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Hurricanes and Climate Change

by

William M. Gray

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Hurricanes and Climate Change:
Assessing the Linkages Following the 2006 Season

by

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Professor William M. Gray has worked in the observational and theoretical aspects of tropical meteorological research for more than 40 years, much of this effort going to investigations of meso-scale tropical weather phenomena. He has specialized in the global aspects of tropical cyclones for his entire professional career. He studied under Professor Herbert Riehl who arranged his early reconnaissance flights into hurricanes in 1958. He has been involved with studies of broad-scale cumulus interactions and has extensively studied the processes associated with tropical cyclone structure, development, and movement. Numerous satellite-based studies of tropical weather systems have also been accomplished. Current areas of research include: 1) tropical cyclone structure, movement and intensity change; 2) seasonal prediction; 3) meso-scale tropical weather systems, 4) diurnal variability of tropospheric vertical motions and 5) ENSO variability. Professor Gray has made Atlantic basin seasonal hurricane forecasts for the last 23 years. He was a pioneer in developing these types of forecasts.

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October 11, 2006

Let's be clear: the work of science has nothing whatever to do with consensus. Consensus is the business of politics. Science, on the contrary, requires only one investigator who happens to be right, which means that he or she has results that are verifiable by reference to the real world. In science consensus is irrelevant. What is relevant is reproducible results. The greatest scientists in history are great precisely because they broke with the consensus…"

--- *Michael Crichton (2003)*

1. ABSTRACT

This talk will briefly discuss the 2006 hurricane season that is climatologically (as of 11 October) about 90 percent complete. Our 3 October updated forecast sees little activity for the rest of the year. I will also show data to indicate that Atlantic and global tropical cyclone activity over the last century and particularly over the last 30 years has not increased despite the global warming that has occurred over the last century and the last three decades.

The second part of this talk will discuss global mean surface temperature change of the last century and the grossly exaggerated role which has been attributed to human-induced greenhouse gas emissions. I have been dismayed over the bogus science and media hype associated with the human-induced global warming hypotheses. My innate sense of how the atmosphere-ocean functions does not allow me to accept these scenarios. Observations and theory do not support these ideas. I anticipate that the trend of global warming over the last few decades will come to an end in a few years and that we will start to see a weak cooling trend similar to that which occurred from the mid-1940s to the mid-1970s.

2. WHO AM I TO COMMENT?

I am a Professor Emeritus of Atmospheric Science at Colorado State University where I have been employed since 1961. I have been performing meteorological re-

[*] The views expressed by the author are solely those of the author and may not represent those of any institution with which he is affiliated.

search, teaching, and forecasting for the last 53 years. I have participated in many tropical field experiments over the last 50 years. These experiments were directed to the study of cumulus convection, condensation heating, evaporation cooling, sea-air energy-moisture exchange, hurricane formation, etc. These are topics of crucial importance to the physics of global temperature change. But they are not well understood by the human-induced global warming proponents. The incorrect handling of these moist processes is responsible for the major flaws in the human-induced global warming scenarios.

I hold MS and PhD degrees in meteorology and geophysical sciences from the University of Chicago. Few professors of atmospheric science have had a finer group of graduate students than I have over the last 40 years (50 MS graduates and 20 PhD graduates).

I am well known for my Atlantic basin seasonal hurricane forecasts of the last 23 years. Making public verified seasonal hurricane climate forecasts (2 to 6 times per year) for 23 years demonstrates, I believe, an in-depth knowledge of the atmosphere. My overall 53 years of experience in weather forecasting, atmospheric research, and teaching is, I believe, more than sufficient to justify the credibility of my comments on hurricanes and global warming. I am more than willing to discuss or debate with any of my critics provided there is an impartial moderator.

I have never had a grant from the fossil-fuel industry. I presently do not draw a salary. I live off of my retirement income. To support my small Colorado State University research project I presently have two quite modest research grants, one from the National Science Foundation (NSF) for hurricane research and the other from Lexington Insurance Company (Boston) for US hurricane landfall probability prediction.

My main motivation to continue my research is to help maintain the integrity of American science which, in my view, has been badly compromised by the global warming issue and now recently by the issue of global warming causing more frequent and more intense hurricanes. Having received federal support for my meteorological endeavors for over 50 years and having devoted my entire career to atmospheric science, I also feel I have an obligation to speak out on issues involving my expertise. I would feel guilty if I did not do so.

3. THE 2006 ATLANTIC BASIN HURRICANE SEASON

Observations through early October 2006 show that we have so far experienced an average Atlantic basin hurricane season (Figure 1, Table 1). August had substantially below-average activity (only 45% of average) while September had above-average activity (about 140% of average). US landfall has been well below average. No hurricanes have made landfall along the US coastline this year. This has occurred in only

18 percent of the hurricane seasons since 1945. In an average year about 90 percent of the seasonal average NTC of 100 occurs by 11 October. Note that most of the 2006 tropical cyclones formed and recurved in the central Atlantic. Total Atlantic basin tropical cyclone activity through early October has been 9 named storms, 5 hurricanes, and 2 major hurricanes.

Our October-only forecast calls for 2 named storms, 1 hurricane and no major hurricanes and NTC activity of 12, which is below the October-only average value of 18. We forecast no tropical cyclone activity in November. Our below-average prediction for October-November activity is largely due to the rapid emergence of an El Niño event during the latter part of this summer.

Atlantic basin tropical cyclone (TC) activity for the 2006 season will be considerable less than the seasonal activity we anticipated in our previous forecasts issued in early December '05, early April, late May, and early August of this year. We judge this reduced seasonal activity to be largely due to unanticipated mid-level dryness in the tropical Atlantic (with large amounts of African dust) which greatly reduced August activity and to the rapid late summer development of an El Niño event which we and nearly all ENSO forecasters did not foresee.

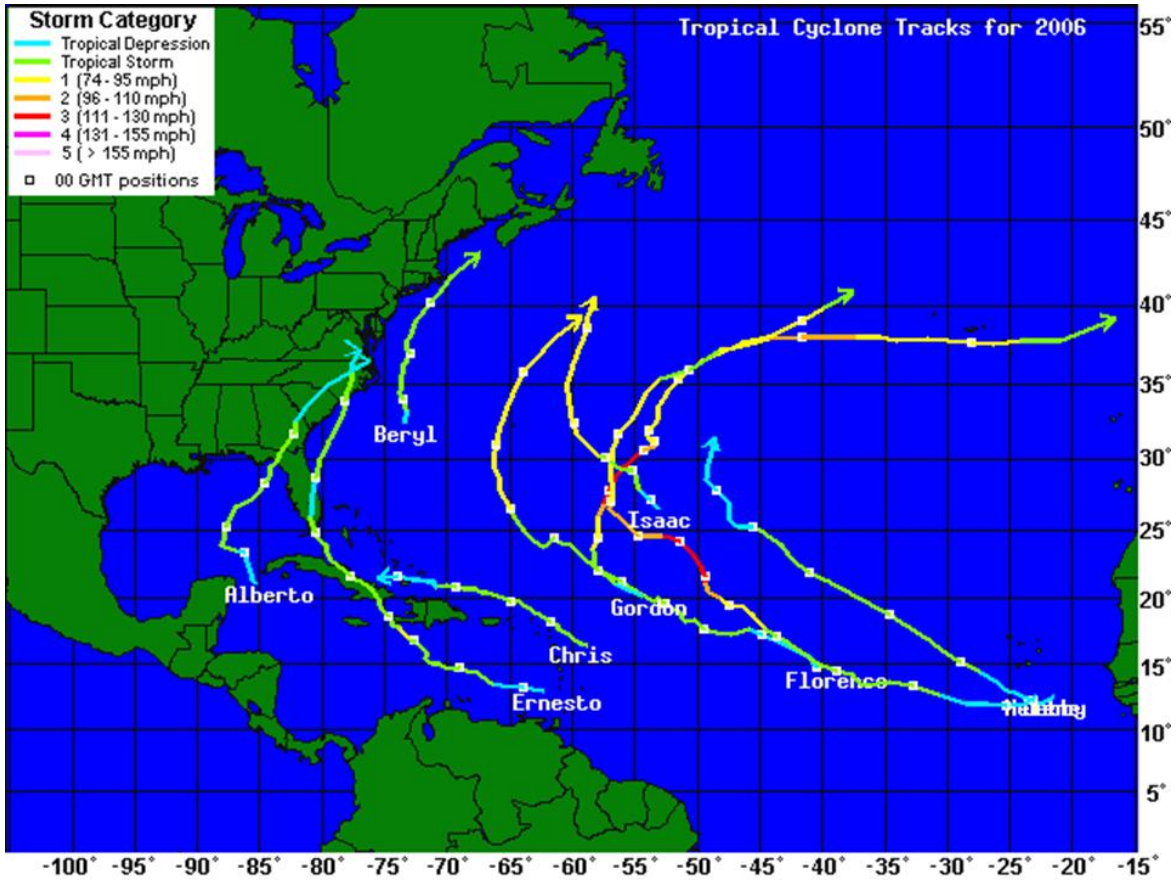


Figure 1. 2006 Atlantic basin hurricane tracks through September 2006.

Table 1. Observed 2006 Atlantic basin tropical cyclone activity to 1 October.

