23]

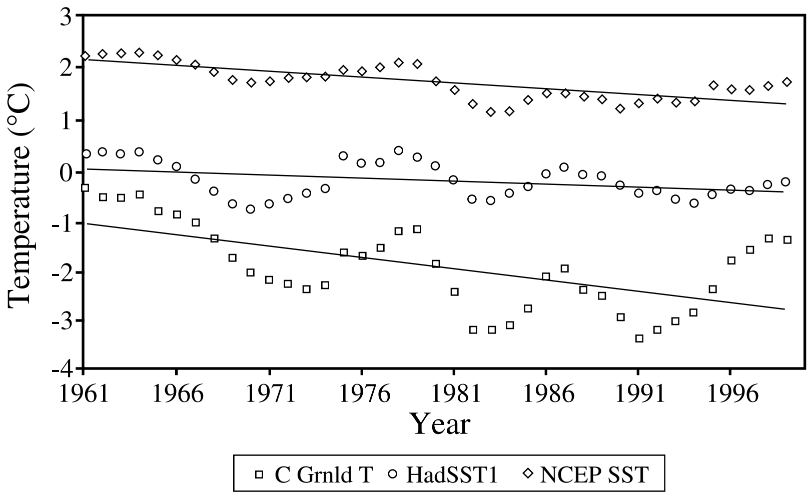
Hanna and Cappelen[24] developed a high-quality data set of Greenland land temperatures from 1958 through 2001 that were quality controlled to check for errors and biases. The eight stations are mostly in coastal southern Greenland—a key area because the edges of the Greenland Ice Sheet, along the coastline, are most sensitive to temperature changes, particularly in summer. Models suggest that ice sheet ablation increases by 20 percent to 50 percent for every 1°C rise in temperature.

Their composite record (Figure 6), smoothed using a five-year moving average, shows temperatures declining significantly since 1958 (since each year represents a five-year average, the middle year is plotted; the first data point, 1961, is the mean of 1959–63). Temperatures in southern coastal Greenland have dropped 1.29°C since 1959. Hanna and Cappelen compared this record with nearby sea-surface temperature measurements from two different sources over the same period (Figure 6). Although the ocean temperatures show less yearly variability (as expected, since water warms and cools more slowly than land, even if the land is very cold), the trend and pattern of year-to-year variation are very similar. So both land and adjacent ocean temperatures were dropping for decades, at least through 2001. (Note that Figure 5 shows 2003 to be an anomalously warm year.)

Chylek et al.[25] recently summarized Greenland's century-scale climate history:

> i) The years 1995 to 2005 have been characterized by generally increasing temperatures at the Greenland coastal stations. The year 2003 was extremely warm on the southeastern coast of Greenland. The average annual temperature and the average summer temperature for 2003 at Ammassalik was a record high since 1895. The years 2004 and 2005 were closer to normal being well below temperatures reached in 1930s and 1940s (Fig. 2) [not included]. Although the annual average temperatures and the average summer temperatures at Godthab Nuuk, representing the southwestern coast, were also increasing during the 1995–2005 period, they generally stayed below val-

Figure 6
Composite Greenland Temperatures



Five-year running average of composite Greenland air temperatures from coastal regions (squares, "C Grnld T") and two different sources of sea-surface temperatures (circles and diamonds, "HadSST1" and "NCEP SST"). All three records exhibit significant temperature declines. From Hanna and Cappelen, p. 32.

ues typical for the 1920–1940 period.

ii) The 1955 to 2005 averages of the summer temperatures and the temperatures of the warmest month at both Godthaab Nuuk and Ammassalik are significantly lower than the corresponding averages for the previous 50 years (1905–1955). The summers at both the southwestern and southeastern coast of Greenland were significantly colder within the 1955–2005 period compared to the 1905–1955 years.

iii) Although the last decade of 1995–2005 was relatively warm, almost all decades within 1915 to 1965 were even warmer at both the southwestern (Godthab Nuuk) and southeastern (Ammassalik) coasts of Greenland.

iv) The Greenland warming of the 1995–2005 period is similar to the warming of 1920–1930 although the rate of temperature increase was by about 50% higher during the 1920–1930 warming period.

The Arctic

A September 2005 press release from NASA generated voluminous news coverage with false-color satellite images comparing Arctic sea ice in 1979 and 2005 (Figure 7). The first complete year of satellite coverage was 1979. NASA scientist Joey Comiso was quoted: "Since 1979, by using passive microwave data, we've seen that Arctic perennial sea ice cover has been declining at 9.6 percent per decade."[26]

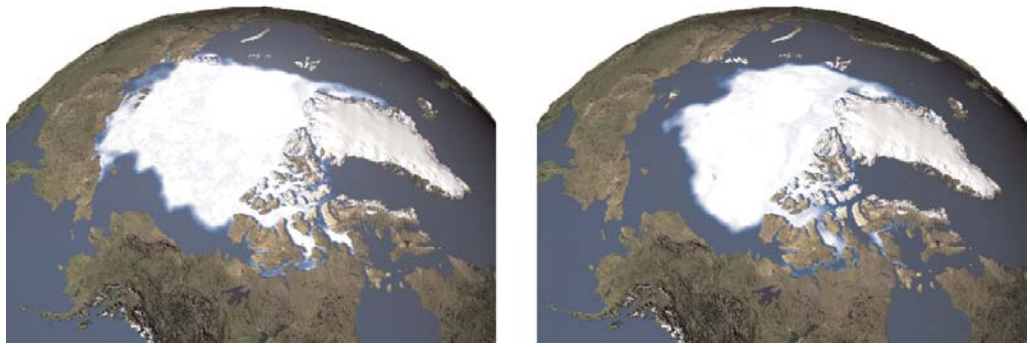
The press release contained a dramatic comparison between 1979, the first year of satellite coverage, and 2005 (Figure 7).

Nowhere does the press release mention that 1979 is right at the end of the second-coldest period in the Arctic in the 20th century. Figures 8a and 8b show two records.

Because temperatures in 1979 had just recovered from their lowest values since before 1920, Arctic ice was at or near its max-

According to Chylek et al., "The rate of temperature increase was by about 50% higher during the 1920–1930 warming period."

