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Comments on Draft Technical Support Document for Endangerment Analysis for Greenhouse Gas Emissions under the Clean Air Act

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Based on TSD Draft of March 9, 2009

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PREFACE

We have become increasingly concerned that EPA has itself paid too little attention to the science of global warming. EPA and others have tended to accept the findings reached by outside groups, particularly the IPCC and the CCSP, as being correct without a careful and critical examination of their conclusions and documentation. If they should be found to be incorrect at a later date, however, and EPA is found not to have made a really careful independent review of them before reaching its decisions on endangerment, it appears likely that it is EPA rather than these other groups that may be blamed for any errors. Restricting the source of inputs into the process to these these two sources may make EPA's current task easier but it may come with enormous costs later if they should result in policies that may not be scientifically supportable.

We do not maintain that we or anyone else have all the answers needed to take action now. Some of the conclusions reached in these comments may well be shown to be incorrect by future research. Our conclusions do represent the best science in the sense of most closely corresponding to available observations that we currently know of, however, and are sufficiently at variance with those of the IPCC, CCSP, and the Draft TSD that we believe they support our increasing concern that EPA has not critically reviewed the findings by these other groups.

As discussed in these comments, we believe our concerns and reservations are sufficiently important to warrant a serious review of the science by EPA before any attempt is made to reach conclusions on the subject of endangerment from GHGs. We believe that this review should start immediately and be a continuing effort as long as there is a serious possibility that EPA may be called upon to implement regulations designed to reduce global warming. The science has and undoubtedly will continue to change and EPA must have the capability to keep abreast of these changes if it is to successfully discharge its responsibilities. The Draft TSD suggests to us that we do not yet have that capability or that we have not used what we have.

We would be happy to work with and assist anyone who might want to undertake such a serious review of the science and hope that these comments will at least illustrate the scope of what we believe is needed.

We hope that the reader will excuse the many unintentional errors that are undoubtedly in these comments. Our only excuse is that we had less than four days to draft these very lengthy and complex comments. It has not been possible to fully adhere to our usual very high standards of accuracy as a result. If there should be questions, we will be happy to try to correct any errors that anyone may find, however.

It is of great importance that the Agency recognize the difference between an effort that has consumed tens of billions of dollars by the IPCC, the CCSP, and some additional European, particularly British, funding over a period of at least 15 years with what two EPA staff members have been able to pull together in less than a week. Obviously the number of peer reviewed papers that exist and the polish of the summary reports cannot be compared. What is actually noteworthy about this effort is not the relative apparent scientific shine of the two sides but rather the relative ease with which major holes have been found in the GHG/CO2/AGW argument. In many cases the most important arguments are based not on multi-million dollar research efforts but by simple observation of available data which has surprisingly received so little scrutiny. The best example of this is the MSU satellite data on global temperatures. Simple scrutiny of this data yields what to us are stunning observations. Yet this has received surprisingly little study or at least publicity. In the end it must be emphasized that the issue is not which side has spent the most money or published the most peer-reviewed papers, or been supported by more scientific organizations. The issue is rather whether the GHG/CO2/AGW hypothesis meets the ultimate scientific test—conformance with real world data. What these comments show is that it is this ultimate test that the hypothesis fails; this is why EPA needs to carefully reexamine the science behind global warming before proposing an endangerment finding. This will take more than four days but is the most important thing we can do right now and in the coming weeks and months and possibly even years.

EXECUTIVE SUMMARY

These comments are based on the draft Technical Support Document for Endangerment Analysis for Greenhouse Gas Emissions under the Clean Air Act (hereafter draft TSD) issued by the Climate Change Division of the Office of Atmospheric Programs on March 9, 2009. Unfortunately, because we were only given a few days to review this lengthy document these comments are of necessity much less comprehensive and polished than they would have been if more time had been allowed. We are prepared, however, to provide added information, more detailed comments on specific points raised, and any assistance in making changes if requested by OAR.

The principal comments are as follows:

As of the best information we currently have, the GHG/CO2 hypothesis as to the cause of global warming, which this Draft TSD supports, is currently an invalid hypothesis from a scientific viewpoint because it fails a number of critical comparisons with available observable data. Any one of these failings should be enough to invalidate the hypothesis; the breadth of these failings leaves no other possible conclusion based on current data. As Feynman (1975) has said failure to conform to real world data makes it necessary from a scientific viewpoint to revise the hypothesis or abandon it (see Section 2.1 for the exact quote). Unfortunately this has not happened in the global warming debate, but needs to if an accurate finding concerning endangerment is to be made. The failings are listed below in decreasing order of importance in our view:

1. Lack of observed upper tropospheric heating in the tropics (see Section 2.9 for a detailed discussion).
2. Lack of observed constant humidity levels, a very important assumption of all the IPCC models, as CO2 levels have risen (see Section 1.7).
3. The most reliable sets of global temperature data we have, using satellite microwave sounding units, show no appreciable temperature increases during the critical period 1978-1997, just when the surface station data show a pronounced rise (see Section 2.4). Satellite data after 1998 is also inconsistent with the GHG/CO2/AGW hypothesis

4. The models used by the IPCC do not take into account or show the most important ocean oscillations which clearly do affect global temperatures, namely, the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation, and the ENSO (Section 2.4). Leaving out any major potential causes for global warming from the analysis results in the likely misattribution of the effects of these oscillations to the GHGs/CO2 and hence is likely to overstate their importance as a cause for climate change.
5. The models and the IPCC ignored the possibility of indirect solar variability (Section 2.5), which if important would again be likely to have the effect of overstating the importance of GHGs/CO2.
6. The models and the IPCC ignored the possibility that there may be other significant natural effects on global temperatures that we do not yet understand (Section 2.4). This possibility invalidates their statements that one must assume anthropogenic sources in order to duplicate the temperature record. The 1998 spike in global temperatures is very difficult to explain in any other way (see Section 2.4).
7. Surface global temperature data may have been hopelessly corrupted by the urban heat island effect and other problems which may explain some portion of the warming that would otherwise be attributed to GHGs/CO2. In fact, the Draft TSD refers almost exclusively in Section 5 to surface rather than satellite data.

The current Draft TSD is based largely on the IPCC *AR4* report, which is at best three years out of date in a rapidly changing field. There have been important developments in areas that deserve careful attention in this draft. The list includes the following six which are discussed in Section 1:

• Global temperatures have declined—extending the current downtrend to 11 years with a particularly rapid decline in 1907-8; in addition, the PDO went negative in September, 2007 and the AMO in January, 2009, respectively. At the same time atmospheric CO_2 levels have continued to increase and CO_2 emissions have accelerated.

• The consensus on past, present and future Atlantic hurricane behavior has changed. Initially, it tilted towards the idea that anthropogenic global warming is leading to (and will lead to) to more frequent and intense storms. Now the consensus is much more neutral, arguing that future Atlantic tropical cyclones will be little different that those of the past.

• The idea that warming temperatures will cause Greenland to rapidly shed its ice has been greatly diminished by new results indicating little evidence for the operation of such processes.

• One of the worst economic recessions since World War II has greatly decreased GHG emissions compared to the assumptions made by the IPCC. To the extent that ambient GHG levels are relevant for future global temperatures, these emissions reductions should greatly influence the adverse effects of these emissions on public health and welfare. The current draft TSP does not reflect the changes that have already occurred nor those that are likely to occur in the future as a result of the recession. In fact, the topic is not even discussed to our knowledge.

• A new 2009 paper finds that the crucial assumption in the GCM models used by the IPCC concerning strongly positive feedback from water vapor is not supported by empirical evidence and that the feedback is actually negative.

• A new 2009 paper by Scafetta and Wilson suggests that the IPCC used faulty solar data in dismissing the direct effect of solar variability on global temperatures. Other research by Scafetta and others suggests that solar variability could account for up to 68% of the increase in Earth's global temperatures.

These six developments alone should greatly influence any assessment of "vulnerability, risk, and impacts" of climate change within the U.S., but are not discussed in the Draft TSD to our knowledge. But these are just a few of the new developments since 2006. Therefore, the extensive portions of the EPA's Endangerment TSD which are based upon science from the IPPC *AR4* report are no longer appropriate and need to be revised before a TSD is issued for comments.

Not only is some of the science of the TSD out-of-date but there needs to be an explicit, in-depth analysis of the likely causes of global warming in our view. Despite the complexity of the climate system the following conclusions in this regard appear to be well supported by the available data (see Section 2 below):

A. By far the best single explanation for global temperature fluctuations appears to be variations in the PDO/AMO/ENSO. ENSO appears to operate in a 3-5 year cycle. PDO/AMO appear to operate in about a 60-year cycle. This is not really explained in the draft TSD but needs to be, or, at the very least, there needs to be an explanation as

to why OAR believes that these evident cycles do not exist or why they are so unimportant as not to receive in-depth analysis.

B. There appears to be a strong association between solar sunspots/irradiance and global temperature fluctuations. It is unclear exactly how this operates, but it may be through indirect solar variability on cloud formation. This topic is not really explored in the Draft TSD but needs to be since otherwise the effects of solar variations may be misattributed to the effects of changes in GHG levels.

C. Changes in GHG concentrations appear to have so little effect that it is difficult to find any effect in the satellite temperature record, which started in 1978.

D. The surface measurements (such as HADCRUT) are more ambiguous than the satellite measurements in that the increasing temperatures shown since the mid-1970s could either be due to the rapid growth of urbanization and the heat island effect or by the increase in GHG levels. However, since no such increase is shown in the satellite record it appears more likely that urbanization and the UHI effect and/or other measurement problems are the most likely cause. If so, the increases may have little to do with GHGs and everything to do with the rapid urbanization during the period. Given the discrepancy between surface temperature records in the 1940-75 and 1998-2008 and the increases in GHG levels during these periods it appears even more unlikely that GHGs have as much of an effect on measured surface temperatures as claimed. These points need to be very carefully and fully discussed in the draft TSD if it is be scientifically credible.

E. Hence it is not reasonable to conclude that there is any endangerment from changes in GHG levels based on the satellite record, since almost all the fluctuations appear to be due to natural causes and not human-caused pollution as defined by the Clean Air Act. The surface record is more equivocal but needs to be carefully discussed, which would require substantial revision of the Draft TSD.

F. There is a significant possibility that there are some other natural causes of global temperature fluctuations that we do not yet really understand and which may account for the very noticeable 1998 temperature peak which appears on both the satellite and surface temperature records. This possibility needs to be fully explained and

discussed in the Draft TSD. Until and unless these and many other inconsistencies referenced in these comments are adequately explained it would appear premature to attribute all or even most of what warming has occurred to changes in GHG/CO_2 atmospheric levels.

These inconsistencies between the TSD analysis and scientific observations are so important and sufficiently abstruse that in our view EPA needs to make an independent analysis of the science of global warming rather than adopting the conclusions of the IPCC and CCSP without much more careful and independent EPA staff review than is evidenced by the Draft TSP. Adopting the scientific conclusions of an outside group such as the IPCC or CCSP without thorough review by EPA is not in the EPA tradition anyway, and there seems to be little reason to change the tradition in this case. If their conclusions should be incorrect and EPA acts on them, it is EPA that will be blamed for inadequate research and understanding and reaching a possibly inaccurate determination of endangerment. Given the downward trend in temperatures since 1998 (which some think will continue until about 2030 given the 60 year cycle described in Section 2) there is no particular reason to rush into decisions based on a scientific hypothesis that does not appear to explain much of the available data.

Finally, there is an obvious logical problem posed by steadily increasing US health and welfare measures and the alleged endangerment of health and welfare discussed in this draft TSD during a period of rapid rise in at least CO_2 ambient levels. This discontinuity either needs to be carefully explained in the draft TSD or the conclusions changed.

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List of Acronyms

AR4	Fourth Assessment Report of the IPCC (2007)
AMO	Atlantic Multidecadal Oscillation
^{0}C	Degrees Centigrade
CCSP	Climate Change Science Program
CERN	European Organization for Nuclear Research
CFC	Chlorofluorocarbon
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Draft TSD	March 9, 2009 version of the TSD
ENSO	El Nino-Southern Oscillation
EPA	Environmental Protection Agency
GCM	General Circulation Model
GHG	Greenhouse Gas
IPCC	UN Intergovernmental Panel on Climate Change
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrogen Oxides
OAR	USEPA Office of Air and Radiation
PDO	Pacific Decadal Oscillation
SO_2	Sulfur Dioxide
TSD	Technical Support Document
TSI	Total Solar Irradiance
US	United States
US$	United States dollar
UHI	Urban Heat Island
UNCED	United Nations Conference on Environment and Development
USEPA	United States Environmental Protection Agency

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1. Draft TSD Is Seriously Dated and the Updates Made Are Inadequate

Although a real effort has been made to introduce references to more recent CCSP reports, the draft endangerment TSD is largely a dated document which relies primarily on the *Fourth Assessment Report* (AR4) of the U.N.'s Intergovernmental Panel on Climate Change (IPCC). A lot has happened in those intervening three years since the input deadline for *AR4*. The IPCC's *AR4* was published in the spring of 2007, but to meet the deadline for inclusion in the *AR4*, scientific papers had to be accepted for publication by early 2006. Given the lag between submission and acceptance the real cut-off for new research was even earlier. So, in the rapidly evolving field of climate change, by grounding its TSD in the IPCC *AR4* the EPA is largely relying on scientific findings that are, by early 2009, largely 3 years or more out of date. The six developments described here, which to our knowledge are not described in the Draft TSD should in our view significantly influence any assessment of "vulnerability, risk, and impacts" of climate change within the U.S. Therefore, the extensive portions of the EPA's Endangerment TSD which are based upon the old science are no longer appropriate and need to be further revised.

1.1 Where to Find a Discussion of Various Topics in These Comments

Section 1 summarizes six of the many important new developments since the cut-off date for the IPCC AR4 report that need to be reflected in the Draft TSD but to our knowledge have not been. These developments primarily affect Section 5 of the Draft TSD as well as the Executive Summary. Section 2 of these comments summarizes some of the critical inconsistencies between the Draft TSD (primarily again Section 5) and data concerning the causes of global warming. Section 3 summarizes data showing continuing increases in US health and welfare during a period of continuing increases in GHG levels. Finally, Section 4 presents detailed comments on specific sections of the Draft TSD, which are related back to the earlier sections so as to avoid repeated presentation of the same material.

1.2 Global Temperatures Have Declined Significantly

Global temperatures have declined (Figure 1a)—extending the current run of time with a statistically robust lack of global temperature rise to eight years (Figure 1b), with some people arguing that it can be traced back for 12 years (Figure 1c).

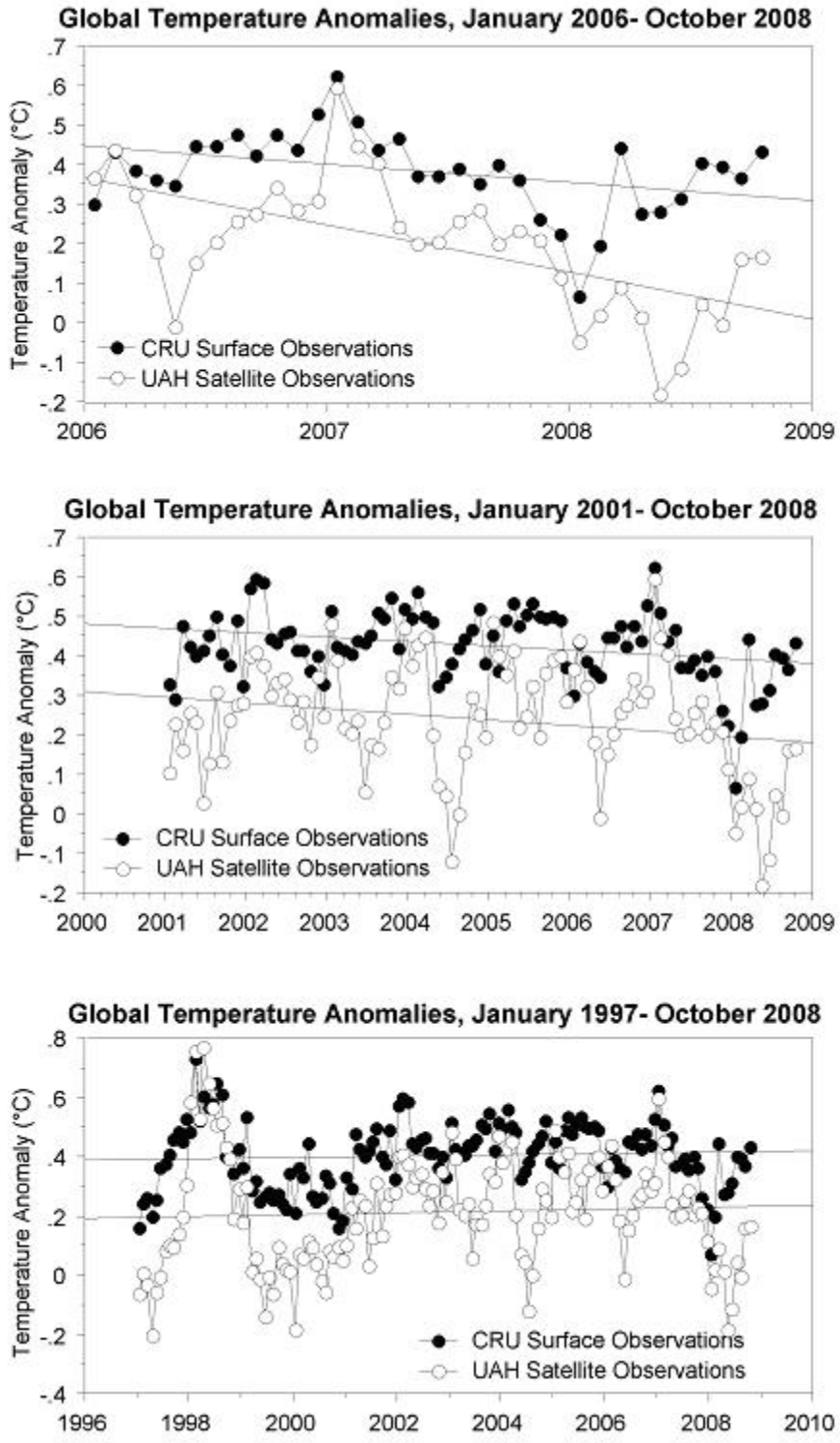


Figure 1-1(a), (b), and (c): Monthly Global Temperature Anomalies (ºC) as Measured At The Surface (Filled Circles) and in the Lower Atmosphere by Satellites (Open Circles)

Top (a), Last three years, January 2006-October 2008; Middle (b) Last eight years, January 2001-October 2008; Bottom (c), last 12 years, January 1997-October 2008.
Sources: Hadley Center; University of Alabama-Huntsville.

In addition, both the PDO and AMO have turned negative in September, 2007 and January, 2009, respectively (see section 2.4 below for a discussion of the crucial role played by PDO/AMO in global temperature changes). The last time that this happened, in the 1960s and 1970s, the climate in at least North America experienced record cold temperatures and generally lower temperatures and global temperatures declined). At the same time atmospheric CO_2 levels have continued to increase and CO_2 emissions have accelerated.

1.3 IPCC Global Temperature Projections Look Increasingly Doubtful

Because of recent substantial decreases in global temperatures, the IPCC projections for large increases are looking increasingly doubtful. This is illustrated by this graph comparing the two:

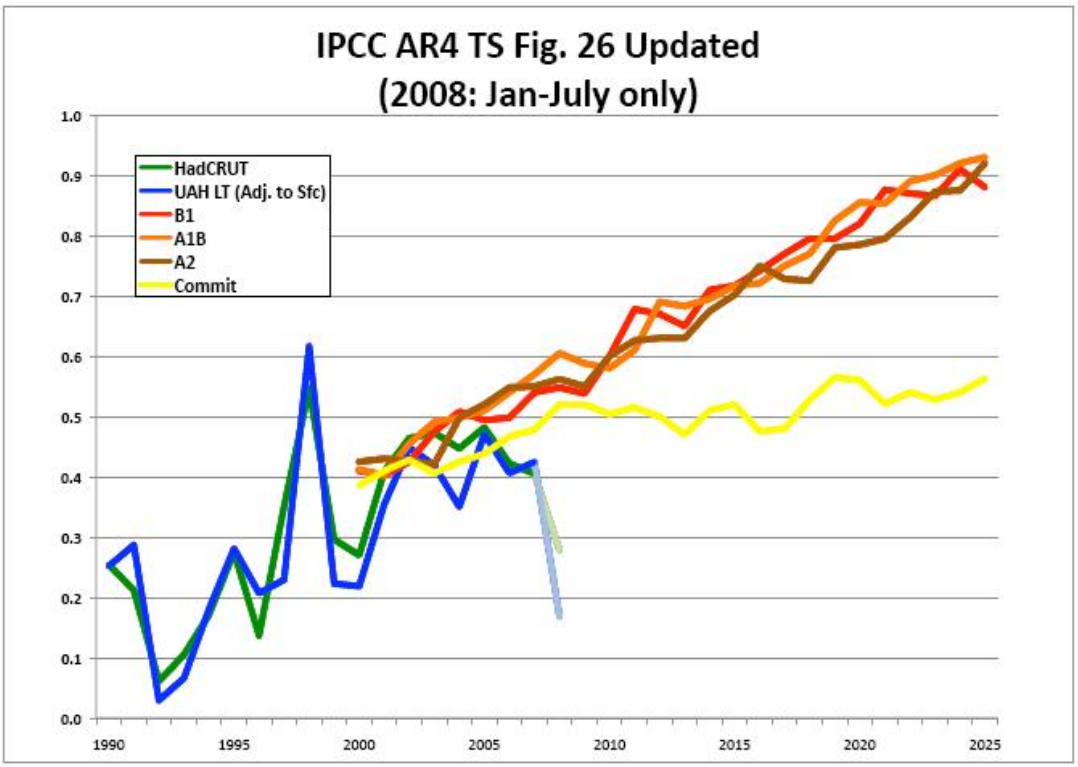


Figure 1-2: IPCC *AR4* Figure 26 Updated

Source: http://icecap.us/images/uploads/ipccchart.jpg; part of article by Marlo Lewis on Planet Gore at http://planetgore.nationalreview.com/post/?q=MTYwMjRiZjJhMmUxYWE2MmQ0NDZhOGM0M2Q3ZWUzMmE; as reproduced on icecap.us on August 14, 2008.

Figure 1-2 shows how climate models and reality diverge. The red, purple, and orange lines are model forecasts of global temperatures under different emission scenarios. The yellow line shows how much warming we are supposedly "committed to" even if CO_2 concentrations don't change according to the IPCC. The blue and green lines are actual temperatures as measured by ground-based (HadCrut) and satellite (UAH LT) monitoring systems. It is fairly evident that the IPCC projections are quite divergent from the actual experience in recent years. Yet if the GHG/CO2 only hypothesis is correct, there would be likely to be a greater correspondence.

If global temperatures are viewed as suggested in Figure 2-8 below the large downward drop in 2007-8 appears to be simply a return to the 1978-97 range and might not be particularly noteworthy. If, on the other hand, global temperatures are viewed as an increasing trend, which the Draft TSD appears to do, then the 2007-8 drop would appear to bring temperatures well outside the likely range suggested by the IPCC projections. So if the former viewpoint is taken, then the Draft TSD needs to explain how it could be that there has been such a great divergence from the IPCC projections.

What's really rather remarkable, is that since 2000, the rates at which CO_2 emissions and concentrations are increasing have accelerated. According to Canadell et al. (2008), fossil fuel and cement emissions increased by 3.3 percent per year during 2000-2006, compared to 1.3 percent per year in the 1990s. Similarly, atmospheric CO_2 concentrations increased by 1.93 parts per million per year during 2000-2006, compared to 1.58 ppm in the 1990s. And yet, despite accelerating emission rates and concentrations, there's been no net warming in the 21st century, and more accurately, a decline.

1.4 Consensus On Past, Present, and Future Atlantic Hurricane Behavior Has Changed

The consensus on past, present and future Atlantic hurricane behavior has changed in our view. Initially, it tilted towards the idea that anthropogenic global warming is leading to (and will lead to) to more frequent and intense storms. Now the consensus is much more neutral,

arguing that future Atlantic tropical cyclones will be little different that those of the past (e.g. Knutson et al., 2008; Vecchi et al., 2008).

Trying to identify a statistically significant and robust human signal in the observed history of Atlantic basin tropical cyclones, whether over the past 100+ years, or in recent decades, is probably untenable. This conclusion is based on increases in hurricane activity in recent decades far exceeds that generally projected by climate models run with observed changes in anthropogenic emissions, and there is ample (and growing) evidence that the Atlantic hurricane record is characterized by multi-decadal oscillations that are tied to multi-decadal oscillations in ocean circulation, atmospheric circulations, and patterns of sea surface temperature variability. That these multi-decadal oscillations can be traced backward in time for at least several centuries, is strong indication that they are a natural part of the earth's climate system, rather than being primarily driven by human alterations of the earth's atmosphere. This conclusion has important implications for the future, as it suggests that as the sign and strength of the natural cycles controlling hurricane behavior wax and wane, so to will the future activity of Atlantic tropical cyclones, both in frequency and intensity. The contrary conclusion—that anthropogenic "global warming" is largely controlling the activity of Atlantic tropical cyclone activity—portends, conversely, an ever-stormier future.

While we have tried to present clear evidence that the scientific tide seems to be turning in the direction of a predominately "natural" origin of past, present, and future, Atlantic tropical cyclone variability, the draft TSD appears to rely on more-dated findings to support its claims of a significant anthropogenic impact on current and future Atlantic hurricane activity in their current draft versions of climate change summary documents. We hope that the revised draft TSD will revised in this regard.

Hurricane researchers Gabriel Vecchi, Kyle Swanson, and Brian Soden published a paper in *Science* magazine which summarizes their view of the subject. They lay out the arguments for each case:

Anthropogenic case:

There is a strong correlation between sea surface temperatures (SSTs) in the tropical Atlantic Ocean and Atlantic tropical cyclone activity. And, in recent decades, as the global temperatures have risen (presumably from human activities) so too have the SSTs in the tropical Atlantic which has promoted an increase in the frequency and intensity of Atlantic hurricanes. As climate

models run with increasing levels of atmospheric greenhouse gases indicate Atlantic SSTs will increase in the future, so too will Atlantic tropical cyclone activity.

Natural case:

There is a strong correlation between the SST changes in the tropical Atlantic Ocean *relative to tropical SSTs in other ocean basins* and Atlantic tropical cyclone activity. In recent decades, the tropical Atlantic Ocean has warmed faster than other tropical oceans and thus, Atlantic tropical hurricane activity has picked up, both in frequency and intensity. As climate models run with increasing atmospheric concentrations of greenhouse gases *do not* project that the tropical Atlantic will warm faster than other tropical oceans, future tropical cyclone in the Atlantic will be driven by natural fluctuations in the patterns of tropical SST increases rather than simply an overall SST increase.