Highest Category	***Name***	***Dates***	***Peak Sustained Winds (kts)/lowest SLP (mb)***	***NSD***	***HD***	***IHD***	***NTC***
TS	Alberto	June 11-14	60 kt / 995 mb	2.75			2.7
TS	Beryl	July 19-21	50 kt / 1001 mb	2.75			2.7
TS	Chris	August 1-4	55 kt / 1001 mb	3.25			2.8
TS	Debby	August 23-26	45 kt / 1000 mb	3.25			2.8
H-1	Ernesto	Aug 25 – Sept 1	65 kt / 988 mb	6.00	0.25		6.8
H-1	Florence	September 5-12	80 kt / 972 mb	7.50	2.75		9.0
IH-3	Gordon	September 8-20	105 kt / 955 mb	9.25	7.50	1.25	24.2
IH-3	Helene	Sept 14-24	110 kt / 954 mb	10.75	7.50	1.75	26.4
H-1	Isaac	Sept 28 – Oct 2	75 kt / 985 mb	4.50	2.00		7.4
Totals	***9***			***50.00***	***20.00***	***3.00***	***84.8***

Late Forming 2006 El Niño. One of the extraordinary features of the 2006 Atlantic basin hurricane season has been the rapid onset of El Niño conditions in the tropical eastern Pacific. The warming of the eastern and central Pacific during the summer of 2006 has been truly remarkable. Only 1997 witnessed a larger increase in Nino 3 anomalies from June-July to August-September than has the 2006 season. But 1997 June-July Nino 3 anomalies were already well above average while 2006 June-July anomalies were not. This is by far the largest warming of SST anomalies in the tropical Pacific for a year that did not already have substantial warming by July. August-September 2006 sea surface temperatures in Nino 3 have warmed by approximately 0.6°C from their June-July values.

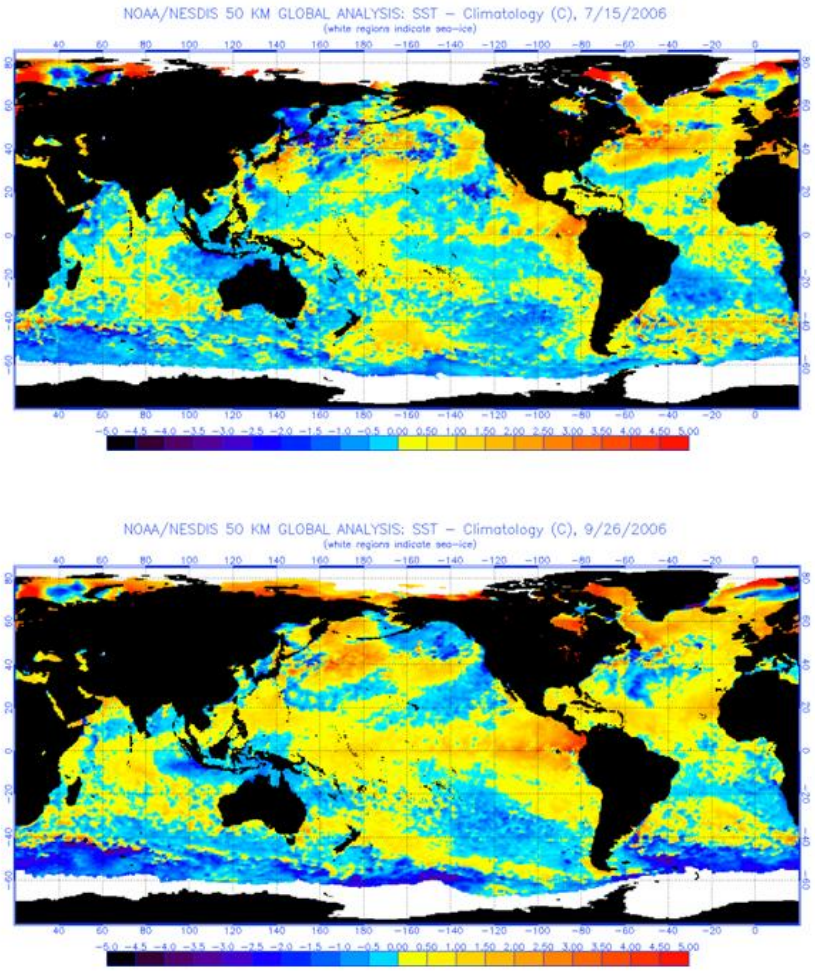
By 1 August, one can usually make a good extrapolated El Niño forecast for the August-October period. This was not the case this year. The typical onset of east Pacific warm SST anomalies associated with El Niño conditions occurs between spring and early summer. The usual El Niño can be detected by June-July. However, this year's July Nino 3 SST anomaly was only 0.22°C and showed little increase from May and June. Figure 2 shows the onset of this year's El Niño between mid-July and the end of September 2006. The rapid warming of SSTs in the eastern and central Pacific during August and September was not forecast by the statistical and dynamical ENSO models.

During the period of August-September 2006, the tropical Atlantic basin manifested several conditions typical of an El Niño year. El Niño years typically have the following tropical Atlantic conditions:

1. stronger than normal 200 mb (~12 km) zonal winds (positive U),

2. dryer middle tropospheric moisture conditions (negative q – specific humidity),
3. somewhat higher than average sea level pressure anomalies (positive SLPA),
4. somewhat higher than average sea surface temperature anomalies (positive SSTA).

Table 2 gives our updated seasonal forecasts from 3 August onward. Information on all of our hurricane forecasts for this year and previous years can be found on our website at: http://hurricane.atmos.colostate.edu/Forecasts. One can also visit our website at http://www.e-transit.org/hurricane for landfall probabilities for 11 US coastal regions, 55 sub-regions and 205 coastal and near-coastal counties from Brownsville, Texas to Eastport, Maine.



Mid-July 2006

Late Sept 2006

Figure 2. Example of the emerging El Niño for 2006.

Table 2. Atlantic basin seasonal hurricane forecast for 2006 as of 3 October 2006.

Full Season Tropical Cyclone Parameters and their *1950-2000 Climatology (in parentheses)*	**Full Season Adjusted 3 August '06 Forecast**	**Full Season Adjusted 1 Sept '06 Forecast**	**Observed Activity Through September**	**Updated Oct-Nov Forecast**	***Full Season Adjusted 3 October '06 Forecast***
Named Storms (NS) *(9.6)*	15	13	9	2	*11*
Named Storm Days (NSD) *(49.1)*	75	50	48	10	*58*
Hurricanes (H) *(5.9)*	7	5	5	1	*6*
Hurricane Days (HD) *(24.5)*	35	13	19	4	*23*
Intense Hurricanes (IH) *(2.3)*	3	2	2	0	*2*
Intense Hurricane Days (IHD) *(5.0)*	8	4	3	0	*3*
Net Tropical Cyclone Activity (NTC) *(100%)*	140	90	83	12	*95*

4. GLOBAL WARMING AND HURRICANES

Although global surface temperatures have increased over the last century and over the last 30 years, there is no reliable data available to indicate increased hurricane frequency or intensity in any of the globe's seven tropical cyclone basins. Meteorologists who study tropical cyclones have no valid physical theory as to why hurricane frequency or intensity would necessarily be altered by small amounts (< ±1°C) of global mean temperature change.

In a global warming or global cooling world, the atmosphere's upper air temperatures will warm or cool in unison with the sea surface temperatures. Vertical lapse-rates will not be significantly altered. We have no plausible physical reasons for believing that Atlantic hurricane frequency or intensity will change significantly if global ocean temperatures continue to rise. For instance, in the quarter-century period from 1945-1969 when the globe was undergoing a weak cooling trend, the Atlantic basin experienced 80 major (Cat 3-4-5) hurricanes and 201 major hurricane days. By contrast, in a similar 25-year period of 1970-1994 when the globe was undergoing a general warming trend, there were only 38 major hurricanes (48% as many) and 63 major hurricane days (31% as many). Atlantic sea-surface temperatures and hurricane activity do not necessarily follow global mean temperature trends.

The most reliable long-period hurricane records we have are the measurements of US landfalling tropical cyclones since 1900 (Table 3). Although global mean ocean and Atlantic surface temperatures have increased by about 0.4°C between these two 50-year periods (1900-1949 compared with 1956-2005), the frequency of US landfall numbers actually shows a slight downward trend for the later period. If we chose to make a similar comparison between US landfalls from the earlier 30-year period of 1900-1929 when global mean surface temperatures were estimated to be about 0.5°C colder than they have been the last 30 years (1976-2005), we find exactly the same US hurricane landfall numbers (54 to 54) and major hurricane landfall numbers (21 to 21).

We should not read too much into the last two hurricane seasons of 2004-2005. The activity of these two years was unusual but well within natural bounds of hurricane variation. Between 1966 and 2003, US major hurricane landfall numbers were below the long-term average. Of the 79 major hurricanes which formed in the Atlantic basin from 1966-2003 only 19 (24 percent) of them made US landfall. During the two seasons of 2004-2005, seven of 13 (54 percent) came ashore. This is how nature sometimes works. What made the 2004-2005 seasons so unusually destructive was not the high frequency of major hurricanes but the high percentage of major hurricanes which were steered over the US coastline. The unanticipated breeching of the New Orleans levees likely doubled or tripled the damage caused by Katrina. The major US hurricane landfall events of 2004-2005 were primarily a result of the favorable, upper-air steering currents which were present during the past two hurricane seasons.

Table 3. U.S. Landfalling tropical cyclones by intensity during two 50-year periods.

YEARS	***Named Storms***	***Hurricanes***	***Intense Hurricanes (Cat 3-4-5)***	***Global Temperature Increase***
1900-1949 (50 years)	189	101	39	+0.4°C
1956-2005 (50 years)	165	83	34	

Although 2005 had a record number of tropical cyclones (27 named storms, 15 hurricanes and 7 major hurricanes), this should not be taken as an indication of something beyond natural processes. There have been several other years with comparable hurricane activity to 2005. For instance, 1933 had 21 named storms in a year where there was no satellite or aircraft data. Records of 1933 show all 21 named storm had tracks west of 60°W where surface observations were more plentiful. If we eliminate all the named storms of 2005 whose tracks were entirely east of 60°W and therefore may

have been missed given the technology available in 1933, we reduce the 2005 named storms by seven (to 20) – about the same number which occurred in 1933.