Figure 7
Extent of Arctic Sea Ice, 1979 and 2005



From NASA press release of September 28, 2005.

Overland and Wood wrote, "Over-winter locations of Arctic discovery expeditions from 1818 to 1859 are surprisingly consistent with present sea ice climatology."

imum extent since 1930 when the satellite became operational. (It is noteworthy that the climate story of the time was the possibility of an imminent ice age.)

The two temperature records shown are obviously quite different, with the record from the recent Arctic Climate Impact Assessment (ACIA) executive summary[27] showing recent years to be more anomalous than those in the Polyakov et al. history. In part, this depends on what "arctic" means. ACIA used land-only stations north of latitude 60°N. Polyakov et al. used land and a small amount of ocean data poleward from latitude 62.5°N. (Note that the Arctic Circle, the latitude at which 24-hour day or night begins, is at 66.5°N.) The main reason that the ACIA record shows so much more warming than Polyakov et al. is because the narrow band from 60.0°N to 62.5°N encompasses north-central Siberia, which has some of the highest rates of warming on the planet. From the 2003 paper by Polyakov et al.:

> Arctic atmospheric variability during the industrial era (1875–2000) is assessed using spatially averaged surface air temperature (SAT) and sea-level pressure (SLP) records. Air temperature and pressure display strong multidecadal variability on timescales of 50–80 yr. Associated with this variability, the Arctic SAT record shows two maxima: in the 1930s–40s and in recent decades, with two colder periods in between. In contrast to the global and hemispheric temperature, the maritime Arctic temperature was higher in the late 1930s through the early 1940s than in the 1990s.[28]

A very interesting study by Overland and Wood[29] examined the logs of 44 Arctic exploration vessels from 1818 to 1910 and found that "climate indicators such as navigability, the distribution and thickness of annual sea ice, monthly surface air temperatures, and the onset of melt and freeze were within the present range of variability." Commenting on the early exploration logs, they noted that "over-winter locations of Arctic discovery expeditions from 1818 to 1859 are surprisingly consistent with present sea ice climatology."

The thinning of ice from 25 to 43 percent, reported in Rothrock's widely cited study,[30] was shown to be an artifact of the sampling of submarine tracks by Holloway and Sou,[31] who "showed thinning by lesser amounts ranging from 12 percent to 15 percent." In addition to the sampling bias, Holloway and Sou also noted that prevailing winds in the 1950s through the 1970s differed from those in the 1990s, and that recent winds have moved ice out of the central Arctic. They stat-

Figure 8a
Observed Arctic Temperature, 1900 to Present (°C)

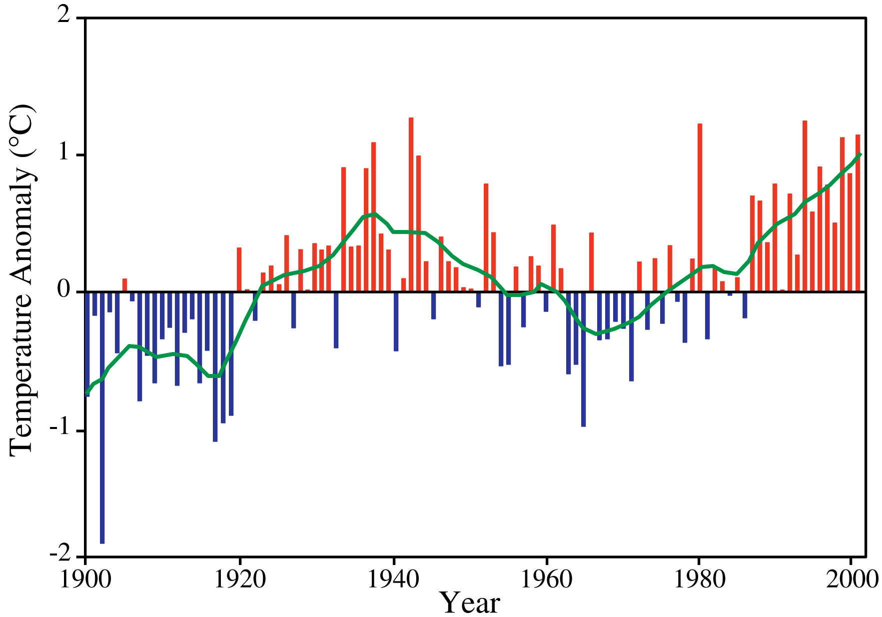
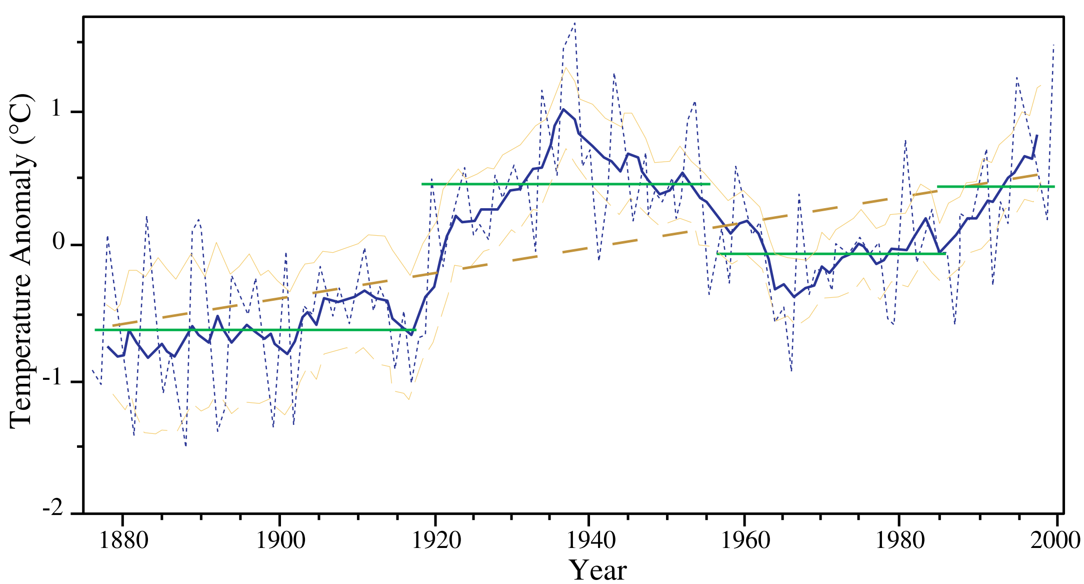


Figure 8b
Surface Air Temperature Anomalies



Top (8a): Arctic temperatures from the Arctic Climate Impact Assessment (ACIA) study, 2004; bottom (8b): Arctic temperatures from Polyakov et al., 2002. See text for explanation of differences.

