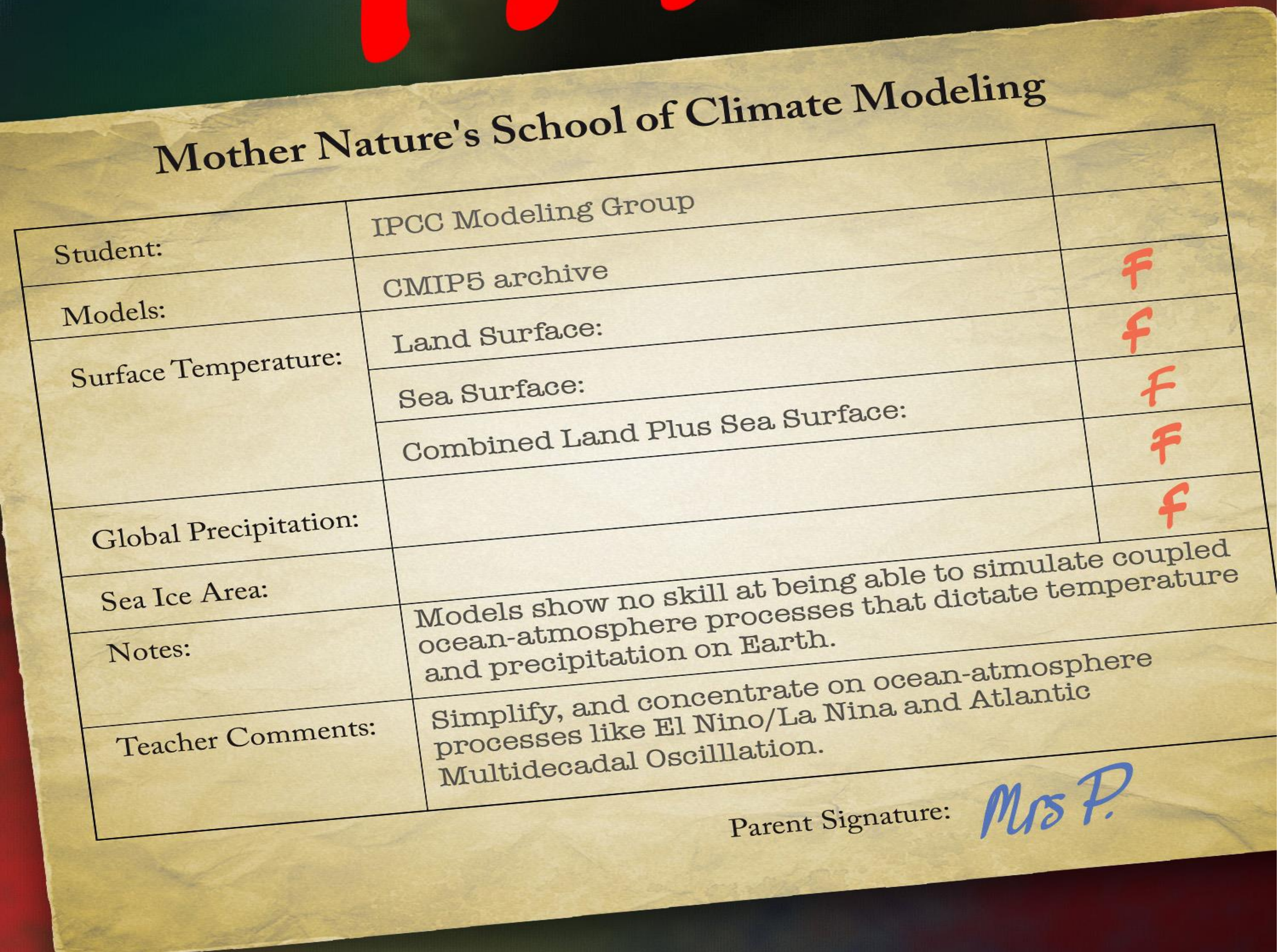
Climate Models FAIL



By Bob Tisdale

Author of *Who Turned on the Heat?*

Climate Models Fail

The IPCC's Climate Models Show No Skill at Simulating Surface Temperatures, Precipitation and Sea Ice Area

By Bob Tisdale – Author of *Who Turned on the Heat?*

***

IMPORTANT NOTE: This ebook was written in 2013. Because websites are constantly being updated, hyperlinks may no longer be operational. Sorry.

Foreword

AN INITIAL NOTE: My apologies to the conscientious climate scientists, who work without agendas to better our understanding of climate, especially those who I have exchanged off-the-record emails with over the years. Please understand, when I am discussing the climate science community in the following pages, I am speaking of those scientists with agendas who, by supporting and encouraging the IPCC's propaganda, have blamed global warming on mankind, without first making the slightest effort to genuinely understand the fundamental processes through which nature contributes to climate change.

# # #

Climate Models Fail is an illustrated overview of observations-based data and the outputs of climate model simulations of surface temperature, precipitation, and sea ice area. The data and the model outputs are available to the public online in easy-to-use formats. By plotting the data and the model outputs on the same graphs, it becomes obvious that the models prepared for the Intergovernmental Panel on Climate Change's 5th Assessment Report show no skill at being able to simulate those variables — no skill whatsoever. The model simulations are so different from the observations that in many cases you may begin to wonder if they are modeling a completely different planet. Now consider that many of the comparisons presented in *Climate Models Fail* cover only the past 3 to 3 ½ decades — a period to which many climate models were "tuned".

Early in Section 1, *Climate Models Fail* includes a chapter about the findings of numerous peer-reviewed scientific studies. Those papers are very critical of climate models, highlighting the models' many flaws.

Most chapters of *Climate Models Fail* include presentations and discussions of model-data comparison graphs. Dozens of graphs.

Since the turn of the century, the warming of global surface temperatures has stopped once again. That is, we've recently entered a period that is similar to the multidecadal period from the mid-1940s to the mid-1970s when surface temperatures did not warm. The current warming slowdown is known by many names: "the hiatus", "the lull", "the pause", "the plateau", and so on. The words "stoppage", "halt" and "cessation" are used throughout this book, because the warming of global surface temperatures has stopped, it has halted, it has ceased, over the past 12 to 16 years, depending on the metric. I prefer "stoppage" because it sounds as if the surface temperatures have gone on strike against the IPCC and their models. Maybe Mother Nature has.

Climate Models Fail also presents model-data comparisons of surface temperatures during this halt in warming. They show which regional land masses and which ocean basins have stopped warming — or have cooled since 2001. Obviously, because there has been a warming stoppage globally, most areas are not warming or they are cooling.

Climate Models Fail is intended for readers without technical or scientific backgrounds. There are introductory chapters that provide basic information. Because this book includes quotes from scientific papers and from political entities such as the IPCC (Intergovernmental Panel on Climate Change), *Climate Models Fail* also explains the scientific terms they use, or, at least, provides a general, non-technical, translation.

Example:

> *In climate research and modelling, we should recognise that we are dealing with a coupled non-linear chaotic system, and therefore that the long-term prediction of future climate states is not possible.*

That quote is from the 3rd Assessment Report from the IPCC (Intergovernmental Panel on Climate Change) published in 2001 – Section 14.2.2.2 Balancing the need for finer scales and the need for ensembles.

The term “coupled” reflects the interrelationship between the oceans and atmosphere. “Non-linear” indicates that a simple proportional relationship between cause and effect does not exist. “Chaotic” in this sense refers to the climate’s sensitivity to an infinite number of possible disturbances, many of which are unknown in climate science.

Of course, the bottom line of that quote from the IPCC is “…long-term prediction of future climate states is not possible.” That requires no translation.

Some readers may find the results of *Climate Models Fail* to be unbelievable — that is, they may not believe the models perform as poorly as I’ve illustrated. For those readers, I have prepared a blog post that provides step-by-step instructions for creating a model-data comparison graph. (See my blog post here.) I used the model-data comparison of global sea surface temperatures over the past 31 years as an example. Over that time period, the climate models used by the IPCC for their 5th Assessment Report estimated that global sea surface temperatures would warm twice as fast as they actually did.

Climate Models Fail has been proofread and edited by someone without a technical background. She has taken the content of this book, originally written in my technical/scientific style, and made it much easier to read and understand, while leaving the content intact. I appreciate the time and massive effort she has put into this work and my heartfelt thanks go out to her. If there are any residual typos, they are my doing.

My special thanks also to Josh of Cartoons by Josh for the cover artwork.

Thank you for purchasing *Climate Models Fail*.

Sincerely,

Bob Tisdale

Climate Models Fail - Table of Contents

Introduction

The last ice age ended about 11,600 years ago and the Earth has been warming ever since. More recently, the instrument temperature record indicates that surface temperatures have slowly warmed for more than a century. During that time, though, the warming stopped from the mid-1940s to the mid-1970s, before renewing until the turn of the century. Surface temperatures have once again stopped warming in the 21st Century. This repeat in the cessation of global warming has renewed interest in the subject of human-induced climate change. And as a result, people are questioning the capabilities of climate models.

It's good that people are questioning them. Climate models cannot simulate past surface temperatures, precipitation or sea ice area. Those are basic components of Earth's climate. If the climate models cannot simulate those basic components, is it likely they can simulate others?

The concern about the latest slowdown in warming was addressed by a recent scientific study by Von Storch, et al. (2013) "Can Climate Models Explain the Recent Stagnation in Global Warming?" The one-word answer to the title question of their paper is, "No". They stated:

> *However, for the 15-year trend interval corresponding to the latest observation period 1998-2012, only 2% of the 62 CMIP5 and less than 1% of the 189 CMIP3 trend computations are as low as or lower than the observed trend. Applying the standard 5% statistical critical value, we conclude that the model projections are inconsistent with the recent observed global warming over the period 1998-2012.*

Note: CMIP3 and CMIP5 refer to climate model archives. CMIP stands for "Coupled Model Intercomparison Project". The current generation of climate models being used for the IPCC's 5th Assessment Report is stored in the CMIP5 archive, and the previous generation of models that were used for the IPCC's 4th Assessment Report (2007) is found in the CMIP3 archive.

According to Von Storch, et al. (2013), both generations of models cannot explain the recent slowdown in warming.

In addition to the instrument-based temperature record, there are other possible indications the Earth had warmed from the mid-1970s to the end of the last century. Glaciers retreated. Yet, glaciers have been retreating since the end of the Little Ice Age — and glaciers will continue to retreat until regional surface temperatures cool or regional snowfall increases to the point that seasonal glacial ice losses can be overcome by seasonal gains. And yet, while the warming of surface temperatures has once again ceased globally, there continue to be indications of elevated temperatures in some regions. For example, annual Arctic sea ice minimums have recently dropped to the point where sailors are fantasizing about traversing a seasonally ice-free Northwest Passage. But glaciers and Arctic sea ice are only symptoms of a warmer world, not of a warming world. They don't tell us why the Earth has warmed or if it will warm again anytime soon. They only indicate that it warmed to the point where seasonal ice losses are greater than seasonal ice gains.

A number of recent facts are exposing the uncertainties of climate science and raising serious doubts about model projections. The Arctic experienced a remarkably cold summer in 2013. As a result, Arctic sea ice did not melt as much as it had in recent years. [Refer to the plot of Arctic sea ice extent from the Danish Meteorological Institute here.] This increases the likelihood that chaotic weather was the huge dominant factor in the exceptional sea ice losses in 2007 and 2012. Only a few years ago scientists, using models, were predicting that Arctic summer sea ice would be all but gone in 2013. [See the December 12, 2007 BBC News article by Jonathon Amos "Arctic summers ice-free 'by 2013'".]