Vecchi et al. (2008) suggest that empirical evidence is insufficient at the current time to draw a distinction between the two scenarios. However, if one were to turn to purely physical arguments or to the latest state-of-the-science dynamical calculations from high temporal and spatial resolution modeling efforts, one would begin to gather enough weight to start to tip the scale in the direction of natural cycles. Vecchi et al. (2008) lay out these lines of evidence and summarize their conclusions in Figure 1-3:

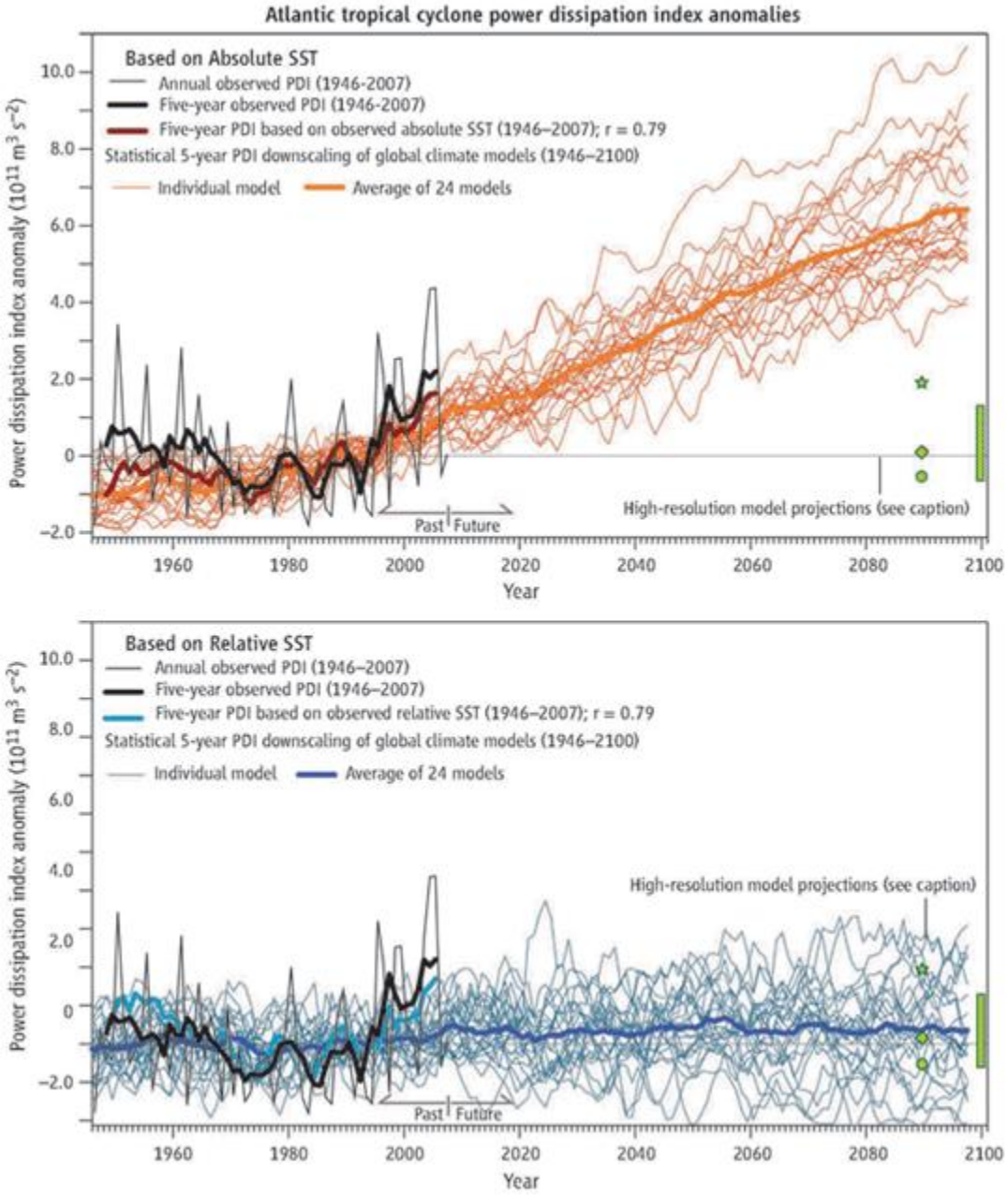


Figure 1-3. Observed Tropical Cyclone Activity in Atlantic Basin, 1946-2007 (Black Lines) and Fit to Absolute Tropical Atlantic SST (Thick Brown Line, Top) and Relative Tropical Atlantic SST (Thick Light Blue Line, Bottom)

Climate model projections to the year 2100 based upon the observed tropical cyclone/absolute SST relationship (orange lines, top) and observed tropical cyclone/relative SST relationship (blue lines, bottom). The projections made by high resolution dynamic hurricane models are indicated by the green symbols on the right of each chart (see Vecchi et al., 2008 for additional details).

The top chart in Figure 1-3 shows a cumulative measure of annual Atlantic tropical cyclone activity (thick black line), a statistical fit to the observed activity using absolute tropical Atlantic SSTs (thick brown line) and the climate model projections of the future Atlantic tropical cyclone activity based upon that statistical fit (thin orange line are individual model projections, the thick orange line is the model average). Cleary, under this scenario, Atlantic hurricane activity is projected to increase dramatically in the future driven by anthropogenic global warming. The bottom chart of Figure 1-3 shows the results of the scenario in which Atlantic tropical cyclone activity (thick black line) is driven by relative changes in the tropical Atlantic SSTs (thick light blue line). Climate model projections of this relationship are indicated by the thin dark blue lines and the thick blue line model average. In this scenario, global warming has little impact on Atlantic tropical cyclone activity.

The current "best thinking" as to the impact of global warming on Atlantic tropical cyclone activity from high resolution dynamical hurricane models is indicated by the elements in green (stars, squares, triangles, bars) at the far right-hand side of each chart. In each case, the high-resolution model results fall within the spaghetti of the model projections depicted in the bottom chart and not within the spaghetti of the top chart. This implies that our best hurricane models are lending their support to side maintaining that there is little impact from global warming, and instead, tropical cyclones are largely modulated by natural variability.

Obviously, there is still a lot of work that needs to be done in the arena of hurricane modeling before this issue can be cleared up, which is the primary message that Vecchi et al (2008) want you to take home with you, but, along the way, Vecchi et al. (2008) strongly demonstrate that based upon what we now know, it seems that natural multi-decadal oscillations in the climate of the Atlantic Ocean trump anthropogenic global warming, when it comes to being the dominant driver of 20th and 21st century Atlantic hurricane activity.

1.5 Changes in Outlook for Greenland Ice Sheet

The idea that warming temperatures will cause Greenland to rapidly shed its ice has been cast into doubt by new results indicating little evidence for the operation of such processes (e.g., van de Wal et al., 2008; Joughin et al., 2008). Even more recently, the *Guardian* reports on another study,[1] not yet available to us and obviously not citable in the TSD, which concludes that global

[1] http://www.guardian.co.uk/environment/2009/mar/10/greenland-ice-sheet-climate-change

temperatures would have to rise even further than other studies have concluded before serious melting of the Greenland ice cap would occur.

A recent but earlier article in *Science* has an alarming title: "Large and Rapid Melt-Induced Velocity Changes in the Ablation Zone of the Greenland Ice Sheet." However, once one examines this paper, there appears to be an amazing twist given the threatening title. To begin, the research was conducted by a large team with the Institute for Marine and Atmospheric Research at Utrecht University, Netherlands; the authors state that "This work was supported by several grants from the Netherlands Organization of Scientific Research and the Netherlands Polar Programme."

Van de Wal et al. focused their attention on measurements that are being made on the ice along the west coast of Greenland just north of the Arctic Circle (Figure 1-4). For the past 17 years, annual measurements have been made along the "K-transect" to measure movements of the ice sheet. However, they state "we started more detailed position measurements in 2005 by taking advantage of technological developments of GPS equipment and data processing. The new instruments record hourly position of stakes, which are drilled into the ice. The GPS (single-frequency) units need to be serviced only once in a year and deliver an ice velocity record with a temporal resolution of 1 day or better." To say the least, geospatial technologies are showing up everywhere in our lives from the family car to the golf course and now to our favorite transects in Greenland.

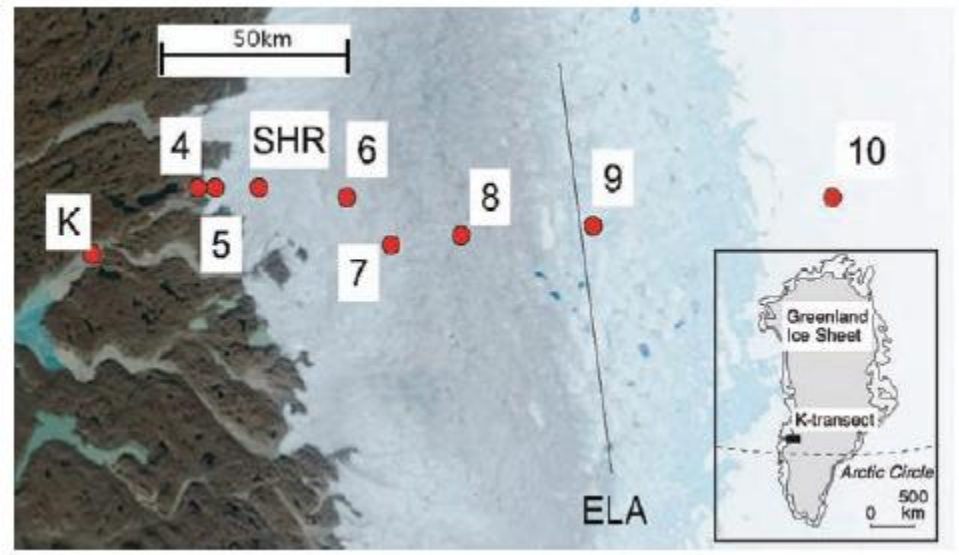


Figure 1-4. The K-transect in West Greenland at 67°N

The background NASA–Modis/Terra image is dated 26 August 2003. K is Kangerlussuaq, whereas 4, 5, SHR, 6, 7, 8, and 9 are surface mass balance sites. ELA, Equilibrium Line Altitude. The equilibrium line (indicated by the black line) is at about 1500 m above sea level. The image clearly shows zones, from right to left, of snow (Site 10), wet snow (Site 9), dark ice (Site 8), and clear ice (Sites 4, 5, and SHR) (from van de Wal et al., 2008).

Probably the largest surprise in the article can be seen in the Figure 1-5 in which we can see the velocity changes at many sites over the 17-year period. The authors note that "The overall picture obtained by averaging all stake measurements at all sites for individual years indicates a small but significant ($r=0.79$, $P < 0.05$) decrease of 10% in the annual average velocity over 17 years". Despite all the talk about moulins, melting, rapid acceleration of ice, van der Wal et al. reveal that the ice movement in western Greenland over the past 17 years has … slowed significantly!

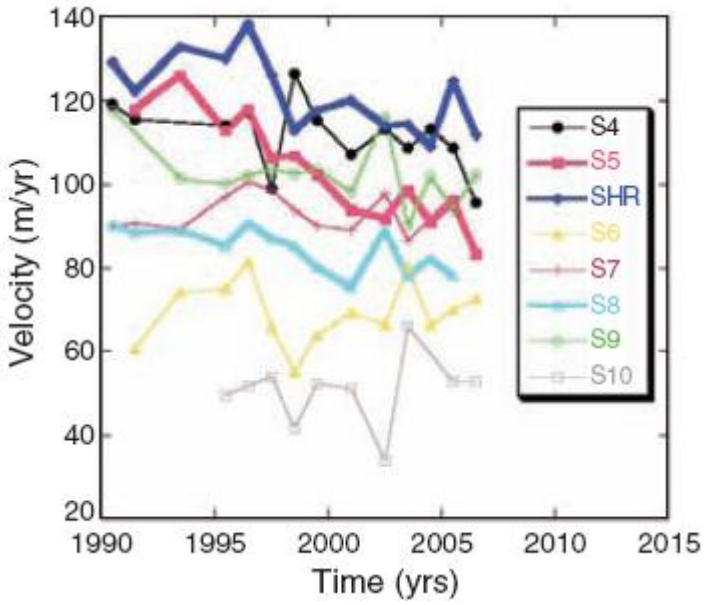


Figure 1-5. Variations in annual velocity along the K-transect over 17 years

Sites with a significant decrease over time are depicted as thick lines.
Source: Van de Wal et al. (2008).

In discussing their results we find some very interesting language, to say the least. At one place they write "it has been suggested that the interaction between meltwater production and ice velocity provides a positive feedback, leading to a more rapid and stronger response of the ice sheet to climate warming than hitherto assumed. Our results are not quite in line with this view." Van der Wal et al. further write "Longer observational records with high temporal resolution in

other ablation areas of the ice sheet are necessary to test the importance of the positive-feedback mechanism between melt rates and ice velocities. At present, we cannot conclude that this feedback is important." Again, we tend to say this moulin link to drowning the World Trade Center Memorial is nonsense, and the empirical evidence is overwhelmingly in our favor.

So how did this article ever get titled "Large and Rapid Melt-Induced Velocity Changes in the Ablation Zone of the Greenland Ice Sheet"? Well, as seen in Figure 1-6, the Garmin's (or some other product line) showed an unusually large increase in velocity from one site a week in August in 2006. No one says Mother Nature is not capable of surprises, and the research team was a bit taken back by the sudden movement. But when we examine this article, we are most impressed with the results over the 17-year period and the lack of support for the notion that somehow the velocity of ice is increasing during a time of greenhouse gas build-up!

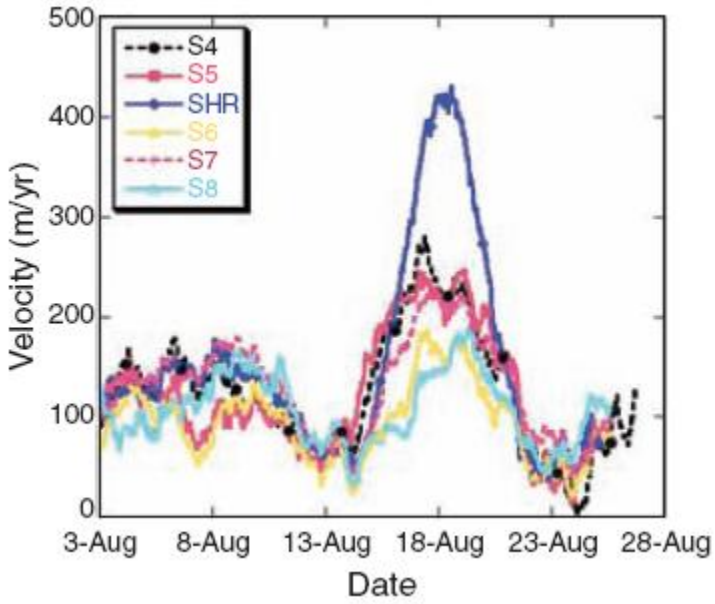


Figure 1-6. Variations in Velocity at Various Sites in August 2006

Source: Van de Wal et al. (2008)

1.6 Serious Recession Has Greatly Decreased GHG Emissions Compared to the Assumptions Made by the IPCC

One of the worst economic recessions since World War II has greatly decreased output and undoubtedly GHG emissions compared to the assumptions made by the IPCC several years ago. To the extent that ambient GHG levels are relevant for future global temperatures and to the

extent that this may be much more than a minor, short recession, these emissions reductions should greatly influence any adverse effects of these emissions on public health and welfare. The current draft TSP does not reflect the changes that have already occurred nor those that are likely to occur in the future as a result of the recession, but it needs to. To our knowledge the topic is not discussed in the Draft TSD.

1.7 Long-term Water Vapor Feedback Reported to Be Negative

A newly published paper in a peer-reviewed journal (Paltridge, 2009) reaches the potentially highly significant conclusion that

> The upper-level negative trends in *q* are inconsistent with climate-model calculations and are largely (but not completely) inconsistent with satellite data. Water vapor feedback in climate models is positive mainly because of their roughly constant relative humidity (i.e., increasing *q*) in the mid-to-upper troposphere as the planet warms. Negative trends in *q* as found in the NCEP data would imply that long-term water vapor feedback is negative—that it would reduce rather than amplify the response of the climate system to external forcing such as that from increasing atmospheric CO_2.

This paper is of particular significance because it concludes with a number of important qualifications that a key assumption in the GCM models concerning a strong positive water feedback is incorrect since it is found to be negative rather than positive. The following long excerpt (from Gray, 2009) explains why this assumption is so crucial and why a change in it is not only expected but of great significance:

> 1. Introduction
>
> There are about 20 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 should be expected to occur from a doubling of atmospheric carbon dioxide (CO2). Carbon dioxide has so far risen about 33 percent (to 385 ppm) over its pre-industrial values and about 15 percent during the last 30 years. It is expected that there will be a doubling of atmospheric CO2 by the latter part of the 21st century. Most of these GCM simulations indicate that there will be a 2-5^{o}C (4-9oF) increase in global mean temperature by the time this doubling takes place. Such large warming as obtained by the GCMs would cause great changes to human society. These large warming scenarios are highly unlikely, however. The GCMs greatly exaggerate the potential warming that will occur. These exaggerations are due to:
>
> 1. GCMs assume that an increase in atmospheric CO_2 will cause weak global warming and an increase in global precipitation that will lead to a large increase in upper-level water vapor and cloudiness. They simulate that this increase in water vapor and cloudiness will block large amounts of infrared radiation emitted to space. New observations by satellite and reanalysis data, however, do not support these GCM assumptions. The global warming that has occurred since the mid-1970s has

been associated with a modest decrease of global upper tropospheric water vapor and an increase of Outgoing Longwave Radiation (OLR). These measurements contradict model predictions.

2. GCMs do not currently accurately model the globe's deep-water ocean circulation. Accurately modeling the global ocean's deep circulation is fundamental to any realistic understanding of global temperature change, as this circulation appears to be the primary control of global surface temperature. The global warming we have seen since the mid-1970s and over the last 100 years is likely largely due to reductions in the rate of global ocean deep water circulation (or the MOC) which is viewed as being driven by global ocean salinity variations. CO2 changes play no role in these ocean changes.

The most basic AGW question appears to be how we would expect upper level water vapor changes to respond to increases of CO2. The GCMs program a very large (and in my view, quite unrealistic) upper level water vapor increase as a response to CO2 doubling. This is a consequence of the GCM's faulty sub-grid convective parameterization schemes and the strict interpretation of the Clausius-Clapeyron (CC) equation to upper level temperature changes which dictate that water vapor increase with temperature increase. Observations indicate that this is not occurring. The cumulus convective schemes employed by the GCMs develop unrealistic high amounts of water vapor which block too much OLR and cause artificial warming which is 2-4 times greater than the warming that would result from the CO2 blockage of OLR by itself.

Observations and other theoretical analysis indicate that little or no upper level water vapor increase will occur with a doubling of CO2. If this is true then the CO2 induced global temperature increases will be only a quarter or a third as much as the GCMs currently indicate.

All the various data sets (Figure 1) that I and some of my colleagues have been working with indicate that upper level water vapor (near the radiation emission level) should not necessarily rise with increases of CO2 and global temperatures. Rather than rise, there appears to be a tendency for a slight upper tropospheric decrease in water vapor as upper level temperature and CO2 have increased. This would allow about as much water vapor induced OLR to space after CO2 amounts have increased as they had before. Little water vapor induced warming should result. There are good theoretical arguments for this being the case. [This does not mean that lower tropospheric water vapor and net precipitable water content will not slightly rise as CO2 amounts double.]

Thunderstorms and cumulonimbus (Cb) activity are the primary mechanisms to bring mass into the global upper troposphere. Such deep convective activity is highly concentrated at any one time to only about 2-3 percent of the global area. The mass that goes up in the deep convective clouds is then advected outward from the convective areas to the environment and sinks in response to the upper tropospheric radiational cooling, cirrus evaporation cooling, and the need for mass balance (Fig 2).

The vertical gradient of saturation vapor pressure in the upper troposphere is very large. Upper level subsidence requires that upper level water vapor and RH values remain low. There appears to be no way a few percent increase in deep convection with CO2 doubling could raise upper level water vapor amounts enough to significantly reduce OLR beyond the reduction of OLR by the increased CO2 by itself.

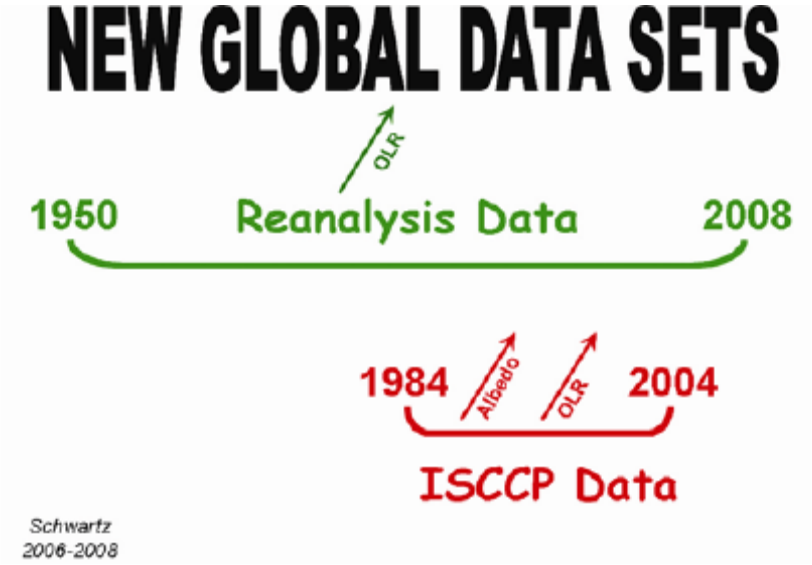


Figure 1. Data sources utilized in this study. NCEP/NCAR Reanalysis data (1950-2008) of wind, thermodynamics and OLR derived radiation, and data from the International Satellite Cloud Climatology Project (ISCCP) for the period of 1984-2004 which contain a variety of radiation components are examined.

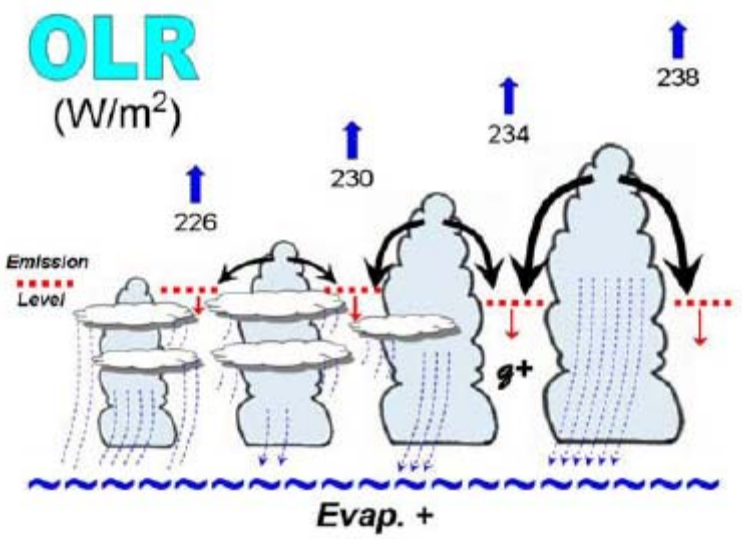


Figure 2. Idealized portrayal of how deeper and more intense cumulonimbus (Cb) convection can lead to progressively more return flow dry subsidence. Enhanced upper level subsidence acts to reduce upper layer water vapor, and enhanced OLR.

2. GCM MODELING PROBLEMS

Skillful initial-value numerical GCM climate prediction will likely never be possible. This is due to the overly complex nature of the global atmosphere/ocean/land system and the inability of numerical models to realistically represent and forecast the full range of this physical complexity.

Small-Scale Problems. In order to integrate over the entire globe and many years into the future it is necessary that the GCMs have rather large grid spacing. This requires that

the GCMs employ sub-grid scale cumulus parameterization schemes which can often be poor approximations of the complex real-world, non-linear, small-scale cumulus convective processes. An important deficiency in the global models is the large amount of compensating up-and-down motion occurring between grid spaces that cannot be explicitly resolved by the models (Figure 3). These poorly-resolved approximations of sub-grid scale processes are 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. Their models assume that changes in lower and upper tropospheric water vapor occur simultaneously which the observations do not verify (Figure 4). Observations show, in fact, that as global warming has occurred since the mid-1970s that lower tropospheric water vapor has increased while upper tropospheric water vapor has decreased. This appears to be a result of there being somewhat more deep Cb convection and a higher rainfall efficiency when the globe is warmer than when it is colder. There are slightly more deep convective updrafts and compensating mass subsidence drying at upper levels during times when the globe is warmer.

Much research on the small scale parameterization of cumulus convection in terms of the large scale circulation patterns was done in the 1970s and 1980s without satisfactory resolution. The topic was too complex to be resolved during this period. To move forward the GCMs 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. This assumption is not valid.

There are many large and complicated variations as to how sub-grid scale cumulus parameterization should be accomplished with respect to differences in latitude, surface characteristics, season, and other conditions. There are no general sub-grid parameterization schemes that can perform this function within various regions and on long climate time-scales.

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. It is thus not surprising that the GCMs produce so much global warming (~2 to 5oC) for only a relatively small increase (3.7 W/m2) of suppressed radiation to space for a doubling of CO2.

It is expected that global rainfall will increase somewhat as human-induced greenhouse gases increase. This increased rainfall is expected to primarily manifest itself in increased and concentrated deep cumulus convection and increased rainfall efficiency in the normal areas where deep convection and rainfall are already occurring. This somewhat greater and more concentrated rainfall will not bring about global upper-level water vapor and cloud increase anywhere near as much as the GCM modelers have assumed. The diagram of Figure 5 gives the author’s concept of how the globe will handle a doubling of CO2 by the end of the 21st century. We will not see a global warming of 2-5oC as the GCM models indicate but rather a much more modest warming of about 0.3-0.5oC.

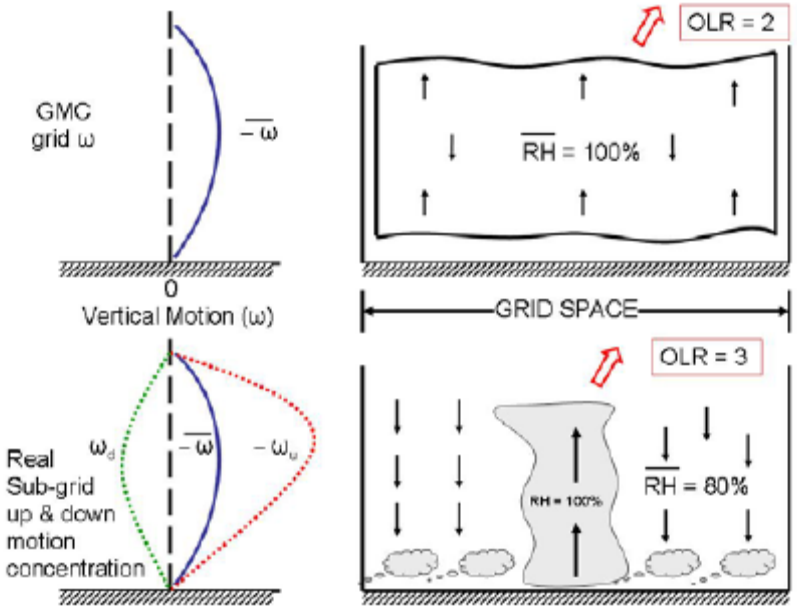


Figure 3. Idealized portrayal of how the grid size of the GCMs is too large to accommodate real sub-grid scale vertical motion. GCMs cannot resolve (top) the concentrated rain or the surrounding cloud downdrafts and subsidence within the scale of its grid space (bottom). The top and bottom diagrams contrast the mean vertical motion of the GCM (top) and the real up-and-down vertical motion of nature if deep convection is occurring within a grid space. Note that the unresolved vertical motion of the top diagram allows less OLR to escape to space.