Siberia and East Russia were more than 4°F warmer than the 19th-century baseline for 7,000 years—from 3,000 to 10,000 years ago.

ed that the rapid ice loss figures cited by the U.N.'s Intergovernmental Panel on Climate Change,[32] a primary source for ACIA, "was mistaken due to undersampling, an unlucky combination of ever-varying winds and readily shifting ice."

It is fair to say that the two polar images in Figure 7 are probably among the most-viewed satellite imagery of 2005 and 2006. But contained in them is a very troubling—and perhaps inadvertent—doctoring of the image.

The September 28 press release can be viewed at http://www.nasa.gov/centers/goddard/news/topstory/2005/article. At that site, the images can be enlarged and viewed in detail. Such enlargement reveals that a substantial, pure white disc has been placed in the data field centered at the North Pole.

It is obvious from the images that the ice fields are more discontinuous in some places than in others, and the image of pure white connotes thick, uninterrupted ice cover. But the white disc is clear on enhancement and indeed covers some obviously discontinuous ice, or maybe even the ice edge, in the area between Greenland and northern Asia.

The National Snow and Ice Data Center, which is not a part of NASA, makes mention of the fact that the Arctic ice images are generated by two instruments that in fact have a large data shadow around the north pole.[33] Most scientists, when presenting maps on which there are missing data, cross-hatch or color the area differently and often write in "no data." NASA, instead, put a solid white mask on the maps, giving the impression of heavy, continuous ice cover.

The size of the "mask" becomes smaller in 1985. Given that the mask clearly went up to the ice boundary in 1979, at the beginning of the record, it is certainly possible that including its entire area as continuous ice may have induced a high bias in ice extent in the early (1979–84) years.

In addition to Greenland, there have been a voluminous number of reports on warming-related changes in the Arctic. Many are based on the 2004 release of the executive summary of the ACIA report.[34]

The initial ACIA summary was hardly comprehensive. For example, it failed to mention the work of Semenov and Bengstsson, who found that the recent temperature rise is largely related to atmospheric circulation factors in the North Atlantic region, while the early 20th-century warming, of similar magnitude, was probably because of sea ice variations.[35] Obviously, this means that the 2005 minimum in the NASA press release may not even be the low point of the last 100 years.

Duplessy et al.[36] reported that Barents Sea temperatures were approximately 4°F warmer 7,000–8,000 years ago than they were at the beginning of the modern record in the 19th century. Johnsen et al.[37] found Greenland temperatures to be 1–4°F warmer than now in the same millennium. If current temperatures are causing an alarming rate of ice loss, then the loss from Greenland for 1,000 years at temperatures above today's would have been enough to deplete approximately half of the ice cover, but there is absolutely no evidence that this happened; such depletion would have been obvious in studies of prehistoric sea levels.

MacDonald et al.[38] found that Siberia and East Russia were more than 4°F warmer than the 19th-century baseline for 7,000 years—from 3,000 to 10,000 years ago. In a comprehensive review of climate since the end of the last ice age (which is nominally given as 11,800 years ago), Kaufman et al.[39] noted that for 2,000 years—from 9,000 to 11,000 years ago, Alaskan temperatures averaged 3°F warmer than now. He[40] found that there have been three similarly warm periods in Alaska: AD 0 to 300, 850–1200, and 1800 to the present. Webb et al.[41] found that northwestern and northeastern North America were more than 4°F warmer than the baseline from 7,000–9,000 and 3,000–5,000 years ago, respectively.

The Alaska Climate Research Center, at the University of Alaska–Fairbanks, maintains the statewide database along with analyses. According to the center's website (http://climate.gi.alaska.edu):

> The period 1949 to 1975 was substantially colder than the period from 1977

to 2003, however since 1977 *no additional warming has occurred in Alaska* [emphasis added] with the exception of Barrow and a few other locations. In 1976, a stepwise shift appears in the temperature data, which corresponds to a phase shift of the Pacific Decadal Oscillation.

Commenting on this shift, in 2005 Hartmann and Wendler wrote:

> The regime shift [was] also examined for its effect on long-term temperature trends throughout the state. The trends that have shown climatic warming are strongly biased by the sudden shift from the cooler regime to a warmer regime in 1976. When analyzing the total time period from 1951 to 2001, warming is observed, *however the 25-year period trend analyses before 1976 (1951–75) and thereafter (1977–2001) both display cooling* [emphasis added].[42]

In summary, a remarkable volume of scientific literature has been ignored in recent scare stories about Arctic ice and the melting of Greenland. An analysis of that literature leads to the clear conclusion that temperatures, and, therefore, ice conditions, of the present era have repeatedly occurred during human occupation of these lands, and that temperatures were clearly warmer in Greenland early in the 20th century. Further, they were also warmer for an entire millennium, and yet there is no evidence for any major rise in sea level.

Hurricanes

Since the 2004 hurricane season, when Florida was struck by four storms, there have been a tremendous number of stories associating an increase in the frequency of severe hurricanes with global warming. They are based largely on a handful of studies in the scientific literature.