Utilizing the National Hurricanes Center's best track database of hurricane records back to 1875, six previous seasons had more hurricane days than the 2005 season. These years were 1878, 1893, 1926, 1933, 1950 and 1995. Also five prior seasons (1893, 1926, 1950, 1961 and 2004) had more major hurricane days. Finally, five previous seasons (1893, 1926, 1950, 1961 and 2004) had greater Hurricane Destruction Potential (HDP) values than 2005. HDP is the sum of the squares of all hurricane-force maximum winds and provides a cumulative measure of the net wind force generated by a season's hurricanes. Although the 2005 hurricane season was certainly one of the most active on record, it is not as much of an outlier as many have indicated.

Most of my tropical cyclone colleagues who have spent years forecasting and studying hurricanes do not subscribe to the alarmist views of those saying we should expect hurricanes to get worse due to human-induced global warming. We believe that the Atlantic basin is currently in an active hurricane cycle. This active cycle is expected to continue for another decade or two at which time we should enter a quieter Atlantic major hurricane period like we experienced during the quarter century periods of 1970-1994 and 1901-1925. Atlantic hurricanes go through multi-decadal cycles. These cycles have been observationally traced back to the mid-19th century and inferred from Greenland paleo ice-core temperature measurements that go back thousands of years.

5. PAST AND FUTURE GLOBAL TEMPERATURE CHANGES

We are seeing glaciers receding and Arctic ice melting because we have been in a general warming trend over the last century and particularly over the last 30 years. The global warming we have witnessed over the last 30 years would, of course, be expected to bring about some ice and glacier melting. The overall northern hemisphere middle-latitude winter wind patterns of the last 30 years have favored warming in Alaska and reduced snow in the European Alps. This is to be expected from such a warming period with the ensuing global circulation anomalies which have been present. But we should not automatically think that this warming trend will continue or that it is caused by humans. Similar warming conditions occurred during the late 1920s to the early 1940s (Figure 3). Warm periods similar to today's climate have also characterized discrete periods of the Holocene Interglacial, especially the Medieval Warm Period and the Holocene climate optimum. Historically, warming or cooling trends such as we have seen over the last 30 years typically do not maintain themselves for much more than 30 years (Figure 4). I predict we are about to enter a weak global cooling period similar to what we experienced from the early 1940s to the early 1970s.

I judge our present global ocean circulation conditions to be similar to that of the period of the early 1940s when the globe had shown great warming since 1910, and there was concern as to whether this 1910-1940 global warming would continue. It did not. A weak global cooling began from the mid-1940s and lasted until the mid-1970s. I predict this is what we will see in the next few decades.

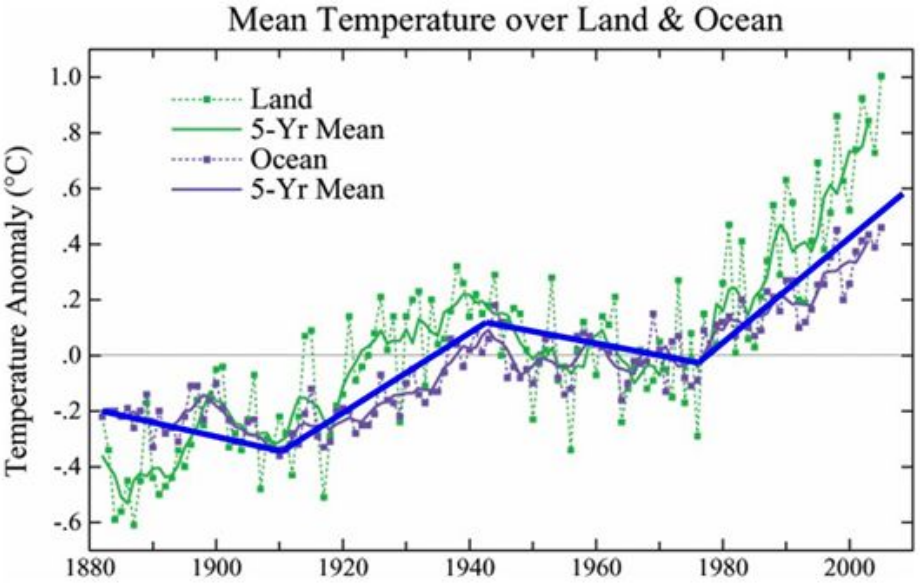


Figure 3. Land (green) and ocean (blue) global mean temperature during the last 125 years. Note the two distinctive multi-decadal periods of cooling (1880-1910 and 1945-1975) and two distinctive periods of warming (1910-1940 and 1975-2005). Most warming and cooling periods do not last more than 30-35 years.

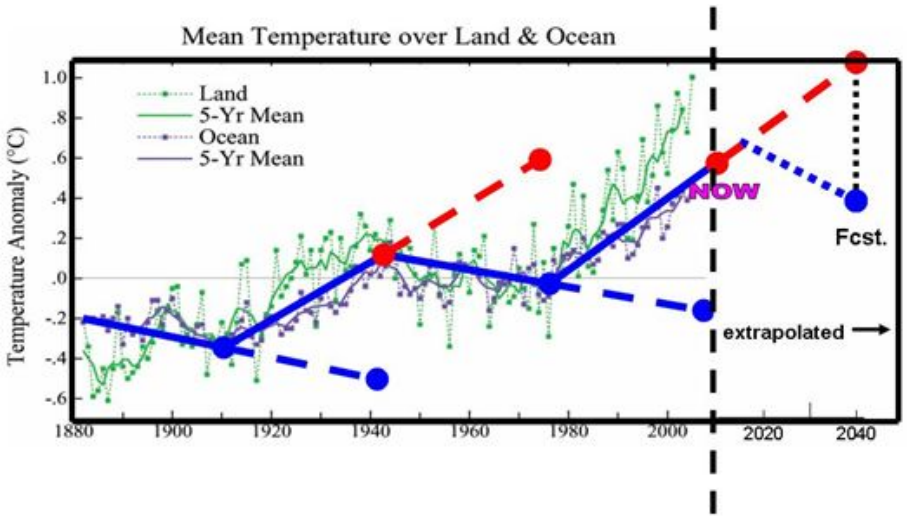


Figure 4. Same as Figure 3, but showing how much error one would have by extrapolating a cooling or warming curve beyond 30-35 years. The current 1975-2005 warming curve should not be expected to continue. It is likely that a global cooling trend will set in within the next few years. My forecast global temperature for 2040 is below the value of today's global temperature.

Various global signals are starting to manifest themselves to indicate the start of a modest global cooling period in the coming years. These include:

a. An initial weakening of the Southern Hemisphere middle-latitude zonal winds and significant amounts of upper-ocean global cooling between 2003 and 2005 (Lyman et al. 2006).

b. The commencement of more North Atlantic and Aleutian region blocking patterns. These are indicative of strong Atlantic Ocean thermohaline circulation (THC) conditions which, with a lag of 10-15 years, are typically associated with a modest global cooling. Such strong THC conditions and global cooling is associated with increased cold water upwelling in the middle latitudes of the Southern Hemisphere (Figure 5).

c. The last 9-year decrease in El Niño activity. Global cooling is typically associated with a significant reduction in El Niño frequency.

d. A recent increase in the rate of global rainfall and global surface evaporation cooling.

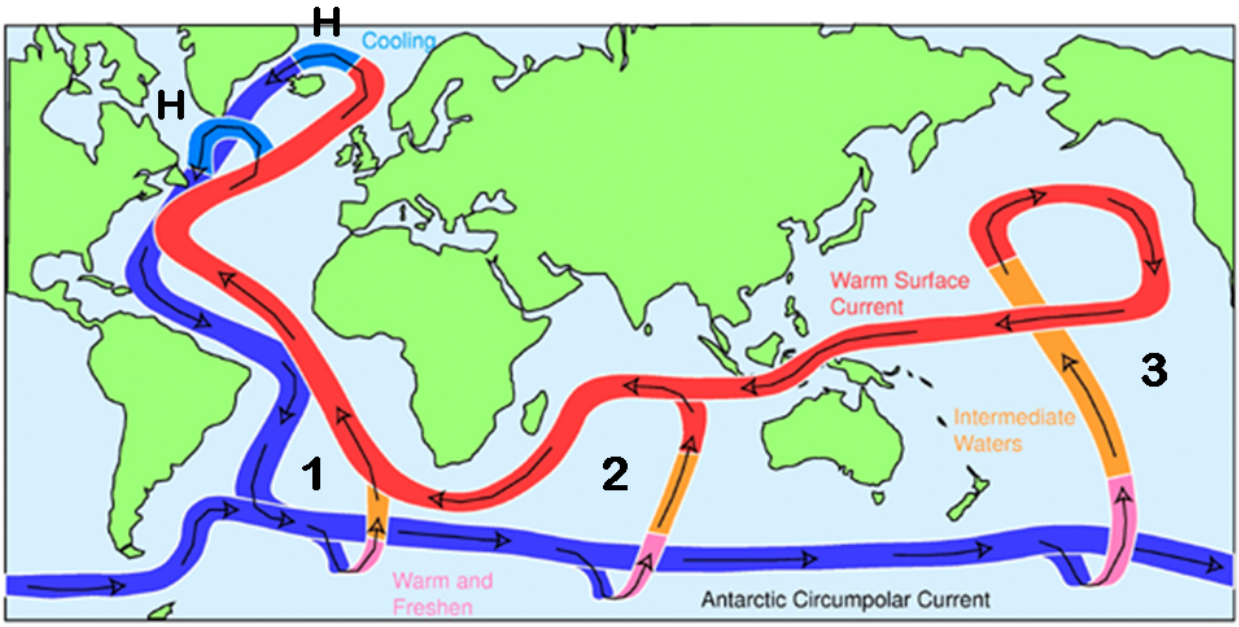


Figure 5. Idealized new estimate of the deep water Global Ocean Conveyor Belt showing the typical locations in the Southern Hemisphere of the required return cold upwelling circulation (areas 1, 2, 3) to balance the North Atlantic thermohaline ocean subsidence (H areas). Figure courtesy of John Marshall, of MIT.