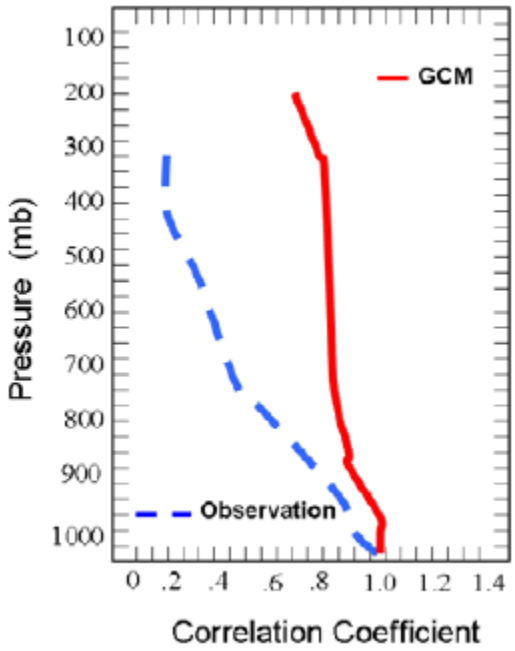


Figure 4. Comparison of correlation coefficient between upper and lower level tropospheric water vapor of the typical GCMs output (red) and that of the Rawinsonde-reanalysis observations (blue line). The GCM outputs are programmed to have a

simultaneous moistening of the lower and upper tropospheric levels, but the observations of upper vs. lower troposphere moisture shows little correlation. This high correlation of the models causes them to artificially moisten the upper troposphere and block too much OLR to space. Adapted from Sun and Held 1996.

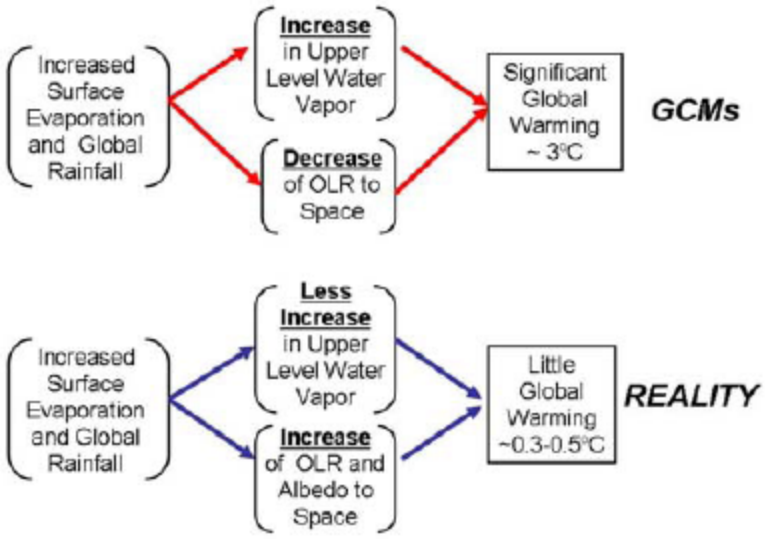


Figure 5. A view of the physical process differences between the global warming for a doubling of CO2 from the GCMs (top) and hypothesized reality (bottom).

Positive or Negative Water Vapor Feedback? Most geophysical systems react to forced imbalances by developing responses which oppose and weaken the initial forced imbalance; hence, a negative feedback response. Recent GCM global warming scenarios go counter to the foregoing in hypothesizing a positive feedback response. Observations indicate that the specific humidity and relative humidity of the middle and upper troposphere have been going down over the last 4-5 decades (Figure 6). The assumed positive water vapor increase with temperature as programmed into the GCMs does occur however at the surface and the lower troposphere. But this simultaneous increase of temperature and water vapor is not found in the upper troposphere near the radiation emission level. It is not the total precipitable water which is most important (measurements show this goes up with temperature) but rather the amount of water vapor near the upper tropospheric emission level which is important. This more closely specifies the amount of OLR.

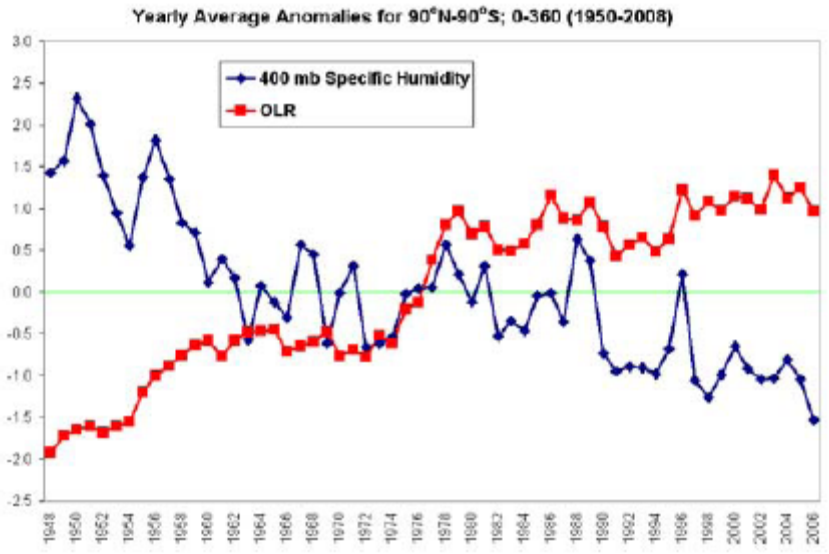


Figure 6. NCEP/NCAR reanalysis of standardized anomalies of 400 mb (~7.5 km altitude) water vapor content (i.e. specific humidity – in blue) and Outgoing Longwave Radiation (OLR) from 1950-2008. Note the downward trend in moisture and the upward trend in OLR.

Faulty Reasoning Behind Climate GCMs. A basic assumption error behind the GCMs has been the model builder's general belief in the physics of the National Academy of Science's (NAS) 1979 study – often referred to as The Charney Report. This report hypothesized that a doubling of atmospheric CO2 would bring about a general warming of the globe's mean temperature between 1.5 – 4.5oC (or an average of ~ 3.0oC). This was based on the report's assumption that the relative humidity (RH) of the atmosphere should be expected to remain quasi-constant if the globe's temperature were to increase. The fundamental tenet of the Clausius-Clapeyron (CC) equation specifies that as the temperature of the air rises its ability to hold water vapor increases exponentially. If relative humidity (RH) were to remain constant as atmospheric temperature rose then the water vapor (q) amount in the atmosphere would accordingly rise (Figure 7 and Figure 8). Observations show that this is indeed a valid assumption for the lower tropospheric levels but does not observationally apply in the upper troposphere (300-400 mb) where water vapor and relative humidity have been observed to slightly decrease as the atmospheric temperatures rises. Lower RH and reduced water vapor content near the upper-atmosphere emission level act to increase the amount of OLR which will be emitted to space.

The GCMs which test the influence of CO2 increases have accepted the hypothesized NAS – Charney Report (1979) scenario. Some of the GCM modelers such as the early NASA-GISS (Hansen 1988) model have even gone further than the Clausius-Clapeyron equation would specify for water vapor increasing with temperature. Hansen's early GISS model assumed that a doubling of CO2 would cause the upper tropospheric RH not just to stay constant but to actually increase. His assumed upper tropospheric increase of water vapor (q) for a doubling of CO2 led to a water vapor increase (Äq) in the upper troposphere of as much as an extremely unlikely 50 percent. These large vapor increases caused Hansen to require that his model have a tropical (30oN-30oS) upper tropospheric

warming for a doubling of CO2 of as much as 7oC (Figure 10). A 7oC warming at the upper level emission level is equivalent to a 23 W/m2 enhancement of OLR for a doubling of CO2 forcing of only 3.7 W/m2. No wonder Hansen got such high values of global warming for a doubling of CO2. This logically followed from his extremely high and unrealistic water vapor assumptions.

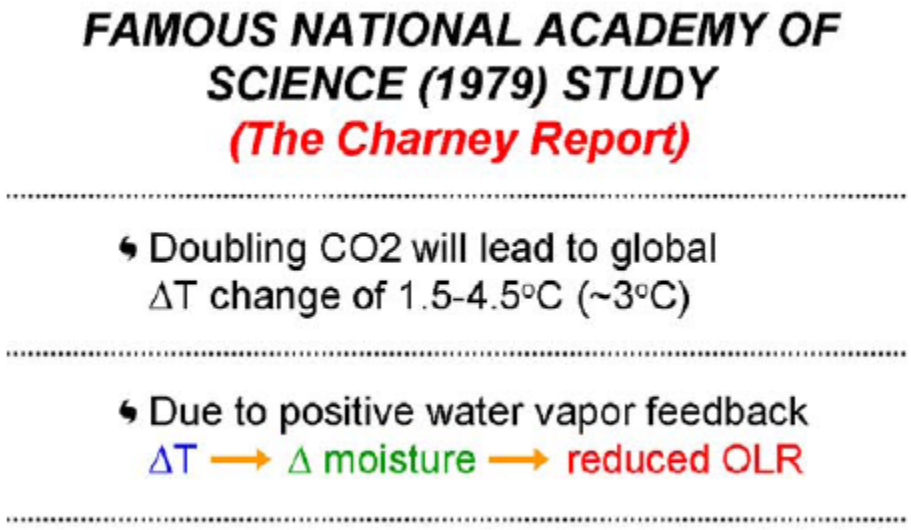


Figure 7. The very influential NAS report of 1979 which deduced that any warming of the globe would occur with near constant relative humidity (RH). Global warming consequently is thought to cause an increase in atmospheric water vapor (q) and a decrease in OLR. This assumption appears valid in the lower troposphere but not for the upper troposphere. Although temperature increase may cause precipitable water to increase in the troposphere, it does not mean that upper tropospheric water vapor will necessarily increase.

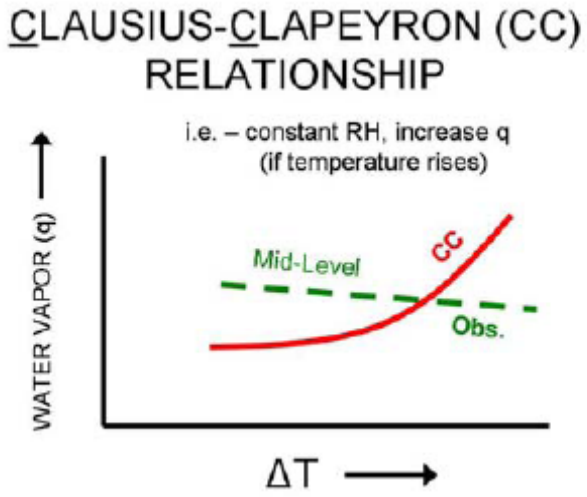


Figure 8. Clausius-Clapeyron (CC) relationship showing the required increase of water vapor as temperature increases at constant RH – red line. The observations of upper tropospheric water vapor – green dashed line – do not follow this theoretical relationship.

This is likely a result of a warmer climate causing more deep convection and more return flow subsidence (as shown in Figure 2).

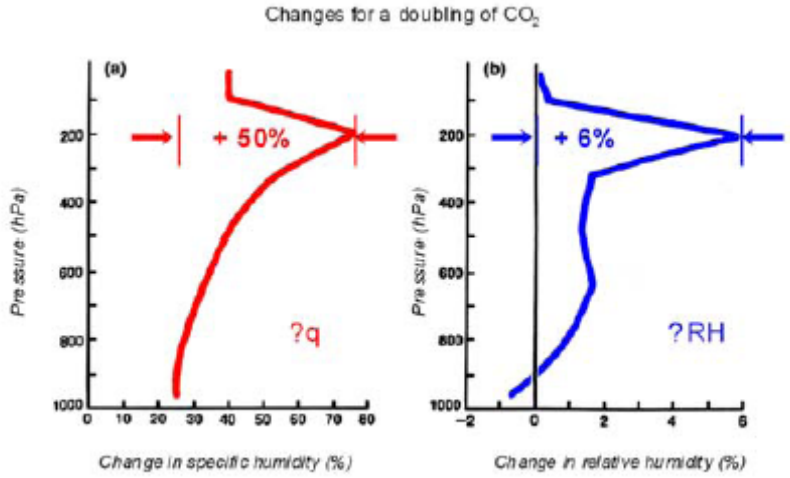


Figure 9. James Hansen's early GISS model showing his assumed increases in specific humidity (q) and RH for a doubling of CO2. Such water vapor assumptions are completely unrealistic, especially for conditions in the upper troposphere where water vapor typically increases less.

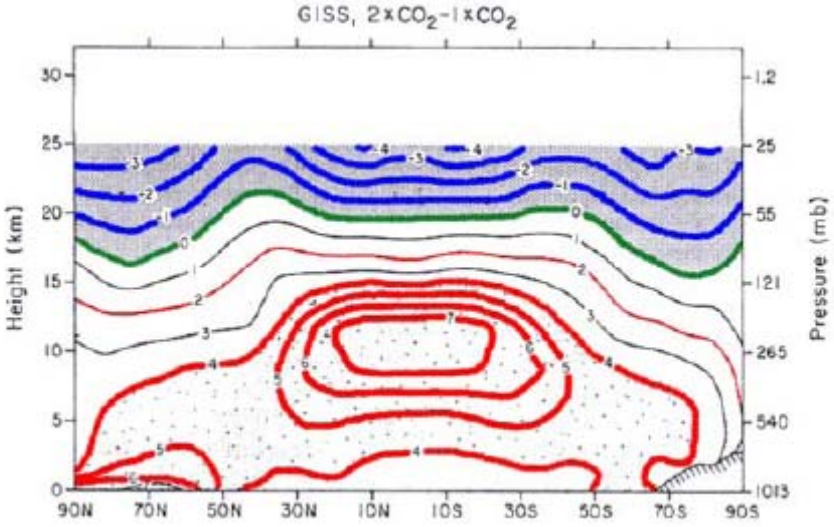


Figure 10. North-South vertical-cross section showing Hansen's early GCM's model change in temperature (oC) that would accompany a doubling of atmospheric CO2. There is no way a doubling of CO2 and an extra 3.7 W/m2 blockage of OLR to space could lead to such extreme upper tropospheric temperature rises. These large temperature increases occurred because of Hansen's unrealistic upper level water vapor assumptions.

In order to obtain the global balance of incoming and outgoing radiation for his assumed high values of upper tropospheric water vapor it was necessary for Hansen to unrealistically raise his model's upper tropospheric temperatures to obtain the amounts of OLR (or óT4) to space that would accomplish net radiation balance. It is amazing that Hansen's high water vapor increase and massively high upper tropospheric temperature rise assumptions for a doubling of CO2 were not immediately challenged.

It was these large amounts of warming resulting from his model's gross over-estimate of water vapor which Hansen presented to a US Senate Committee hearing at the request of then Senator Al Gore during the hot summer of 1988. The media and much of the general public accepted it all. The environmentalists salivated. Hansen had secured his place in the sun. History will reverse such adulation when his warming predictions are inevitable proven to be wrong.

Not only have Hansen's extreme and unrealistically high values of upper tropospheric moisture and temperature changes (for a doubling of CO2) not been challenged, they were instead closely emulated by most of the other prominent early GCM groups of NOAA-GFDL (Figure 11), NCAR (Figure 12) and the British Met Service (Figure 13). They all followed suit and incorporated unrealistically high amounts of upper tropospheric water vapor and, as a result, obtained unrealistically high values of global upper and surface temperature just as Hansen had. The fact that most of the (assumed independent) GCMs produced similar warming results were used as verification of each model's results. But this was untrue. All the modelers were wrong in the same direction and in the same way.

Although the more recent GCM runs of Hansen's GISS model and the more recent, GFDL, NCAR and UKMET models have been improved, they are still fundamentally flawed. I expect the current set of GCM modelers will say I am referring to older model runs that are now obsolete. This argument does not hold however. If the more recent year models are superior to the older ones, then we would be seeing a revision downward of their warming estimates. But their newer models give much the same magnitude of warming as their older ones.

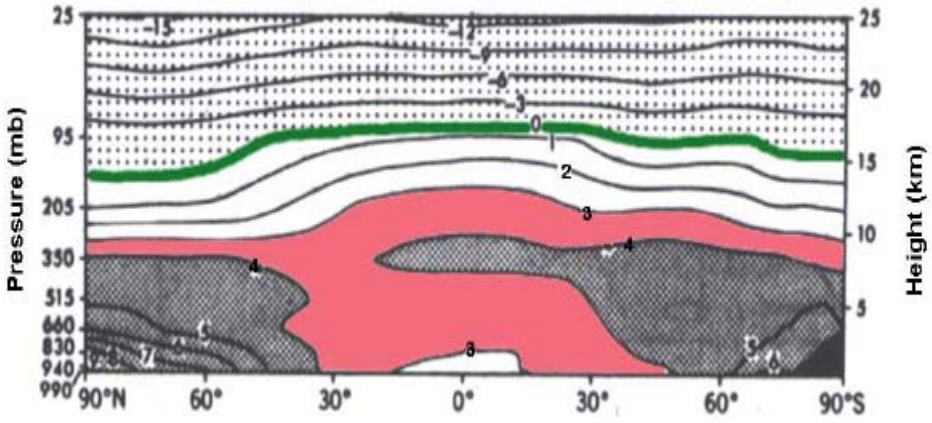


Figure 11. Same as Figure 10 but for the NOAA-GFDL GCM.

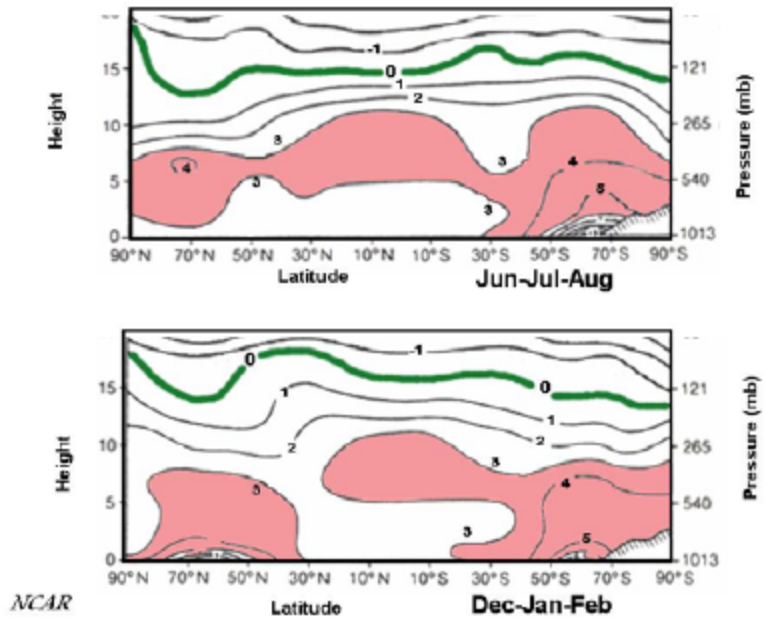


Figure 12. Same as Figure 10 but for the NCAR's GCM.

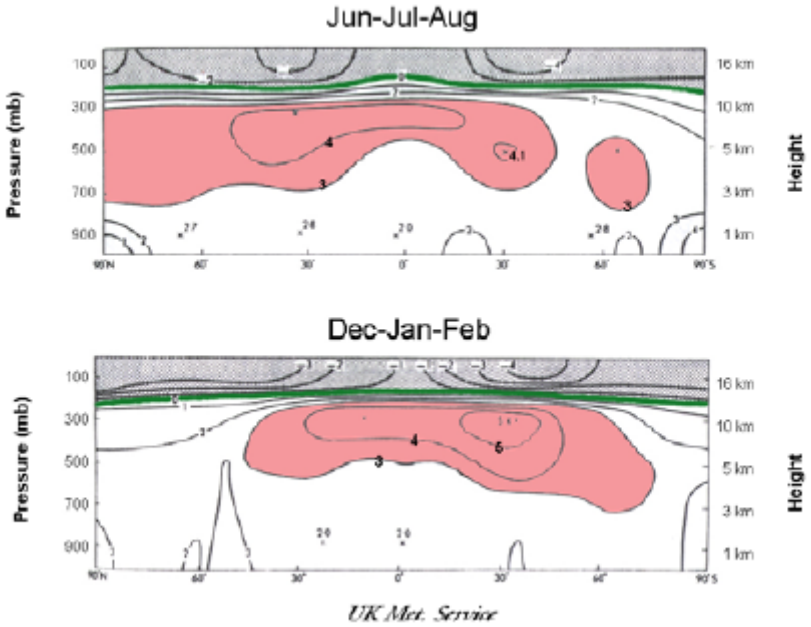


Figure 13. Same as Figure 10 but for the UKMET GCM.

3. IMPOSSIBILITY OF SKILLFUL GCM CLIMATE PREDICTION

Skillful initial-value numerical weather forecasts currently cannot be made for more than about two weeks into the future. This is because 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 integration of longer than a week or two. Skillful short-range prediction is possible because there tends to be conservation in the initial value momentum-pressure fields which can be skillfully

> extrapolated or advected for a week or two into the future. But after 1-2 weeks, one must deal with the far more complex variation of the moisture and energy fields. Model results soon decay into chaos.
>
> If skillful GCM forecasts were possible for a longer period of a season to a few years, we would be eager to track their skill. Currently, GCMs do not make official seasonal or annual forecasts. They dare not issue these forecasts because they know they are not skillful and would quickly lose their credibility if they gave real time forecasts that could actually be verified. 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?
>
> [End of quotation from Gray paper]

A major cause for concern with regard to the Enhanced Greenhouse Effect espoused by the IPCC is that a crucial implied assumption may not be valid based on real world data. The IPCC models imply that global relative humidity is a constant as a result of various assumptions about evaporation and participation. This appears not to be the case, however, as shown in the following graph. Stockwell (2008) provides a discussion of the pros and cons for EGE and concludes that it is doubtful. Ref: http://landshape.org/enm/greenhouse-thermodynamics-and-gcms/

Gregory and others say that the IPCC models all assume that global relative humidity is a constant.[2] We note that this assumption would appear to imply their result since increases in temperature increase the amount of water vapor that the atmosphere can hold. This in turn results in an increased GHG warming effect, and so on and on, just as the IPCC concluded. Gregory puts it this way:

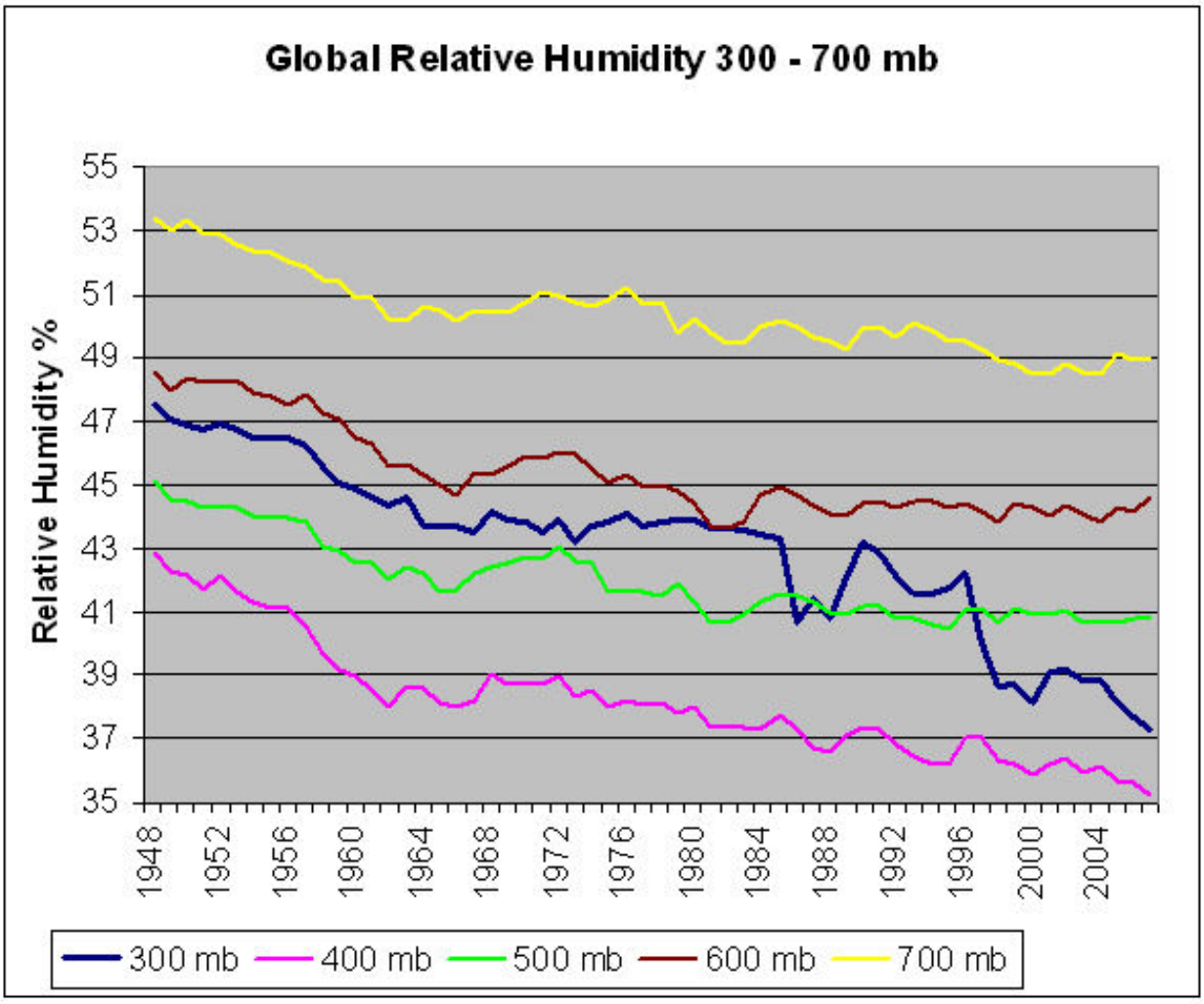
> There is no physics in support of this assumption, and no way to calculate its value from first principles. This assumption means that if temperatures increase for any reason, the amount of water vapour in the atmosphere increases. But water vapor is the most important greenhouse gas, so the GHE becomes stronger and temperatures increase more. The current theory does not determine this -- it is only an assumption. If this assumption is only slightly wrong, it

[2] Gregory has expanded on the issue of what constitutes constant relative humidity as follow: "Yes, I agree. I don't mean to suggest someone types in relative humidity = constant into the computer code. I said in my write-up 'Relative humidity = constant (or various parameters to achieve the same effect.)' Is this O.K?
"They model evaporation and precipitation to achieve an almost constant relative humidity. This is based on short term observations of temperature changes. During these observations CO_2 concentrations are approximately constant, so these observations only hold true over periods when CO_2 does not change much. It is invalid to extrapolate these observations to long term periods with increasing CO_2. Comments by Ken Gregory — June 21, 2008 @ 4:04 am

completely changes the expected response of increasing CO_2 because water vapour is such a dominant greenhouse gas.