There are some significant differences between what was contained in the news stories and what was in the papers themselves. The first of the new wave of hurricane papers was by Knutson and Tuleya.[43] *New York Times* science writer Andrew Revkin summarized it this way:

> Global warming is likely to produce a significant increase in the intensity and rainfall of hurricanes in coming decades, according to the most comprehensive computer analysis done so far.[44]

The authors' own words in the *Journal of Climate* paper were: "CO2-induced tropical cyclone intensity changes are unlikely to be detectable in historical observations and will probably not be detectable for decades to come."[45]

Knutson and Tuleya began with model projections of future sea-surface temperatures, vertical temperature profiles, and vertical moisture profiles over regions where tropical cyclones form, using them to define a climate in which they used a finer-resolution hurricane model to spin up tropical cyclones. They then compared the characteristics of the model-derived storms in the model-derived future climate with the model-derived storms in the current observed climate. They found that in the virtual future climate, 80 years from now, hurricanes had a 14 percent increase in the central pressure fall, a 6 percent increase in the maximum surface wind, and an 18 percent increase in the average rate of precipitation within 60 miles of the storm center over the model-derived hurricanes in the current climate. All those changes were indications that the virtual hurricanes of the model-derived future would be more intense than the model-derived hurricanes of today.

Note that this study was completely confined to behavior within a computer model. Real-world comparisons yield a much different picture.

First, carbon dioxide levels in the modeled atmosphere were increased at a rate of 1 percent per year, which produces atmospheric

A remarkable volume of scientific literature has been ignored in recent scare stories about Arctic ice and the melting of Greenland.

Many authors have commented that the rate of carbon dioxide increase commonly applied to climate models is far too high.

carbon dioxide concentrations 80 years from now (the period Knutson and Tuleya chose to define the future climate conditions) that are more than double the levels of today.

In reality, carbon dioxide levels have grown much more slowly, and continue to do so. The average yearly increase in atmospheric concentration in the decade through 2004 was 0.49 percent, in the decade before that, 0.42 percent, and 0.43 percent three decades ago.[46] Despite three decades of predictions of a dramatic increase in the rate of increase, it simply has not occurred.

The lag time between carbon dioxide input and total realization of warming has been given as 60 years by Schlesinger,[47] but a new multimodel study gives around 35 years,[48] a number that was independently determined without a computer model by Michaels et al.[49] in 2001. Consequently, any changes in hurricanes modeled by Knutson and Tuleya have to be greatly exaggerated for several decades into the future.

Many authors have commented that the rate of carbon dioxide increase commonly applied to climate models is far too high. According to Covey et al.:

> The rate of radiative forcing increase implied by 1% per year increasing CO2 is nearly a factor of two greater than the actual anthropogenic forcing in recent decades, even if non-CO2 greenhouse gases are added in as part of an "equivalent CO2 forcing" and anthropogenic aerosols are ignored. Thus [the 1%/year] increase cannot be considered as realistic for purposes of comparing model-predicted and observed climate changes during the past century. It is also not a good estimate of future anthropogenic climate forcing, except perhaps as an extreme case in which the world accelerates its consumption of fossil fuels while reducing its production of anthropogenic aerosols.[50]

The modeled hurricanes grow in a climate that is ideal for growing storms—specifically, there is virtually no change in the vertical distribution of wind speed and direction, which is known as vertical wind shear. Vertical wind shear acts to interfere with the development of tropical systems by basically blowing away the tops of the storms and preventing them from becoming well organized. One phenomenon that is responsible for increasing the vertical wind shear in the tropical Atlantic is El Niño.

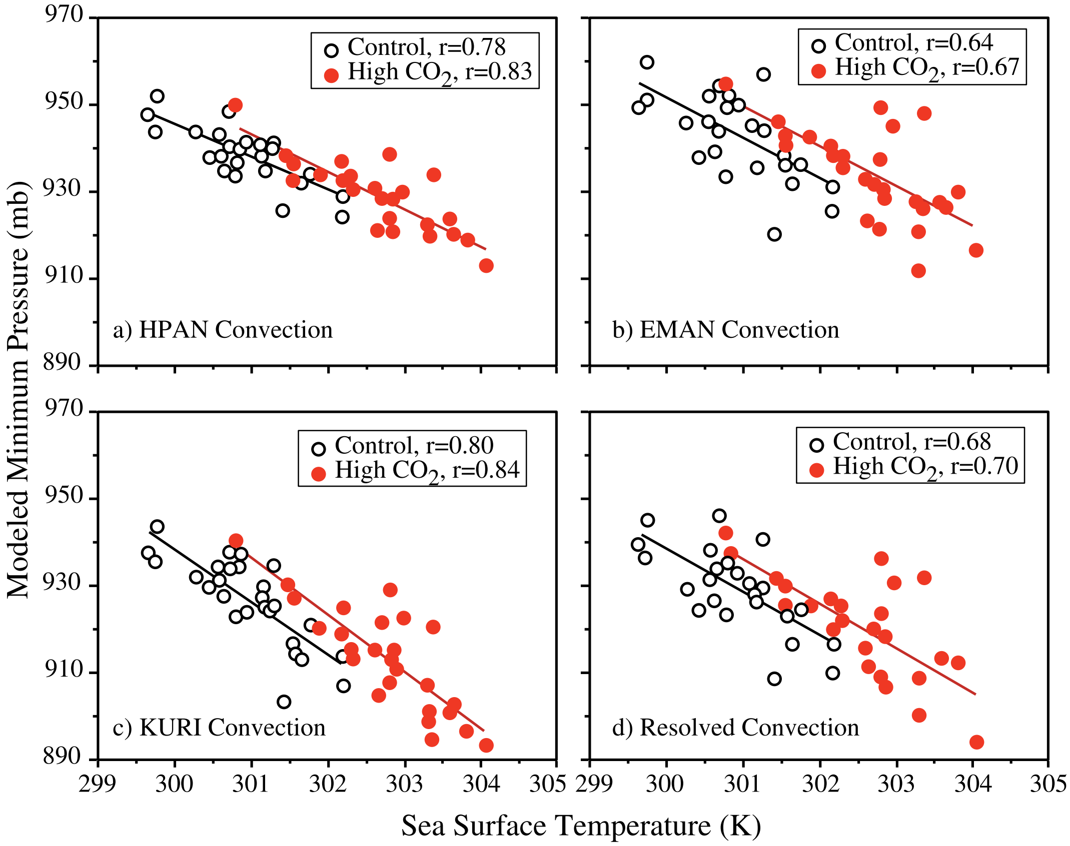
Pielke Jr. and Landsea demonstrated that the tropical cyclone activity in the Atlantic Ocean decreases in years with El Niños, as does the chance that the storms that do develop make landfall in the United States.[51] Some climate models suggest that increased El Niño-like conditions are possible in the future.[52] The assumption in Knutson and Tuleya that there would be no change in wind shear set up an idealized climate for developing strong hurricanes—with the strength of the storms largely governed by the temperature of the underlying ocean surface.