Hurricanes are also not cooperating. Brian K. Sullivan's August 30, 2013 Bloomberg News article titled "No Atlantic Hurricane by August in First Time in 11 Years" begins:

> *August is about to end without an Atlantic hurricane for the first time since 2002, calling into question predictions of a more active storm season than normal.*

And last December, Roger Pielke, Jr. noted that, as of the start of the 2013 hurricane season, there would have be an unprecedented drought of Category 3 or stronger hurricanes making landfall in the United States. We're a number of months into the hurricane season, and as of this writing, we have yet to see a hurricane make landfall in the U.S., so that unprecedented drought continues. [See Pielke, Jr.'s blog post Record US Intense Hurricane Drought Continues and his September 2013 update here.]

The two primary climate change metrics of interest are global surface temperatures and global precipitation. Will the future be warmer or cooler, and will it be wetter or drier? And by how much? The problem: climate models show **no skill** at being able to answer those fundamental questions about climate change. No skill at all. Numerous peer-reviewed papers discuss climate model flaws, but they are overlooked by the mainstream media. As a result, most people don't realize how many problems climate models have.

Sea level is also of interest, especially for those living along the coasts and on islands, and understandably so. Unfortunately, the modeling groups do not make their climate model outputs for sea level available in easy-to-use formats, so there are no model-data comparisons for sea level in this book. For those concerned about sea level, I've included a few brief notes later in the introduction, under the heading of "Subjects Not Addressed in *Climate Models Fail*".

I've made two assumptions while preparing this book. First, I've assumed those of you interested in this subject can read and understand time-series graphs and color-coded global maps. I have not explained how to read them. My second assumption is that the device on which you're reading this book will allow you to view the graphs and maps in color.

Most people know very little about climate models. I was reminded of this by the recent PBS "Idea Channel" video, "Is the Discovery of Global Warming Our Greatest Scientific Achievement?" At about the 3:35 minute mark, the narrator says two sentences that promote three misunderstandings:

> *We have enough computing power to turn it [data] into something sensible and useful. We create realistic models and simulations that themselves create climate knowledge.*

The first misunderstanding promoted by those two sentences is that data are used in all climate models. Data are not used in all climate models, and especially not in the ones that make the long-term projections. Climate models are tuned using observational data. Sometimes the models use data, e.g., sea surface temperatures, as inputs, but the climate models which try to simulate past climate (for attribution studies) or future climate (for projections) contain no data within themselves. Also, climate model simulations are often initialized from data observed at a specific point in time. From that point forward, however, the models go on their merry way, blithely crunching numbers, trying to guess at the past (known as hindcasts) or trying to guess at the climate of the future (known as projections). The models make two massive assumptions: 1) that future human emissions of greenhouse gases and other anthropogenic factors turn out to be what they guess they will be; 2) that climate on Earth actually responds to those greenhouse gases and other anthropogenic factors the way the modelers guess that it does — that's a massive assumption…an assumption that is not supported by data nor by the models.

A principal problem with that last assumption extends back to the primary task the IPCC (Intergovernmental Panel on Climate Change) established for climate science community. That task was to study the range of possible impacts of human-induced global warming — not to study the natural contribution to the warming. Adhering to the IPCC's directive, climate scientists made models that created an imaginary, modeled world where anthropogenic forcings make warming happen. "Modeled" is the operative term in that sentence. In the **real** world, could that same amount of warming actually be caused by natural ocean-atmosphere processes? The climate science community under the control of the IPCC doesn't know because they cannot simulate those natural processes.

The second misunderstanding promoted by those two short sentences from the PBS video is that climate models are realistic. In no way are models realistic representations of climate. And climate modelers know this. The NCAR (National Center for Atmospheric Research) is one of the main climate modeling groups. NCAR has a number of webpages that introduce their climate models. Down at the bottom of the webpage here, below the very strict disclaimer and under the heading of "Scenario A2", NCAR states (my boldface):

> ***Climate models are an imperfect representation of the earth's climate system*** *and climate modelers employ a technique called ensembling to capture the range of possible climate states.*

NCAR was very candid: "Climate models are an imperfect representation of the earth's climate system…" And yet, somehow, most people have wrong ideas about climate models.

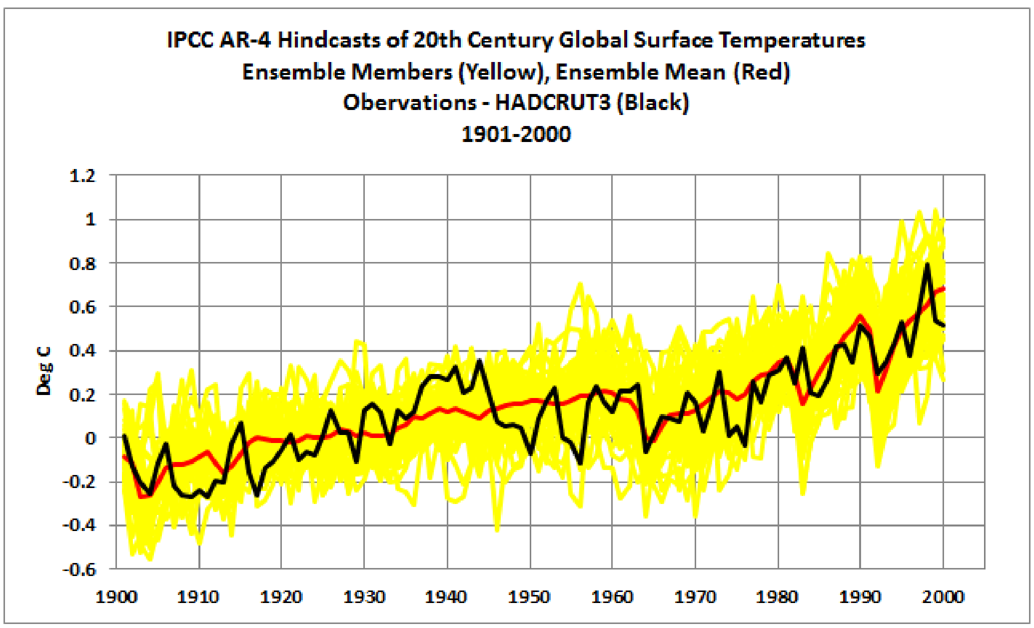


Figure I-1

Let's look at a typical example of climate model outputs, to get an idea of just how imperfect those climate models really are. Figure I-1 is a replica of a graph from the 4th Assessment Report from the IPCC (Intergovernmental Panel on Climate Change). [The original is here.] In it, the IPCC compares observations-based global surface temperature anomalies since 1901 (**black** curve) to the outputs of the individual climate model simulations prepared for their 4th Assessment Report (yellow curves). The **red** curve is the average of all the yellow curves and it is called the "multi-model ensemble mean". Each of the yellow curves represents the output of one simulation — one model run. There are so many simulations and they are so diverse that they make a big yellow cloud around the data. One thing is quite obvious, however. Some models grossly **unde**restimate the rate of warming since 1901 and some of the models grossly **over**estimate it. If climate models were reasonably accurate, all of the yellow curves would align fairly closely with the data, the black curve. They do not.

In addition, the data have also been modified. And, not surprisingly, the adjustments to the data always seem to make it fit the model outputs better.

Looking at the red curve, the average of all the model simulations, it might appear the climate models as a whole do a reasonable job of simulating the past. Look closer. The black curve shows the rate at which global temperatures warmed in the early part of the 20th Century (from the mid-1910s to the mid-1940s) is similar to the rate of warming after the mid-1970s. Yet the model mean, the red curve, doesn't show a similar warming rate in the 1910s through 1940s. With the models, the period after the mid-1970s warms at a rate that's about three times faster than the modeled rate of early warming period of 20th Century. I'll show that in more detail in a separate chapter and discuss why it's important. Also note: the models do not properly simulate the halt in warming from the mid-1940s to the mid-1970s.

The third misunderstanding is about climate models creating "climate knowledge." The reality is that climate models only generate the output the modelers have programmed. That is, the models do nothing more than regurgitate their programming. If the climate model produces an output the software writer doesn't like, the modeler simply rewrites the software. Climate models are tuned, through trial and error, to match, as closely as they can, the expectations of the programmers.

For further information about climate model tuning, refer to Mauritsen, et al. (2012) Tuning the Climate of a Global Model [paywalled]. A preprint edition is here.

The above three distortions about climate models in that PBS video may be based on the scriptwriters' misunderstandings, or the authors upon whose writing PBS based its script may be overstating the capabilities of the models. This book presents how poorly climate models simulate past climate on Earth and that climate models show no skill whatsoever at hindcasting — which means climate models FAIL, for they are not realistic, not even for the last few decades.

Instrument-based temperature records do nothing to prove the hypothesis of human-induced global warming. The observations-based temperature records only indicate that temperatures had warmed (past tense) — not that manmade greenhouse gases were responsible for the warming.

Climate models are used by the climate science community in attempts to attribute climate change to manmade greenhouse gases. Climate models do not prove anything. Unfortunately, coupled ocean-atmosphere general circulation models have been falsely portrayed as accurate and their uncertainties have been glossed over.

Over the past few years, I've examined the outputs of climate models — sea surface temperatures, land surface temperatures, and the combined land+sea surface temperatures, along with precipitation and hemispheric sea ice area. My examinations were simple. I compared climate model outputs to observations-based data, globally and regionally, and presented their warming rates, precipitation rates, etc., based on their linear trends. I don't do anything magical. See the example in Figure I-2. I use publically available data and climate model outputs. I download them to a spreadsheet and the spreadsheet software calculates the trends. I try to make the graphs easy to read and understand. Then, I write a blog post about my findings.