6. GLOBAL WARMING DUE TO NATURAL PROCESSES

The global warming that has been observed since the mid-1970s should not automatically be blamed on human-induced greenhouse gases. There are a number of

other physical processes that could account for this 30-year warming trend and the last century long warming trend besides increase in greenhouse gases. These include:

1. A weaker Atlantic Ocean thermohaline circulation (THC) for a number of decades. When this happens the Southern Hemisphere oceans upwell less cold water into their upper mixed layer, and the globe gradually warms. When the Atlantic thermohaline circulation (THC) is stronger than normal, the cold global deep water upwelling circulation into the Southern Hemisphere upper-mixed layer is enhanced for long periods and the globe gradually cools (Figure 6). I judge the THC to have been generally weaker over the last century and especially over the 25-year period from 1970-1994. It is this weaker THC and not the increase in global CO_2 that is likely the cause of the recent global warming we have observed (Figures 3 and 4). The globe typically reaches its highest temperature in the 10-12 year following the onset of a strong thermohaline circulation (THC) period. We are now very close to this maximum global warming period. Continued warming should not be anticipated.

2. Slight reductions in global rainfall can also cause global temperature increase. Less rainfall leads to reduced surface evaporation cooling and a warming of the globe. During the 20-year period of 1975-1995 we had reduced global rainfall consistent with the global warming which occurred during this period.

3. Slight reductions in global albedo (amount of global solar energy reflected or scattered back to space) would cause the globe to undergo a warming. For example, melting of alpine glaciers reduces its albedo or brings on more warming.

4. Slight increases of upper-level cloudiness would lead to an inhibiting of longwave radiation loss to space and bring about a global temperature increase.

5. Slight decreases in low-level cloudiness would cause reduced reflected solar energy to space which could bring about a warming of the globe.

To believe that humans are the cause of the global warming we have seen requires that one believe that all of the above climate change mechanisms (and others not mentioned) all sum to zero. Who can sacrifice their objectivity to this degree?

I believe that the natural mechanisms of climate change (decreased strength of THC and reduced global rainfall) could explain most of the global temperature increase we have seen over the last 30 years and over the last century. We do not need human-induced greenhouse gases to explain the global warming which has been observed.

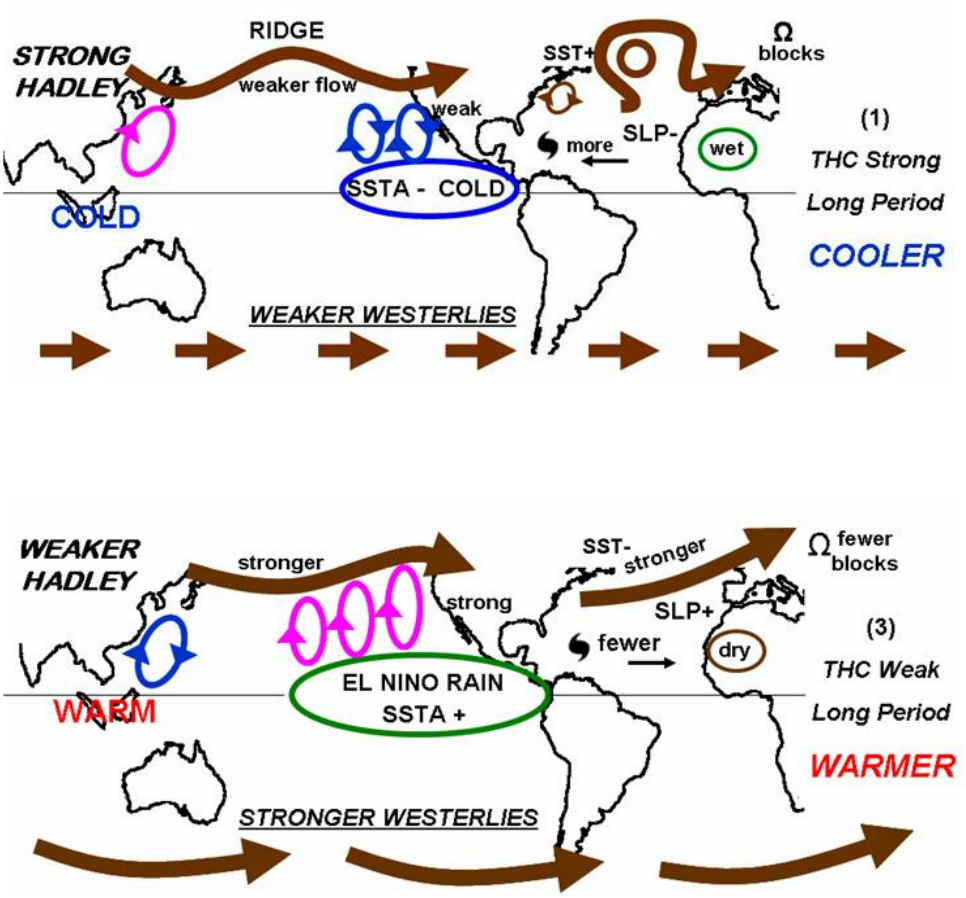


Figure 6. Comparison of typical global wind patterns when the Atlantic Thermohaline Circulation (THC) has been strong for a long period and cold water upwelling in the Southern Hemisphere has been strong. Global temperatures become cooler than average (top). Bottom diagram shows the typical global wind patterns when the Atlantic THC has been weak for a long period and there has been reduced cold water upwelling in the Southern Hemisphere. The globe becomes warmer during these periods.

Figure 7 gives a comparison of the various atmospheric moist-energy sources and sinks of condensation, evaporation and surface evaporation-precipitation in comparison with the energy change of CO_2 increases to 2006 and for a doubling of CO_2 at the end of the 21st century. Note that very small changes in atmospheric condensation-evaporation or surface evaporation-rainfall could completely overwhelm changes in CO_2. How is it possible for the warming proponents to know how all the non- CO_2 components will behave and not act to balance out the CO_2 changes? The warming proponents have assumed that all these massive moisture processes do not change. Or if they do change their changes are controlled by the CO_2 alterations. How does one accept such an unlikely scenario with a straight face?

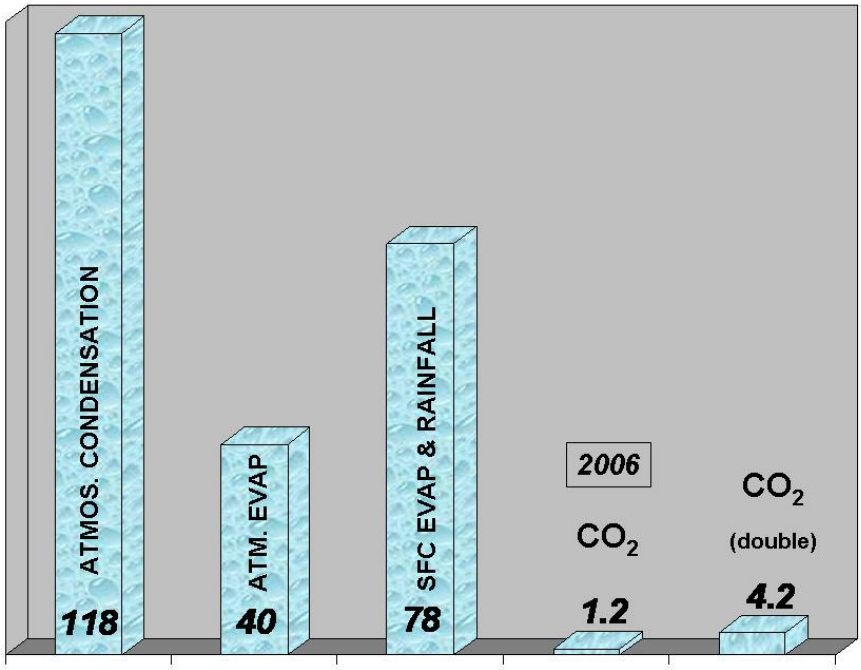


Figure 7. A comparison of moist energy sources and sinks (in $^{Watts}/_{m}^{2}$) of condensation-evaporation-rainfall in comparison with the energy gains due to CO_2 since the industrial revolution (~1.2 $^{Watts}/_{m}^{2}$) and for a doubling of CO_2 by the late 21st century.

I am convinced that in 15-20 years, we will look back on this period of global warming hysteria (1988-2006) as we now look back on so many other popular, and trendy, scientific ideas -- such as the generally accepted Eugenic theories of the 1920s to 1940s, that now has been fully discredited, as well as the Lysenko ideas of inheritance which the Soviet government so strongly supported during the 1930s through the 1950s.

Yes, some human-induced global warming has likely occurred from increased human-induced greenhouse gas emissions. But these increased greenhouse emissions should be expected to cause only a small rise in global mean temperature (~0.3°C for a doubling of human-induced greenhouse gases). And besides, we are helpless to do anything substantial about CO_2 increases. China, India, Brazil and other emerging countries would never agree to cut down on their growing industrial greenhouse gas outputs regardless of what we in the western world do to curtail ours.