The authors note a strong correlation between sea-surface temperatures (SSTs) and hurricane intensity—the warmer the sea surface, the stronger the storm. Figure 9 shows the relationship between SSTs and hurricane intensity used by Knutson and Tuleya. In their model, sea-surface temperatures alone explain between 45 percent and 72 percent of the change in hurricane intensity. Since all the global climate models warm up the oceans when carbon dioxide levels are enhanced (even more so when they are unrealistically enhanced to levels that are more than double current levels in 80 years), higher CO2 leads to higher SSTs that lead to strong tropical cyclones.

Although the temperature of the underlying ocean surface is certainly a critical factor in tropical cyclone development (the SST must be at least 80°F for storms even to develop at all), other factors, such as wind shear, affect the developing storm.[53]

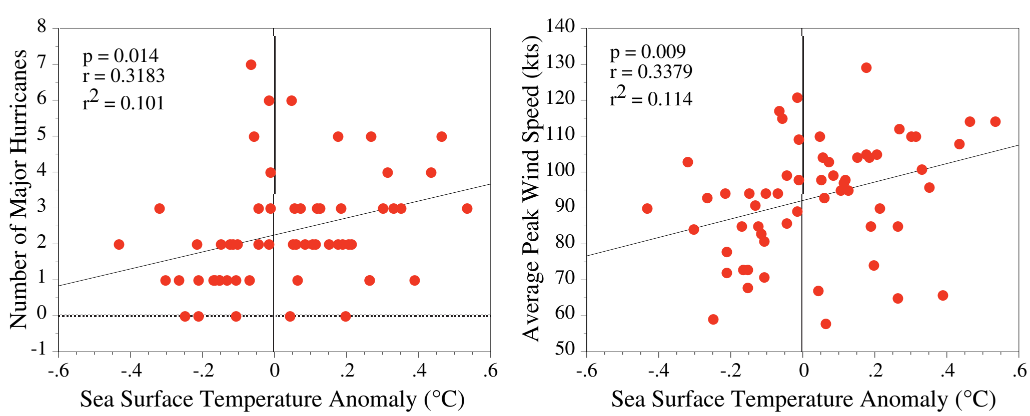
Figure 10, from Michaels et al.,[54] shows the real-world relationship between sea-surface temperatures in the region of the Atlantic used by Knutson and Tuleya and two measures of hurricane intensity—average peak

Figure 9
Hurricane Intensity vs. SST



Relationship between sea-surface temperatures and hurricane intensity as measured by minimum central pressure (the lower the pressure, the stronger the storm) in the models used by Knutson and Tuleya.

Figure 10
Sea-Surface Temperatures and Hurricane Intensity



Observed relationship between sea-surface temperatures and two measures of hurricane intensity—the number of major hurricanes (Category 3, 4, and 5) each year (left), and the average peak wind speed in the five strongest storms in each year (right). From Michaels, Knappenberger, and Landsea, p. 5181.

No connection has been established between greenhouse gas emissions and the observed behavior of hurricanes.

wind speed in the five strongest storms each year and the total annual number of severe hurricanes (Category 3, 4, or 5 storms).

Comparing Figures 9 and 10 shows that Figure 9 is a clear overstatement. The observations show that the relationship between hurricane intensity and SSTs is not nearly as well-defined as the models imply. In fact, in the real world, SSTs explain 11 percent of the annual variation in hurricane intensity (compared to an average of 55 percent in Knutson and Tuleya's computer models).

Pielke Jr. et al. have written extensively on the relationship between global warming and hurricanes. Writing in the *Bulletin of the American Meteorological Society*, they stated:

> To summarize, claims of linkages between global warming and hurricane impacts are premature for three reasons. First, no connection has been established between greenhouse gas emissions and the observed behavior of hurricanes. Emanuel is suggestive of such a connection, but is by no means definitive. In the future, such a connection may be established 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 exists that any future changes in hurricane intensities will likely be small in the context of observed variability, while the scientific problem of tropical cyclogenesis is so far from being solved that little can be said about possible changes in frequency. And third, under the assumptions of the IPCC, 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 while 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.
>
> Yet, claims of such connections persist, particularly in support of a political agenda focused on greenhouse gas emissions reduction. But a great irony here is that invoking the modulation of future hurricanes to justify energy policies to mitigate climate change may prove counterproductive. Not only does this provide a great opening for criticism of the underlying scientific reasoning, it leads to advocacy of policies that simply will not be effective with respect to addressing future hurricane impacts. There are much, much better ways to deal with the threat of hurricanes than with energy policies. There are also much, much better ways to justify climate mitigation policies than with hurricanes.[55]

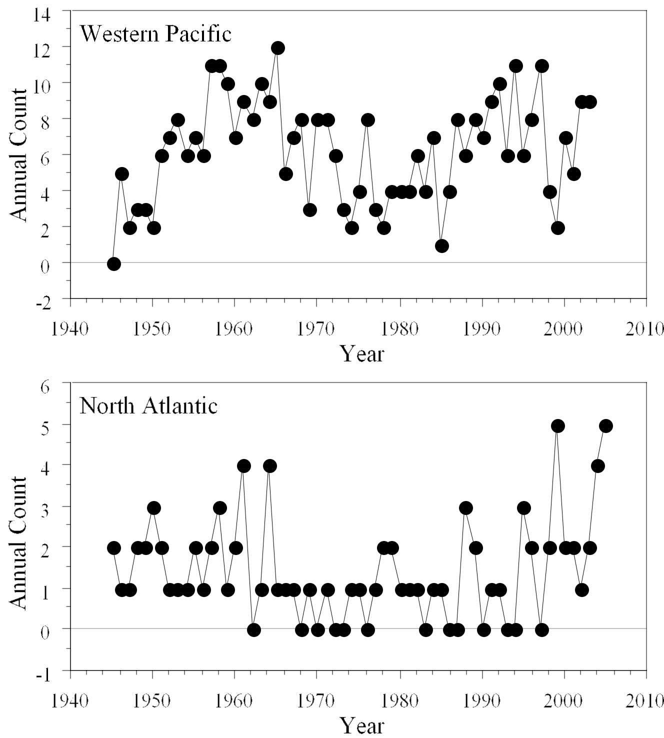
The debate and discussion in the scientific literature spawned by Knutson and Tuleya were soon followed by three highly cited papers, from Emanuel,[56] Webster et al.,[57] and Hoyos et al.[58]; the latter two citations are from the same research team at Georgia Institute of Technology.