So if this arbitrary assumption does not hold, then there is no positive feedback effect. If accurate, the chart below appears to support the anti-AGW case.

One recent alternative to the IPCC's approach is a new theory proposed by Miskolczi (2007). Whether it is correct or not is not yet known, but it does offer the advantage that it may explain several observed atmospheric observations better than the models relied on by the IPCC. Gregory (2008) argues that the IPCC approach violates energy conservation laws. He argues that the new theory shows that the application of these laws requires that the atmosphere maintain a "saturated" greenhouse effect controlled by water vapor content (ie, any "excess" of GHGs gets "rained out"). As a result any increase in other GHGs (like CO_2) results in a decrease in water vapor, the main GHG. Gregory concludes that *"almost all of the global warming of the last century must have been due to changes of the Sun or albedo."* The following chart shows that global relative humidity has indeed been falling for 60 years, particularly at the higher (blue) altitudes which he believes are the most relevant.



Source: Gregory (2008), citing NOAA at http://www.cdc.noaa.gov/cgi-bin/Timeseries/timeseries1.pl

The Miskolczi theory argues that the IPCC approach violates energy conservation laws. Global relative humidity is controlled by the laws of physics, not IPCC's arbitrary assumption that it is a constant, which is NOT the case over the last 60 years.

Implications of New Theory

According to Ken Gregory (June, 2008) "The long wave upward radiation from the surface is limited to 1.5 times the short wave downward radiation from the Sun.

"This limits the temperature to very close to the current temperature.

"Therefore, almost all of the global warming of the last century must have been due to changes of the Sun or albedo." –Ken Gregory, June, 2008

What all of this argues is that there is considerable doubt as to the validity of the IPCC GCM models because they do not correspond with observational data in a very important aspect. Since these models are the principal underpinning for the IPCC conclusions, and therefore the Draft TSD, it is vital that these doubts and uncertainties be carefully explained in the TSD so that readers understand these issues which directly affect the proposed finding of endangerment.

1.8 Scafetta and West: GHG Contribution to Global Warming May Be Much Smaller than Alleged by IPCC

As noted below in Section 2.4, solar variability (including sunspots) has attracted the attention of scientists for many centuries. Until the last couple decades, many scientists appear to have recognized the importance of the changes in the sun as a substantial contributor to changes in the climate. ("Changing Sun, Changing Climate," AIP, available at http://www.aip.org/history/climate/solar.htm)

With the advent of satellite-based instrumentation beginning in the late 1970s which measured on the sun's energy output (Total Solar Irradiance, or TSI in watts/square-meter), researchers were now able tract with substantial accuracy and precision the energy reaching the top of the earth's atmosphere.

The IPCC (2007) report examined all of the satellite data and found that the amplitude of the sun's TSI varied by only about 0.1% based with no apparent secular trend using an analysis that combined the data from several satellites. The analysis was complicated by a critical gap in the high-quality data that occurred from mid-1989 to 1991.75. The IPCC report based its conclusion of no secular trend in the data by adjusting the data based on a particular TSI proxy model that was believed to provide the best overall fit while bridging the so-called ACRIM-gap by using lower-quality data from other satellites. This way of constructing the TSI data has been challenged. If the alternative TSI reconstruction is used, it is suggested that the Sun could account for as much as 69 % of the increase in the Earths average temperature (Scafetta & West (2008).

The possibility that IPCC (2007) has erred in its attribution of most of the relatively recent gobal warming to GHG increased with the publication of the Scafetta and Wilson (2009). This paper concludes that reconstruction of the solar TSI used by the IPCC appears to have been seriously flawed. This suggests that a secular increase in the sun's TSI may actually be

responsible for a substantial part of the global temperature increase attributed to GHGs. This matter deserves additional review by other researchers and solar specialists.[3] If this peer-reviewed analysis is correct, then the sun "could account for as much as 69% percent of the increase in the Earth's average temperature, depending on the TSI reconstruction used" (see Scafetta & West, 2008).

Until this new paper was published, one might have dismissed the above view by arguing it appears to be based on an erroneous reconstruction of the TSI. However, now the burden of proof seems to have switched to those scientists that continue to support the IPCC (2007) conclusions on solar variability.

[3] A detailed slide set in pdf with extensive references and the 2/26/2009 climate science seminar video by Dr. Nicola Scafetta is available at: http://www.epa.gov/economics/

2. Some Major Inconsistencies in the Science of Global Warming that at Least Need to be Explained

In addition to the more recent inconsistencies discussed in Section 1 above, there are a number of others of somewhat longer standing that at least need to be discussed in the draft TSD in our view. They are so serious, however, that we believe that there is a need to change the conclusions of the draft TSD. For a more complete list of inconsistencies that others have found see Gregory (2009) and Singer (2008). Gregory's list has approximately 30 items, few of which are addressed in the draft TSD. Although these lists themselves have not been peer-reviewed, many of the references have been. All these inconsistencies are included in these comments by reference. This includes the important missing heating of the upper troposphere in the tropics, which is discussed below in Section 2.9 and briefly mentioned in the Draft TSD. These lists and the references they cite, unless carefully and successfully answered in the draft TSD, largely eliminate the GHG hypothesis as a serious contender for explaining a significant part of the global warming that has occurred. This leaves the most fundamental issue as to what does cause global temperature fluctuations. It is possible that a chaotic system such as climate varies with little rhyme or reason, of course, but curiously there appear to be a few regularities in the data. Failure to consider a number of other factors beyond those that the IPCC and the Draft TSD consider makes the draft TSD one-sided and unscientific in its discussion since it appears to pre-suppose the answer and the answer does not explain the observed fluctuations in global temperatures. Until the causes are clearly understood most any control effort (except stratospheric geoengineering—see Carlin, 2007 and 2008) is likely doomed to failure. It is only by taking a new and fundamental look at this question that a meaningful understanding of the endangerment can be reached. Although the hour may be late, it is only by doing so that an accurate endangerment TSD can be prepared.

2.1 What Is Science?

The first question is what science is. Science as used in these comments is the process of generating hypotheses and experimentally determining their validity by comparison with real world data—in other words, the application of the scientific method. We do not believe that science is writing a description of the world or the opinions of world authorities on a particular subject, or the number of scientists who agree on a particular issue. Science, we believe, is also

not a statement of belief by scientific organizations. The question in our view is not what someone or some group believes but how what they believe corresponds to real world data. It is important to note that science evolves over time as new discoveries are made and new hypotheses are formulated and discarded. There is no such thing as permanent or settled science. Only continuing research can insure that important relationships are taken into account. Richard Feynman (1965) expressed this as follows:

> In general, we look for a new law by the following process. First, we guess it. Then we compute the consequences of the guess to see what would be implied if this law that we guessed is right. Then we compare the result of the computation to nature, with experiment or experience; compare it directly with observation to see if it works. If it disagrees with experiment it is wrong. It's that simple statement that is the key to science. It does not make any difference how beautiful your guess is. It does not make any difference how smart you are, who made the guess, or what his name is---if it disagrees with experiment (observation) it is wrong.

Fundamental to the science of global warming and of climate change is what determines the evident changes in global temperatures over time. Until this is firmly understood any attempt to determine the effects of particular changes in the climate environment such as increases in ambient GHG levels on temperatures or human health and welfare is extremely risky since it runs the risk of being incorrect, with the result that any alleged endangerment may prove to be incorrect along with any actions that may be taken under the Clean Air Act as well.

2.2 What Determines Changes in Global Temperatures?

Global temperatures have long fluctuated both in the short and long term. Until we clearly understand these fluctuations it is not possible to make any meaningful conclusions as to the cause of either global warming. Numerous hypotheses have been offered, but they all cannot be correct since they differ greatly. One clue may be that there appears to be considerable cyclicality in temperatures over time; here is a brief synopsis of some of what we believe is known in terms of the length of the cycles involved:

Over 150 million year periods: There appears to have been a distinct approximately 150 million year cycle in Earth's temperatures. One explanation that has been offered is the change

in level of galactic cosmic rays resulting from the Solar System's movements above and below the galactic plain resulting in higher cosmic ray levels when it is not in the plain (see Figure 2-10).

Over 100,000 year periods: For the last 3 million years or so the Earth has gone through a succession of ice ages interspersed with relatively brief interglacial periods such as the one we are now in (called the Holocene). In the early part of this period they averaged about 40,000 years each but more recently they have averaged about 100,000 years in length. Global temperatures are believed to have been 5 to 10^{o}C less during ice ages than during interglacial periods. Various hypotheses have been proposed to explain this but the predominant view appears to be that it is due to changes in the Earth's orbit which change the intensity of the sun's radiation reaching the Earth (the so-called Malenkovitch cycles). One problem with this explanation is that it does not explain the shift from 40,000 years to 100,000 year cycles. What appears evident, however, is that Earth's climate is unstable on the downside during the interglacial periods and unstable on the upside during ice ages. There appears to be something which has prevented the Earth from getting even colder than it has during ice ages or warming more than it has during interglacial periods. It is far from clear what these somethings are, but this asymmetry appears to have existed for at least 3 million years.

Over 1500 year (or so) periods: The Earth has had repeated cooler and warmer periods during the current interglacial (Holocene) period as shown One view of global temperatures during the Holocene is shown in Figure 2-1.

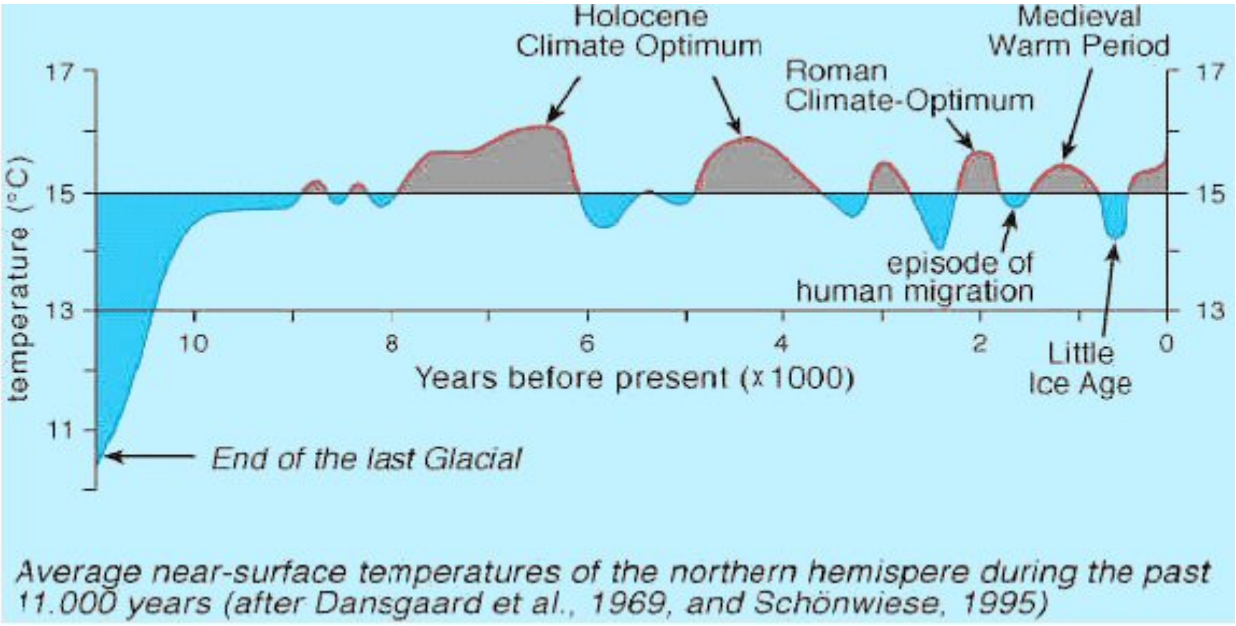


Figure 2-1: One View of Temperature Variation during the Holocene

Source: Gregory (2008)

This graph comes from a skeptic and may or may not accurately represent temperatures during this approximately 10,000 year period. The important thing is not its accuracy but rather that there appear to have been many temperature variations of roughly one ^{o}C on either side of 15^{o}C throughout this long period.

The last previous very warm period is known as the Medieval Warm Period and extended from about 800 to 1200 AD. The last very cold period was known as the Little Ice Age and extended from roughly 1450 to the early 1800s. This was followed by the current warm period, particularly in the last quarter of the 20th Century. The total variation appears to have been about +/- 2^{o}C according to this particular graph. The cause for some or all of these variations may be variations in solar radiation or other causes. It is clearly not related to levels of human-caused carbon dioxide until very recently since humans had little to do with such emissions during most of this period. It is known that sunspots were either absent or very few during the depths of the Little Ice Age (the so-called Dalton and the more serious Maunder minimums), however, which suggests that the solar variations may be related to at least these longer term variations.

Over about 60 year periods: In the last 120 years or more there has been a clear variation in global temperatures with roughly alternating warming and cooling periods each lasting about 30 years for a cycle length of about 60 years total. During this period, there is a fairly clear pattern of trends either up or down lasting about 30 years (see Figure 2-3). In a 30 year time-frame the trends, once started, appear to be remarkably uniform. The reasons for this cycle are not widely agreed on, but any attempt to explain global temperatures needs to explain these observations if it is to be credible. One strong possibility is oscillations in sea surface temperatures since changes in the direction of global temperatures seem to have a remarkable coincidence with at least some of these oscillations. Perhaps the most important of these cycles is the Pacific Decadal Oscillation (PDO), although others such as the Atlantic Multidecadal Oscillation (AMO) have been identified in other major oceanic areas. The PDO is a long-lived El Niño/La Niña-like pattern that is observed in the sea-surface temperatures (SST) of the Northern and Central Pacific Ocean. Positive (/negative) phases of the PDO are typified by warmer (/cooler) than normal temperatures in the North-eastern and a Tropical Pacific Ocean and cooler (/warmer) than normal temperatures in the region to the south-west of the Aleutian Islands (see Figure 2-2). It is important to note that while the El Niño/La Niña oscillation varies on a time scale of 4 – 5 years, the PDO variations are governed by a time scale that is much longer. The immediate point here is that both the PDO and global temperatures have recently turned negative in the last few years. Similarly, both turned positive in the 1970s. The reasons for this are speculative at best, but the correlation appears to be overwhelming for the period for which we have much data. One possibility is variations in solar output, but much more complicated hypotheses have been proposed (see, for example, Wilson, 2008). It is worth noting, however, that human concerns about climate change appear to have followed these PDO variations quite closely with concerns about global cooling and a possible new ice age near the end of the last PDO cooling period in the 1970s and concern about global warming in the 1990s and 2000s.

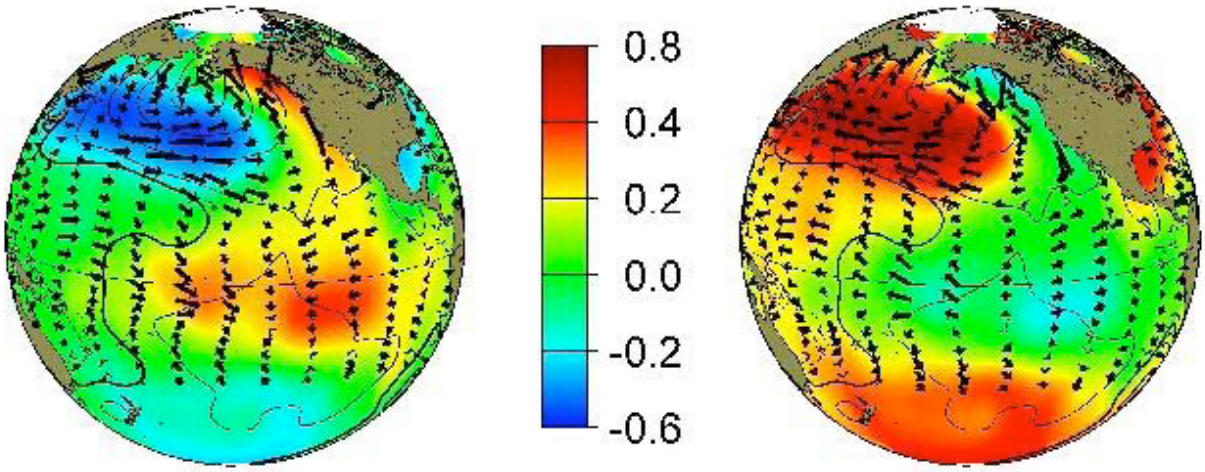


Figure 2-2: Pacific Ocean Water Temperatures during a positive and negative PDOs

Source: Wilson (2008), p. 23

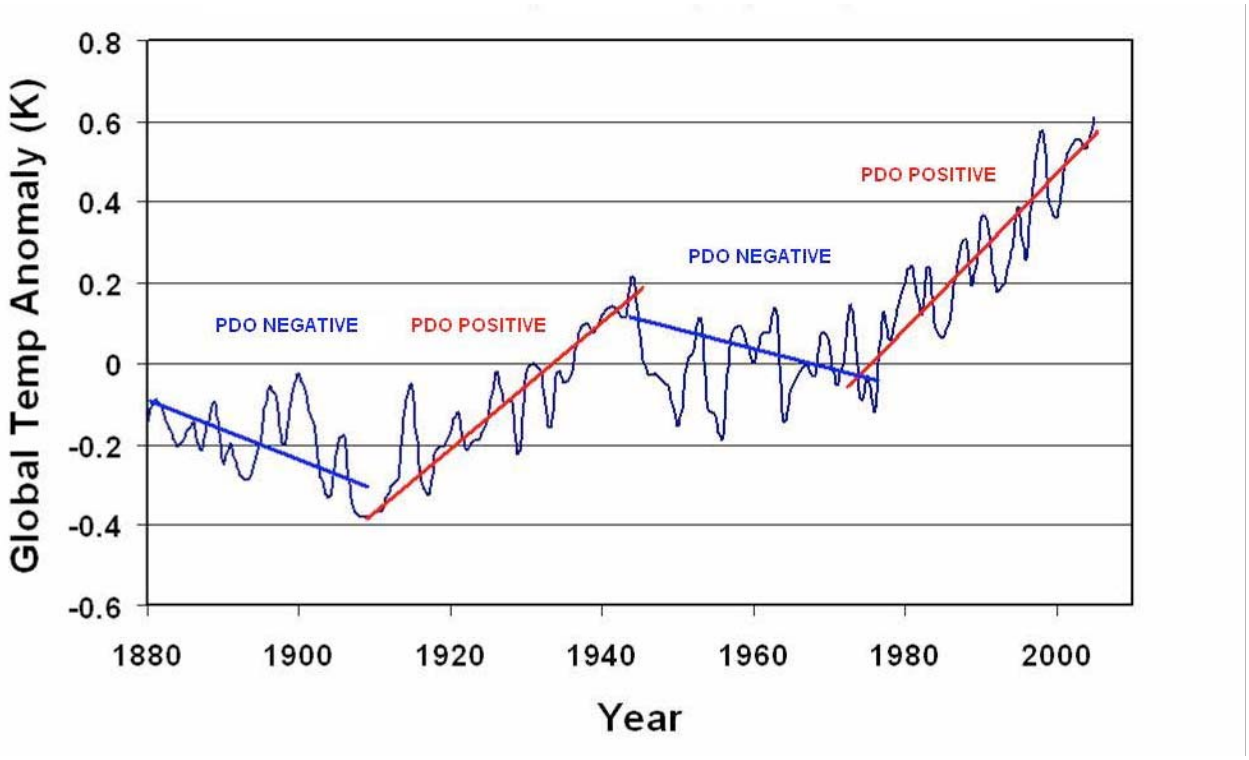


Figure 2-3: Sixty-year Cycle in Global Temperatures Showing Clear Trends

Over 3-5 year periods: There also appear to be a much shorter-term cycle and influences on global temperatures due to El Nino/LaNina (ENSO) oscillations and volcanic eruptions and perhaps other factors. These cycles are clearly evident in both the satellite (see Figure 2-7) and

the ground data. There may be some argument as to their cause, but the evident similarity of these short-term cycles to the ENSO cycle is hard to ignore (see again Figure 2-7).

The climate is believed to be chaotic in nature and substantial year-to-year variations can be expected and have been observed. The surprising thing is actually how well ordered all these cycles actually seem to have been in terms of the available global temperature data.

Against this very complicated set of cycles and other factors that appear to influence global temperatures, those concerned about global warming in the 1990s and 2000s have put forth the hypothesis that the global warming since the 1970s has been due to increases in the global levels of carbon dioxide and other GHGs, and that these levels are a result of human-caused emissions of this compound. There is considerable evidence that increased levels of carbon dioxide may lead to higher global temperatures all things being equal. But are these increases the predominant reason? To explore this topic it is vital to see how well the increases in CO_2 relate to increases in temperature. This is what we will do in the next subsection.

2.3 Evidence for a Predominant Influence of Carbon Dioxide

A useful task is to explain these variations since that may provide clues as to what is influencing our current and future climate, and therefore what might be effective in reducing these fluctuations if that should be desired. Figure 2-4 shows global surface temperatures and CO_2 levels for the period 1880 to 2003. Hypotheses concerning the causation of temperature changes should be rejected if they do not explain at least recent satellite temperature history which appears to be the best available data, and should be replaced by alternative hypotheses that provide at least the possibility of offering such an explanation. Table 2-1 provides a comparison between the correlations between several factors and global surface temperature data over the last hundred years or so. Although this is a somewhat simplistic approach it suggests what the most important factors are in the order of their significance:

1. Ocean warming index (PDO and AMO)

2. Total solar irradiance

3. Carbon dioxide

4. Carbon dioxide last decade

CO2 will be discussed in this section, solar variability in Section 2.5, and ocean oscillations in Section 2.5.

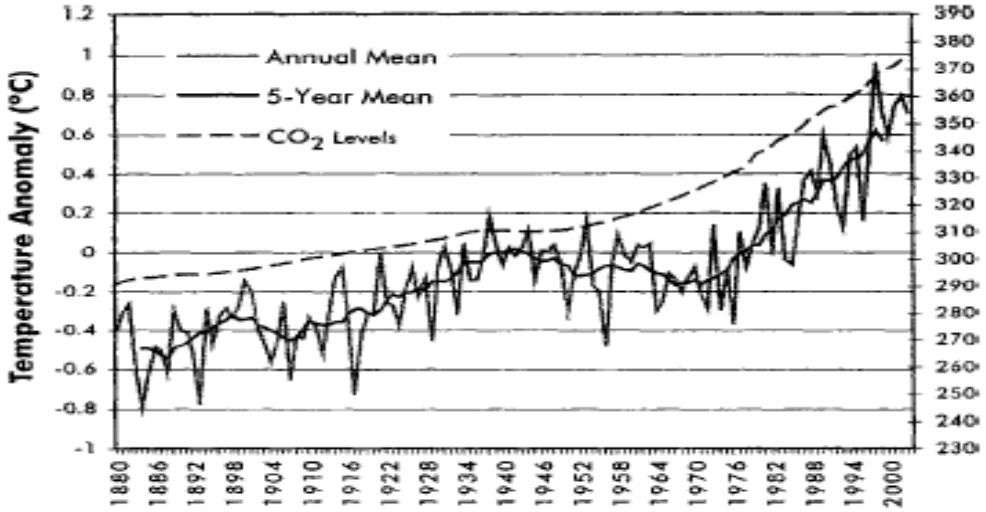


Fig. 4. Global temperature (left scale) from ground stations vs. CO_2 concentration in ppm in atmosphere (right scale) from 1880–2003. Available at: www.GISS.NASA.gov. Accessed 2003.

Figure 2-4: Global Temperatures and CO_2 Levels, 1880-2003

Factor	Years	Correlation (Pearson Coefficient)	Correlation Strength (R-squared)
Carbon Dioxide	1895-2007	0.66	0.43
Total Solar Irradiance	1900-2004	0.76	0.57
Ocean Warming Index (PDO & AMO)	1900-2007	0.92	0.85
Carbon Dioxide Last Decade	1998-2007	-0.14	0.02

Table 2-1: Correlation between Global Temperatures and Various Single Explanatory Factors

Source: d'Aleo (2008)

The problems become particularly evident when one examines the downtrend period from roughly 1940 through the early 1970s, shown in Figure 2-4, and that for the 2000s, shown in Figure 2-6. For both of these periods, there does not appear to be any relationship between CO_2 levels and global temperatures. Without fully understanding these relationships, or the lack thereof, it is difficult to understand the possible causes of these climate changes on the basis of the GHG/CO2 hypothesis:

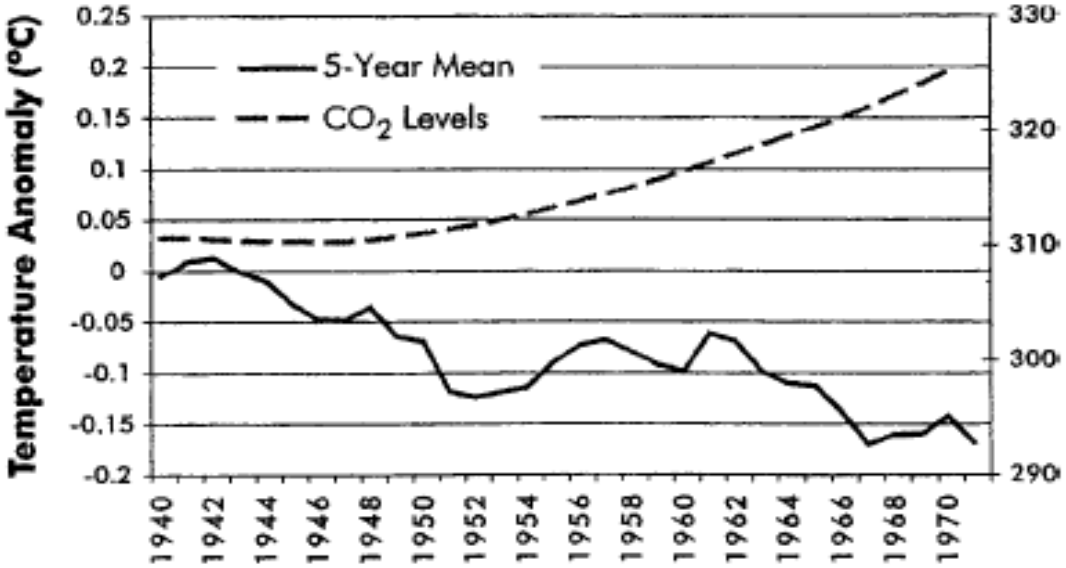


Fig. 1. Global temperature (left scale) from ground stations vs. CO_2 concentration in ppm in atmosphere (right scale) from 1940–1970. Available at: GISS.NASA.gov. Accessed 2003.

Figure 2-5: Global Surface Temperature Anomaly and CO_2 Levels, 1940-70[4]

[4] Based on GISS data and reproduced from Joel M. Kauffman, "Climate Change Reexamined," *Journal of Scientific Exploration*, Vol. 21, No. 4, pp. 723–749, 2007.