7. FLAWS IN THE GCM SIMULATIONS OF GLOBAL WARMING

There are about 12-14 different General Circulation Model (GCM) groups around the world that have been conducting extensive numerical modeling simulations of the likely changes in global mean temperature that will occur from the doubling of

human-induced greenhouse gases. Human-induced greenhouse gases have so far risen about 30 percent over their pre-industrial values and about 15 percent during the last 30 years (Figure 8). It is expected that there will be a doubling of these gases by the end of the 21st century. Most of these GCM simulations indicate that there will be a 2-5°C (4-9°F) increase in global mean temperature by the time this doubling takes place. Such large warming would cause great changes in human society and global economies. Such large warming scenarios are highly unlikely, however. The GCMs greatly exaggerate the potential warming that will occur. These exaggerations are due to:

1. Models assuming that an increase in the rate of global precipitation leads to an increase in upper-level water vapor and cloudiness. This is known as the positive water-vapor feedback effect. Observations indicate that from a global perspective this is not a valid assumption. Although additional rainfall causes extra upper-level moistening and cloudiness around the areas of the globe where the rainfall occurs, the broad clear regions of subsidence produce drying which causes more global infrared (IR) radiation loss to space (a net negative water-vapor feedback). Global GCMs do not correctly simulate this water vapor feedback process. They produce an artificial global increase in upper-level water vapor and cloudiness that should not be expected to occur in nature. If the water vapor feedback in these models was neutral (neither positive nor negative), the global warming scenarios would be greatly reduced (Figures 9 and 10).

2. The GCMs inability to resolve individual cumulus scale convection at the scales found in nature. Individual convective elements currently must be parameterized in terms of the larger-scale circulation. This causes the GCMs to obtain upper-level water vapor values which are too high. This artificially-enhanced upper-level water vapor blocks too much infrared radiation loss to space and causes an artificial warming that does not occur in nature (Figure 11).

3. GCMs do not currently model the globe's deep-water ocean circulation accurately. Modeling the ocean's deep circulation is fundamental to any understanding of global temperature change. I believe that such global deep water circulation patterns are the primary control of global surface temperature. The global warming we have seen over the last 30 years and over the last 100 years is largely due to naturally occurring-reductions in the rate of global ocean deep water circulation (or Great Ocean Conveyor Belt Circulation) which is largely driven by global ocean salinity variations.

Recent GCM global warming scenarios assume that a stronger hydrologic cycle (due to increased human-induced greenhouse gases) will cause additional upper-level atmospheric water vapor and cloudiness. This assumption allows the small initial warming due to increased CO_2 to be unrealistically multiplied 5-10 times. This is where most of the global warming from the GCMs comes from, and these simulations are not

realistic (Figure 12). As human-induced greenhouse gases increase, it does not follow that the net global upper-level water vapor and cloudiness will increase. Observations of upper tropospheric water vapor over the last few decades show that water vapor has in fact undergone a small decrease. The assumed positive water vapor and cloud feedback as programmed into the GCM models is not occurring. Energy budget studies indicate that if atmospheric water vapor and rainfall were held fixed, a doubling of carbon dioxide would result in only a small amount (~0.3°C) of global warming. This is much less than the 2-5°C warming predicted in the GCM models from a doubling of greenhouse gases.

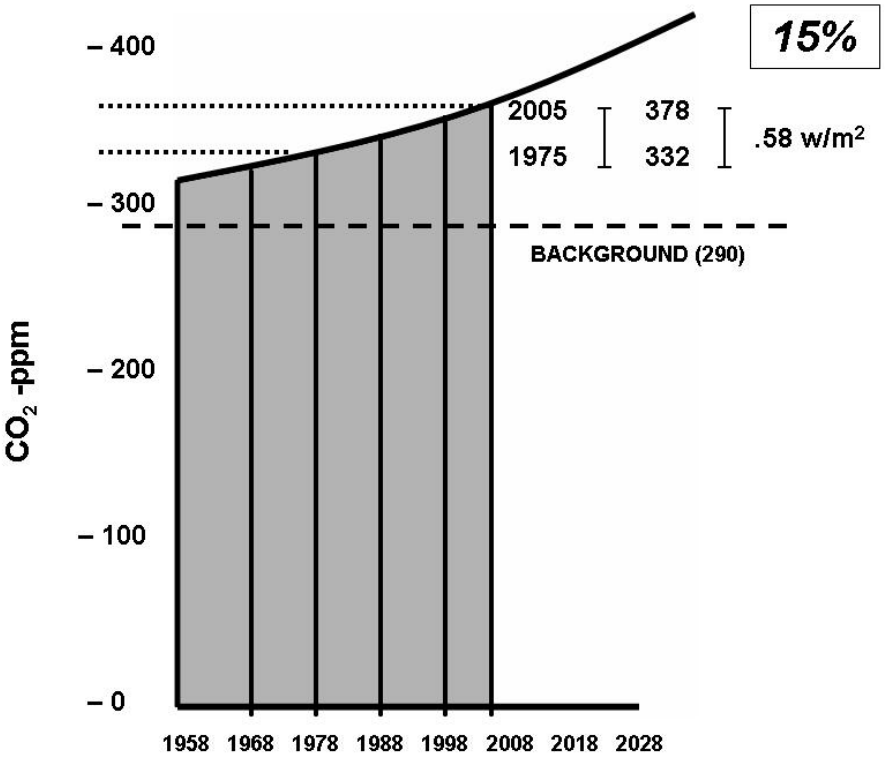


Figure 8. Illustration of CO_2 increase (in ppm) since 1958 and the increase during the last 30-year warm period (1975-2005) of 15 percent. All other factors held constant, this is equivalent to an increase of 0.58 w/m^2 of energy.

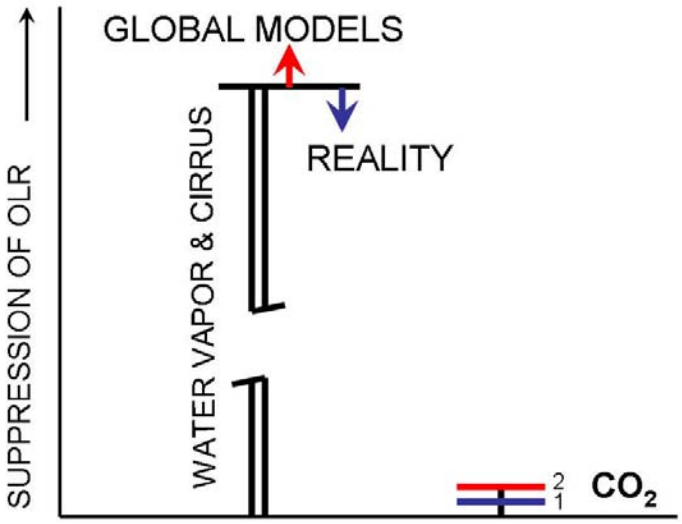


Figure 9. Illustration of relative comparison of water-vapor cirrus cloud and CO_2 suppression of outgoing longwave radiation (OLR). Global circulation models (GCMs) assume that more rainfall due to CO_2 doubling inhibits OLR (positive feedback) and that this causes additional warming. Observational analysis of enhanced global rainfall however, indicates a weak negative water-vapor cirrus feedback loop and therefore little global warming.

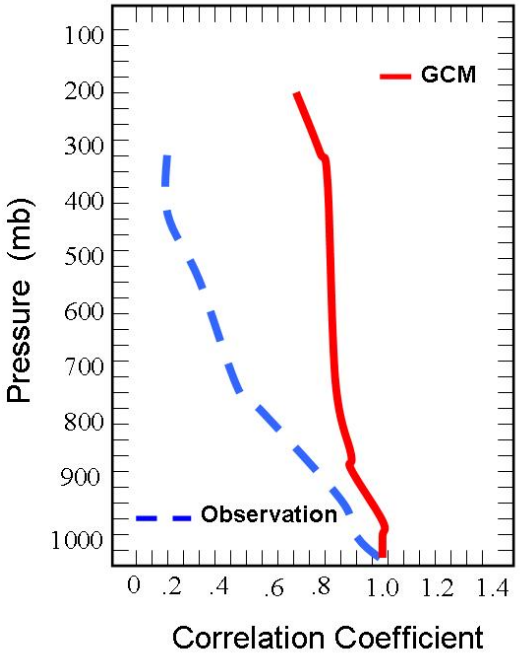


Figure 10. Comparison of correlation coefficient between upper and lower level tropospheric moisture of the GCMs model output (red) and the Rawinsonde observations (blue). As soon as the GCMs obtain a moistening of the lower levels, their parameterization schemes immediately transfer this moistening to the upper levels (Sun and Held, 1996).

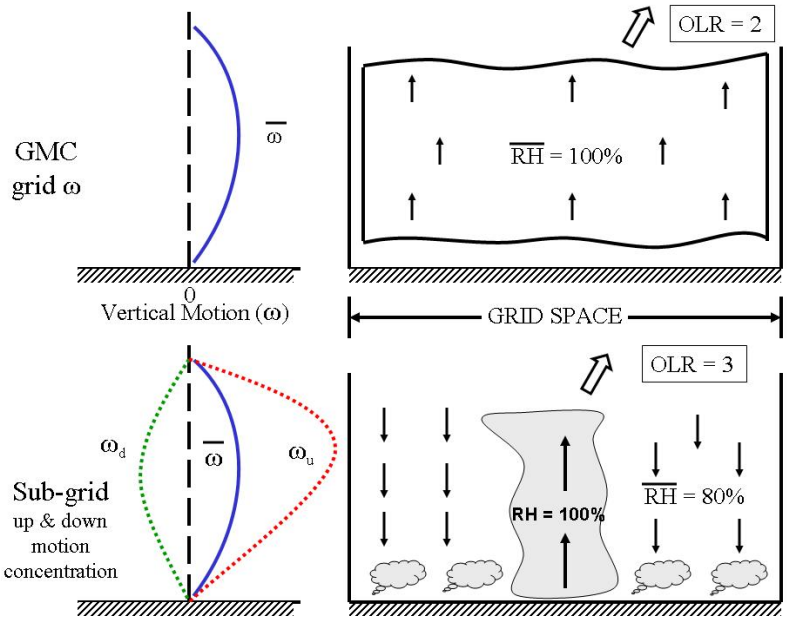


Figure 11. Idealized portrayal of how the grid size of the GCMs is too large to accommodate the real sub-grid scale vertical motion. GCMs can't resolve (top) the concentrated rain or the surrounding cloud downdrafts and subsidence within the scale of its grid space (bottom). The top and bottom diagrams contrast the mean vertical motion of the GCM (top) and the real up-and-down vertical motion of nature. Note that the unresolved vertical motion of the top diagram allows less OLR to escape to space.