Emanuel developed a "power dissipation index," which is essentially the annual sum of the cube of the maximum wind speed in observed hurricanes since 1950, which led him to conclude that "current levels of tropical storminess are unprecedented in the historical record."[59]

The North Atlantic and Western Pacific are the world's two most active tropical cyclone regions. Although global coverage of all of the world's hurricane basins began in 1970 with the advent of satellites, these two basins have been intensely monitored with aircraft since 1945 because of their military significance and the vulnerability of the highly populated U.S. and Asian coasts and Japan.

Because Emanuel calculates the cube (third power) of maximum hurricane wind speed, the more destructive storms, in the

Figure 11
Category 4 and 5 Hurricanes



Counts of the number of Category 4 and 5 (intense and extreme) hurricanes in the Atlantic and Western Pacific basins in the mid-20th century were similar to what is being observed today. Data from National Hurricane Center and Joint Typhoon Warning Center.

Saffir-Simpson Category 4 and 5 classifications, contribute inordinately to his index. A plot of frequency of these storms back to 1945 in fact reveals that in both the Atlantic and the Western Pacific the frequency of these storms around the mid-20th century (Figure 11) was not significantly different than it is in the current era.[60]

Emanuel claims “unprecedented” recent activity because he *reduced* observed hurricane winds in the first two decades of his study. He did so because the relationship between the lowest pressure measured in hurricanes in the 1950s and 1960s would indicate that winds may have been overestimated, as originally noted by Landsea.[61] However, Emanuel decreased the winds much more than Landsea warranted, as much as 25 mph in the strongest hurricane prior to 1970.

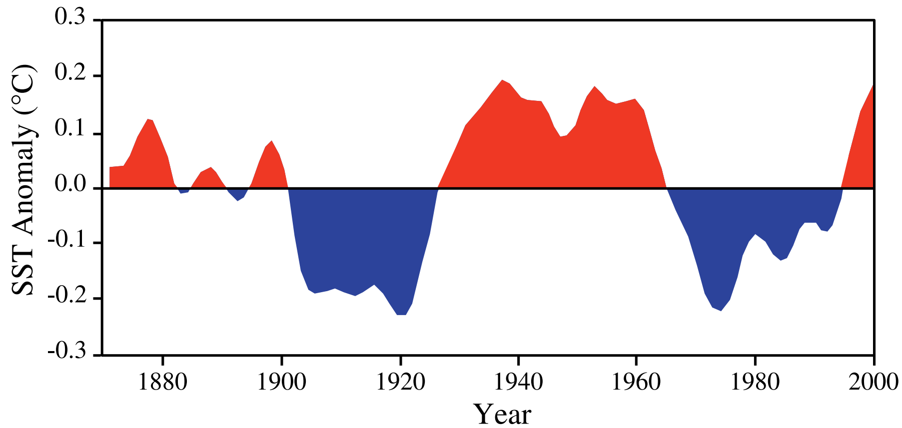
In response, Landsea wrote that this adjustment is no longer justified:

> In major hurricanes, winds are substantially stronger at the ocean’s surface than previously realized, so it is no longer clear that Atlantic tropical cyclones of the 1940s–60s call for a sizeable systematic reduction in their wind speeds. It is now understood to be physically reasonable that the intensity of hurricanes in the 1970s through the early 1990s was *underestimated*, rather than the 1940s and 1960s being overestimated [emphasis added].[62]

Emanuel’s calculations indicate that hurricanes have more than doubled in power since the early 1970s. Pielke Jr. wrote, “If hurricanes indeed are becoming more destructive over

Landsea wrote: “It is now understood to be physically reasonable that the intensity of hurricanes in the 1970s through the early 1990s was underestimated, rather than the 1940s and 1960s being overestimated.”

Figure 12
Time-History of AMO



Time-history of the Atlantic Multidecadal Oscillation from Knight et al. Hurricanes are favored by high values and suppressed by low ones.

All studies of hurricane activity that claim a link between human causation and the currently severe hurricane regime must somehow account for the equally active period around the mid-20th century.

time, then this trend should manifest itself in more destruction,"[63] but that, in reality, there is no significant difference whatsoever in U.S. damages between the first (cooler) and second (warmer) halves of the 20th century, after adjusting for population and property values. This result holds even when one includes the very destructive 2005 Hurricane Katrina.

Note that Webster et al.'s 2005 study begins in 1970, which, as shown in Figure 10, is at or near the low point of severe hurricane activity for the last 60 years. The follow-on paper by Hoyos et al. demonstrated a statistically significant relationship between warming ocean temperatures and strong hurricane frequency; the mid-1970s marked the end of a 30-year cooling period. Since then, temperatures have warmed and severe hurricanes have become more common.

The Hoyos et al. study started in 1970 because it used satellite data. Although this allowed for global coverage, it neglected the earlier behavior of the Atlantic and Western Pacific, as noted above.

Hoyos et al. also found that, in general, tropical atmospheres are becoming more unstable; that is to say, conditions are more favorable for general upward motion, which is also favorable for hurricane development and intensification. It is a universal characteristic of climate models run with increasing amounts of carbon dioxide that the *opposite* occurs, most recently documented in the 2004 Knutson and Tuleya study.