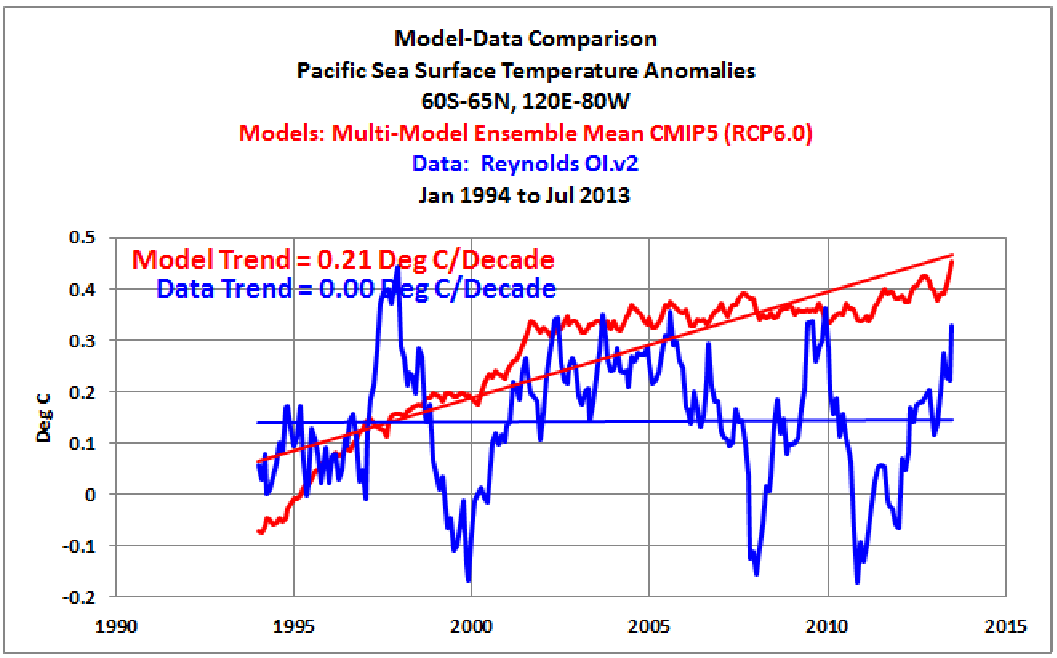


Figure I-2

Figure I-2 is one of my favorite model-data comparisons. It includes the sea surface temperature data for the Pacific Ocean and the average of the simulations of those Pacific surface temperature anomalies by the models being used by the IPCC for their 5th Assessment Report. The data and model outputs start in January, 1994, nearly 20 years ago. The Pacific Ocean is by far the largest body of water on this planet. It covers more of Earth's surface than all of the continental land masses. As shown, the sea surface temperatures there have not warmed in almost 2 decades. They warm and cool temporarily in responses to El Niño and La Niña events, but, over the past 20 years, based on the linear trend of the data, the surface temperatures have not warmed. On the other hand, the climate models being used by the IPCC have simulated that the surface temperatures of the Pacific should've, would've, could've warmed more than 0.4 deg C, if manmade greenhouse gases were capable of warming the surface of the Pacific Ocean. There's obviously something missing from some equation somewhere. Something else to consider: since 1994, the IPCC has published their 2nd, 3rd, and 4th Assessment Reports, and they're about to publish the 5th. In that time, the surface of the largest body of water on Earth has NOT warmed.

Climate scientists present similar model-data comparisons, but they try to display models in flattering ways. Take the blog RealClimate, for example. The contributors there are climate scientists. Each year, they publish an annual update of model-data comparisons. [See an example here.] They tried to put the models in a good light, but there was nothing they could do to fix the model-data comparison for ocean heat content once they discovered the error they had made in earlier updates. (For more on that controversy, see the post here.) I, on the other hand, am not employed as a climate scientist or as a climate model programmer. I have no self-interested need to make the models appear as though they have skill. Promoting climate models is not in my job description. On the other hand, I do not have to take any extraordinary steps to make climate models look bad — they do a great job of that all on their own.

I've studied the outputs of the models prepared for the IPCC's 4th Assessment Report (AR4), which was published in 2007, and the models which were run for their 5th Assessment Report (AR5). [Refer to the IPCC Reports webpage.] The model outputs of many climate-related metrics, like the observations-based data, are available to the public in easy-to-use formats. I use the KNMI Climate Explorer as a source for data and model outputs. I also use NOAA's NOMADS website for satellite-era sea surface temperature data. Anyone with internet access and spreadsheet software can do what I've done. I've simply been curious enough to investigate them and, as a pensioner, I've had the time. I've presented those findings in numerous posts at my blog Climate Observations. Many of my posts were also published at the world's most-viewed website about global warming and climate change WattsUpWithThat? Based on my comparisons of model outputs to observations-based data, I can say emphatically that **climate models have no skill** at simulating past climate. Once you examine the contents of this book, you will no doubt come to the same conclusion. Additionally, based on my findings, I personally do not believe the model projections of future climate have any credibility.

This book is a collection of climate model-data comparisons. The failures of the models are hard to miss. I hope this book gives you a better understanding of just how poorly climate models perform. What you do with your new knowledge is up to you.

Hypothetical global warming has reached religious levels for some people. While reading this book, they might refuse to believe their own eyes. For such readers, as noted earlier, I have an entire chapter dedicated to scientific papers that describe the many problems with climate models. The climate science community knows about these failings, but I doubt many persons outside their clique do.

Climate models are not super models, not in any sense of the word super — other than cost. Dozens of modeling groups around the globe have mainframe supercomputers crunching numbers around the clock, week after week, year after year, with each of those computers consuming enough electricity to power a small town. Yet, they simulate climate very poorly. They show no proficiency at being able to simulate past regional or global surface temperatures (land or ocean), precipitation, sea ice area, or coupled ocean-atmosphere processes.

Like snake-oil salespeople of the environmental movement, a number of climate modelers/scientists have vigorously promoted those deeply flawed models of Earth's climate. Those modelers/scientists were happy to seek the limelight through repeated media interviews and by testifying before governmental committees. Some of those activist-scientists have become household names. They downplayed uncertainties about the future and failed to present to the public how poorly climate models simulate the past. And remember, in speaking of "the past", I'm only talking about the 20^{th} Century and, sometimes, only the last 2 or 3 decades.

I say climate modelers did the promoting. Some did. Some didn't. Sometimes it's the international government organizations like the IPCC doing the hard-sell marketing. Of course, the task of promoting climate models also falls into the hands of national government bodies like the UK Met Office (UKMO), the U.S. National Climate Assessment and Development Advisory Committee (NCADAC), NOAA, and others.

Climate models are being used as marketing tools both for governments and for the environmental movement to try to force the free industrialized world to abandon fossil fuels and to keep developing nations from enjoying the benefits of inexpensive energy. With the help of the mainstream media, those far-from-super models have been raised high on pedestals of gold as though they were as valuable as precious metal…when they plainly are not. They are only money sinks. They consume gold.

Governments around the globe have fed climate models billions of dollars annually trying to prove that human greenhouse gases have a significant effect on climate.

The assumptions the modelers have made while writing the programs are clearly flawed. Why then should anyone have the slightest amount of confidence in the Carnac the Magnificent-like prognostications of future climate that are based on their flawed assumptions?

Over the past couple of decades, based on **speculative model outputs**, climate scientists have published thousands of scientific papers in peer-reviewed journals; governments have produced periodic reports to their nations about current and future climate; and the collective operated by the United Nations, the IPCC, included those flawed, model-based studies in their reports as well. Mainstream media then sifted through that giant heap of conclusions, looking for the most alarming prognostications, and added their own exaggerations of gloom and doom.

Then, something unexpected happened. Global temperatures stopped warming. The standstill in global warming has shown a spotlight on the many uncertainties of climate science. Climate models, which were once viewed as the *piece de resistance* of a new field of science, are now exposing its weaknesses.

Scrambling to explain the stoppage in global warming, climate researchers have no answers, only excuses, excuses, and more excuses. Paul Voosen's October 2011 article "Provoked Scientists Try to Explain Lag in Global Warming" includes quotes from a few well-known activist climate scientists — each giving a different excuse for the warming stall. The key word in the title of Paul Voosen's article is "try". They do not succeed at providing convincing answers. The lack of consensus within the climate science community about the cause or causes for the halt in warming suggests that the climate science community really didn't know why surface temperatures warmed during the latter part of the 20th Century. If they can't explain the cause of the lack of warming, they can't plausibly claim to understand what caused the warming.

After decades of modeling efforts by numerous groups, climate models still cannot simulate inter-annual and multidecadal ocean-atmosphere processes. In other words, they can't model basic modes of climate. This has led to finger-pointing by a former lead author of IPCC assessment reports. David Appell's 2013 article "W(h)ither global warming? Has global warming slowed down?" includes an eye-opening quote from Dr. Kevin Trenberth, Distinguished Senior Scientist from the NCAR (National Center for Atmospheric Research). Bear in mind, Dr. Trenberth was one of the lead authors of the IPCC's 2nd, 3rd, and 4th Assessment Reports published in 1995, 2001, and 2007. David Appell's article reads:

> *"One of the things emerging from several lines is that the IPCC has not paid enough attention to natural variability, on several time scales," he [Dr. Trenberth] says, especially El Niños and La Niñas, the Pacific Ocean phenomena that are not yet captured by climate models, and the longer term Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation (AMO) which have cycle lengths of about 60 years.*

Dr. Trenberth, a lead author of past IPCC reports, now claims the IPCC did not pay enough attention to naturally occurring ocean processes that can either advance or stop global warming. Natural variability is now being touted as the factor that can enhance or suppress human-caused global warming. That is, climatologists are now trying to say that there is an underlying but all-powerful and controlling manmade global warming component, which Mother Nature can either amplify or dampen. Unfortunately, given the dictates of the IPCC, climate scientists still have no idea whether the natural contribution to warming was 50% from the mid-1970s to the early 2000s or if the natural contribution was 80%, or 90%, or higher. Climate models certainly can't help them to determine the natural contribution and there are two reasons why the models can't help: (1) Climate models were only designed to prove that CO2 was the primary cause of the warming, and (2) climate models still can't simulate the naturally occurring ocean processes that cause global warming and cooling over multidecadal periods.

A side note: Dr. Trenberth included the Atlantic Multidecadal Oscillation among the natural multidecadal phenomena to which the IPCC has not paid enough attention. In "Using Data to Attribute Episodes of Warming and Cooling in Instrumental Records", Tung and Zhou (2012) studied the longest surface air temperature record, Central England Temperature, and also the HADCRUT4 land-plus-ocean surface temperature record. Both contained an Atlantic Multidecadal Oscillation signal. The last sentence of the abstract for Tung and Zhou (2012) reads:

> *Quantitatively, the recurrent multidecadal internal variability, often underestimated in attribution studies, accounts for 40% of the observed recent 50-y warming trend.*

40% is a sizable contribution to global warming from the Atlantic Multidecadal Oscillation—a contribution that is ignored by the models prepared for the IPCC.

Recently, the Royal Netherlands Meteorological Institute (KNMI) prepared and presented their recommendations for the future of the IPCC. [Refer to their document titled Submission by The Netherlands on the future of the IPCC.] Under the heading of "The IPCC needs to adjust its principles", KNMI begins:

> *We believe that limiting the scope of the IPCC to human-induced climate change is undesirable, especially because natural climate change is a crucial part of the total understanding of the climate system, including human-induced climate change.*

Climate scientists and scientific agencies from around the globe now admit that it was wrong for the IPCC to focus only on human-induced global warming. They even acknowledge now that we must understand **natural** climate change before we can hope to identify any human contribution.

One of the IPCC's marketing strategies has been to show that only climate models forced by anthropogenic factors like carbon dioxide could reproduce the warming of the latter part of the 20th Century, and that the models forced by only natural factors could not simulate the warming. A more rational explanation is that the models didn't correctly simulate the natural contributions to warming. But the IPCC overlooked that logic, insisting that, based on the models, in which they believe implicitly, only manmade greenhouse gases could be responsible for the recent warming. [See Figure 9.5 from the IPCC's 4th Assessment Report.] Chapter 9 Understanding and Attributing Climate Change, under the Heading of "9.4.1.2 Simulations of the 20th Century, includes:

> *Figure 9.5 shows that simulations that incorporate anthropogenic forcings, including increasing greenhouse gas concentrations and the effects of aerosols, and that also incorporate natural external forcings provide a consistent explanation of the observed temperature record, whereas simulations that include only natural forcings do not simulate the warming observed over the last three decades.*

The IPCC's ploy has backfired. It broadcasts loud and clear, to anyone listening, the failings of the climate models, and those failings are due to the models' inabilities to simulate natural ocean-atmosphere processes on inter-annual, decadal, and multidecadal time scales.