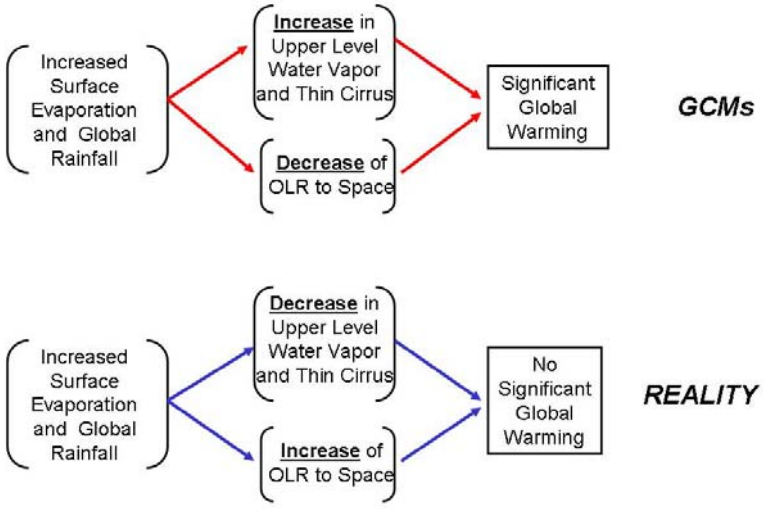


Figure 12. Comparison of the primary physical process (middle brackets) where there is major disagreement on the interpretation by which the GCMs (top) incorrectly forecast too much upper level moisture-cloudiness and cause an anomalous global warming and how nature (bottom) does it.

Nature of Hydrologic Cycle. About half of the global rainfall at any time is concentrated in short-lived deep convective cells, each of which is a few kilometers wide and lasts less than an hour. In aggregate, these heavy rainfall areas at any one time typically cover less than one-quarter of one percent of the earth's surface. The typical grid space and time resolution of GCMs currently making greenhouse gas simulations are about 400 km and 30 minutes, respectively. These simulations cannot resolve such concentrated heavy rainfall, and precludes direct representations of key elements of the hydrologic cycle. These grid sizes dictate that the influence of the fundamentally important cumulus convection elements and other sub-grid scale processes have to be approximated (or parameterized) in terms of the large-scale circulation features. This cannot be accurately accomplished.

Small-Scale Problems. All sub-grid scale cumulus convection parameterization schemes currently in use are poor approximations of the real-world complex, nonlinear small-scale convective processes. The primary deficiency is the large amount of compensating up-and-down motion occurring within the grid spacing that cannot be calculated by the GCMs larger resolvable scales. These poorly-resolved approximations of the sub-grid scale processes are then integrated by the models for hundreds of thousands of time steps into the future. This guarantees large errors. Realistic sub-grid scale parameterization schemes have yet to be developed. Most GCM modelers are unfamiliar with the detailed functioning of the hydrologic cycle. Most research on the small scale parameterization of cumulus convection in terms of the large scale was done in the 1960s through the 1980s without satisfactory resolution. The topic was too complex to be resolved during this period. To move forward the GCM models primarily ignored this difficult task. They chose not to get 'down-in-the-trenches' on such a complex topic. They accepted a few simple compromised schemes (with known problems) and went forward with their broader-scale modeling integrations assuming that their sub-grid schemes were 'good enough' or that the errors would average out in the end. But the sub-grid scale approximations they have used are not good enough and the multitude of errors does not average out.

There are large and complicated variations as to how sub-grid scale parameterization should be accomplished with respect to latitude, land-sea differences, seasons, and other conditions. There are yet to be sub-grid parameterization schemes that can perform this function on the long climate time-scales. This is the 'Achilles heel' of climate modeling.

The net effect of the GCM's sub-grid scale parameterization schemes is to underestimate sub-grid subsidence drying, and to unrealistically suppress OLR to space. This is how the GCMs are able to develop their artificial warming. It is thus not surprising that the GCMs produce so much global warming (~2-5°C) with a relatively small increase in anthropogenic greenhouse gases. This warming occurs due to the large positive water-vapor feedback in most GCMs.

There can be no question that global rainfall will increase as human-induced greenhouse gases increase. This increased rainfall will primarily manifest itself in small amounts of increased and concentrated deep cumulus convection and increased rainfall efficiency in the normal areas where deep convection and rainfall are already occurring. This somewhat more concentrated rainfall will not bring about global upper-level water vapor and cloud increase as the modelers have assumed. Figure 10 shows the difference in how increased global rainfall will cause a moistening of the atmosphere and more cloudiness (GCM view) or, by contrast, drying of the atmosphere and less cloudiness.

A doubling of anthropogenic greenhouse gases will produce an increase of global rainfall of about 3 percent. This extra rainfall would primarily occur within concentrated areas where rain is already occurring. There will have to be a slight enhancement of subsidence in the broader areas of the clear and partly cloudy regions to compensate for this enhanced rainfall. Enhanced subsidence in the oceanic subtropical anticyclones would also occur. This extra sinking motion would slightly warm, slightly lower the atmospheric water vapor level, and slightly reduce upper-level cloud amounts. All three of these processes would bring about a small enhancement of outgoing longwave radiation (OLR) to space. This added outgoing OLR would bring about a small cooling of the troposphere. This cooling would act to balance out and compensate for the majority of the impinged energy gain for the increased CO_2. Doubling of anthropogenic greenhouse gases should not be expected to bring about anything but small amounts of global temperature increase (<0.3°C).

The complementary (negative feedback) relationship between water vapor-cirrus clouds and anthropogenic greenhouse gases is due primarily to the greater concentration of rainfall and increased rainfall efficiency as the hydrologic cycle becomes stronger (Figure 13). Rainfall efficiency is defined as the ratio of the amount of surface rain to the total amount of cloud condensation which occurs. The global average is about 50-60 percent. Why is it that the GCMs do not explicitly discuss changes in water-vapor which is the overwhelming dominate greenhouse gas, and precipitation efficiency which is the dominate feature in global temperature change?

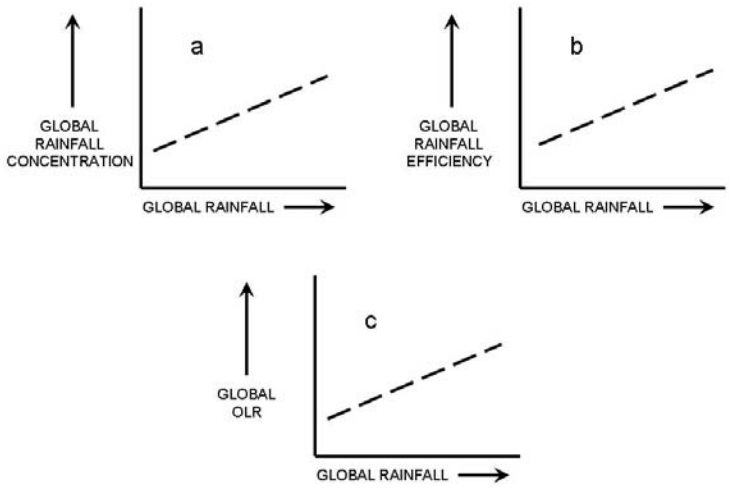


Figure 13. Idealized qualitative illustration of how global rainfall concentration (a) and global rainfall efficiency (b) increase with the global rainfall amount. Diagram (c) shows how global OLR would go up (due to moisture-cloudiness decrease) as rainfall goes up.