Another important factor for Atlantic hurricane development is an index called the Atlantic Multidecadal Oscillation (AMO), which is a mathematically derived measure of the sea-surface temperature pattern displayed in the tropical and northern Atlantic Ocean. When it is high (see Figure 12[64]), as it was in the mid-20th century and in the last decade, hurricanes are frequent and strong. When it is low, as it was around 1970 and in the early 20th century, activity is less.

In general, a world warmed by greenhouse gases will have high AMO values. However, it is clear from Figure 12 that we have not yet exceeded AMO values that have been common in the last 100 years, so the current high values cannot explicitly be associated with human influence on climate. That does not preclude such an influence on hurricanes in the future, but it has to be balanced against the other positive and negative factors that will be induced by anthropogenerated climate change.

In summary, all studies of hurricane activity that claim a link between human causation and the currently severe hurricane regime must somehow account for the equally active period around the mid-20th century. But global studies that begin in 1970 do not contain those data, and they begin at a cool point in the hemispheric temperature history.

Further, the linkages between a warming world and hurricane activity are often quite weak and conflicting. Knutson and Tuleya found that approximately 55 percent of the variation in hurricane strength was related to sea-surface temperature that was in a computer simulation that lacked many real-world constraints on hurricane activity. When Michaels et al. examined the observed history in the last quarter century, only 11 percent of the variation in strength was statistically related to sea-surface temperatures. El Niño, which disrupts Atlantic hurricanes, may become stronger or more frequent, or both, in a warmer world. And perplexing indeed is the fact that the stability of the tropical atmosphere is decreasing, which is conducive to stronger storms, while all models of anthropogenerated warming show that stability increases.

Extinctions

Parmesan[65] published the first widely quoted paper linking global warming and species extinction. She examined areas in the western United States where Edith's Checkerspot butterfly had been reported in previous years and found that populations were disappearing in the southern end of the range (southern California and northern Mexico) and expanding in the northern end (southern British Columbia). She hypothesized that this was consistent with global warming.

Edith's Checkerspot is not a migratory butterfly. So when it is not reported, the local population may have gone extinct. Parmesan found the greatest extinctions in northern Mexico. Figure 13, data published by P. D. Jones,[66] shows the temperature history of that region, from the Climate Research Unit at the University of East Anglia (the standard reference that is also used by the UN Intergovernmental Panel on Climate Change), at the time Parmesan's paper appeared.

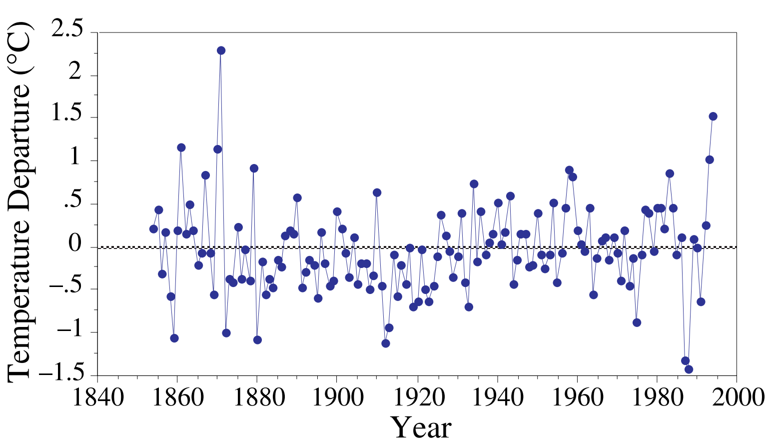
There is no warming in the region where the most "extinctions" occurred. In addition, where the species expansion was taking place, in southern British Columbia, there was also no warming trend for the previous 65 years.

There are also substantial extinctions in the latitude/longitude cell immediately to the west, which is astride the Santa Barbara–Tijuana urban corridor. And there is warming. But is it global, or local?

This can be determined by subtracting the readings in the eastern (rural) cell from those in the western (urbanized) one. If there indeed is a general warming, there will be no trend in this figure as time goes on. Instead, there is an obvi-

Perplexing indeed is the fact that the stability of the tropical atmosphere is decreasing, which is conducive to stronger storms, while all models of anthropogenerated warming show that stability increases.

Figure 13
Temperature History of Northern Mexico



Temperature history from northern Mexico, the region with the most butterfly extinctions. This record is the available data at the time Parmesan's 1996 paper appeared. From Jones.

The geographic diversity of butterflies *expanded* because of global warming. What's so bad about that?

ous and sharp increase in the difference between the two cells that begins around 1975, a sure sign that the warming in the western cell is due to urbanization, not carbon dioxide. In other words, a substantial number of the increasing extinctions at the southern end of the range were the result of citification of the Pacific Coast.

In 1999 Parmesan, along with several new coauthors,[67] expanded her work to Europe, using survey data from butterfly enthusiasts. Some of the records began in 1910, others only in the 1960s. The records were rarely continuous.

The input data were highly anecdotal. For example, if someone today reported a certain species of butterfly in central England, but if it had been reported around London in, say, 1920, then this would be called a northward (warming-related) expansion.

Parmesan et al. examined 52 species of nonmigratory butterflies. They found that at the northern edge of the range, 65 percent of the species extended their distribution northward, 34 percent did not change, and only 2 percent shifted southward (the total is 101 percent because of rounding). At the southern margin, 5 percent extended south, 22 percent moved north, and 72 percent remained stable.

Parmesan et al. wrote, "Here we provide the first large-scale evidence of poleward shifts in entire species' range."[68] That is true, but it failed to emphasize the larger reality: because there were extensive northward shifts at the northern margin, but relatively few at the southern edge, the geographic diversity of butterflies *expanded* because of global warming. What's so bad about that?

Months before Parmesan's second paper, Pounds et al.[69] also gained considerable attention with a paper claiming that the golden toad, a species so famous that it has its own laboratory (the Golden Toad Laboratory for Conservation), was threatened with extinction because of global warming.

Pounds et al. argued that the toad, which lives in the cloud forest, was threatened because the cloud base was rising (decreasing local cloudiness) because of global warming. This was predicted by a global-scale computer model with doubled atmospheric carbon dioxide concentration. In fact, these types of models *cannot* resolve at the level of the limited habitat of the golden toad.