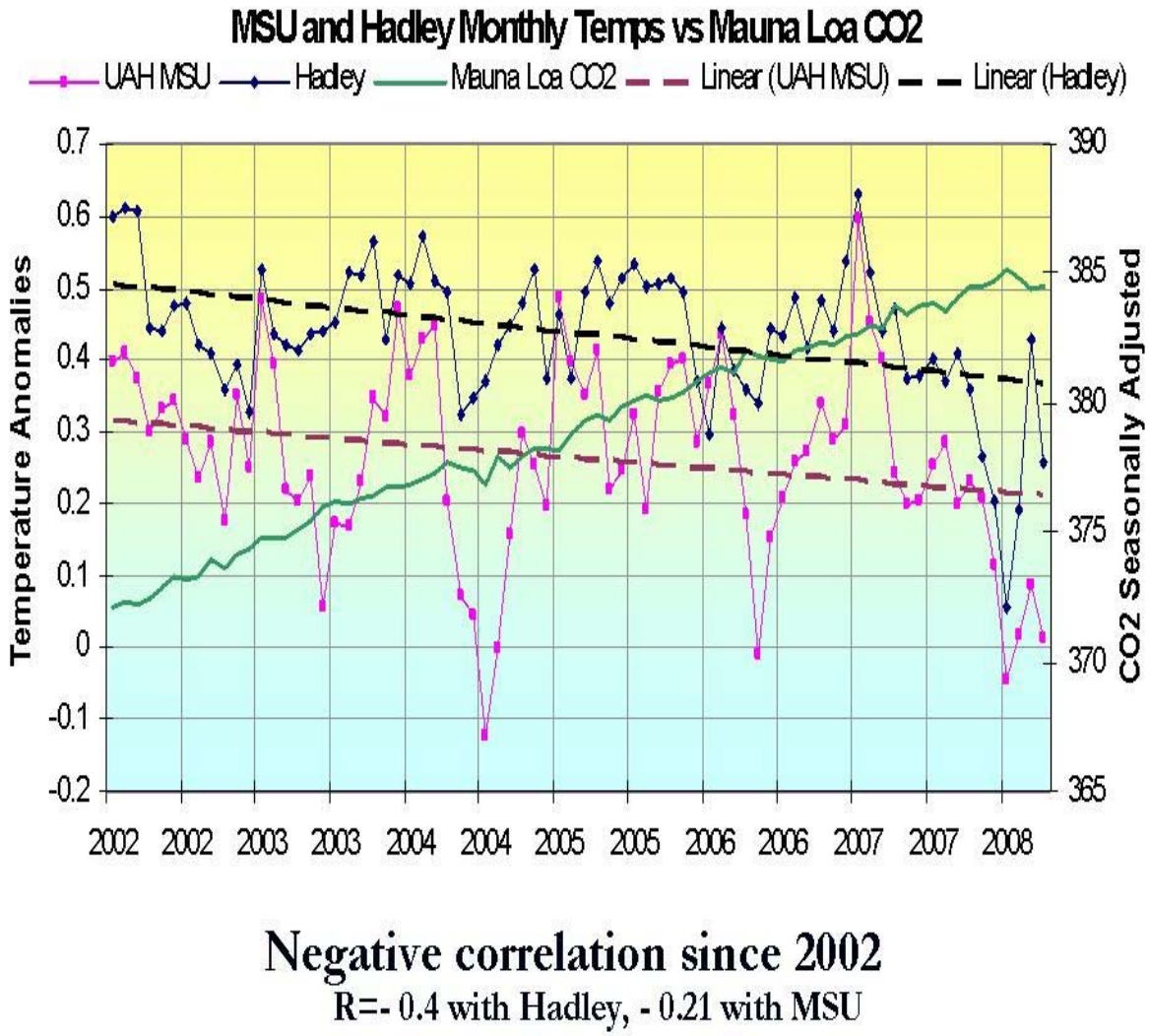


Figure 2-6: Global Temperature Anomalies and CO_2, 2002-8

Source?

It is very clear that the strongest correlation is between the ocean warming index (PDO + AMO) and temperature; the next strongest is with TSI, and the weakest is with CO_2. In fact, CO_2 alone has no explanatory power over the last decade according to this analysis.

It appears that over the last 130 years ambient CO_2 levels are believed by GISS to have risen whether or not global temperatures have risen with the exception of the early 1940s when they either plateaued or fell slightly. If as hypothesized by the IPCC and Draft TSD global

temperatures are primarily a function of CO_2 levels it is very difficult to understand why temperatures fell from 1940 to 1975 and after 1998 at the same time that CO_2 levels were increasing since there were no major volcanic eruption during either of these periods. The CO_2 hypothesis does allow for the possibility of large volcanic eruptions, which cool the planet, but this does not appear to explain these two downturns in global temperatures. One possibility is that there may be other important factors at work determining global temperatures besides CO_2 levels.

2.4 Pacific Decadal Oscillation/Atlantic Multidecadal Oscillation and ENSO as Explanations for Global Temperature Changes

Perhaps the closest simple "explanation" for the observed changes in global temperatures is provided by the PDO and/or AMO together with ENSO In fact, major changes in the PDO from positive to negative and back appear to coincide almost exactly with observed changes in global temperature trends over 20-30 year timeframes, as shown in Figure 2-2. Since this chart was prepared the temperature trend has been negative and the PDO has also gone negative.

[5] Don Easterbrook (2008) reaches the following conclusions:

> The IPCC prediction of global temperatures, 1° F warmer by 2011 and 2° F by 2038 (Fig. 1), stand little chance of being correct. NASA's imagery showing that the Pacific Decadal Oscillation (PDO) has shifted to its cool phase is right on schedule as predicted by past climate and PDO changes (Easterbrook, 2001, 2006, 2007). The PDO typically lasts 25-30 years and assures North America of cool, wetter climates during its cool phases and warmer, drier climates during its warm phases. The establishment of the cool PDO, together with similar cooling of the North Atlantic Oscillation (NAO), virtually assures several decades of global cooling and the end of the past 30-year warm phase. It also means that the IPCC predictions of catastrophic global warming this century were highly inaccurate.
>
> The switch of PDO cool mode to warm mode in 1977 initiated several decades of global warming. The PDO has now switched from its warm mode (where it had been since 1977) into its cool mode. As shown on the graph above, each time this had happened in the past century, global temperature has followed. The upper map shows cool ocean temperatures in

[5] Watts blog

blue (note the North American west coast). The lower diagram shows how the PDO has switched back and forth from warm to cool modes in the past century, each time causing global temperature to follow. Comparisons of historic global climate warming and cooling over the past century with PDO and NAO oscillations, glacial fluctuations, and sun spot activity show strong correlations and provide a solid data base for future climate change projections.

The Pacific Ocean has a warm temperature mode and a cool temperature mode, and in the past century, has switched back forth between these two modes every 25-30 years (known as the Pacific Decadal Oscillation or PDO). In 1977 the Pacific abruptly shifted from its cool mode (where it had been since about 1945) into its warm mode, and this initiated global warming from 1977 to 1998. The correlation between the PDO and global climate is well established. The announcement by NASA's Jet Propulsion Laboratory that the Pacific Decadal Oscillation (PDO) had shifted to its cool phase is right on schedule as predicted by past climate and PDO changes (Easterbrook, 2001, 2006, 2007). The PDO typically lasts 25-30 years and assures North America of cool, wetter climates during its cool phases and warmer, drier climates during its warm phases. The establishment of the cool PDO, together with similar cooling of the North Atlantic Oscillation (NAO), virtually assures several decades of global cooling and the end of the past 30-year warm phase.

Comparisons of historic global climate warming and cooling over the past century with PDO and NAO oscillations, glacial fluctuations, and sun spot activity show strong correlations and provide a solid data base for future climate change projections. As shown by the historic pattern of GDOs and PDOs over the past century and by corresponding global warming and cooling, the pattern is part of ongoing warm/cool cycles that last 25-30 years. The global cooling phase from 1880 to 1910, characterized by advance of glaciers worldwide, was followed by a shift to the warm-phase PDO for 30 years, global warming and rapid glacier recession. The cool-phase PDO returned in ~1945 accompanied by global cooling and glacial advance for 30 years. Shift to the warm-phase PDO in 1977 initiated global warming and recession of glaciers that persisted until 1998. Recent establishment of the PDO cool phase appeared right on target and assuming that its effect will be similar to past history, global climates can be expected to cool over the next 25-30 years. The global warming of this century is exactly in phase with the normal climatic pattern of cyclic

warming and cooling and we have now switched from a warm phase to a cool phase right at the predicted time….

Just how much cooler the global climate will be during this cool cycle is uncertain. Recent solar changes suggest that it could be fairly severe, perhaps more like the 1880 to 1915 cool cycle than the more moderate 1945-1977 cool cycle. A more drastic cooling, similar to that during the Dalton and Maunder minimums, could plunge the Earth into another Little Ice Age, but only time will tell if that is likely.

One student of the subject (Ian Wilson, 2008) was so struck by the apparently strong relationship between the PDO and global temperatures that he has hypothesized a complicated explanation of global temperature changes and PDO changes involving length of year, planetary motions, and other factors. Whether or not his hypothesis is correct, the relationship between the PDO and global temperatures is so striking that it surely deserves much further research. Unfortunately, the IPCC reports do not consider or attempt to model PDO changes so this interesting possibility has not been explored by them. The Draft TSD needs to do so, however.

An interesting and important observation is that most of the shorter term variations in the satellite temperature data appear to be explained by the ENSO as can be seen in Figure 2-7 below which shows a surprising number of short term highs and lows marked as El Nino or La Nina. The PDO can be characterized as the envelope or larger, longer term ENSO. The effects of ENSO are illustrated in Figure 2-7 showing some of the widely acknowledged factors influencing temperatures at various times since 1978:

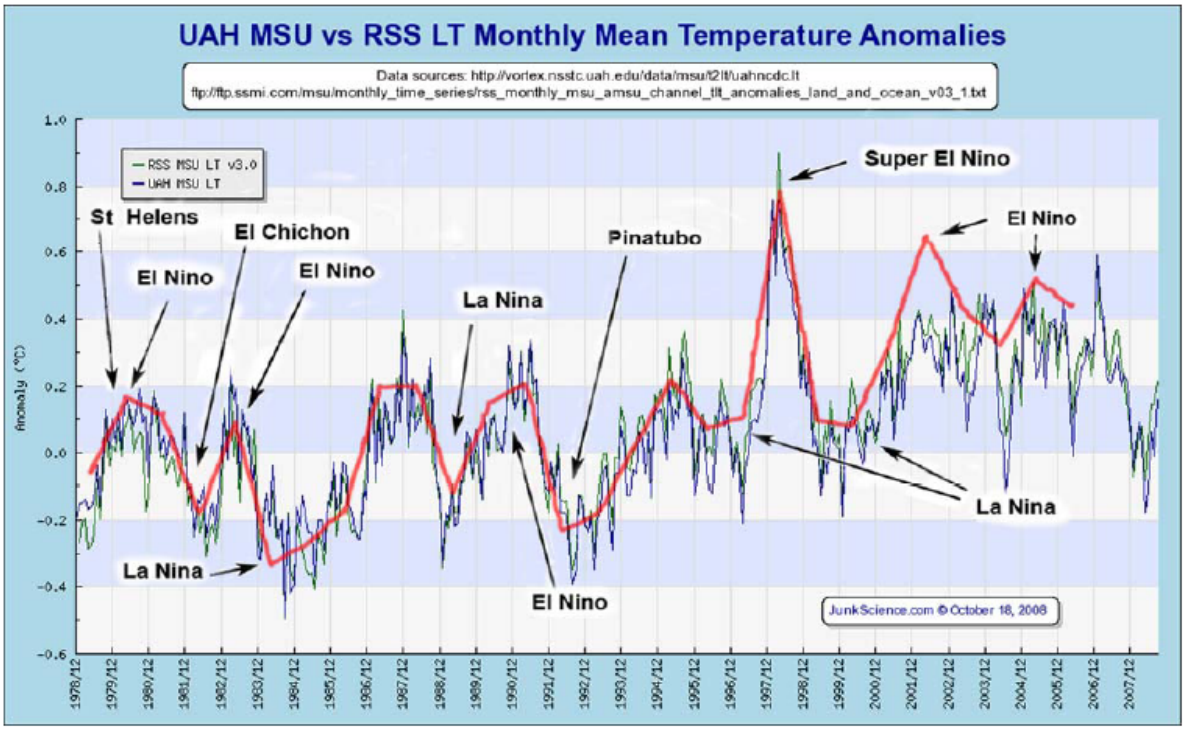


Figure 2-7: Common Identifications Made of Causes for Global Temperature Fluctuations

Source: Arrak (2009)

This graph is also very interesting in another respect. This is that if the data is examined without trying to draw a straight trend line from the beginning of the satellite data in 1978 until 1997 there is no indication that the data varies as a result of changes in GHGs. Rather the satellite data looks more like this:

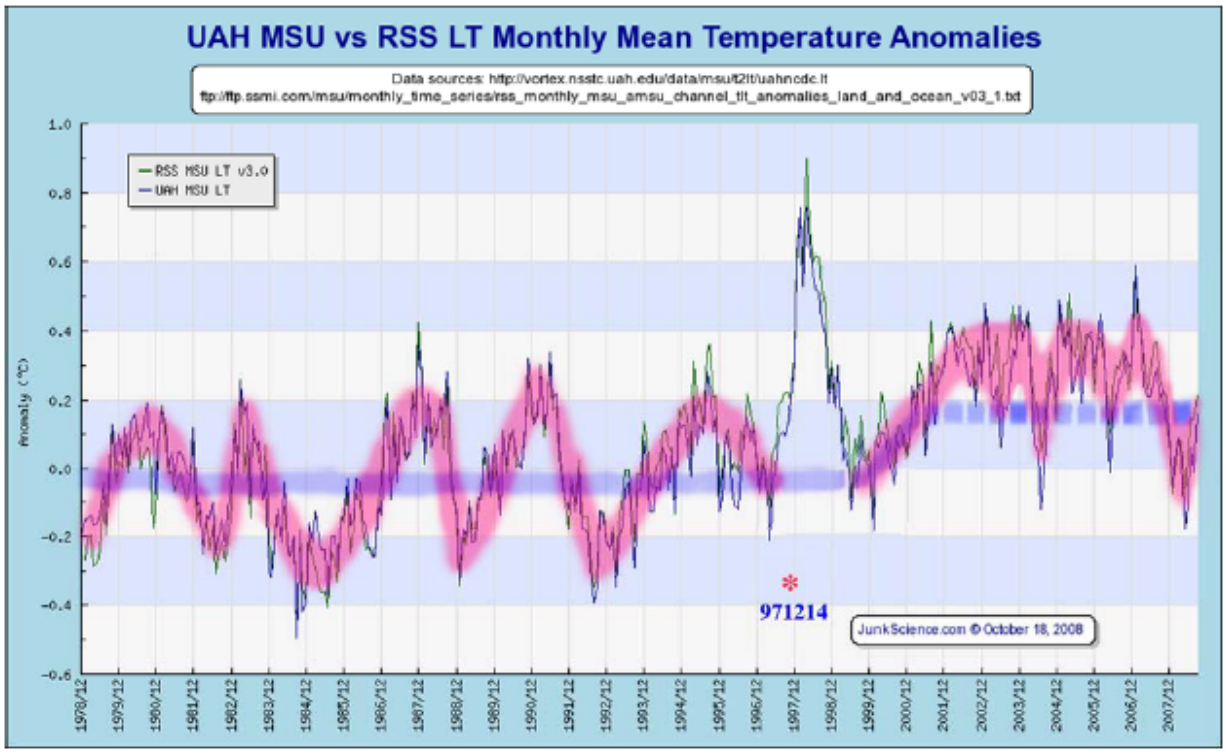


Figure 2-8: MSU Data with Addition of Center Lines

Source: Arrak (2009).

Drawing a straight trend line in many ways limits the options examined and even presupposes the GHG/CO2/AGW hypothesis. Much better is to utilize more of the data by trying to fit a more robust pattern to it. Ambient CO_2 levels were increasing throughout this 1978-97 period yet global temperatures remained in a narrow band with little apparent increase. Further, the sharp spike in temperatures in 1998 appears highly unlikely to have been caused by changes in GHG levels since they vary only very slowly rather than exhibiting the sharp spike seen here. The reason for the 1998 spike and its possible after effects in the 1999-2006 period are unknown but would seem very important to learn about before assuming that it is related to changes in GHGs.[6] Similarly, the period 1999 to 2006 shows another narrow but higher band of temperatures with no increase during the period. One possibility is that the elevated temperatures during this period were an after-effect of the sudden surge in 1998, perhaps caused by the sudden input of energy at that time. Finally, the period 2007-9 shows a strong downward trend in temperatures which is surely not related to steadily increasing GHG emissions and

[6] Arno Arrak has suggested the possibility that the 1998 spike was due to gamma ray burst 971214, but he emphasizes that this is only a possibility.

atmospheric levels. Thus it is very hard to see any effect during the period 1978 to 2009 that can reasonably ascribed to changing CO_2 or GHG levels. This is in marked contrast with ground level measurements such as the HADCRUT series, which show a marked increase in temperatures throughout the period until 1998 (but not thereafter). One possible explanation for this apparent inconsistency between the HADCRUT and MSU data is that ground level measurements may inevitably be compromised by the urban heat island effects, which presumably increased rapidly during the period due to rapid urbanization in many parts of the world.

2.5 Solar Variability

Prior to the advent of the IPCC and interest in the effects of increasing CO_2, the predominant view appears to have been that variations in global temperatures over periods less than 100,000 years were primarily due to solar variability since the Sun is Earth's major source of heat and light. A number of researchers have studied this over the years, and they have found some apparent relationships between sunspot cycles and global temperatures. Some (prominently Svensmark, 1998) have even developed a hypothesis to explain this apparent relationship. This hypothesis is roughly as follows:

Solar variability has been studied for at least 400 years. The general conclusion prior to 1990 was that the Sun is the major driver but there was little agreement as to the exact mechanism. But starting in 1990, the IPCC instead atttributed warming to GHGs/humans. In 1998, however, Svensmark suggested a mechanism for indirect solar variability effects. Now many or even most GW skeptics cite solar variability as the major cause and basis for their skepticism. In recent years there has been a furious debate/war on this issue. There has been some new research in recent years, however, some of which will be summarized in the following sections.

Predominant Views Prior to 1990

- "Earth's temperature often seems to correlate directly with solar activity: when this activity is high the Earth is warm"
- "During the famous 'Little Ice Age' during the 17th Century, the climate was notably cooler….This correlated with the Maunder Minimum on the sun, an interval of few sunspots and aurorae"

- "In the 11th and 12th centuries, a "Medieval Maximum" in solar activity corresponded to the "Medieval Optimum" in climate"
- "The 20th century has been marked by generally increasing levels of solar activity"—Hoyt and Schatten, 1997

Indirect Solar Variability May Be Major/Better Explanation than GHGs

Although Total Solar Irradiance (TSI) may not vary much, that does not rule out indirect effects of solar variability as the major cause of global climate changes. The impact of changes in solar eruptions, wind, and magnetic field may explain some or all known global climate changes during the Holocene together with volcanic eruptions. TSI even varies with sunspot cycles. Other researchers agree that solar variability may be related to temperature variations prior to mid-20th Century. Svensmark (1998) hypothesized that the Sun's magnetic field varies with sunspots and determines the number of cosmic rays available to stimulate low level clouds on Earth.

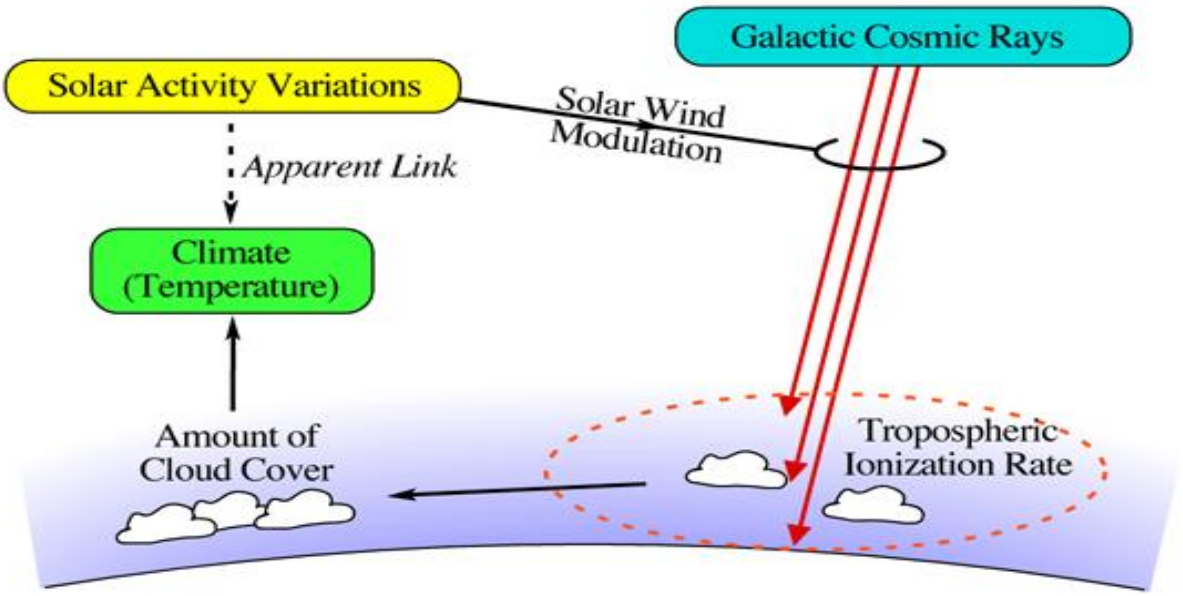


Figure 2-8 : One Interpretation of Svensmark Hypothesis[7]

2.5.1 CERN Study

In 2007 Jasper Kirkby of the CERN published a review article which reached the following major conclusions:

[7] http://www.sciencebits.com/files/pictures/climate/crcFig2.jpg

- "Over the last few years… diverse reconstructions of past climate change have revealed clear associations with cosmic ray variations recorded in cosmogenic isotope archives, providing persuasive evidence for solar or cosmic ray forcing of the climate."
    - "The high correlation of the temperature variations in the Δ14C record suggests that solar/cosmic ray forcing was a major driver of climate" [over the last 2000 years].
- "Two different classes of microphysical mechanisms have been proposed to connect cosmic rays with clouds:"
    - Production of cloud condensation nuclei
    - Global electrical circuit in the atmosphere and, in turn, on ice nucleation and other cloud microphysical processes."
- "Considerable progress on understanding ion-aerosol-cloud processes has been made in recent years, and the results are suggestive of a physically-plausible link between cosmic rays, clouds and climate."

His conclusions were based on a broad review of the evidence for GCR impact on climate using a number of different time periods and lines of evidence. The important points would appear to be the following:

- Galactic cosmic rays (GCRs) are strongly related to global temperatures
- Solar activity modulates GCRs reaching earth, with the modulation related to sunspot cycles

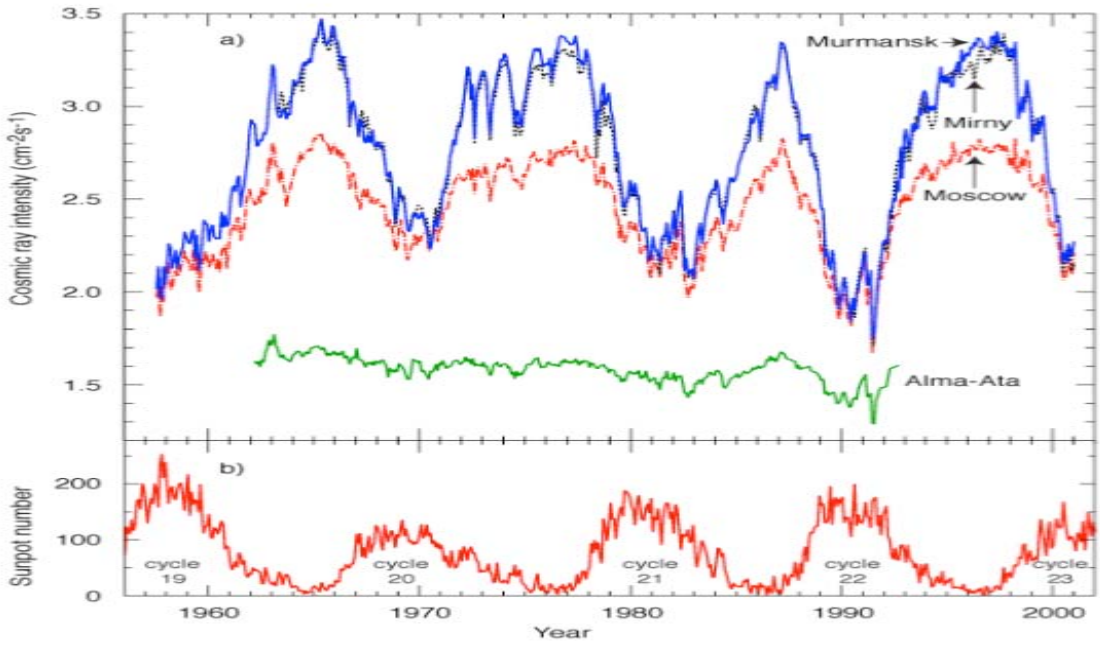


Figure 2-9: Solar Modulation of Galactic Cosmic Rays, 1957-2001

Source: Kirkby (2008)[8]

[8] Mirny is in Antarctica. (a) based on balloon measurements of the cosmic ray intensity at shower maximum (15-20 km altitude) measured by the Lebedev Physical Institute. Based on CERN 2001-007, 41-62 (2001) and Babarykin et al (1964).