The IPCC appears to be ready to make the same presentation of climate model failures once again. Figure SPM.5 from the leaked draft of the Summary for Policymakers for the IPCC's 5th Assessment Report shows the same fatally flawed tactic of presenting model simulations based on only natural forcings (solar and volcanic aerosols) versus those based on anthropogenic (primarily manmade greenhouse gases) and natural forcings. The IPCC seems content at highlighting the models' failures to properly simulate natural coupled ocean-atmosphere processes that can cause surface temperatures to warm — or to stop that warming without notice. (See the blog post here.)

More than 20 years have passed since the IPCC's first assessment report in 1990, yet the climate science community still cannot simulate the natural factors that can cause global warming over multidecadal periods and that can also stop it cold in its tracks. There's a very basic reason for this: in their consensus-building efforts, governments have only paid for research about the speculative impacts of anthropogenic greenhouse gases. They did not fund research to determine why climate has actually changed and will change.

Just look at how the IPCC defines its role. The following quote is from the IPCC organization History webpage:

> *Today the IPCC's role is as defined in Principles Governing IPCC Work, "...to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.*

Climate science is now bogged down, stagnating, unable to free itself of an astronomically high percentage of peer-reviewed climate science studies, which blame, without evidence, manmade greenhouse gases for climate change, without meaningfully taking into account the natural factors that actually cause multidecadal variations in temperatures and precipitation.

For decades, government funding agencies would only pay for studies that indicated manmade greenhouse gases were responsible for climate change. In other words, they created a consensus the old-fashioned way: they bought a consensus. Some of you might say those governments got exactly what they paid for: a field of science utterly without merit.

As the years pass, the climate science community cannot account for the ever widening difference between the models and observations. As they become ever more desperate, climate scientists have started to use phrases such as “climate model evidence”, but all the models can truly produce is fatally flawed conjecture.

Recently, climate scientists are suggesting that the missing heat has been sequestered deep in the oceans. How deep? Below 700 meters (about 2300 feet), where we are not able to measure it with any degree of certainty. Why do they have to look so deep? The surface temperatures of the global oceans show little to no warming during the warming halt. The top 700 meters also show little warming. The adjusted data for the depths of 700 to 2000 meters (about 6600 feet) continue to show warming, but at a rate that is far below that warming determined by the climate models. Although it’s entirely possible for the oceans to warm at depths of 700 to 2000 meters while the top 700 meters do not warm, the climate science community has provided no mechanism by which the waters below 700 meters could warm without the top 700 meters also warming. And because they cannot account for natural contributions, they have no clue if the warming at those depths is due to manmade greenhouse gases. To take the absurdity a level higher, some have proclaimed that the mythical heat driven deep into the oceans will somehow come back to haunt us — again without providing a mechanism for how that could possibly happen. Also bear in mind that the temperature-measuring devices used for deep ocean sampling have so many problems that the measured temperatures of the oceans to depths of 2000 meters have to be adjusted to show any discernible warming. That’s right — without those adjustments (“corrections”, “modifications”, “tweaks”) to the data, the warming of the global oceans to depths of

2000 meters has also slowed to a crawl in recent years. Even with those all of those adjustments, the warming rate of the global oceans to those depths is far less than that estimated by climate models. So where'd the missing heat go? Was there any heat to "go missing"? All the IPCC offers as an answer is speculation; they have no proof of any of the above claims.

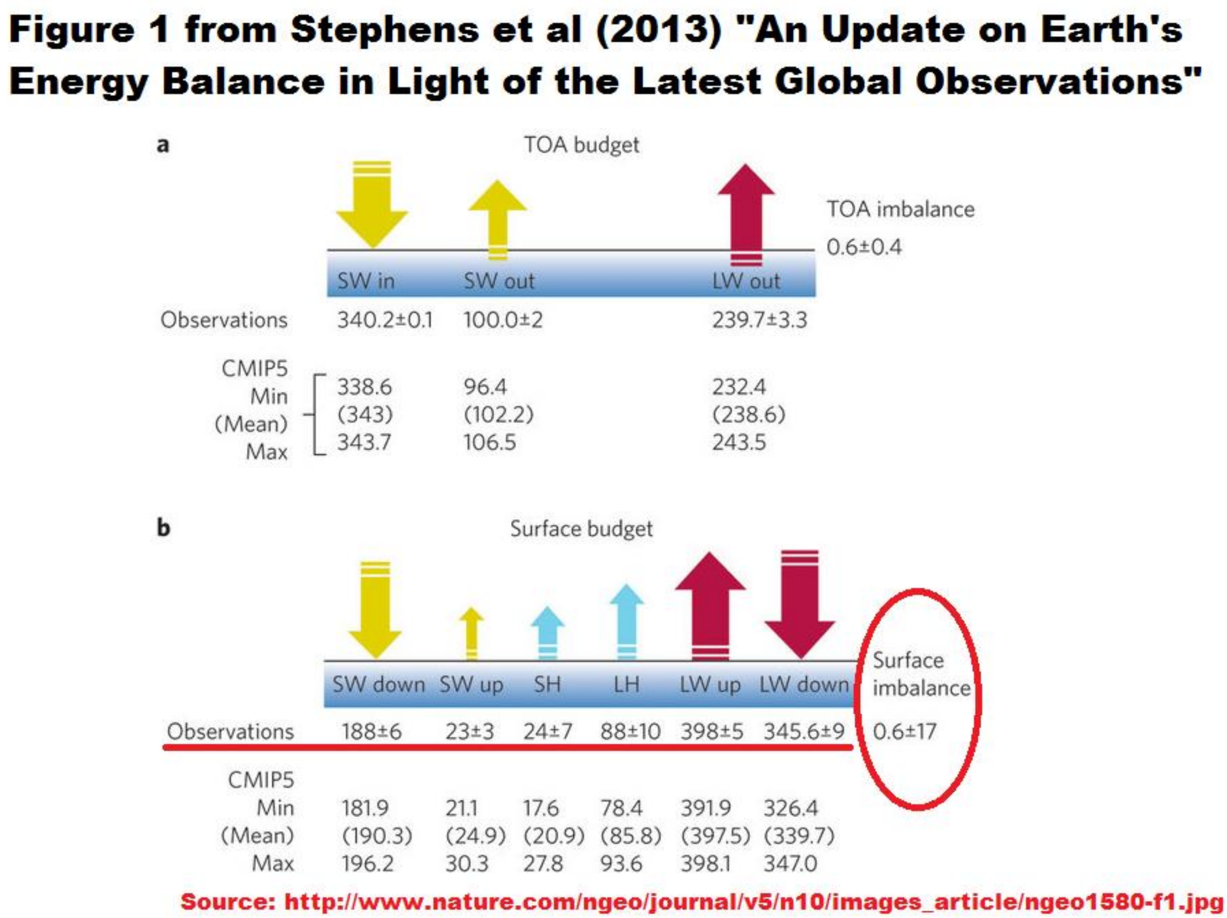


Figure I-3

Let's confirm that the missing heat's existence is uncertain. One of the metrics used to portray human-induced global warming is "radiative imbalance". "Radiative imbalance" is basically the difference between incoming and outgoing radiation from the sun and infrared radiation from manmade and natural greenhouse gases. It is estimated to be 0.6 watts/meter^2 ("watts/meter^2" is read watts per square meter). See Figure I-3, which is Figure 1 from Stephens et al (2013) "An Update on Earth's Energy Balance in Light of the Latest Global Observations". I've highlighted the surface numbers. The total of the downward shortwave (solar) radiation and longwave (infrared) radiation is about 534 watts/meter^2, so the estimated imbalance of 0.6 watts/meter^2 is only about 0.1% of the total downward radiation at the surface. Or, in other words, the total amount of downward radiation at the surface is about 890 times more than the difference. Also note the uncertainty in the imbalance. The estimated imbalance is 0.6 +/- 17 watts/meter^2. That is, the uncertainties are 28 times greater than the estimated value. Bottom line: the surface imbalance may exist or it may not.

Note: Radiative imbalance is the metric that alarmists like to portray in terms of atomic bombs. What the alarmists fail to tell their readers is that sunlight and natural levels of infrared radiation at the surface are almost 890 times the number of atomic bombs they're claiming, and that the uncertainties in radiative imbalance are 28 times the radiative imbalance.

Bottom line: As a result of the focus on manmade greenhouse gases, climate science has not progressed in two decades. Climate scientists are no closer now at being able to discern any fingerprint of human-induced climate change than they were two decades ago. What a colossal waste of time and money.

Subjects Not Addressed in *Climate Models Fail*

Climate Models Fail is not about the politics behind the global movement bent on demonizing carbon dioxide. I'm not a political person. Personally, I find politics extremely boring and counterproductive.

This book is not about alternate sources of energy or renewable energy. There are pros and cons with each new fad, as there are pros and cons to fossil fuels.

Nor is this book about the craze of attributing every weather event to humanity, though I will discuss it briefly here in the Introduction.

As you progress through this book and you see how poorly climate models perform, you'll begin to understand why alarmists are making those claims. It's out of desperation. Many of their claims aren't supported by data, and they definitely aren't supported by climate models.

Hurricane Sandy is a prime example of the mania of attributing every weather event to humans. The *Bloomberg Businessweek* cover in Sandy's wake included a grim photograph of a flooded New York street with the headline "It's Global Warming, Stupid". Refer also to the article by Paul M. Barrett included in that issue.

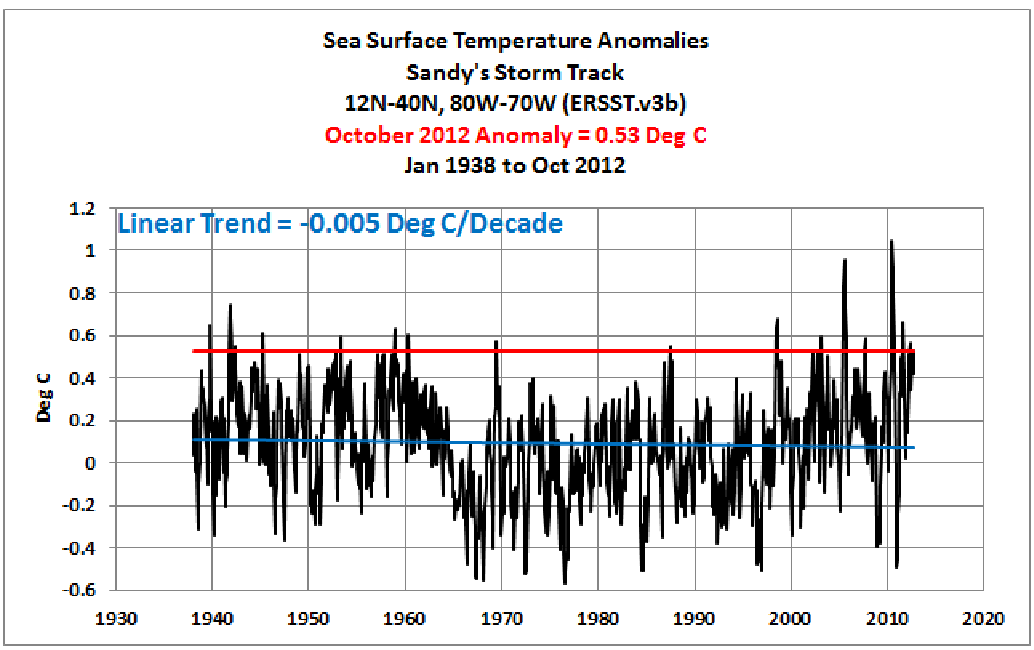


Figure I-4

Hurricanes are fueled by the seasonally warmed waters of the North Atlantic. What alarmists failed to understand — or they elected not to disclose — was that the sea surface temperatures of Sandy's storm track haven't warmed in 70-plus years, not since the Great New England Hurricane of 1938. [See the linear trend line and the calculated cooling rate in Figure I-4.] The trend line is colored blue, and the trend has a very slight negative value, indicating that sea surface temperatures have not warmed along Hurricane Sandy's storm track since 1938. Granted, the October 2012 sea surface temperature anomalies (red line) were warm, but they were not unusually warm. In fact, comparable values existed during the 1940s and 50s.