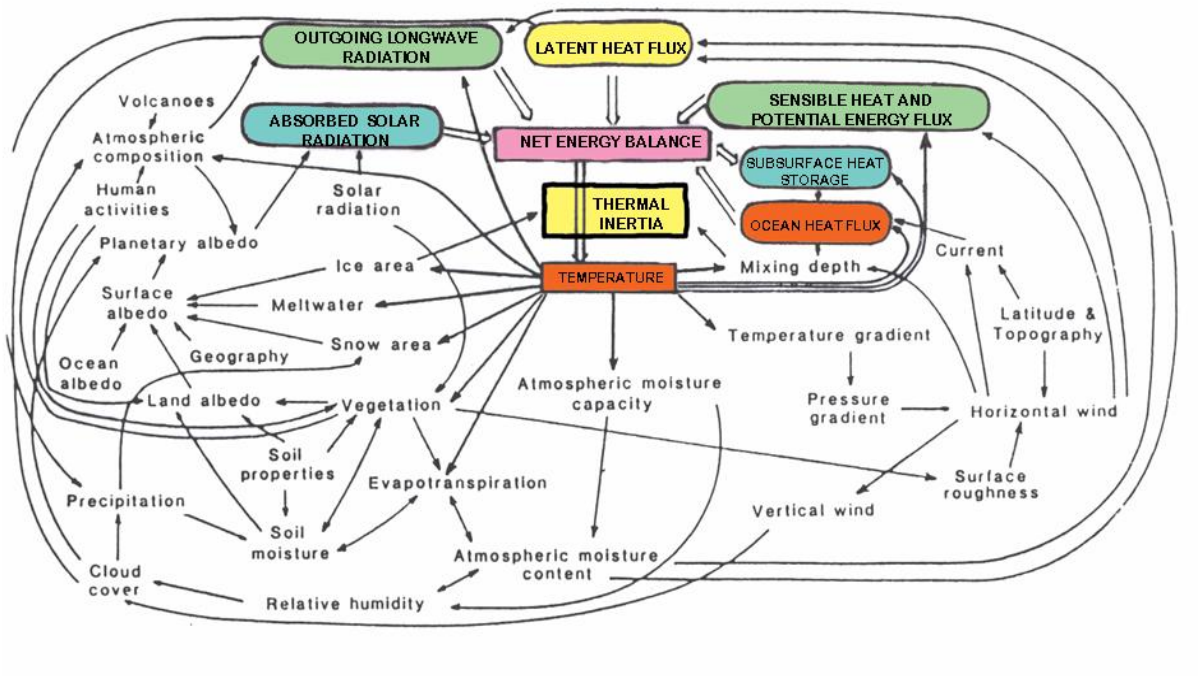
The long-term stability of global temperature despite ice-albedo, ocean current, and other energy change impingements argues for one or more energy regulatory mechanisms. The hydrologic cycle is one of these regulatory mechanisms. When the earth experiences an anomalous energy gain, it develops a stronger hydrologic cycle with more concentrated and efficient rainfall which acts to increase OLR to space. This helps to balance out a portion of the anomalous energy gain. By contrast, when the earth has a cooling or negative energy impingement, the hydrologic cycle is reduced in strength. There is less rainfall, less rainfall concentration and rainfall efficiency, and OLR to space is reduced. The reduced OLR acts to bring about a reduction in surface cooling. The NOAA reanalysis data of the last 55 years supports this idea of the hydrologic cycle acting as an energy regulation mechanism, not as a destabilizing mechanism as the GCM modelers incorrectly envision.

8. IMPOSSIBILITY OF SKILLFUL GCM CLIMATE PREDICTION

Skillful initial-value GCM climate prediction will likely never to be possible. This is due to the overly complex nature of the atmosphere/ocean/land system (Figures 14 and 15) and the inability of numerical models to realistically represent the full range of physical complexity and to integrate this complexity forward for hundreds of thousands of time steps into the future. Realistic initial-value forecasts currently cannot be made more than a week or two into the future. Any imperfect representations of the highly non-linear parameters of the atmosphere-ocean system tend to quickly degrade (the so-called butterfly effect) into unrealistic flow states upon long-period integration. Skillful short-range prediction is possible because there tends to be conservatism in the initial momentum fields which can be extrapolated or advected for short periods. But beyond

about 1-2 weeks, the many multiple unknown and non-linear energy-moisture exchanges within the earth system become dominant. Model results soon decay into chaos as indicated in the top diagram of Figure 16.

If skillful GCM climate forecasts were possible, we would be eager to track their skill. Currently, GCMs do not make seasonal or yearly forecasts. They dare not issue these forecasts because they know they are not skillful. GCM climate forecasts cannot compete with empirical climate forecast schemes. How can we trust GCM climate forecasts 50 and 100 years into the future (that cannot be verified in our lifetime) when these same models are not able to demonstrate shorter range forecast skill of a season or a year?



Flow diagram for climate modeling, showing feedback loops.
From Robock (1985).

Figure 14. *Flow diagram of the climate system illustrating the massive and complicated physical processes and multiple feedback loops. It is impossible to write numerical code that would accurately replicate these many physical and non-linear feedback loops. Accurate climate forecasts require these complex interactions to be accurately integrated for hundreds of thousands of time steps into the future. This is impossible.*

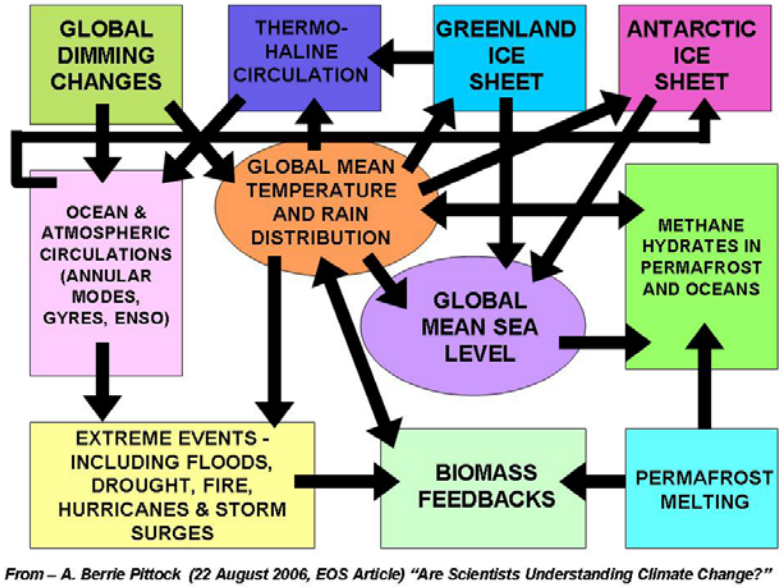


Figure 15. Similar to Figure 13, this figure illustrates the many complex interacting loops of the earth/atmosphere/ocean climate system.

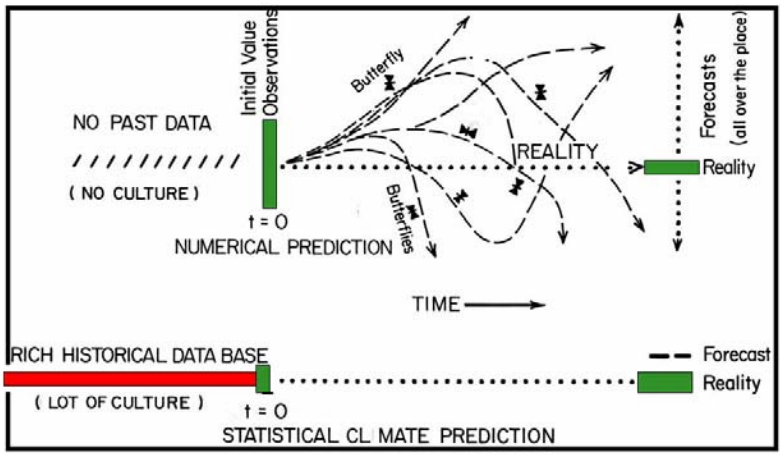


Figure 16. Illustrating the two types of climate prediction. The top diagram gives a depiction of initial value numerical modeling where prior data is not consulted and after 10-15 days the non-linear imperfections of the model grows into random turbulence (or butterflies). The bottom diagram shows statistical prediction which is based on how the atmosphere-ocean functions in many seasons or many years of past data.

Besides the physical uncertainty concerning how to represent the complexity of the atmosphere-ocean climate system in quantitative terms, climate models have become too complex for any one person to understand. This great complexity inhibits an

understanding of the true reasons for the failures of the GCMs to predict climate change. These models have been developed by teams of specialists who concentrate on different parts of the global model. No one person is able to understand the whole suite of individual GCM simulations. Most model developers are talented and skilled at their specialties. Few, however, have ever performed extensive research with meteorological data or have experience at making real-world weather forecasts.

Until GCMs can demonstrate consistent ability to issue skillful seasonal and yearly forecasts, they should play no role in political decision making concerning future climate. The potential for climate modeling mischief and false scares from incorrect climate model scenarios is enormous. Numerical modeling output gives an air of authenticity which is not warranted by the input physics and long periods of integration.

9. THE BUSY ONE-WAY ONLY HIGHWAY

The role of humans in climate change is very complex and is not yet well known or understood. But most global governments and most climate scientists have already made a claim without that the observed global temperature rise (~ 0.7°C) of the last century is a result of human activity.

This ever-growing unity of views on global warming by climate scientists and government leaders like Al Gore has led to billions of dollars of research being spent over the last 20 years to construct global models and to attempt to array data sets to verify their general warming beliefs.

The minority of scientists who are skeptical that humans have had large influences on climate change have been purposely squeezed out of the climate research funding picture. Most of our country's climate research has been going down a wide one-way only global warming highway.

There is no question that there are many basic and diverse human-induced environmental problems in the world. Most of these environmental problems are unique to a local region and have to be dealt with on their own special needs and requirements. All environmental problems have an economic component which must be balanced against societal gains or losses. Most human-induced environmental problems are related to technological developments and population gains and have next to nothing to do with human-induced global warming.

If I were the CEO of an energy or automobile company, I would want to know if the claims of the fossil-fuel warming proponents that have been so widely propagated to the general public are really valid. I would not accept the summary views of those who have been funded explicitly to find fossil-fuel influences on global temperature. I would want objective scientific evaluations by climate specialists, who are not on the payroll of the federal government.

A few tens of million dollars being spent to try to find flaws in the current global warming arguments would appear quite appropriate. Let there be at least an opposite-directed bicycle path on the side of this one-way only global warming highway. There is no reason to think that climate research funded by energy and automobile companies would be any more biased than the research that has been coming forth over the last two decades from the consortium of government-sponsored human-induced global warming advocates.

Why are the global warming advocates so desirous to cut off all dissenting views? This can only mean that they have marginal confidence in their views and are not sure that their warming hypotheses will stand up to close scrutiny.