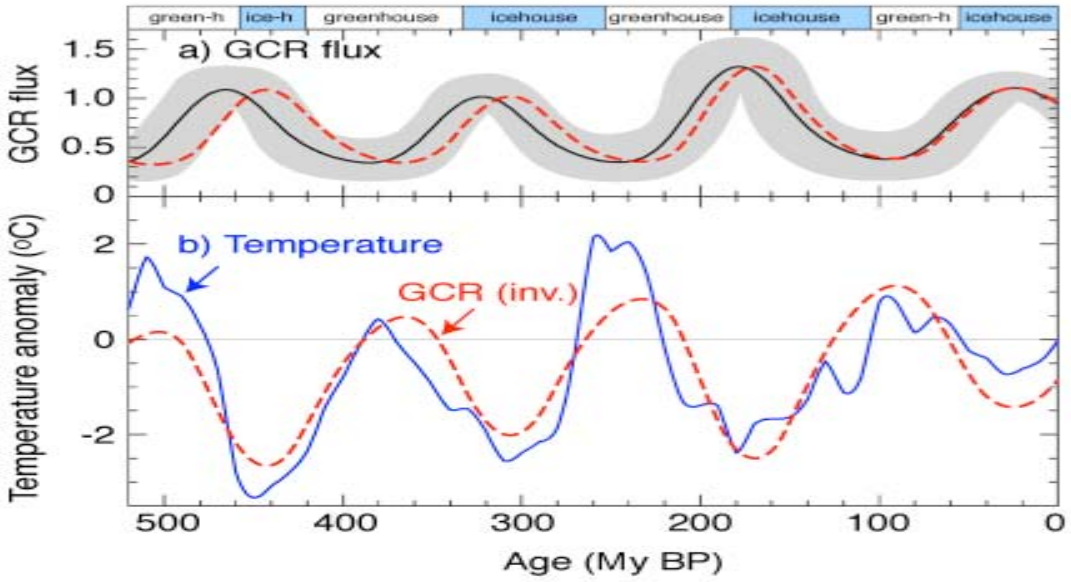


Figure 2-10: Galactic Cosmic Rays and Climate: Past 500 myr

Source: Kirkby (2008)

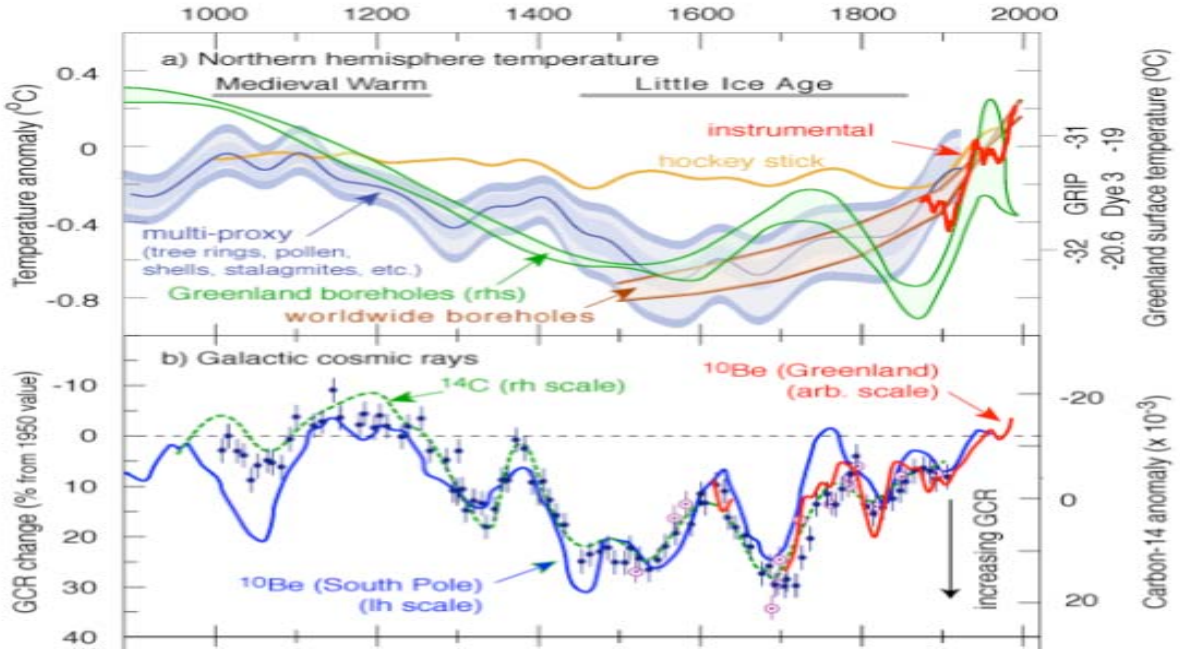


Figure 2-11: Galactic Cosmic Rays & Temperatures: Last 1100 yrs

Source: Kirkby (2008)

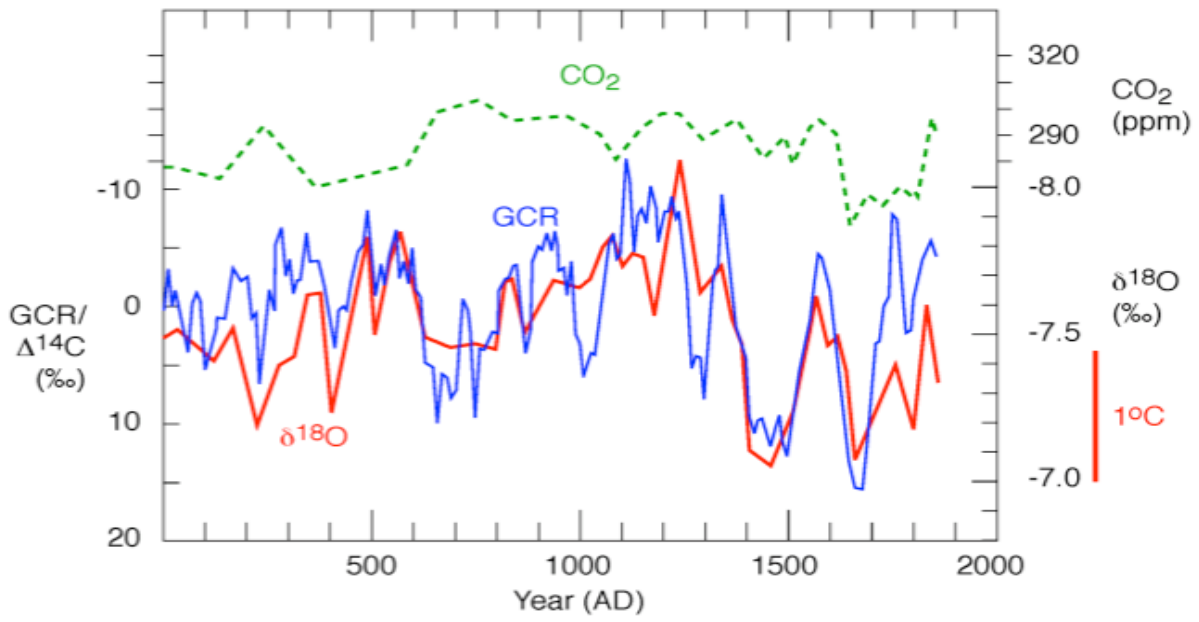


Figure 2-12: Temperature Reconstruction for the Central Alps over Last Two Millennia, Obtained from O-18 Composition of Speleothem from Spannagel Cave, Austria, Showing Little Relation to CO2 Changes

Source: Kirkby (2008) based on Mangini et al. (2005)

2.6 Urban Heat Island Effects and Other Problems of Surface Temperature Measurements

It appears that there is another major influence on global temperature measurements—but significantly only for surface temperature measurements. This is the effect of rapidly expanding urbanization worldwide and a number of other factors that appear to be corrupting surface measurements. Because most surface measurements are made in urban areas there is a high risk that the urban heat island effect will influence the measurements made. This UHI effect is well known and well documented. Strong support for this effect can be found in the extreme divergence between surface and satellite temperature measurements. This is shown in Figure 2-13 below:

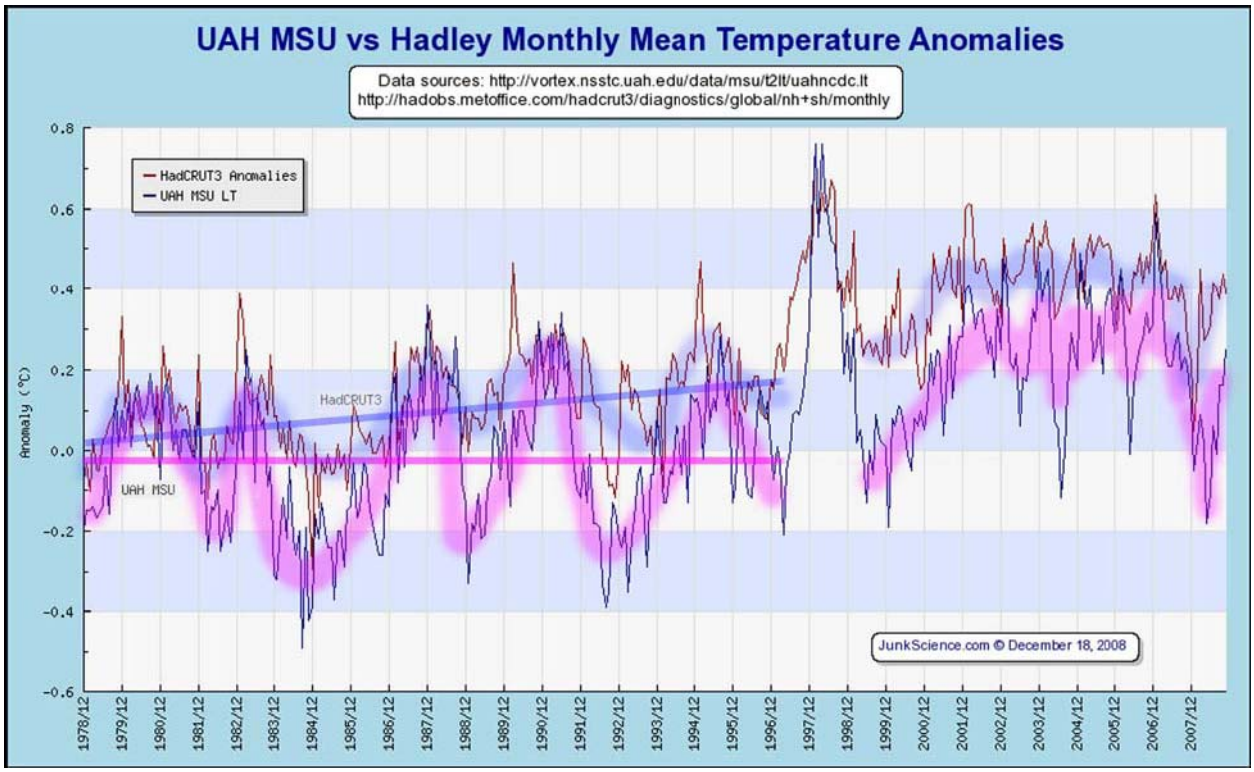


Figure 2-13: Satellite (UAH MSU LT) and land-based (HADCRUT3) Temperature Anomolies Compared

Source: Arrak (2009)

Note that the difference between the satellite and the ground data steadily increased during the 1978-97 period, at the same time that worldwide urbanization also increased. It is possible, of course, that the two approaches are measuring different things, so the comparison may be suspect for this reason, but the draft TSD needs to explain why there was no increase in lower troposphere temperatures during this long period. Without any, the case for GHG-caused temperature increases during this critical period is greatly weakened.

In addition to the problems of urbanization and the UHI, surface measurements also suffer from a number of other problems including major station dropout, missing data, bad siting, instruments with known warm biases being introduced without adjustment, difficulties in obtaining data from oceans and other areas with few monitors, and sometimes even black-box and man-made adjustments designed to maximize [reported] warming, as documented in great detail by Anthony Watts and others. Given these many problems it would appear to be much better to trust the satellite rather than the surface measurements even when carried out by neutral groups with the best of intentions. There are two satellite databases which appear to be

in close agreement, unlike the surface measurement databases, which show significant differences between the HADCRUT and GISS.

One of the most obvious places to look to try to understand these variations during the Holocene including the two recent periods is to look at variations in the Sun, the source of Earth's heat and light. There are two possible types of solar variation. The first and most visible is direct variation, usually measured by Total Solar Irradiance (TSI). This is the variation of the sun's total radiation output. The second type of solar variance is often referred to as indirect since it involves the impact of solar variation on other aspects of Earth's climate system, which in turn affect global temperatures, among other things. The discussion here will start with direct effects and then proceed to indirect.

Direct Solar Variability

Most measurements show only small variations, usually about 0.1 percent, but it is not known how it may have varied before accurate measurements have become available. One important aspect of these variations is that they vary with the sunspot cycle, with the highest TSI roughly coinciding with the maximum number of sunspots.

Perhaps the best known aspect of solar variations and the place to start is sunspot cycles, shown in Fig. 2-13 over the last 400 years. The first thing to note is the amazing correspondence between the average number of sunspots and the global temperatures depicted in Fig. 2-11.

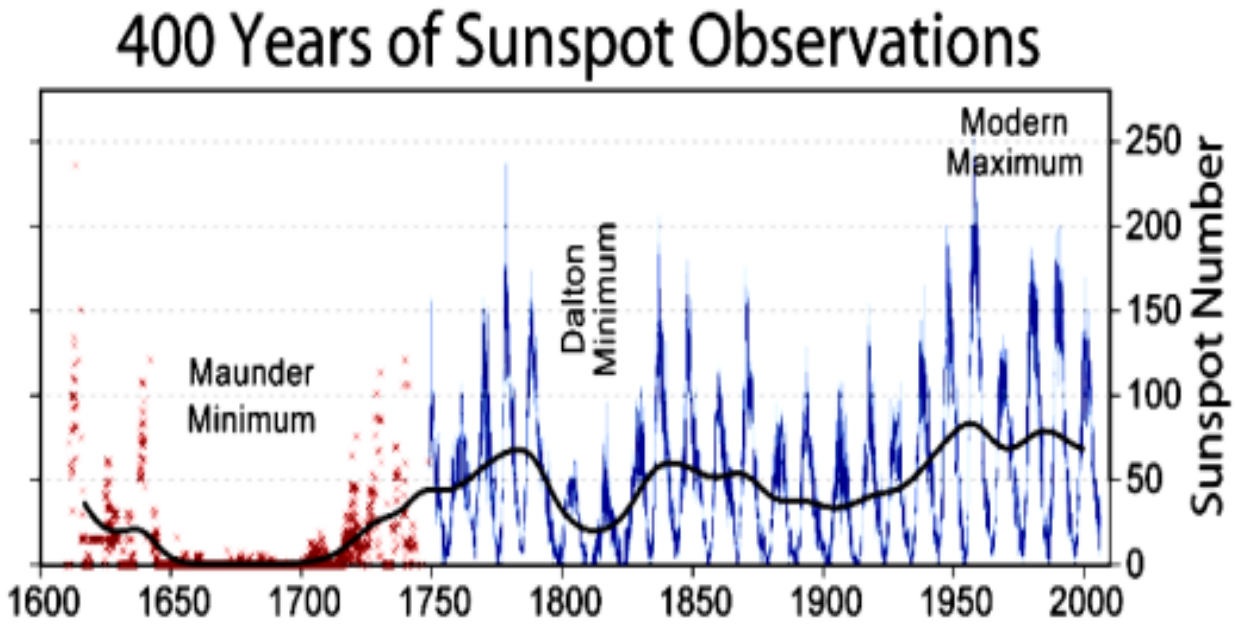


Figure 2-14: Relation of Sunspots (or Lack Thereof) to Little Ice Age Periods

Phil Chapman has made the following observation concerning the new sunspot cycle 24:[9]

> The new cycle, No.24, was supposed to start several years ago, with a gradual build-up in sunspot numbers. It did not happen. The first Cycle 24 sunspot appeared in January 2008 and lasted only two days. Other minor ones have come and soon gone since then.
>
> The reason this matters is that there is a close correlation between variations in the sunspot cycle and Earth's climate. The previous time a cycle was delayed like this was in the Dalton Minimum, an especially cold period that lasted several decades from 1790.
>
> Northern winters became ferocious: in particular, the rout of Napoleon's Grand Army during the retreat from Moscow in 1812 was at least partly due to the lack of sunspots.
>
> Whether the rapid temperature decline in 2007 coincided with the failure of cycle No.24 to begin on schedule is unknown but may be of interest.

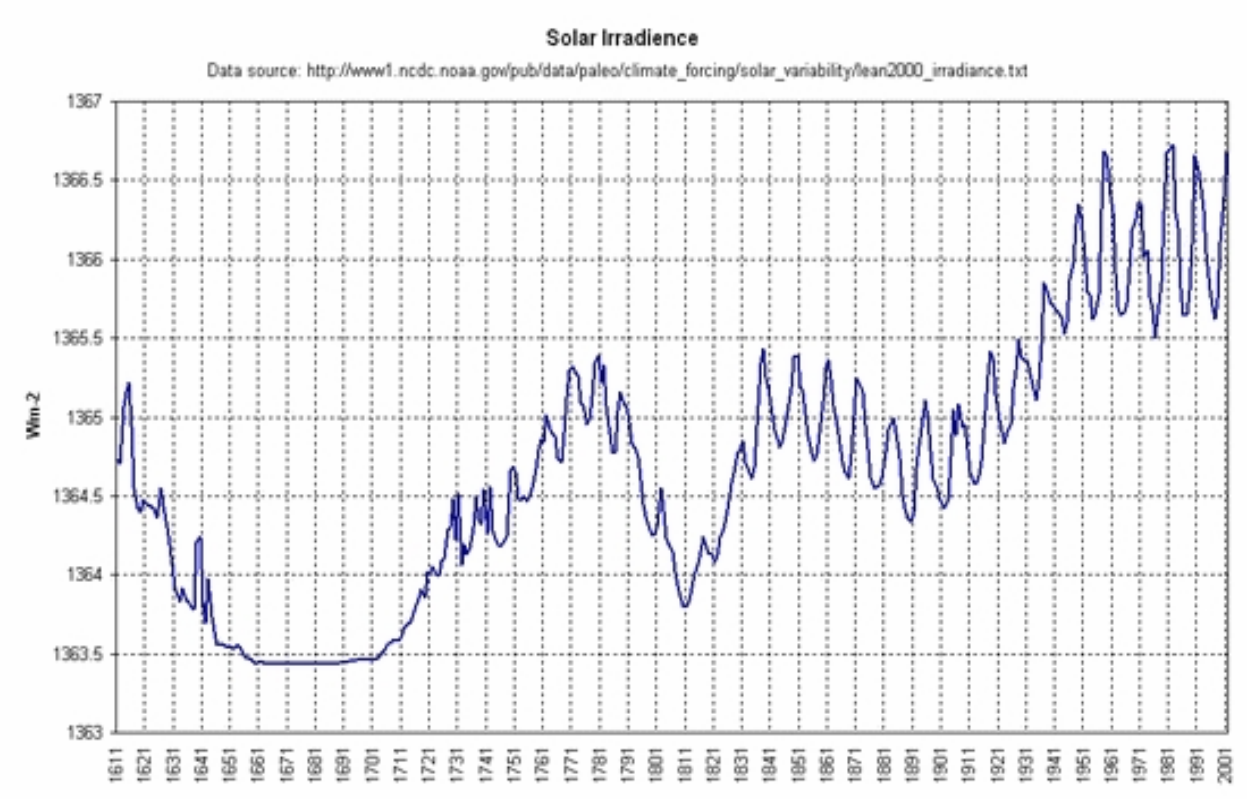
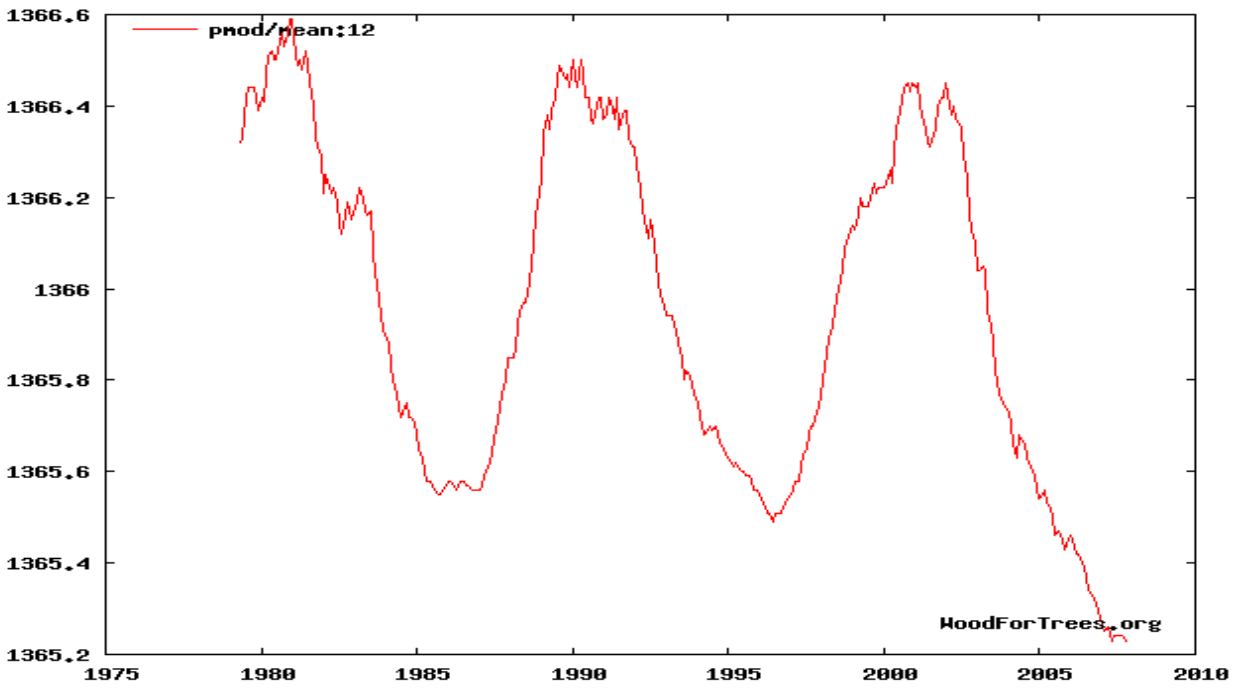


Figure 2-15: Solar Irradiance since 1611[10]

[9] Phil Chapman, "Sorry to Ruin the Fun, but an Ice Age Cometh," *The Australian*, April 23, 2008.



[10] From http://www.junkscience.com/Greenhouse/irradiance.gif

Figure 2-15: Solar Irradiance since 1979 Showing the Recent Downward Trend[11]

2.7 Summary of Evidence for CO_2 and Sun/Cosmic Ray Warming Hypotheses

Besides the most apparent comparisons between global temperatures and CO_2 levels, the CO_2 only and sun/cosmic ray hypotheses imply a number of predictions involving observable evidence. An interesting comparison of the predictions of the CO_2 and the sun/cosmic ray hypotheses with available data is the following:

Issue	Prediction - CO_2 Hypothesis	Prediction - Sun/Cosmic Ray Hypothesis	Actual Data	Hypothesis Offering Best Explanation
Antarctic and Arctic Temperatures	Temperatures in the Arctic and Antarctic will rise symmetrically	Temperatures will initially move in opposite directions	Temperatures move in opposite directions	Sun/Cosmic Ray
Troposphere Temperature	Fastest warming will be in the troposphere over the tropics	The troposphere warming will be uniform	Surface warming similar or greater than tropospheric warming	Sun/Cosmic Ray
Timing of CO_2 and Temperature Changes at End of Ice Age	CO_2 increases then temperature increases	Temperature increases then CO2 increases	CO_2 concentrations increase about 800 years after temperature increases	Sun/Cosmic Ray
Temperature correlate with the driver over last 400 years	NA	NA	Cosmic ray flux and Sun activity correlates with temperature, CO_2 does not	Sun/Cosmic Ray
Temperatures during Ordovician period	Very hot due to CO_2 levels > 10X present	Very cold due to high cosmic ray flux	Very cold ice age	Sun/Cosmic Ray
Other Planets' Climate	No change	Other planets will warm	Warming has been detected on several other planets	Sun/Cosmic Ray

[11] http://www.woodfortrees.org/plot/pmod/mean:12
From PMOD; SORCE solar irradiance instrument does not show the additional decline

Source: Gregory (2009)

Gregory (2009) provides a much more detailed description of each of these issues and his basis for reaching the conclusions that he has. In contrast, the IPCC reports conclude that since the CSI variation is small therefore solar variability makes at most a very minor contribution to global temperature changes and can be safely ignored in most of their actual models and conclusions. This does not address the possibility, however, as hypothesized by Svensmark (1998), that there may be indirect pathways by which solar variability can have substantial effects on the Earth.

To the extent that Gregory has accurately captured the comparison, the sun/cosmic ray hypothesis appears to offer a much better explanation of all these comparisons. Gregory (2009) also compares the temperature increases predicted by the IPCC computer models during the 20th Century with the actual temperature increases and says that the predicted was 1.6 to 3.74°C while the observed was about 0.6°C. He comments that "a model that fails to history match is useless for predicting the future."

2.8 Are Sunspot Cycles Telling Us Anything?

2.8.1 Sunspot Cycle 23 Is Now Over 12 Years Old

Sunspot cycle 23 reached its 12th birthday in May, 2008. Cycle 22 was only 9.5 years long. There have only been three small and short-lived Cycle 24 spots to date. It is widely believed that the longer cycle 23 lasts and the later and weaker Cycle 24 is, the colder global temperatures will be. It is presently unknown how soon Cycle 24 will start and how strong it will be if and when it should start.

2.8.2 Penn and Livingston

In 2006, two astrophysicists, Penn and Livingston of the National Solar Observatory published a paper reporting on their measurements of the computed magnetic field from the Zeeman splitting of the Fe I 1564.8 nm line, shown for umbral spectra observed from 1998 through 2005. While there is a large variation between different sunspots, nonparametric tests confirm that the data show a highly significant trend. Mean values for each calendar year are shown as data points in Figure 2-16, and the error bars show the standard error of the mean. The best-fit linear function (fit to the original 906 data points) reveals a decrease in the average magnetic field strength of 52 G/yr. Magnetic field and intensity changes observed over time in

the sunspot umbrae from different spots behave in the same way as the magnetic field and intensity changes observed spatially across single sunspots. If these trends continue the authors say that sunspots may vanish by 2015. Given the strong association between sunspots and global temperatures, this suggests the possibility that we may be entering a period of global cooling rather than warming. This possibility needs to be discussed in the Draft TSD.