Let's take the examination one step farther: the media-fueled hysteria grew exponentially as Sandy drove northward off the east coast of the U.S. Yet, as shown in Figure I-5, sea surface temperature anomalies for the extratropical portion of Sandy's path (24N-40N, 80W-70W, which captures the coastal waters from the tip of Florida to New Jersey), have actually cooled in that time period.

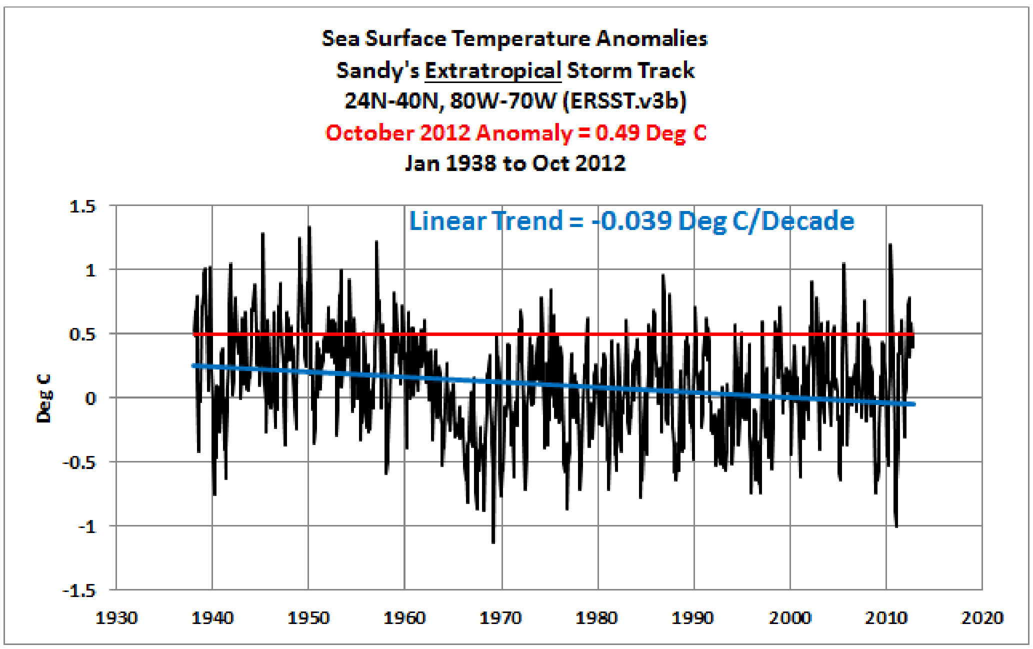


Figure I-5

Additionally, lower troposphere temperature anomalies over the extratropical portion of Sandy's storm track show very little warming since 1985 — more than 28 years. [See Figure I-6.] Lower troposphere temperatures are the temperature of the atmosphere at an altitude of about 3000 meters (about 9800 feet) above sea level. Lower troposphere temperatures are determined by satellite measurements. The October 2012 value was above the average for the period of 1981 to 2010, but it was not unusually warm when Sandy arrived there.

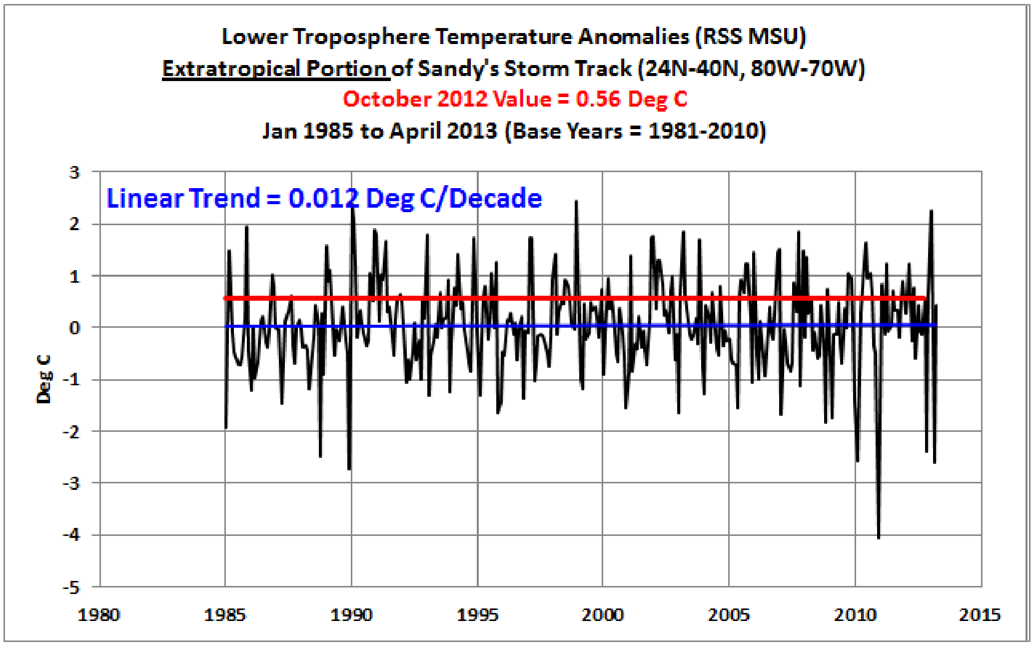


Figure I-6

# # #

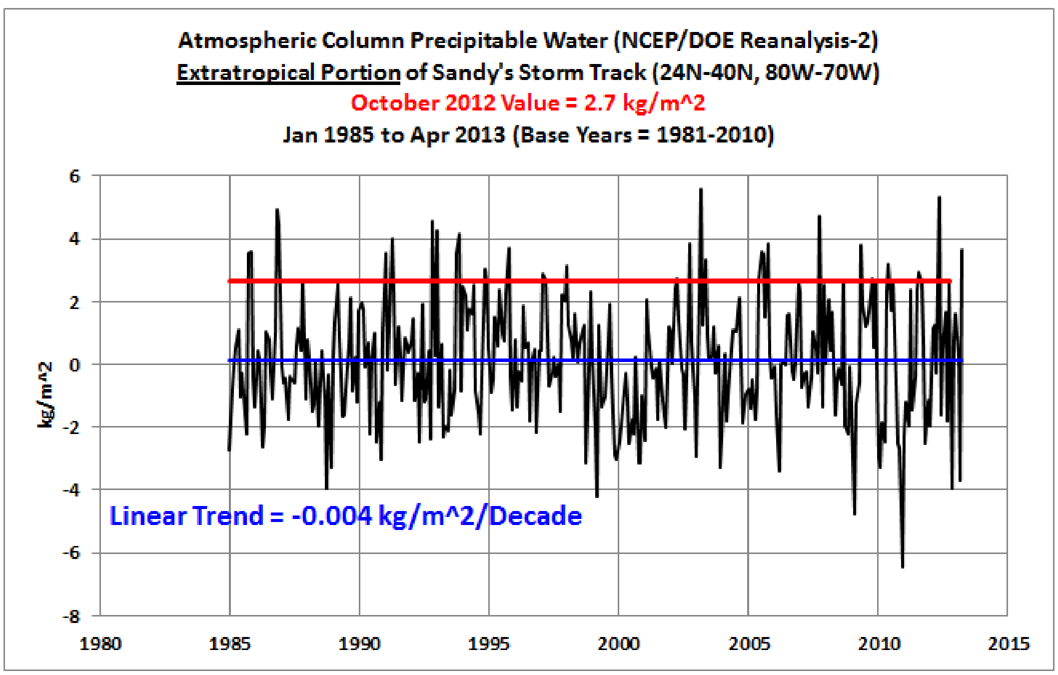


Figure I-7

Another typical alarmist claim is that global warming has increased the amount of moisture in the atmosphere, and, multiplying their error, they claim that the additional moisture has contributed to the severity of storms like Sandy. A dataset called "Precipitable Water" is the measure of the amount of water in the column of atmosphere if all the water in that column were to be precipitated as rain. As illustrated in Figure I-7, the precipitable water in the atmosphere above the extratropical portion of Sandy's storm track was, in fact, above the 1981 to 2010 average, but the amount has regularly been exceeded before and after October 2012—about 2 dozen times. Also, based on the linear trend (blue horizontal line), the precipitable water in the atmosphere above the extratropical portion of Sandy's storm track hasn't increased since 1985.

The above 4 graphs are modified versions of graphs from the blog posts here and here.

One wonders whether those making the erroneous claims about hurricane Sandy had even bothered to check the available data, because the data contradicts the claims.

Then there was the March, 2012 heat wave in the United States. While Midwesterners were outdoors in shirtsleeves, enjoying the break from the winter, alarmists were tolling the end-is-nigh bell. The media helped strengthen it by turning their amplifier volume up to the "This is Spinal Tap" setting of 11. About a year later—and well forgotten by the media by that time—the scientific papers appeared, and they explained that the heat wave was a natural event. As an example, refer to Dole, et al. (2013) "The Making of an Extreme Event: Putting the Pieces Together". Their abstract begins and ends:

> *We examine how physical factors spanning climate and weather contributed to record warmth over the central and eastern U.S. in March 2012, when daily temperature anomalies at many locations exceeded 20°C … We conclude that the extreme warmth over the central and eastern U.S. in March 2012 resulted primarily from natural climate and weather variability, a substantial fraction of which was predictable.*

Further to extreme weather, a Who's Who of climatologists from numerous organizations around the United States contributed to Peterson, et al. (2013) "Monitoring and Understanding Changes in Heat Waves, Cold Waves, Floods, and Droughts in the United States: State of Knowledge". Full paper here. The conclusions begin (my boldface):

> *Four key types of climate extremes (i.e., heat waves, cold waves, floods, and droughts) were assessed.* ***The data indicate that over the last several decades heat waves are generally increasing, while cold waves are decreasing. While this is in keeping with expectations in a warming climate, decadal variations in the number of U.S. heat and cold waves do not correlate that closely with the warming observed over the United States. The drought years of the 1930s had the most heat waves, while the 1980s had the highest number of cold waves.*** *River floods do not show uniform changes across the country; flood magnitudes as represented by trends in annual peak river flow have been decreasing in the Southwest, while flood magnitudes in the Northeast and north-central United States are increasing.*

Confounding the analysis of trends in flooding is multiyear and even multidecadal variability likely caused by both large-scale atmospheric circulation changes as well as basin-scale "memory" in the form of soil moisture. ***Droughts too have multiyear and longer variability. Instrumental data indicate that the Dust Bowl of the 1930s and the 1950s drought were the most widespread twentieth-century droughts in the United States, while tree ring data indicate that the megadroughts over the twelfth century exceeded anything in the twentieth century in both spatial extent and duration.***

My Figure I-8 is Figure 1 from Peterson, et al. (2013).