Moreover, climate models all predict that moisture *increases* in the atmosphere. If daytime temperature does not change, this will lower the level at which moisture condenses, expanding the habitat for the toad. In fact, in a subsequent paper, Pounds et al.[70] documented a *decline* in daytime temperature of 0.6°C and an increase in depth of the moist zone in the cloud forest. During the night, temperatures rose 1°C, but the fact that nights are inherently cooler than days makes the daytime temperature the primary driver of changes in cloud base.

Pounds' 2006 *Nature* paper, titled "Widespread Amphibian Extinctions from Epidemic Disease Driven by Global Warming," commanded the front page of the *New York Times*, the *Washington Post*, and a host of other prominent media.

The paper described amphibian extinctions in Central America and northern South America that were caused by a class of fungi known as Chytrids and claimed that the range of the fungus expanded because of increased (!) cloud cover. Pounds et al. claimed that 69 percent of the amphibian species in the region had become extinct.

The amphibians' habitat ranges from sea level to 4,000 meters (13,100 feet). Pounds et al. did not explicitly calculate the changes in Chytrid range that would result from the observed decline in daytime temperature, but such a calculation is elementary meteorology. The expansion of the range is 250 meters, or about 6 percent of the 4,000-meter range of the amphibians. Taking into account the fact that there are about twice as many amphibian species living in the middle of that range as there are in at the low and high extremes (which can be seen in figure 4d in Pounds et al.), the most liberal estimate would be that twice as many amphibian species—12 percent—might be affected by changes in fungal distribution, but all of these are not likely to go extinct.

One could surely question how a paper with analysis so sloppy could have made it into *Nature*, but there were additional major problems.

The seminal paper noting the extinctions was published in 2005 in the journal *Biotropica*, in which La Marca et al.[71] documented that most of the amphibian extinctions took place between 1984 and 1996 in the region studied by Pounds et al. This was shortly after the first discovery of the Chytrid fungus in the region, first described by Lips et al. in the *Journal of Herpetology*.[72] The Chytrid fungus was introduced to the region by humans (Dasak et al.[73]), probably by ecotourists or field researchers, or both.

It is a central tenet of ecological theory, first described in Charles Elton's 1958 classic study, *The Ecology of Invasion by Animals and Plants*, that introduction of exotic species, such as the Chytrid invasion of Central and South America, produces genetic pandemics over broad climatic ranges.[74] This is what killed the amphibians, not the climate.

Perhaps the most frightening study relating extinction and climate change was published by Thomas et al. in 2004.[75] When interviewed by the *Washington Post*, Thomas said: "We're talking about 1.25 million species. It's a massive number."[76]

Thomas used a variety of scenarios for future climate change. The "low" scenario, with a global average warming of 0.8°C (1.4°F) resulted in an extinction of approximately 20 percent of the world's species.

Like many glib statements about global warming, this forms a testable hypothesis, which fails miserably. Surface temperature changed this amount in the 20th century, and there is simply no evidence for a massive climate-related extinction. What seems remarkable, though, is that the peer-reviewers at *Nature* did not pick this up.

In calculating extinctions, Thomas et al. simply noted the observed temperature envelope in which a species lives today, and if that environment no longer existed on the species' landmass because of global warming, it was assumed to be "extinct."

This neglects the fact that species often thrive beyond their gross climatic envelope. Almost all major tree species in North America have separate "disjunct" populations far away from their main climatic distribution. A fine example is the northern Christmas tree, *Abies balsamea*, whose main distribution is across Canada. But there is a tiny forest of the balsam fir naturally occurring in eastern Iowa, hundreds of miles south (and several degrees (F) warmer) than the climatic envelope that Thomas et al. would assume.[77]

Disjunct populations are the rule, not the exception, and are one reason why the most diverse ecosystem on earth—the tropical rainforest—managed to survive the ice age, by taking refuge in small disjuncts whose local climate was much different from the regional one. Variations in topography and landform create cul-de-sacs where species thrive far from their gross climate envelopes. It is logical to assume that a fractionating (changing) climate will produce more disjuncts, not fewer.

Discussion and Conclusion

It is apparent that many recent stories on melting of high-latitude ice, hurricanes, and extinctions are riddled with self-inconsistencies, are inconsistent with other findings, and are reported—as much by scientists themselves as by reporters—in extreme or misleading fashions that do not accurately portray the actual research.

This begs for an explanation. Perhaps it is simply the way science always has been, but that the dramatic policy implications of global warming compel some people (including this author) to examine the refereed literature with more scrutiny than would normally be applied. The alternative is that recently the peer review process has begun to allow the publication of papers that should have been dramatically modified before being accepted.

If the latter is true, then another explanation is required. One hypothesis would be that

Like many glib statements about global warming, this forms a testable hypothesis, which fails miserably.

The recent tidal wave of global warming papers on polar ice, hurricanes, and extinctions has included an incredible number of omissions and inconsistencies.

"public choice" dynamics is now entering into science. But this would seem to require unethical behavior on the part of a wide scientific community. Under this model, the review process becomes less stringent if a paper promotes the economic well-being of the reviewer, and more stringent if it does not.

"Well-being" here means professional advancement and reward. It is a fact that in the United States the taxpayer outlay for so-called global change science is now in excess of $4 billion annually. Universities reward their faculty on the amount and quality of research that they produce, which, in climate science, requires considerable taxpayer funding. If the funding stream is threatened by findings downplaying the significance of climate change, the public choice model would predict rather vociferous review. If it is enhanced, this model would predict a glowing, positive review.

Whether public choice dynamics is indeed responsible for the current rather sloppy state of global warming science is a testable hypothesis, but beyond the scope of this paper.

It can be tested by noting that adding new information to a forecast has an equal probability of changing the forecast in either a positive or a negative direction. It would be interesting to undertake a comprehensive analysis of the recent scientific literature on climate change to see whether results are significantly biasing our view of the future into one that is almost always "worse than we thought" and rarely "not as bad as we thought."

Whether or not this bias exists, the recent tidal wave of global warming papers on polar ice, hurricanes, and extinctions has included an incredible number of omissions and inconsistencies. It is to be hoped that this paper will help to set the record straight on these aspects of climate change.

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