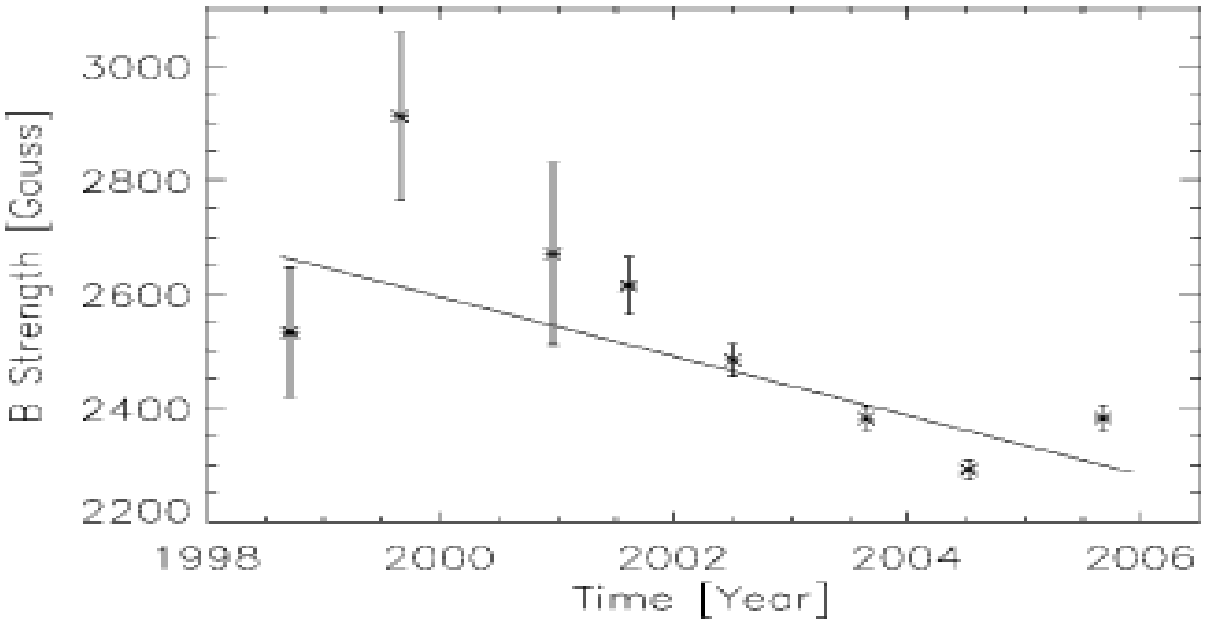


Figure 2-16: Decay in Sun's Magnetic Field since 1999

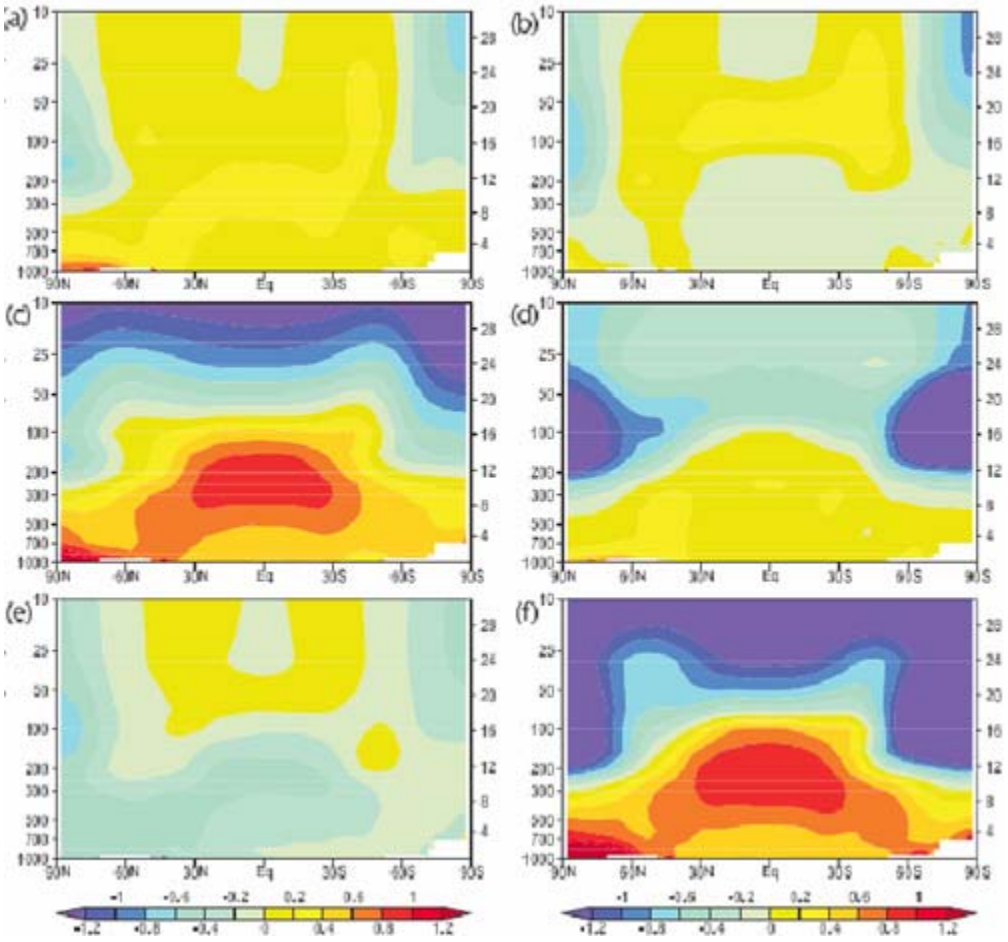
Source: Penn and Livingston (2006)

2.9 The Missing Heating in the Tropical Troposphere

Computer models based on the theory of GHG/CO_2 warming predict that the troposphere in the tropics should warm faster than the surface in response to increasing CO_2 concentrations, because that is where the CO_2 greenhouse effect operates. Sun-Cosmic ray warming will warm the troposphere more uniformly.

The UN's IPCC *AR4* report includes a set of plots of computer model predicted rate of temperature change from the surface to 30 km altitude and over all latitudes for 5 types of climate forcings as shown below.

Computer Model Predicted Temperature Change



The six plots show predicted temperature changes due to:

a) Sun

b) Volcanic activity

c) Anthropogenic CO2 and other greenhouse gasses

d) Anthropogenic ozone

e) Anthropogenic sulphate aerosol particles

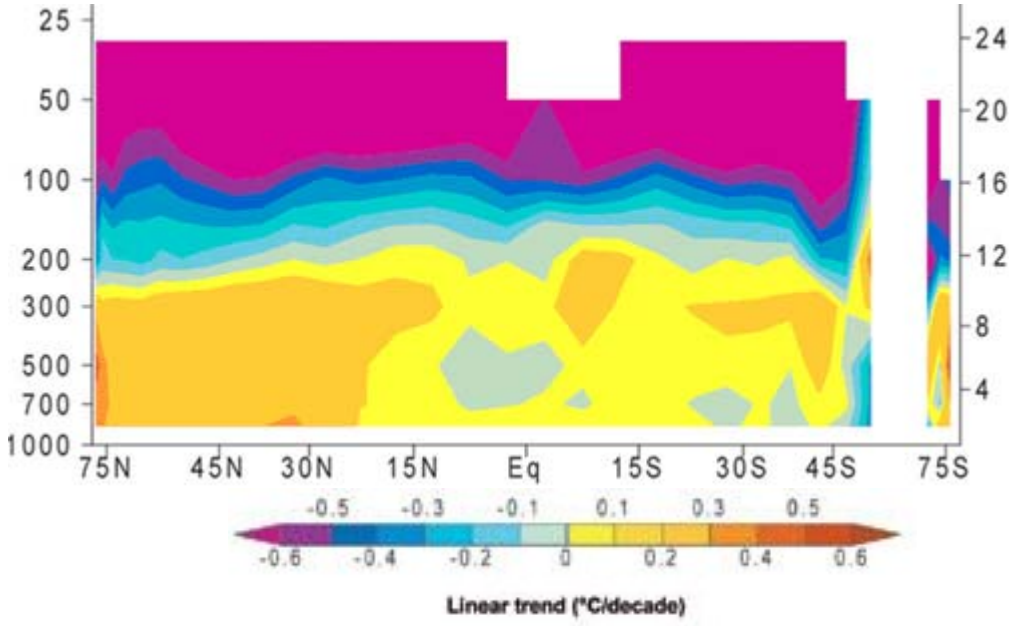
f) All the above forcings combined

The rate of temperature change is shown by the colour in degrees Celsius per decade. It is apparent that plot c) of warming caused by greenhouse gasses is strikingly distinct from other causes of warming. Plot f) is similar to plot c) only because the IPCC assumes that CO_2 is the dominant cause of global warming.

The computer models show that greenhouse warming will cause a hot-spot at an altitude between 8 and 12 km over the tropics between 30 N and 30 S. The temperature at this hot-spot is projected to increase at a rate of two to three times faster than at the surface.

The Hadley Centre's real-world plot of radiosonde temperature observations shown below, however, does not show the projected CO_2 induced global warming hot-spot at all. The predicted hot-spot is entirely absent from the observational record. This shows that most of the global temperature change cannot be attributed to increasing CO_2 concentrations.

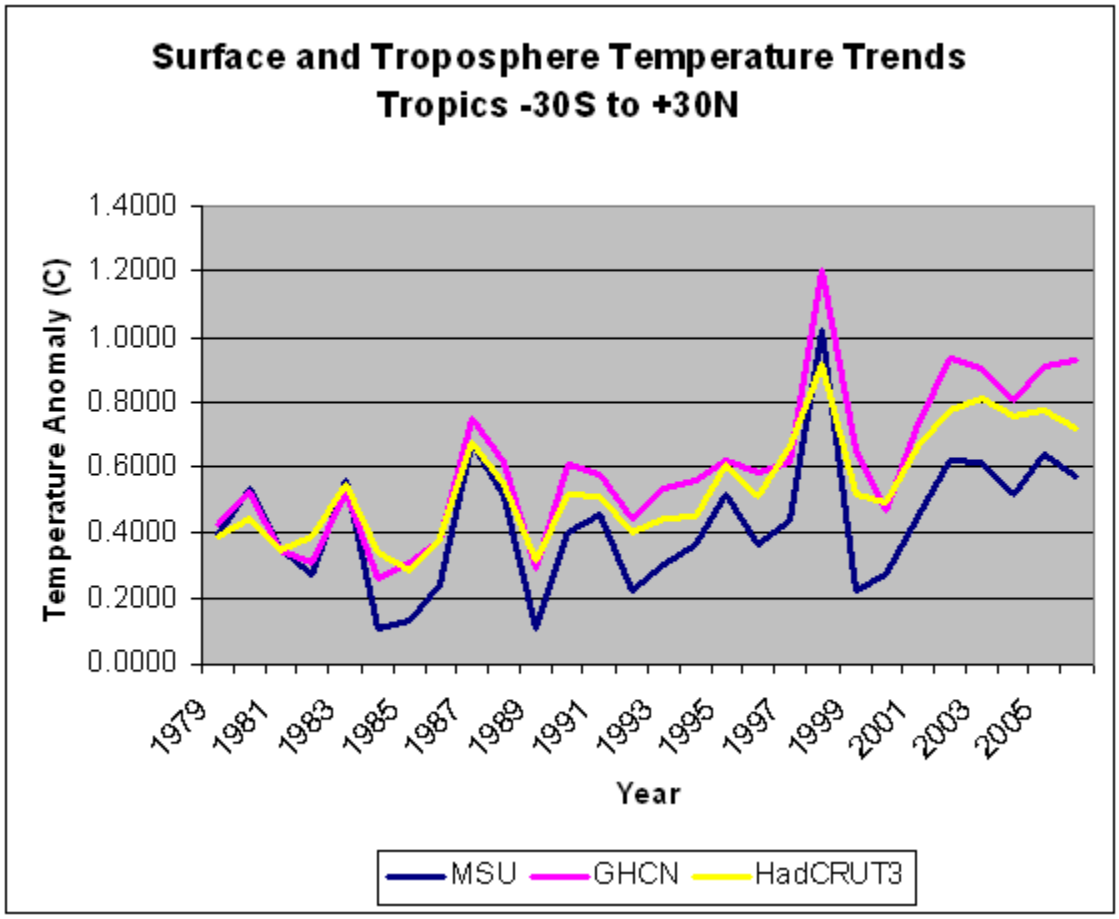
HadAT2 Radiosonde Data 1979 - 1999



The left scale is atmosphere pressure in hPa. The right scale is altitude in km.
Source: HadAT2 radiosonde observations, from Santer et al. (2006), p. 116, fig. 5.7
This graph compares the annual temperatures of the troposphere to the surface measurements in the tropics from 30 degrees North to 30 degrees South.

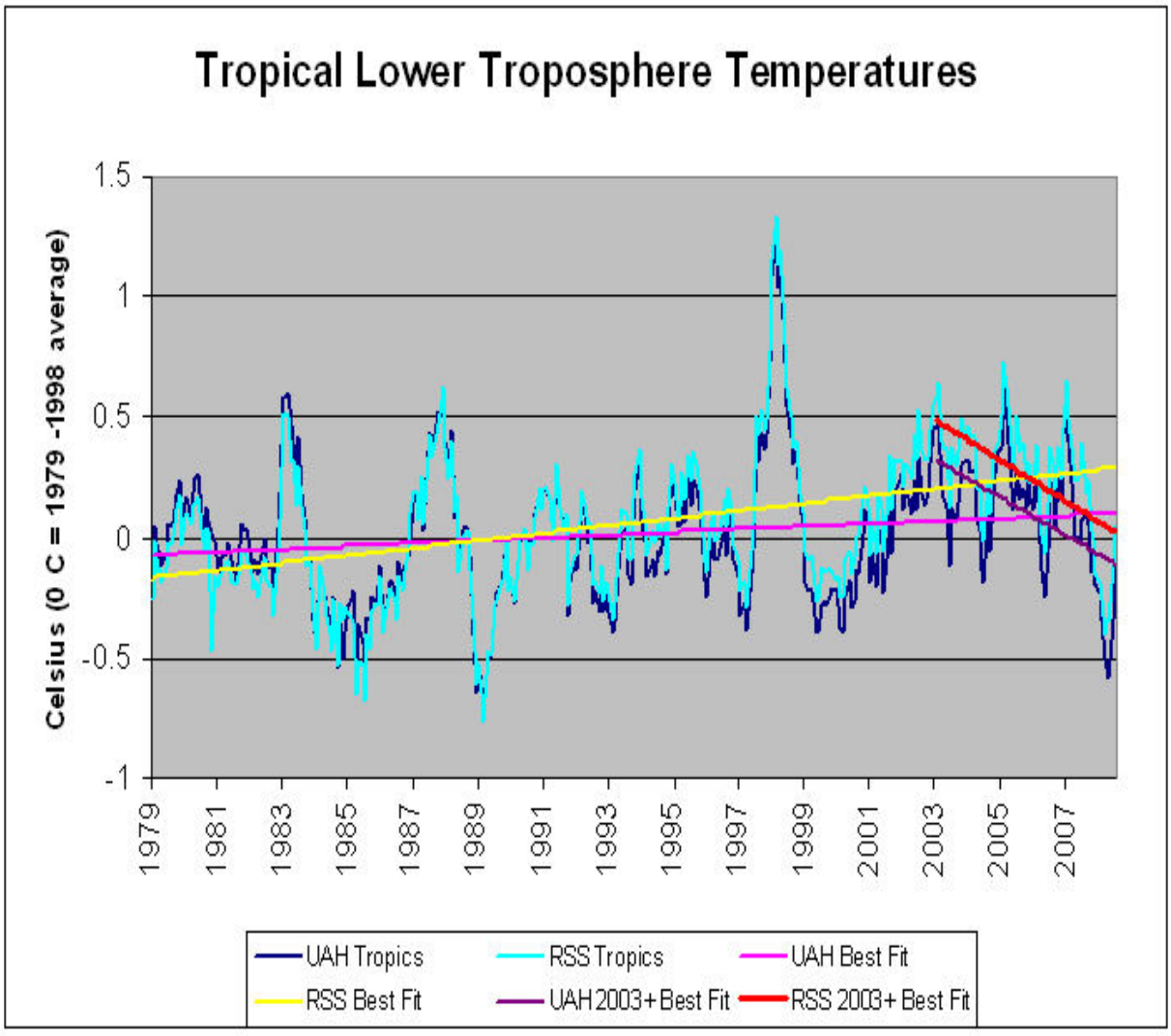
The Draft TSD indeed notes that the lack of heating in the tropical troposphere is a problem but says that the data has been questioned. *While this is being sorted out or if it is never sorted out, the prudent thing to do is to assume that the data is correct and therefore that the hypothesis is invalid until shown otherwise by new and better science.* Not to do so is to take a major risk since otherwise very expensive remediation actions may be taken on the basis of a claim that data is questionable when it may indeed be correct. Our non-expert take on the data,

for what it may be worth, is that it probably is correct given the widespread use of the methods used to gather it.



The MSU curve is the Microwave Sounding Unit satellite measurements. It measures the temperature of the troposphere up to approximately 8 km. The GHCN curve is the Global Historical Climatology Network data set of land surface temperatures from the National Climatic Data Center. The HadCRUT3 curve is the Land and Sea-Surface Temperatures data set from UK Met Office. The three curves are scaled so that the average of the first 5 years are the same.

A comparison of the records show that the surface has warmed faster than the troposphere, the opposite of what is predicted by the theory of CO_2 warming. Observations therefore agree with the Sun-Cosmic ray warming theory (Kirkby, 2007). The response of the troposphere temperatures in the tropics is sometimes called the fingerprint of the CO_2 contribution to warming.



This graph shows two analyses of Microwave Sounding Unit (MSU) satellite temperature measurement data of the troposphere over the tropics from 20 degrees North to 20 degrees South. The UAH analysis is from the University of Alabama in Huntsville and the RSS analysis is from Remote Sensing Systems. The two analyses use different methods to adjust for factors such as orbital decay and inter-satellite difference. The overall trend lines to July 2008 shows increasing temperatures at 0.06 C/decade for UAH and 0.15 C/decade for RSS. However, since January 2003, the temperatures have been declining at 0.76 C/decade for UAH and 0.83 C/decade for the RSS data. The IPCC projections do not agree with the data.

2.10 Another Possible Inconsistency: Do Changes in CO_2 Cause Changes in Temperature?

The IPCC (2007) argues that it is changes in ambient CO_2 levels that have and will largely determine temperature changes. A number of skeptics dispute this. One of their arguments is that changes in temperature have preceded changes in CO_2 by hundreds of years rather than the other way around over the last quarter million years (see Gregory, 2008, citing Caillon et al., 2003; and Singer, 2008, citing Fischer, 1999). They argue that this is incompatible with changes in CO_2 levels having any effect on temperature. According to Gregory (2009), "Logic demands that cause must precede effect. Increases in air temperature drive increases in atmospheric CO_2 concentration, and not vice versa."

2.11 Conclusions with Regard to the Best Explanation for Global Temperature Fluctuations

The reason for this extensive review of some of the available science is to use it to derive some implications for the endangerment TSD. Several general conclusions stand out as a result of this analysis. These are based largely on inspection of the available surface and satellite data. Despite the complexity of the chaotic climate system the following conclusions appear to be well supported by the available data:

A. What appears to be by far the best single explanation for global temperature fluctuations is variations in the PDO/ENSO. ENSO appears to operate in a 3-5 year cycle. PDO/AMO appear to operate in about a 60 year cycle.

B. There appears to be a strong association between solar sunspots/irradiance and global temperature fluctuations. It is unclear exactly how this operates, but it one possibility is through indirect solar variability such as the effect on cloud formation.

C. Changes in GHG concentrations appear to have so little effect that it is difficult to find any effect in the satellite temperature record, which started in 1978.

D. The surface measurements (HADCRUT) are more ambiguous than the satellite measurements in that the increasing temperatures shown since the mid-1970s could either be due to the rapid growth of urbanization and the heat island effect or by the increase in GHG levels or by other measurement problems. However, since no such increase is shown in the satellite record it appears more likely that urbanization and the

UHI effect are the most likely cause. If so, the increases may have little to do with GHGs and everything to do with the rapid urbanization during the period. Given the discrepancy between surface temperature records in the 1940-75 and 1998-2008 and the increases in GHG levels during these periods it appears even more unlikely that GHGs have much effect on measured surface temperatures either. These points need to be very carefully and fully discussed in the draft TSD since they bear directly on the plausibility of the GHG/CO2 hypothesis.

E. Hence it is not reasonable to conclude that there is any endangerment from changes in GHG/CO2 levels based on the satellite record, since almost all the fluctuations appear to be due to natural causes and not human-caused pollution as defined by the Clean Air Act. The surface record is more equivocal but needs to be carefully discussed with all its nuances.

F. There is a significant possibility that there are one or more other natural causes of global temperature fluctuations that we do not yet fully understand and which may account for the 1998 temperature peak which appears on both the satellite and surface temperature records. This possibility needs to be fully explained and discussed in the Draft TSD.

Resolving the remaining uncertainties would appear to be of great importance before a endangerment TSD is finalized on the assumption that the GHG/CO2 only hypothesis is correct. The important factors affecting global temperatures may include any of the three hypothesized in this section or all of them or others not discussed here or even others not currently understood. We do not currently have sufficient evidence to determine which, if any, are of importance and how important each might be. The currently favored GHG/CO2 only hypothesis does not explain a number of aspects of the available data so it alone appears unlikely to be the sole explanation. There is an urgent need to update and improve on the IPCC reports by taking an independent perspective and including new information not included in their reports concerning all the factors summarized above.

3. Contrast between Continuing Improvements in US Health and Welfare and their Alleged Endangerment Described in the draft TSD

One of the problems with the EPA's Endangerment TSD is the nearly complete disregard of observed trends in a wide array of measures which by and large show that despite decades of increasing anthropogenic greenhouse gas emissions the U.S. population does not seem to have been adversely affected by any vulnerabilities, risks, and impacts that may have arisen (to the extent that any at all have actually occurred as the result of any human-induced climate changes).

For instance, despite the overall rise in U.S. and global average temperatures for the past 30 years, U.S. crop yields have increased (Figure 3-1), the population's sensitivity to extreme heat has decreased (Figure 3-2), and our general air quality has improved (Figure 3-3). Further, there has been no long-term increase in weather-related property damage once changes in inflation, population size, and population wealth are accounted for (an essential step in any temporal comparison). All of these trends are in the opposite sense from those described in the EPA's Endangerment TSD.

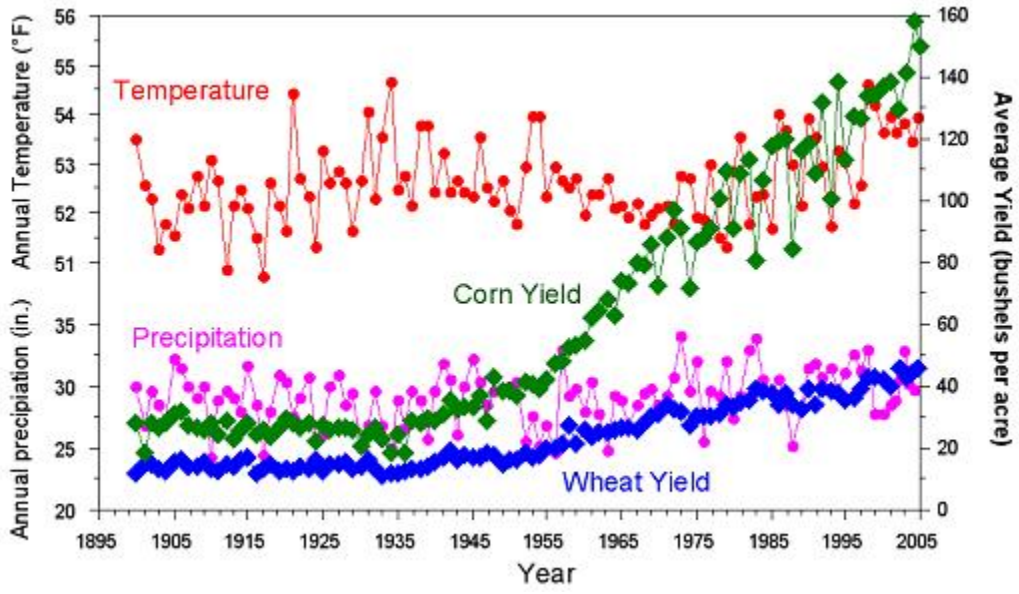


Figure 3-1: Yields of Major Cash Crops such as Corn and Wheat

Data sources: NCDC, USDA

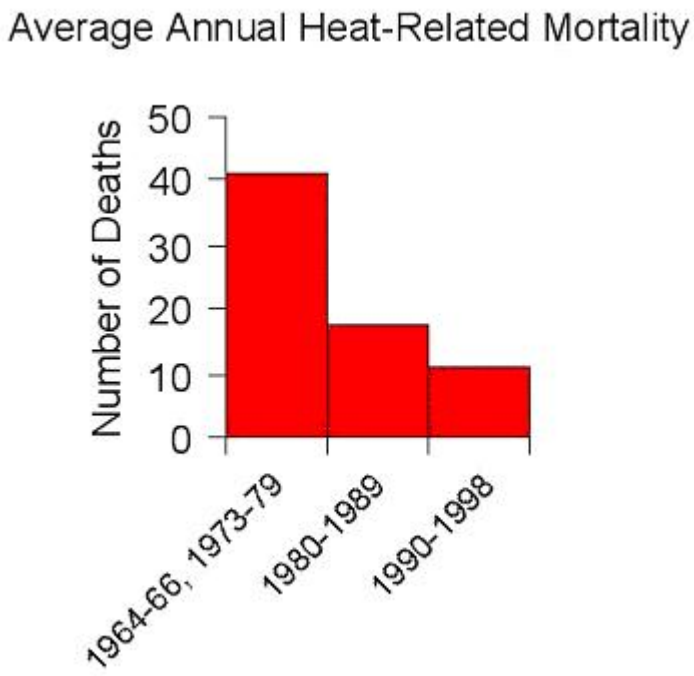


Figure 3-2. Average Annual Heat-Related Mortality Per Standardized Million People in the U.S.

(Source: Davis et al., 2003).

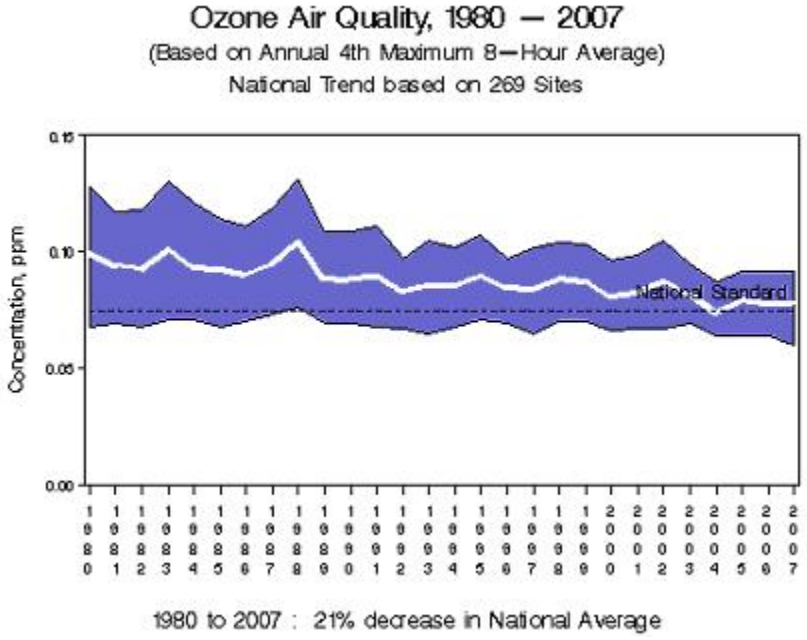


Figure 3-3. Trends in ozone air quality

Source: http://www.epa.gov/airtrends/ozone.html

Perhaps, most significant of all, the average lifespan of Americans has increased (Figure 2-5).

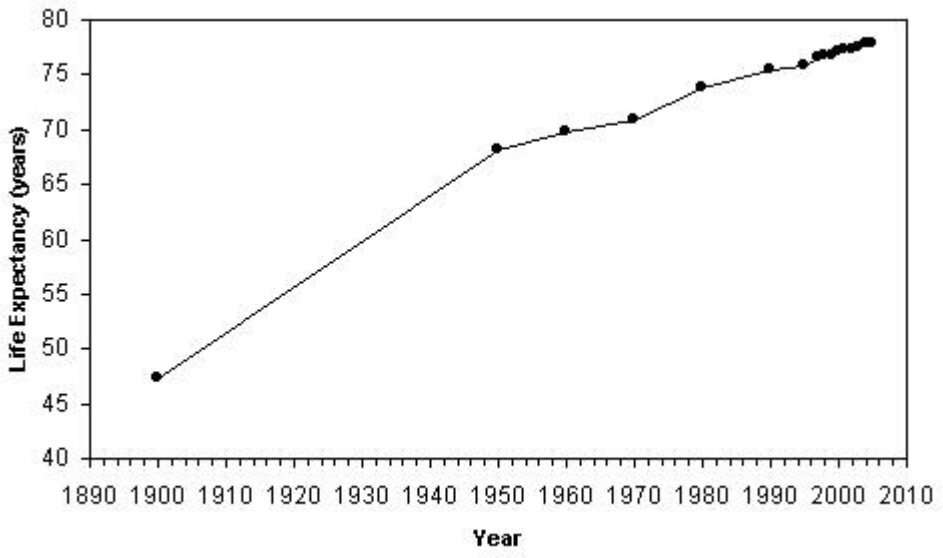


Figure 3-5: Life Expectancy at Birth in the U.S.