Figure 1 From Peterson et al (2013)

"Time series of decadal-average values of heat wave (red bars) and cold wave (blue bars) indices."

1895 Through 2010

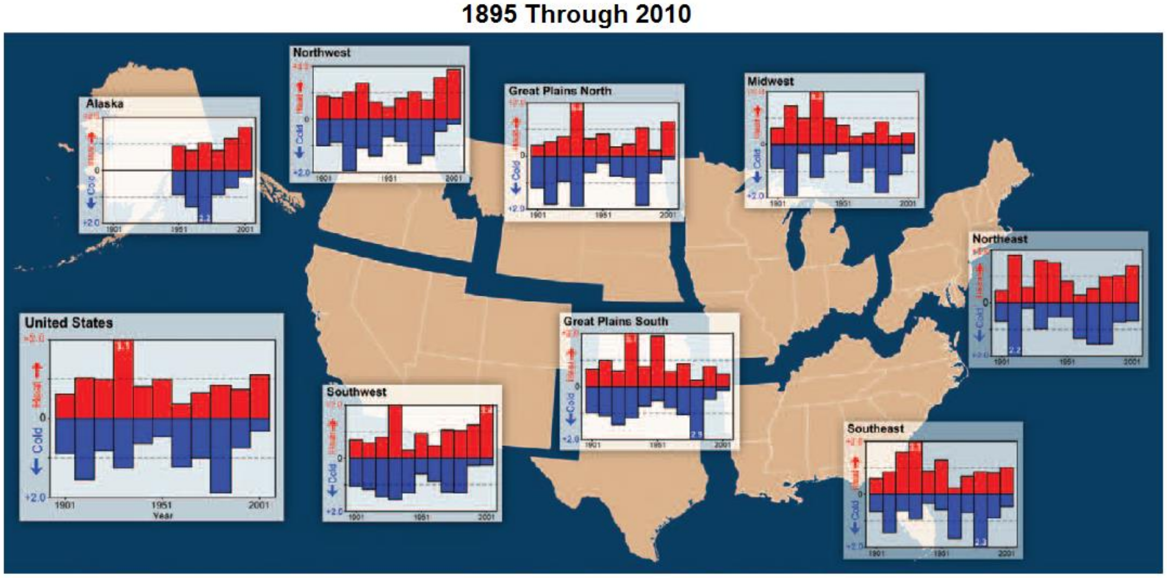


Figure I-8

Its caption reads:

Fig. 1. Time series of decadal-average values of heat wave (red bars) and cold wave (blue bars) indices. These indices are a normalized (to an average value of 1.0) metric of the number of extreme temperature events for spells of 4-day duration. An event is considered extreme if the average temperature exceeds the threshold for a 1- in 5-yr recurrence. The calculations are based on a network of 711 long-term stations with less than 10% missing temperature values for the period 1895–2010. The horizontal labels give the beginning year of the decade. Recent decades tend to show an increase in the number of heat waves and a decrease in the number of cold waves but, over the long term, the drought years of the 1930s stand out as having the most heat waves. See the SM for details on

the daily data used in this analysis and procedures used to calculate the indices.

A few of the graphs in Figure I-8 are somewhat misleading. For a clearer view, refer to their Figure 1 from the full paper here. Some of the bars include numbers indicating that the heat waves were greater than the range of the graph, and others show numbers where the cold waves exceeded the range. This skews the appearances of those graphs. (Personally, I've never seen data presented in a graph where the range of the graph is less than range of the data.)

And to confirm the discussion of drought from the conclusions above, Peterson, et al. (2013) presented their Figure 4, which I've included as my Figure I-9.

Figure 4 From Peterson et al (2013)

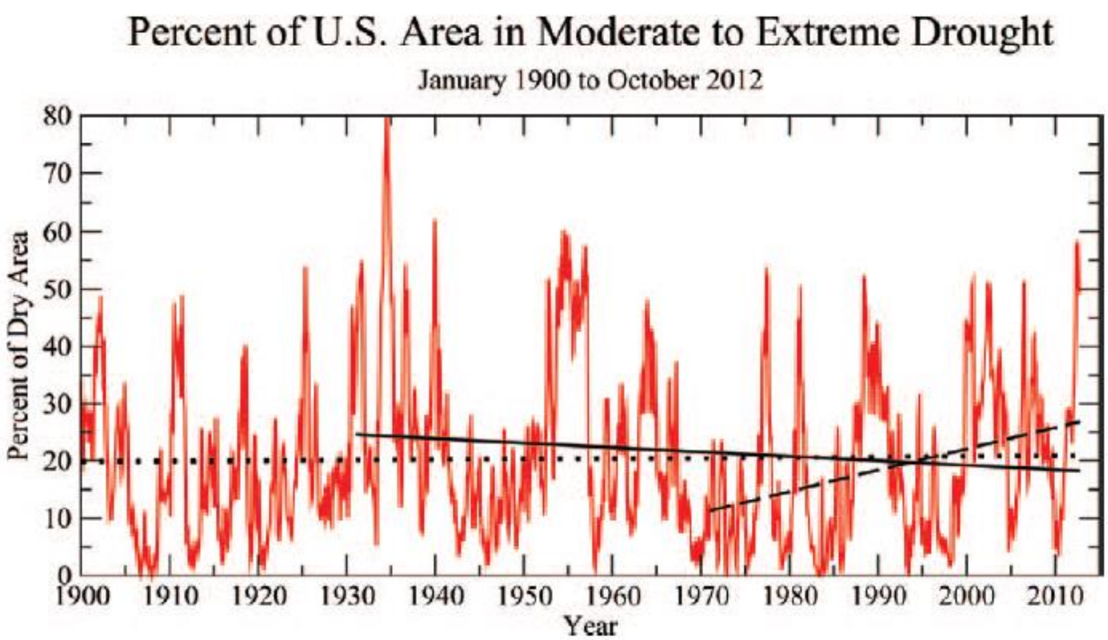


Figure I-9

The caption for their Figure 4 (my Figure 1-9) reads:

Fig. 4. The percent area of the contiguous United States experiencing moderate to extreme drought [Palmer drought severity index (PDSI) ≤ –2.0] from January 1900 to October 2012 (red curve). Widespread persistent drought occurred in the 1930s (central and northern Great Plains, Northwest, and Midwest), 1950s (southern Great Plains and Southwest), 1980s (West and Southeast), and the first decade of the twenty-first century (West and Southeast). The dotted line is a linear regression over the period of record (linear trend = +0.09% decade–1), the solid line is for January 1931–October 2012 (–0.78% decade–1), and the dashed

line is for January 1971–October 2012 (+3.70% decade–1).

When alarmists think of drought, they must only be considering the period from the 1970s to present, because that trend is rising. But we could drop back to the 1930s to show a decrease in droughts. Then again, based on the dotted linear trend line, there has been little change in droughts since 1900.

Yet some members of the climate science community and also of the mainstream media, regularly spin tall tales about weather growing more extreme in recent years. That is nothing but nonsense.

This book also does not discuss sea level. Many readers probably consider rising sea levels a done deal anyway. Sea levels have climbed 100 to 120 meters (about 330 to 390 feet) since the end of the last ice age, and they were also 4 to 8 meters (13 to 26 feet) higher during the Eemian (the last interglacial period) than they are today. (Refer to the press release for the 2013 paper by Dahl-Jensen, et al. "Eemian Interglacial Reconstructed From a Greenland Folded Ice Core".) Whether or not we curtail greenhouse gas emissions (assuming they significantly affect climate at all), if surface temperatures remain where they are (or even if they resume warming, or if surface temperatures were to cool a little in upcoming decades), sea levels will likely continue to rise. Refer to Roger Pielke, Jr.'s post "How Much Sea Level Rise Would be Avoided by Aggressive CO2 Reductions?" It's very possible, before the end of the Holocene (the current interglacial), that sea levels could reach the heights seen during the Eemian. Some readers might believe it's not a matter of if sea levels will reach that height; it's a matter of when.

Then again, sea level data even during the satellite era is problematic. The final sentence of Wunsch, et al. (2007) "Decadal Trends in Sea Level Patterns: 1993–2004" reads:

> *It remains possible that the database is insufficient to compute mean sea level trends with the accuracy necessary to discuss the impact of global warming—as disappointing as this conclusion may be. The priority has to be to make such calculations possible in the future.*

Considering that sea level has been studied for decades, that's not very encouraging.

This book does not discuss how to adapt to a changing world, though I do have a quick thought. As noted above, the last interglacial (period between ice ages) was the Eemian. Sea levels were 4 to 8 meters (13 to 26 feet) higher during the Eemian than they are today, but in order to melt that much ice, land surface air temperatures were much warmer, about 4 to 8 deg C (7 to 14 deg F) warmer in Greenland, than they are today, and they remained warmer for 6,000 years. Refer again to the press release for the 2013 paper by Dahl-Jensen, et al. "Eemian Interglacial Reconstructed from a Greenland Folded Ice Core". Therefore, regardless of whether or not you believe humanity is responsible for the current bout of warming, it is entirely possible that sea levels could climb much higher before the end of this interglacial. However, satellite altimetry-based sea level data show sea levels rising at a rate of only 3.2 millimeters (0.16 inches) per year and that equates to 0.32 meters (a little more than 1 foot) per century. At that rate it would take a millennium for sea levels to rise ten feet.

Subjects Discussed in *Climate Models Fail*

Climate Models Fail presents numerous examples of the differences between data and climate model outputs. Those comparisons show how poorly climate models simulate past temperatures, precipitation and sea ice area. And for datasets like sea surface temperatures, it discusses why the model failings are important even though we live on land. If you like graphs, there are oodles of graphs.

This book provides the reader with a brief entry-level overview of climate models. It explains terms like ensemble, ensemble member, and multi-model ensemble mean. I then discuss why I'm presenting the multi-model ensemble mean for comparison to data. Also as part of the introduction, I'll discuss why I present the data and model outputs in anomaly form and not absolutes.

Climate Models Fail presents climate model outputs and climate-related data. Both are available to the public from a number of online sources. You're more than welcome to verify what I've illustrated. People have been checking for years. In fact, I've furnished a link to a blog post that provides simple step-by-step instructions for you to do so.

After the initial discussions, many of the model-data comparisons will go quickly. It's simply show and tell. I occasionally use a type of graph that you may not be familiar with, so I've explained how to read it.

You'll start with simple examples and work your way toward more complex discussions. The first topic is sea ice area in the Northern and Southern Hemispheres. Then you'll move to model-data comparisons of precipitation, globally and regionally.

Next are surface temperatures, specifically model-data comparisons of global surface temperature anomalies since 1880. Then I'll discuss the two continents where the models show no skill at being able to simulate temperatures over the past few decades. Imagine that: the modelers overlooked 2 entire continents in their model tuning efforts. The models poorly simulate trends in daily high and low temperatures and the difference between them called the diurnal temperature range, so you'll be interested in that discussion. And you've no doubt heard of polar amplification, so I'll illustrate the model failings there. Next, you'll look at a few regional model-data comparisons: Alaska, Greenland, and Scandinavia. To close out the model-data comparisons, you'll spend some time on sea surface temperature anomalies during the satellite era, which cover the last 3 decades.