It is appalling that the Royal Society of the UK, a model of the organized scientific establishment for over three centuries, would feel it necessary to compose a letter to the CEO of the Exxon oil company complaining about Exxon's funding of a few million dollars for climate-related research at Stanford University. Also, there have been recent complaints by a number of US scientists and US media outlets to the quite modest ($150K) research grant from a coal company to University of Virginia professor and state climatologist, Patrick Michaels. What monumental hypocrisy! Why is it all right in the eyes of the media and most climate scientists for our federal government to award hundreds of million of dollars to climate researchers that are trying to find human influences on global warming and then complain about the pittance of climate funding to scientists with opposite viewpoints? Are those scientists receiving large federal grants not tools of the federal government? This is the type of McCarthyism that has been prevalent for many years in the climate research area.

It is important that the general public realize that if one is known to have scientific reservations about the importance and magnitude of human-induced global warming, it has been very difficult for that person to obtain federal grant research through normal federal government channels. One needs agreement from one's peer scientists and from the federal agency's project mentor to obtain federal support. Valuable climate change research with an alternate viewpoint is not coming forward because these scientists do not fit into the currently accepted climate change mode. They are not able to overcome peer-review and project monitor scrutiny. This is not healthy for a determination of the extent of human influence on climate.

Our Anglo-Saxon legal system is founded on the idea that the best way to garner truth and render justice is from the give-and-take of open debate between two opposing advocacy persons or groups. If our country was really interested in getting to the bottom of the human-induced global warming question, there would be funding available to scientists from both sides of the warming issue. All pro and con arguments supporting or refuting human-induced climate change would be brought out. If humans are really altering the global climate in an adverse way, it will eventually come out in an honest pro and con debate of both sides. Given the current one-sided conditions, how

wise is it for the US and the world to move forward with forcible greenhouse gas restrictions?

Most of the strong advocates of human-induced global warming appear to be too personally invested in global warming both from a scientific and a career perspective. They cannot (and will not) back away from their unrealistic warming ideas. It appears that only a new set of climate researchers who are not already committed to the warming straight-jacket will be able to render an objective assessment of human influence on climate.

RECOMMENDATION – That the global energy and automobile companies band together and pool their resources to establish an international climate research institute that would make research funding available to well-credentialed scientists to study climate change. This research would be done from an unbiased point of view and be free of federal government biases. It is one thing to regulate energy and automobile exhaust for health and pollution mitigation but quite a different thing to impose fossil-fuel restrictions based on a faulty belief that such emissions are causing global warming.

Having funding available for serious climate research that might be able to conclude that fossil-fuels are not causing the global warming suggested by the current scientific consensus would likely bring about economic and social benefits to our country and to the world at large.

10. SUMMARY

It is irresponsible to claim that the scientific debate on global warming is settled. A true scientific debate on this topic has not yet taken place. The debate that has occurred has been conducted largely by the media, the environmentalists, and the scientists receiving federal grant support to supply evidence of human involvement in global temperature rise. Most warming skeptics have been purposely ignored. Federal research funding for scientists skeptical of the human-induced global warming hypothesis has not been available.

Human-induced global warming scenarios have been in the headlines since the hot summer of 1988. These scenarios have been grossly exaggerated by a broad spectrum of scientists who know little about the processes of the atmospheric- hydrologic cycle and how the globe's atmosphere and oceans function in unison. It has been to their careers advantage to exaggerate human-induced global warming. They have received notoriety, career advancement, and research grants from their warming exaggerations.

Many of my older colleagues and I, who have invested decades of our lives in the study of how the atmosphere functions, have been appalled by the many alarmist statements issued by high-ranking government officials and prominent scientists who have little real understanding of how the atmosphere and ocean function. Their views

have been shaped by selective sources, in particular the environmentalists and the large GCM groups, who have a vested interest in promoting the warming threat.

It is surprising that more experienced meteorologists and oceanographers have not spoken out about the reliability of the general circulation model simulations and the overly simplified arguments of the warming advocates. This may be partly due to the mild form of McCarthyism that has developed toward those scientists who do not agree that human-induced global warming is a great threat to society. Those holding contrary views have often been smeared as tools of the fossil-fuel industry, as if those warming advocates receiving large federal grants or grants from environmental groups were not also tools of the federal government or the environmental lobbyists. Our country has far more serious problems to worry about than human-induced global warming. Figure 17 shows the cover of *Time Magazine* almost 30 years ago when the majority of meteorologists and world governments were worried about and predicted a coming ice-age.

Figure 17. Time Magazine cover illustrating the expected coming cold and perhaps Ice-Age conditions as scientists thought possible in the mid-1970s. This view was formed by the extrapolation of the 30 year (1945-1975) global cooling curve as portrayed in Figure 4.

Michael Crichton (2004) Comment on human-induced global warming.

"Now we are engaged in a great new theory, that once again has drawn the support of politicians, scientists, and celebrities around the world. Once again, the theory is promoted by major foundations. Once again, the research is carried out at prestigious universities. Once again, legislation is passed and social programs are urged in its name. Once again, critics are few and harshly dealt with.

Once again, the measures being urged have little basis in fact or science. Once again, groups with other agendas are hiding behind a movement that appears high minded. Once again, claims of moral superiority are used to justify extreme actions. Once again, the fact that some people are hurt is shrugged off because an abstract cause is said to be greater than any human consequences. Once again, vague terms like *sustainability* and *generational justice* – terms that have no agreed definition – are employed in the service of a new crisis."

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APPENDIX

How Did We Get Into This Warming Hysteria?

We will probably have to wait a few decades for history to fully explain to us what really has been going on during the last 15-20 years and how human induced global warming was thrust before the world as such a major threat. How was it possible to 'brainwash' so many scientists, government officials, the general public, etc.? We likely can't put all the pieces together right now, but we already know enough to speculate on some of the reasons which are listed below in no particular order:

1. The winding down of the cold war and the perceived need to generate a new common enemy so as to keep the public willing to continue to support the large science efforts typical of our prior perceived need to keep ahead of the Soviets.

2. The banding together of an international group of sagacious government leaders, scientists, environmentalists, etc. who wanted a science-based political cause to unite behind. Global warming was an ideal vehicle for their desire to organize, propagandize, force conformity, and exercise political influence. Big world government could best lead (and control) us to a better world!

3. Natural causes of global climate change are not well understood. Who would be able to say with confidence that global warming was not human induced if you had no other physical mechanism to blame it on? Of course, many examples of temperature increase are going to be found during any warming trend. There has been a selective emphasis on observations of warming and a glossing over of data that shows no temperature change or cooling. The ignorance of other past historic events (Medieval Warm Period and Little Ice Age trends) and the many paleo-global warming-cooling events has also contributed.

4. The grant money desires of a broad spectrum of agriculturists, biologists, environmentalists, disease specialists, sociologists, weather and climate types, etc. New research missions to justify grant support needed to be found. The dangling of research funds is a powerful persuader. It didn't matter much if the globe warmed or not. What was necessary was to know what would happen if it did. Who among us would be stupid enough to criticize this 'need to know' if we could get grant support to study it.

5. The media's desire to profit from controversy of any type at the expense of critical evaluation. For instance, the surrender of media judgment by mouthing the verbatim views of almost any credentialed scientist out for notoriety, grant money, or who has a selective warming observation to show off. It makes for good press. Opposite examples of no climate change or cooling doesn't make news. Why discuss these examples?

6. It is interesting to note that most of the primary players in the international global warming crusade are credible and experienced scientists with well deserved reputations. Most of them, however, have had limited or no experience with real weather and climate studies and weather forecasting. They are being asked to make technical decisions on topics for which they have little or no background. They tend to believe what a selective set of politically motivated scientists tell them. But how are Nobel Prize winners in physics, chemistry, or medicine (as brilliant as they might be) able to make scientifically sensible statements on the possible association of rising level of CO_2 and global warming? They are just responding to the similar upward-slope of these two curves.

7. The universally recognized momentous contributions to society of the computer and the growing belief that almost everything coming out of a computer is numerically correct and valid. But computer output is only as good as input, and most of the GCM modelers have not put all the right things in. Computers only allow for a bad model to be precisely wrong!

8. The last 40 years of continuous improvement in initial value global numerical weather prediction out to 5-10 days. This has been a great success story. It has led to the false belief among many scientists (most of whom are without forecast experience) that this same approach could be extended to the longer climate periods.

9. The great technical achievements in the computer industry led to the encouragement of never before held beliefs that skillful numerical climate models could actually be constructed that would be able to deal with the gross complexity and infinite chaos of the climate system. All you needed was bigger and better computers.

10. The lack of understanding of the complicated physics of the cumulus convection process of the tropics and higher latitudes. This led to the naïve assumption that climate modelers would be able to 'hop-scotch' over the sub-grid scale parameterization problems in their models and get results which had validity. They were wrong. Cumulus convection was too complex of a problem for GCMs to face up too. Right or wrong, the GCMs proceeded forward with their output runs not knowing how to deal with the sub-grid scales. They, of course, would obtain the inevitable global warming output that they wanted. And this created a stir that led to favorable publicity and continued grant support. After awhile the GCMers had gone too far to turn back. They were now too committed to global warming to worry about their sub-grid scale parameterization problems. Retreat was unthinkable. Global warming had to be the answer at least until their retirement.

11. The take-up of the global warming cause by so many celebrities to demonstrate their social consciousness. Global warming was an 'IN' and fashionable cause among the elite. That they had absolutely no technical background to make such judgments did not matter.

12. The overall 'quietude' of the meteorological community – many of whom knew better. We are scientists and should be above all this media-hype and controversial political in-fighting? To paraphrase John Burke, "All that was required for the triumph of human-induced global warming was that a substantial number of those meteorologists who knew better said nothing."

* * *

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