Source: http://www.cdc.gov/nchs/data/hus/hus07.pdf#027

What better measures of human health and welfare are there? In fact, there is no better way to obtain a good picture of how human health and welfare may trend in the future under increases in greenhouse gas emissions than to assess how we have fared in the past during a period of increasing greenhouse gas emissions and ambient levels. True, hurricanes will strike again in the future and cause a great deal of damage and suffering. But that will largely occur because our climate is one which includes hurricanes. The same is true for tornadoes, droughts, floods, heat-waves, cold outbreaks, strong thunderstorms, heavy rains, hail, lightning, snowstorms, blizzards, freezing rain, etc. Those are all aspects of our climate.

Climate *change* may alter the strength, path, or frequency of these events—lessening some and increasing others. But to the large part, our nation's climate in the future will be made up of the same characteristics as it is today.

4. Detailed Comments by Draft TSD Part and Section

This is the section that has suffered most from the very short review time allowed for EPA offices to comment.

4.1 Executive Summary

Page ES-7, new separate paragraph anywhere on the page: Based on the Sections 1.7 and 2 above we suggest adding the following paragraph:

> Despite the IPCC and CCSP reports there is substantial evidence that the factors most closely correlated with temperature changes are the following:
>
> 2. Oceanic climate oscillations, particularly PDO, AMO and ENSO
> 3. Solar variability
> 4. Carbon dioxide
>
> There are a number of inconsistencies between the GHG/CO2/AGW hypothesis and available observed data that make this hypothesis scientifically invalid unless they can be resolved:
>
> 1. Lack of observed upper tropospheric heating in the tropics
> 2. Lack of observed constant humidity levels, a very important assumption of all the IPCC models, as CO2 levels have risen
> 3. Satellite data show no appreciable temperature increases during the period 1978-1997, just when the surface station data show a pronounced rise (see Section 2.5). Satellite data after 1998 is also inconsistent with the GHG/CO2/AGW hypothesis
> 4. The models used by the IPCC do not take into account or show the most important ocean oscillations which clearly do affect global temperatures, namely, the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation, and the ENSO. Leaving out any major causes for global warming from the analysis results in the likely misattribution of the effects of these oscillations to the GHGs/CO2 and hence is likely to overstate their importance as a cause for climate change.
> 5. The models and the IPCC ignored the possibility of indirect solar variability, which if important, would again be likely to have the effect of overstating the importance of GHGs/CO2.

6. The models and the IPCC ignored the possibility that there may be other significant natural effects on global temperatures that we do not yet understand. This possibility invalidates their statements that one must assume anthropogenic sources in order to duplicate the temperature record. The 1998 spike in global temperatures is very difficult to explain in any other way.

Page ES-7, lines 13-8: This paragraph is misleading in several ways and can be made much more accurate and less misleading if reworded as follows:\

> Warming of the climate system was unequivocal in the first half of the 20th Century and between 1997 and 1998. Cooling, however, occurred from about 1940 and 1975 and after 1998. The period from 1978 to 2007 is in doubt because surface measurements show an increase while satellite data show little if any change during this period. Global mean surface temperatures rose by 0.74°C during the 20th Century, but have declined since 2008, particularly when satellite data is used. The cause of a sudden upward blip in temperatures in 1998 is uncertain but appears to be too rapid to ascribe to changes in GHG/CO2 concentrations.

Page ES-7, lines 25-30: The cited temperature changes are misleading at best. There is a profound difference between surface and satellite measurements which is not discussed. Satellite data shows no significant change between 1978 and 2008 and thus does not support the view that there was an increased rate of warming in the last 30 years. In fact, it says that there has been no appreciable change. As discussed in Section 2.5 above there are strong reasons to believe that the satellite data is more accurate so any statement along these lines needs to carefully explain the differences between the measurement approaches and explain why one is superior to the other. It is also misleading to quote changes since 1900 since it is highly unlikely that GHG changes were appreciable before 1940.

4.3 Part III

Section 5: Page 38, lines 21-2: The Draft TSD does not explain the serious problems with depending on computer-based climate models as the primary tools for simulating the likely patterns of response of the climate system to different forcing mechanisms. Gary (2009), reproduced in part in Section 1.7 above, for example, explains these limitations in considerable detail and concludes that it is impossible to use them for the purpose that the IPCC used them for. These limitations are crucial to any assessment of the results these models produced and

need to be explicitly described in the Draft TSD. We believe that the following language would be appropriate, but suspect that you can craft better language:

> Skillful initial-value numerical weather forecasts currently cannot be made for more than about two weeks into the future. This is because 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 integration of longer than a week or two. Skillful short-range prediction is possible because there tends to be conservation in the initial value momentum-pressure fields which can be skillfully extrapolated or advected for a week or two into the future. But after 1-2 weeks, one must deal with the far more complex variation of the moisture and energy fields. Model results soon decay into chaos.
>
> If skillful GCM forecasts were possible for a longer period of a season to a few years, many would be eager to track their skill. Currently, GCMs do not make official seasonal or annual forecasts. People do not dare to issue these forecasts because they know they are not skillful and would quickly lose their credibility if they gave real time forecasts that could actually be verified. It therefore appears highly unlikely that we should 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.

Section 5: Page 38, lines 22-4: This sentence only discusses the positive aspects of using the models but not the negative ones as suggested above. This sentence is at best misleading because it does not mention that the models used some not yet accepted physical principles as well as accepted ones. The most important example is the indirect assumption that relative humidity levels will be unchanged by increased CO2 levels. Recent research (for example, Paltridge. 2009 and Gray, 2009) does not support this assumption and in fact finds that humidity is decreased, which has an important effect on the model predictions. In addition, "their ability to reproduce observed features of current climate and past physical changes" shows nothing more than that the models were made to fit past and current data available when they were run. The test for these models is not what they show for past outcomes but for future periods when there is no data to fit the models. As shown in Figure 1-2 above, there is already considerable doubt as to how well they are able to do this. Our alternative language would be as follows:

> Although the models use a number of accepted physical principles they also make other assumptions, particularly with regard to humidity levels with added CO_2, that do not correspond with current observations (Paltridge, et al., 2009). Furthermore, the ultimate test of these models, whether they can accurately predict the future, and the current data suggests that they have greatly overestimated global temperatures in the last few years since the latest IPCC report was issued [attach Figure 1-2 from Section 1 above here]. This does not prove the models to be wrong, but suggests the need for caution in applying the IPCC model results and further study.

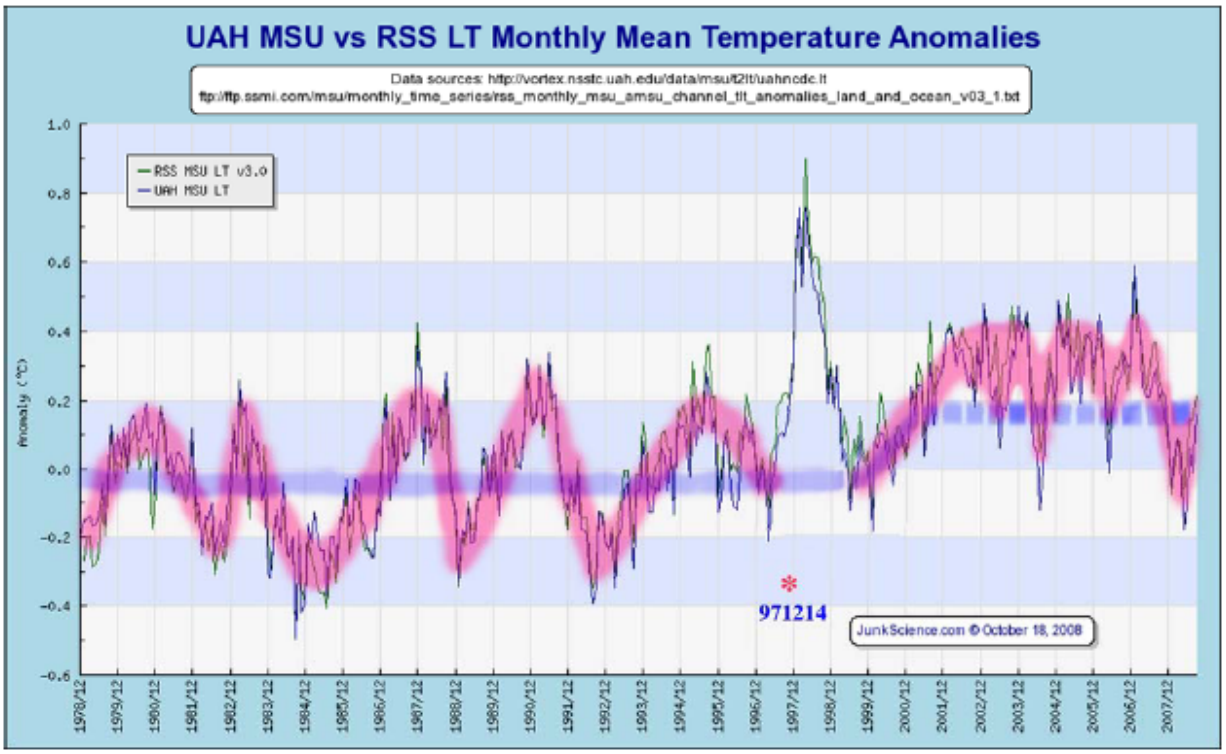
Section 5, Page 38, lines 24-28: Neither the IPCC nor the TSD explore the possibility that indirect solar variability, urban heat island effects, increasing urbanization, monitoring station dropouts, missing temperature data, bad siting, instruments with known biases introduced without adjustment, the difficulties of obtaining representative data from oceans and other areas with few monitors, and possibly even black-box and man-made adjustments to maximize reported warming have occurred in the case of surface stations. In addition, neither the IPCC nor the TSD have explored the effects of the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation or the ENSO may also explain all or some of the global temperatures and forcings. Our proposed alternative language is as follows:

> Although there have been some efforts made to learn whether observed changes in global temperatures are consistent with the model results, many alternative explanations have not received the scrutiny they deserve, including indirect solar variability (Kirkby, 2007), urban heat island effects, increasing urbanization, monitoring station dropouts, missing temperature data, bad station siting, instruments with known biases introduced without adjustment, the difficulties of obtaining representative data from oceans and other areas with few monitors, and possibly even black-box man-made adjustments to maximize reported warming that may have occurred in the case of surface stations, the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation, and the ENSO. These possible alternative explanations need urgent attention by independent analysts.

Section 5, Page 38, lines 30-2: It may be true that such studies exist, but there are others who find much more ambiguous results. See Section 1.7 above discussing the research by Scafetta et

al., 2008 and 2009 and the extended discussion of the satellite global temperature data in Section 2.4 suggesting much smaller or no possibly no influence from the growth of GHG levels. Our proposed alternative language is as follows:

> Although a CCSP study (Karl et al., 2006) found evidence of human influences on the climate system by using patterns of observed temperature change, recent work by Scaffeta and others (2008 and 2009) found that solar irradience has increased more than previously thought and that all or much of the change in global temperatures may be attributable to non-human sources. In addition, a review of satellite global temperature data suggests that few if any of the changes observed appear likely to be the result of the gradual increase in GHGs, as shown in the following graph:



> Drawing a straight trend line as is often done in many ways limits the options examined. It is much better is to utilize more of the data by trying to fit a more robust pattern to it. Ambient CO_2 levels were increasing throughout this 1978-97 period yet global temperatures remained in a narrow band with little apparent increase. Further, the sharp spike in temperatures in 1998 appears highly unlikely to have been caused by changes in

GHG levels since they vary only very slowly rather than exhibiting the sharp spike seen here. The reason for the 1998 spike and its possible after effects in the 1999-2006 period are unknown but would seem very important to learn about before assuming that it is related to changes in GHGs. Similarly, the period 1999 to 2006 shows a higher shows another narrow but higher band of temperatures with a slight negative trend during the period. One possibility is that the elevated temperatures during this period were an after-effect of the sudden surge in 1998. Finally, the period 2007-9 shows a strong downward trend in temperatures which is surely not related to steadily increasing GHG emissions and atmospheric levels. Thus it is very hard to see any effect during the period 1978 to 2009 that can reasonably ascribed to changing CO_2 or GHG levels. This is in marked contrast with ground level measurements such as the HADCRUT series which show a marked increase in temperatures through 1998 (but not thereafter). One possible explanation for this apparent inconsistency between the HADCRUT and MSU data is that ground level measurements may inevitably be compromised by the urban heat island effects which presumably increased rapidly during the period due to rapid urbanization in many parts of the world. Until the significant differences between the surface and satellite data in the critical 1978 to 1997 period are better understood it would appear premature to reach any conclusions as to GHG endangerment.

Section 5, Page 39, lines 17-19: But others indicate just the opposite, as discussed above. Our suggested rewording would be as follows:

Climate modeling simulations run by the IPCC, shown in Figure 5.1, suggest to them that natural forcings alone cannot explain the observed warming (for the globe, the global land, and global oceans) and that the observed warming can only be reproduced with models that contain both natural and anthropogenic forcings. This, however is contrary to the findings of Scafetta and others (2008 and 2009) and for the reasons discussed in the previous entry do not appear to apply to satellite data for the period 1978-2008.

Section 5, Page 39, lines 20-21, Figure 5.1: For the reasons discussed in Section 2.5 above, this Figure has some very serious problems which need to be carefully explained to avoid misleading the reader. It appears that this Figure is based on surface (as stated in the header) rather than

satellite lower troposphere data. The difference needs to be pointed out along with an explicit comparison with the satellite data. Then there needs to be a discussion of the relative merits of satisfying either the satellite data or the surface data. As it is the reader has no idea that there is such a large difference between the two and to ask the obvious question as to why and which one he/she rely on (see Section 2.4 for a discussion of all this). In fact, unlike the surface data the satellite data cannot reasonably be explained by possible anthropogenic causes. Perhaps that is why it is not used here. Our suggestions for revision [although not the specific proposed language in this case] would be as follows:

> Add a second row of graphs for the satellite data comparing it in the same way with each of the three cases. Also include a graph showing Figure 2-7 above and explicitly explain the extreme difficulty of explaining this data assuming anthropogenic causes (see Section 2.4 above for the detailed explanation). Finally, carefully explain the advantages and disadvantages of relying on the two data sources, including the severe reliability problems posed by the surface data because of urban heat island effects, increasing urbanization, monitoring station dropouts, missing temperature data, bad station siting, instruments with known biases introduced without adjustment, the difficulties of obtaining representative data from oceans and other areas with few monitors, and possibly even black-box man-made adjustments to maximize reported warming that may have occurred in the case of surface stations. Conclude by saying that this means that there is a great need to fully understand the reason for the differences between the two data sets before reaching any conclusions as to the anthropogenic causes of the warming that occurred in the period 1978 to 2007. Also mention the severe drop in temperatures since the summer of 2007, which does not appear to be accounted for by the models. There is also a need to note exactly which natural forcings the IPCC used and to point out that they did not use PDO/AMO, ENSO, and indirect solar variability, despite their potentially great importance as causes of global temperature changes.

Section 5, Page 40, lines 1-3: This sentence probably needs a comma after “temperatures” to be clear.

[add text if time permits]

Section 5, Page 40, lines 5-7: This is a curiously worded statement that ignores the argument (see Section 2.10 above) that Antarctic ice cores show that at temperature minimums, CO_2 increases follow temperature increases by about 800 years. This suggests the following revised wording:

> Analyses of paleoclimate data show that CO2 increases follow temperature increases rather than the other way around (Fischer et al., 1999) and (Caillon, 2003). This strongly suggests that CO_2 may not be causing higher temperatures, but rather that higher temperatures cause a rise in CO_2 levels (which is logical given the reduced capacity of water to hold CO_2 at higher temperatures).

Section 5, Page 40, lines 9-12: Once again, the Draft TSD and presumably the IPCC ignore the following possible "natural causes" so it is difficult to take this statement seriously: including indirect solar variability (Svensmark et al., vvv), urban heat island effects, increasing urbanization, monitoring station dropouts, missing temperature data, bad station siting, instruments with known biases introduced without adjustment, the difficulties of obtaining representative data from oceans and other areas with few monitors, and possibly even black-box man-made adjustments to maximize reported warming that may have occurred in the case of surface stations, the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation, and the ENSO. It also does not mention the Scafetta and others (2008 and 2009) studies which reach a different conclusion.

Section 5, Page 40, lines 18-46 in Figure 5.2: This graph suffers from all the same problems as Figure 5.1 and needs to be revised in an analogous way as proposed above. It once again uses surface temperatures and ignores the important comparison with satellite data during the years for which it is available. There is also no reason to omit the important data since 2000. Reliance on the satellite data would probably contradict most of the quoted conclusions in lines 4-11 of page 40, but we have not had sufficient time to actually obtain and analyze the North American data given the short time given for our review.

Section 5, from line 39 on page 40 to line 2 on page 41: This is a very important caveat but it is important for the reader to understand just how important it is. As mentioned in the quote from Richard Feynman in Section 2.? Above, good science requires that even a single inconsistency

between an hypothesis and real world data should invalidate the hypothesis. Until this question of possible errors in the data is resolved (and in our view there is actually very little question that it is correct—and hence the hypothesis invalid) it would appear inappropriate to reach any conclusions on whether the hypothesis is correct. This also would be a good point to discuss the atmospheric relative humidity problem discussed above in Section 1.7 since this is a similar problem which also appears to invalidate the GHG/CO2 hypothesis assuming that the data is correct (it appears to us to be). So our suggested revision would be to add the following at the end of line 2:

> The question posed here is a matter of great scientific importance because failure of any detail of a hypothesis to explain the observed data invalidates the hypothesis until it may be revised so that it conforms with the observed data (Feynman, 197?). Given this, the hypothesis is not ready to be used for policy purposes until this issue is fully resolved. This is not the only such problem with the hypothesis; a similar one is the fact that balloon monitoring shows that atmospheric relative humidity has fallen in recent years at the same time that CO2 concentrations have risen. Since the models all assume in one way or another that this is not the case, and this assumption is the basis for the all important positive feedback from water vapor, this problem is another one which needs to be resolved before any finding of endangerment is made (Gray, 2009, Miskolczi, 2007, and others).

Section 5, Page 41, lines 32-7: It is odd that the draft TSD pays such attention to the Southern and Northern Annualar Modes here given the obvious relationships between ENSO and PDO/AMO in explaining global temperature changes (see Section 2.4 above for a detailed discussion). This might be a good point to explain all this by using the text in Section 2.4 above so that the reader can easily see how global temperatures are apparently affected by these natural oscillations. Figure 2-3 would be particularly important to include in this regard.

Section 5, Page 41, lines 39-45: As discussed in Section 1.4 above, this paragraph appears to be somewhat outdated. We suggest the following alternative language:

> Although anthropogenic influences may have contributed to Tropical Atlantic hurricane behavior, the tide of opinion on this subject may be changing. Gutowski et al. (2008), as

cited in the CCSP (2008i) report find evidence suggesting a human contribution to recent hurricane activity, but emphasize that more research is needed. Vecchi et al. (2008) suggest that empirical evidence is insufficient at the current time to draw a distinction between natural and anthropogenic causes. However, if one were to turn to purely physical arguments or to the latest state-of-the-science dynamical calculations from high temporal and spatial resolution modeling efforts, one would begin to gather enough weight to start to tip the scale in the direction of natural cycles. Vecchi et al. (2008) lay out these lines of evidence and summarize their conclusions in the following figure:

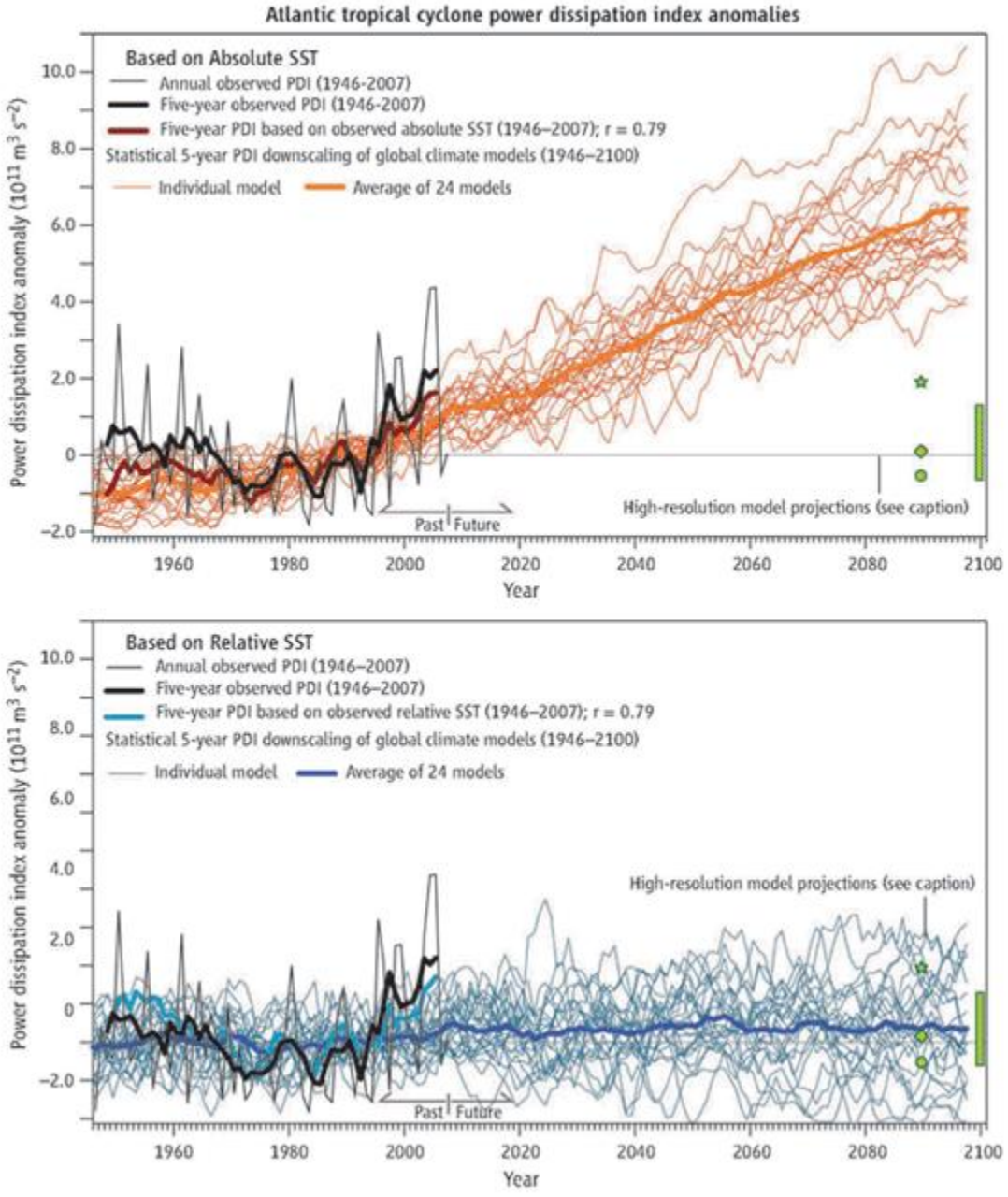


Figure 5.?. Observed Tropical Cyclone Activity in Atlantic Basin, 1946-2007 (Black Lines) and Fit to Absolute Tropical Atlantic SST (Thick Brown Line, Top) and Relative Tropical Atlantic SST (Thick Light Blue Line, Bottom)

Climate model projections to the year 2100 based upon the observed tropical cyclone/absolute SST relationship (orange lines, top) and observed tropical cyclone/relative SST relationship (blue lines, bottom). The projections made by high resolution dynamic hurricane models are indicated by the green symbols on the right of each chart (see Vecchi et al., 2008 for additional details).

The top chart in Figure 5.? shows a cumulative measure of annual Atlantic tropical cyclone activity (thick black line), a statistical fit to the observed activity using absolute tropical Atlantic SSTs (thick brown line) and the climate model projections of the future Atlantic tropical cyclone activity based upon that statistical fit (thin orange line are individual model projections, the thick orange line is the model average). Cleary, under this scenario, Atlantic hurricane activity is projected to increase dramatically in the future driven by anthropogenic global warming. The bottom chart of Figure 5.? shows the results of the scenario in which Atlantic tropical cyclone activity (thick black line) is driven by relative changes in the tropical Atlantic SSTs (thick light blue line). Climate model projections of this relationship are indicated by the thin dark blue lines and the thick blue line model average. In this scenario, global warming has little impact on Atlantic tropical cyclone activity.

The current "best thinking" as to the impact of global warming on Atlantic tropical cyclone activity from high resolution dynamical hurricane models is indicated by the elements in green (stars, squares, triangles, bars) at the far right-hand side of each chart. In each case, the high-resolution model results fall within the spaghetti of the model projections depicted in the bottom chart and not within the spaghetti of the top chart. This implies that our best hurricane models are lending their support to side maintaining that there is little impact from global warming, and instead, tropical cyclones are largely modulated by natural variability.

Obviously, there is still a lot of work that needs to be done in the arena of hurricane modeling before this issue can be cleared up, which is the primary message that Vecchi et al (2008) want you to take home with you, but, along the way, Vecchi et al. (2008) strongly demonstrate that based upon what we now know, it seems that natural multi-decadal oscillations in the climate of the Atlantic Ocean trump anthropogenic global warming, when it comes to being the dominant driver of 20th and 21st century Atlantic hurricane activity.

4.4 Part IV

Section 7, Page 64, or elsewhere in Section 7: It is important to note that human lifespans in the US have been steadily increasing during the entire 20th Century despite rising GHG/CO2 levels,

as shown in Figure 3-2 above, so if there has been an endangerment, it must have been a very minor one. We also suggest inclusion of this Figure in the TSD.

Section 8, Page 70, or elsewhere in Section 8: It is important to note that ozone levels in the US have been steadily increasing during the entire 20th Century despite rising GHG/CO2 levels, as shown in Figure 3-3 above, so if there has been an endangerment, it must have been a very minor one. We also suggest inclusion of this Figure in the TSD.

Section 9, Page 75, or elsewhere in Section 9: It is important to note that crop yields in the US have been irregularly increasing during the entire 20th Century despite rising GHG/CO2 levels, as shown in Figure 3-1 above so if there has been an endangerment, it must have been very minor at most. We also suggest inclusion of this Figure in the TSD.

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About the Comments

This comments have been prepared by Alan Carlin in the National Center for Environmental Economics (NCEE) in the EPA Office of Policy, Economics, and Innovation. Considerable assistance has been received from John Davidson of NCEE although the views expressed do not necessarily represent his views.