Climate Models Fail also provides a detailed look at sea surface temperatures because the oceans cover 70% of the surface of the planet. One would have thought that modelers would have made a little effort in their simulations of sea surface temperatures. Land surface temperatures depend on them. Land surface temperatures mimic and exaggerate the variations in sea surface temperatures. Climate models simulate sea surface temperatures so poorly it makes one wonder how they could have attempted to simulate land surface temperatures.

The recent cessation of warming is of interest to many readers, so I've compared modeled and observed land surface temperatures since 2001 on a regional basis, and done the same for the sea surface temperatures on an ocean-basin basis. As you'll recall, 2001 was the start year chosen by Kevin Trenberth for the most recent period in his article to the Royal Meteorological Society Has Global Warming Stalled? As one would expect, some parts of the globe continue to warm, and some have cooled—a few with startling downward shifts. Others show little change either way. The intent of these discussions is basically to show where surface temperatures are not cooperating with model simulations.

At the end of the book, I discuss in detail why it's important for models to be able to simulate El Niño and La Niña events. This section is based on my 4-plus years of research into the long-term effects of the natural ocean-atmosphere processes called El Niño and La Niña and the reasons why ocean heat content data and the satellite-era sea surface temperature data both indicate the oceans warmed via naturally fueled processes, not manmade greenhouse gases.

An Eye-Opening Article in *Nature*

As I was preparing this book, the capabilities of climate models came under scrutiny numerous times. There was a very recent article in *Nature* by Jeff Tollefson titled "Climate Change: The Forecast for 2018 Is Cloudy With Record Heat". (pdf version here.) The subtitle is "Efforts to Predict the Near-term Climate Are Taking Off, but Their Record So Far Has Been Patchy". "Patchy" is an extremely generous way to put it. Please take the time to read it. It's an interesting article for several reasons. First, a number of well-known climate scientists are interviewed and the quotes are remarkable. Second, note the divergence of the models and data in the graph with the heading "Hazy View". Some readers seem to believe the article suggests that, while short-term predictions are still plagued with problems, the long-term projections are on track. However, the graphs show long-term projections are far from being on track. The ever-warming red and blue curves are the models, but the global surface temperature anomalies (black curve) are flat since 2001 and they haven't risen above the 1998 peak associated with the 1997/98 El Niño. Third, that graph in the *Nature* article doesn't include the latest short-term prediction from the UK Met Office/Hadley Centre. This was pointed out in the blog post "Nature Hides the Decline" by Steve McIntyre of ClimateAudit. The bottom line: **climate models show no skill** as short-term prediction tools. And that clearly undermines their value as tools for long-term projections of future climate

Section 1 - Introduction to Climate Models…and Their Lack of Skill

In this section, I'll discuss climate models and models in general. I'll present quotes from scientific papers critical of climate models, and then discuss climate model outputs — ensemble members, ensembling, and model mean — including why I'm using the multi-model mean in the model-data comparisons.

Chapter 1.1 – Climate Model Overview and a General Discussion of Models

Before I discuss climate models, I must first define "climate." The WMO (World Meteorological Organization) provides a definition of climate on their Frequently Asked Questions webpage:

> *Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.*

In their report "The Global Climate 2001-2010: A Decade of Climate Extremes - Summary Report," the WMO also notes (my boldface):

> *Distinguishing between natural climate variability and human-induced climate change will also require datasets that are more complete and long-term.* ***A decade is the minimum possible timeframe for detecting temperature changes****.*

Weather is chaotic. Many persons were made aware of the "chaos theory" by the 1993 movie "Jurassic Park." Chaos theory was pioneered by Edward Lorenz, a mathematician and meteorologist, in the 1960s. Chaos theory resulted from his work with a weather model. He discovered that miniscule differences in the initial conditions programmed into the models resulted in very large differences in the weather patterns they predicted.

In summary, weather is chaotic and climate is chaotic weather averaged over long periods of time, typically 30 years, with 10 years as the minimum timeframe. On to climate models.

The IPCC in Chapter 8 of their 4th Assessment Report provides a brief explanation of climate models. They write near the beginning of their Frequently Asked Question 8.1:

> *Climate models are mathematical representations of the climate system, expressed as computer codes and run on powerful computers.*

In other words, climate models are an attempt to simulate Earth's climate in mathematical terms, using specially designed computer programs. Due to the complexity of the software and the time periods modeled, climate models are typically run on mainframe computers.

What do we know about models — not just climate models, but models in general?

In a 1976 paper titled "*Science and Statistics,*" published in the *Journal of the American Statistical Association*, George E. P. Box wrote (My boldface for the next couple of quotes.):

> *Since **all models are wrong** the scientist cannot obtain a "correct" one by excessive elaboration. On the contrary following William of Occam he should seek an economical description of natural phenomena. Just as the ability to devise simple but evocative models is the signature of the great scientist so overelaboration and overparameterization is often the mark of mediocrity.*

George E. P. Box and Norman Draper continued along that line when they wrote in their book *Empirical Model Building and Response Surfaces* (1987 - John Wiley & Sons, New York, NY):

> *Essentially, **all models are wrong**, but some are useful.*

And:

> *Remember that **all models are wrong**; the practical question is how wrong do they have to be to not be useful.*

There's an obvious "all models are wrong" theme there.

The first quote from George E. P. Box above reminded me of the state of climate science. Climate modelers are not able to simulate natural processes such as El Niño and La Niña events which dominate climate variability on Earth — and which cause long-term changes in global climate. One would have thought that somewhere over the past 3 decades there would have been a concerted effort to incorporate natural processes into the climate models. Obviously, that has not taken place. Yet even without that basic understanding of how climate on this planet works and how to model it, the IPCC keeps directing its modelers to put more and more complexity into every climate model upgrade. The IPCC's upcoming 5th Assessment is said to include shorter-term regional forecasts. Instead of creating "simple but evocative models", which as George E. P. Box noted are a "signature of the great scientist", the climate science community under the direction of the IPCC pursues "overelaboration and overparameterization", which is "often the mark of mediocrity."

CHAPTER 1.1 SUMMARY

Climate models are attempts to represent, in mathematical terms, weather over decadal and multidecadal periods. There are two underlying difficulties with those efforts: (1) Weather is chaotic, thus climate, weather averaged over decadal and multidecadal time periods, is also chaotic; and (2) All models are wrong, it is only a matter of how wrong they are.

Moreover, as you will see, climate models show such appalling lack of skill — such utter incompetence — that it's hard to imagine their being useful at all.

Chapter 1.2 – Scientific Papers Critical of Climate Models

This book presents examples of just how poorly climate models simulate surface temperatures, precipitation, and sea ice area. I illustrate this very simply, using easy-to-read time-series graphs. Additionally, many members of the climate science community are also quite critical of climate model performance, and examples of their research papers are presented in this chapter.

BASIC EL NIÑO AND LA NIÑA PROCESSES

Because in my own research I also focus on El Niño and La Niña processes and their aftereffects, I often refer to the following paper in my blog posts: Guilyardi, et al. (2009) "Understanding El Niño in Ocean-Atmosphere General Circulation Models: Progress and Challenges." It is a detailed overview of the many problems climate models have in their attempts to simulate El Niños and La Niñas. The authors of that study cite more than 100 other papers. The following is the most revealing statement in Guilyardi, et al. (2009):

> *Because ENSO is the dominant mode of climate variability at interannual time scales, the lack of consistency in the model predictions of the response of ENSO to global warming currently limits our confidence in using these predictions to address adaptive societal concerns, such as regional impacts or extremes (Joseph and Nigam 2006; Power, et al. 2006).*

In other words, because climate models cannot accurately simulate El Niño and La Niña processes, the authors of that paper have little confidence in climate model projections of regional climate or of extreme events.

Guilyardi, et al. (2009) is just one example. There are many other papers about climate model failings. Dr. Roger Pielke, Sr. included quotes from numerous such papers in his blog post here. The examples from his blog post follow.

REGIONAL CLIMATE

Dawson, et al. (2012) in "Simulating Regime Structures in Weather and Climate Prediction Models" noted:

> *We have shown that a low resolution atmospheric model, with horizontal resolution typical of CMIP5 models, is not capable of simulating the statistically significant regimes seen in reanalysis, …….It is therefore likely that the embedded regional model may represent an unrealistic realization of regional*

climate and variability.

CMIP5 stands for Coupled Model Intercomparison Project Phase 5. It is essentially an archive where climate model outputs are stored. The CMIP5-archived models are being used by the IPCC for their 5th Assessment Report.

DROUGHTS & PRECIPITATION

In "Afternoon Rain More Likely Over Drier Soils," Taylor, et al. (2012) wrote:

> *…the erroneous sensitivity of convection schemes demonstrated here is likely to contribute to a tendency for large-scale models to `lock-in' dry conditions, extending droughts unrealistically, and potentially exaggerating the role of soil moisture feedbacks in the climate system.*

Climate models poorly simulate the processes that result in drought, "extending droughts unrealistically."

Further to precipitation, in the 2012 paper, "An Improved Dynamical Downscaling Method with GCM Bias Corrections and Its Validation with 30 Years of Climate Simulations," Xu and Yang wrote:

> *…the traditional dynamic downscaling (TDD) [i.e. without tuning] overestimates precipitation by 0.5-1.5 mm d-1.....The 2-year return level of summer daily maximum temperature simulated by the TDD is underestimated by 2-6°C over the central United States-Canada region.*

The UNFCC (United Nations Framework Convention on Climate Change) here defines downscaling as:

> *… a method for obtaining high-resolution climate or climate change information from relatively coarse-resolution global climate models (GCMs).*

In simpler terms, downscaling is a method that theoretically allows global climate models to be used to simulate the regional climate at more finite levels. As Xu and Yang (2012) noted, however, a widely used form of downscaling both overestimates precipitation and underestimates absolute temperatures. It is important to note that Xu and Yang (2012) were not saying the models underestimated long-term warming; they found modeled summertime temperatures were too cold.

Further to precipitation, Stephens, et al. (2010), whose title, "Dreary State of Precipitation in Climate Models," underscores their findings, write:

> *...models produce precipitation approximately twice as often as that observed*

> *and make rainfall far too lightly.....The differences in the character of model precipitation are systemic and have a number of important implications for modeling the coupled Earth system ....little skill in precipitation [is] calculated at individual grid points, and thus applications involving downscaling of grid point precipitation to yet even finer-scale resolution has little foundation and relevance to the real Earth system.*

RESPONSES TO VOLCANIC ERUPTIONS

Then there's Driscoll, et al. (2012) "Coupled Model Intercomparison Project Phase 5 (CMIP5) Simulations of Climate Following Volcanic Eruptions". They wrote:

> *The study confirms previous similar evaluations and raises concern for the ability of current climate models to simulate the response of a major mode of global circulation variability to external forcings.*

El Niño and La Niña events (discussed in Guilyardi, et al. 2009) and explosive volcanic eruptions (discussed in Driscoll, et al. 2012) are the two factors that have the largest influence on global and regional climate. Remarkably, climate models can't simulate either of them accurately.

REGIONAL CLIMATE

Anagnostopoulos, et al. (2010) in "A Comparison of Local and Aggregated Climate Model Outputs with Observed Data" compared models to data at 55 places around the globe and 70 places in the United States. They write:

> *.... local projections do not correlate well with observed measurements. Furthermore, we found that the correlation at a large spatial scale, i.e. the contiguous USA, is worse than at the local scale.*

METHODS USED TO REDUCE MODELING COSTS

"Parameterization of Instantaneous Global Horizontal Irradiance at the Surface. Part II: Cloudy-sky Component" (2012) by Sun, et al. notes:

> *Radiation calculations in global numerical weather prediction (NWP) and climate models are usually performed in 3-hourly time intervals in order to reduce the computational cost. This treatment can lead to an incorrect Global Horizontal Irradiance (GHI) at the Earth's surface, which could be one of the error sources in modelled convection and precipitation. …… An important application of the scheme is in global climate models….It is found that these errors are very large, exceeding 800 W m-2 at many non-radiation time steps due to ignoring the effects of clouds….*

That is, Sun, et al. are critical of one of the methods that climate modelers use to reduce modeling costs: dividing the day into 3-hour time intervals. They then suggested a way of correcting it that does not greatly increase modeling costs.

SEA SURFACE TEMPERATURES

SST in the following title stands for Sea Surface Temperature, which is one of the variables I'll be illustrating and discussing. In the Van Haren, et al. (2012) paper "SST and Circulation Trend Biases Cause an Underestimation of European Precipitation Trends," the authors write (my boldface):

> *To conclude, modeled atmospheric circulation and SST trends over the past century are significantly different from the observed ones. These mismatches are responsible for a large part of the misrepresentation of precipitation trends in climate models. The causes of the large trends in atmospheric circulation and summer SST are not known.*

That requires no clarification. The same holds true for the quote from the next scientific paper.

ADAPTATION

Kundzewicz and Stakhiv (2010) write in their editorial "Are Climate Models Ready for Prime Time in Water Resources Management Applications, or Is More Research Needed?":

> *Simply put, the current suite of climate models were not developed to provide the level of accuracy required for adaptation-type analysis.*

GLOBAL SURFACE TEMPERATURES

Fyfe, et al. (2011) in Skillful Predictions of Decadal Trends in Global Mean Surface Temperature note that they had to adjust the model outputs for their evaluations:

> *….for longer term decadal hindcasts a linear trend correction may be required if the model does not reproduce long-term trends. For this reason, we correct for systematic long-term trend biases.*

Remarkable. The models performed so poorly that Fyfe, et al. (2011) adjusted the models' outputs before they evaluated the models.

At the end of his blog post, Dr. Pielke Sr. concludes with:

> *Unless the NSF, Linda Mearns and her co-authors, ect [sic] can refute these peer reviewed findings, if they continue to ignore these studies and persist in*

> *presenting their multidecadal climate predictions to the impacts communities, they are failing to serve as objective scientists. I wholeheartedly endorse the assessment of multidecadal predictability. The papers I list earlier in this post as excellent examples of quality science in this context*
>
> *However, providing predictions (i.e. projections/forecasts) to the impacts communities and policymakers, in which they are claimed to be skillful, is not a robust scientific endeavor.*
>
> *I also add, this issue is independent of the debate as to the importance of CO2, and other human climate forcings, on the regional climate in coming decades. It means, however, that providing regional multidecadal predictions is not only without a demonstrated skill, but is misleading the impact and policy communities as to what are the actual risks that we face.*

There's no need for me to expand on that.

My thanks to Dr. Roger Pielke, Sr. for assembling the above quotes from papers critical of climate models in a single blog post.

###

Since Roger Pielke's post, more scientific studies have been critical of climate model performance.

BASIC EL NIÑO AND LA NIÑA PROCESSES

As noted earlier, El Niño and La Niña events are the dominant mode of natural ocean-atmosphere variability on Earth. They have long-term impacts on temperature and precipitation patterns globally. The following paper, Bellenger, et al. (2013): "ENSO Representation in Climate Models: From CMIP3 to CMIP5," is a more recent confirmation of how poorly climate models simulate El Niños and La Niñas. Preprint copy is here. The section titled "Discussion and Perspectives" begins:

> *Much development work for modeling group is still needed in order to correctly represent ENSO, its basic characteristics (amplitude, evolution, timescale, seasonal phaselock…) and fundamental processes such as the Bjerknes and surface fluxes feedbacks.*

Notes: 1) "Phaselock" in this paper appears to refer to the fact that El Niño and La Niña events are tied to the seasonal cycle. 2) "Bjerknes feedback," very basically, means how the tropical Pacific and the atmosphere above it are coupled; i.e., they are interdependent, a change in one causes a change in the other and they provide positive feedback to one another. The existence of this positive "Bjerknes feedback" suggests that El Niño and La Niña events will remain in one mode until something interrupts the positive feedback.

To sum up Bellenger, et al. (2013), the climate modeling groups are still having problems with the basic "fundamental processes" of El Niño and La Niña. On to another mode of natural variability.

ATLANTIC MULTIDECADAL OSCILLATION

The AMO (Atlantic Multidecadal Oscillation) is the subject of the next paper. For further information about the Atlantic Multidecadal Oscillation, see NOAA's AOML (Atlantic Oceanographic and Meteorological Laboratory) Frequently Asked Questions webpage here, and my blog post here and my introduction to the Atlantic Multidecadal Oscillation here. Also see Tung and Zhou (2012) "Using Data to Attribute Episodes of Warming and Cooling in Instrumental Records." Tung and Zhou (2012) found that the Atlantic Multidecadal Oscillation contributed about 40% to the warming since 1950.

In 2013, Ruiz-Barradas, et al. published "The Atlantic Multidecadal Oscillation in Twentieth Century Climate Simulations: Uneven Progress from CMIP3 to CMIP5." The full paper is here. At the beginning of their "Concluding Remarks" they explain why it's important for climate models to be able to accurately simulate the Atlantic Multidecadal Oscillation (my boldface):

> *Decadal variability in the climate system from the AMO is one of the major sources of variability at this temporal scale that climate models must aim to properly incorporate because its surface climate impact on the neighboring continents. This issue has particular relevance for the current effort on decadal climate prediction experiments been analyzed for the IPCC in preparation for the fifth assessment report. The current analysis does not pretend to investigate into the mechanisms behind the generation of the AMO in model simulations, but to provide evidence of improvements, or lack of them, in the portrayal of spatiotemporal features of the AMO from the previous to the current models participating in the IPCC.* ***If climate models do not incorporate the mechanisms associated to the generation of the AMO (or any other source of decadal variability like the PDO) and in turn incorporate or enhance variability at other frequencies, then the models ability to simulate and predict at decadal time scales will be compromised and so the way they transmit this variability to the surface climate affecting human societies.***

The only way they could have been clearer would have been to state point blank that climate models will have value only if they are ever able to simulate the decadal and multidecadal characteristics of natural ocean processes. Ruiz-Barradas, et al. (2013) then describe the many problems with climate model simulations of the Atlantic

Multidecadal Oscillation. The paper ends with:

> *The current analysis does not provide evidence on why the models perform in the way they do but suggests that that the spurious increase in high 10–20 year variability from CMIP3 to CMIP5 models may be behind the unsatisfying progress in depicting the spatiotemporal features of the AMO. This problem, coupled with the inability of the models to perturb the regional low-level circulation, the driver of moisture fluxes, seem to be at the center of the poor representation of the hydroclimate impact of the AMO.*

In Ruiz-Barradas, et al. (2013), "hydroclimate" appears to mean the variations in precipitation as they relate to drought. They write:

> *Decadal control of hydroclimate from the AMO over North America and Africa is one of the main reasons to worry about having this phenomenon properly incorporated in climate models. Multi-year, summer and fall droughts over North America and Africa have been observationally linked to decadal SST variability in the Atlantic (e.g., Enfield et al. 2001; Ruiz-Barradas and Nigam 2005; Wang et al. 2006; Zhang and Delworth 2006; McCabe et al. 2008; Shanahan et al. 2009; Kushnir 2010; Nigam et al. 2011).*

NORTH ATLANTIC HURRICANES

Hurricanes are suppressed by El Niño events in the tropical Pacific. This has been known for nearly 30 years, ever since Dr. William Gray published a 2-part study that discussed ENSO as one of the significant factors that influence tropical cyclone development. [See Gray (1984) "Atlantic Seasonal Hurricane Frequency. Part I: El Niño and 30 mb Quasi-Biennial Oscillation Influences" and "Atlantic Seasonal Hurricane Frequency. Part II: Forecasting Its Variability."] Dr. Gray notes in the abstract of Part I (my boldface):

> *El Niño events are shown to be related to an anomalous increase in upper tropospheric westerly winds over the Caribbean basin and the equatorial Atlantic. Such **anomalous westerly winds inhibit tropical cyclone activity by increasing tropospheric vertical wind shear** and giving rise to a regional upper-level environment which is less anticyclonic and consequently less conductive to cyclone development and maintenance.*

In 2012, Shaman and Maloney published "Shortcomings in Climate Model Simulations of the ENSO-Atlantic Hurricane Teleconnection." The abstract begins (my boldface):

> *A number of recent studies have used model projections to investigate how the North Atlantic environment in which tropical storms develop, as well as hurricane*

> *activity itself, might change in a warming world. However, accurate projection of the North Atlantic environment in the future requires, at a minimum, accurate representation of its mean state and variability in the current climate. Here we examine one metric of Atlantic basin tropical cyclone variability—its well-documented association with the El Niño-Southern Oscillation (ENSO)—in reanalyses and Intergovernmental Panel of Climate Change (IPCC) 4th Assessment Report (AR4) twentieth century and Atmospheric Model Intercomparison Project simulations.* ***We find that no individual model provides consistently good representation of ENSO-related variability in the North Atlantic for variables relevant to hurricane activity (e.g. vertical wind shear, genesis potential). Model representation of the ENSO influence is biased due to both inaccurate representation of ENSO itself and inaccurate representation of the response to ENSO within the North Atlantic.*** *Among variables examined, ENSO impacts on vertical wind shear and potential intensity were most poorly simulated.*

Granted, those were the models prepared for the IPCC's 4th Assessment Report. But, even the most current, the CMIP5, models still do not correctly represent El Niño and La Niña processes. In addition, the "Atmospheric Model Intercomparison Project" models, also known as AMIP, use sea surface temperature data as inputs to the models as part of the climate model tuning process. Even using the crutch of actual sea surface temperatures, the models could not simulate "the response to ENSO within the North Atlantic." That is a monumental flaw. Finally, I haven't found any recent papers that note **any** improvement in the CMIP5 generation of models with respect to the impacts of ENSO on hurricanes.

ARCTIC SEA ICE

Arctic sea ice loss outpaced the predictions of an earlier generation of climate models (those stored in the CMIP3 archive), and the latest generation of models (CMIP5) still has difficulties. These are discussed in Stroeve, et al. (2012) "Trends in Arctic sea ice extent from CMIP5, CMIP3 and Observations" [paywalled]. The abstract reads (my boldface):

> *The rapid retreat and thinning of the Arctic sea ice cover over the past several decades is one of the most striking manifestations of global climate change. Previous research revealed that the observed downward trend in September ice extent exceeded simulated trends from most models participating in the World Climate Research Programme Coupled Model Intercomparison Project Phase 3 (CMIP3). We show here that as a group, simulated trends from the models contributing to CMIP5 are more consistent with observations over the satellite era (1979–2011).* ***Trends from most ensemble members and models***

> ***nevertheless remain smaller than the observed value. Pointing to strong impacts of internal climate variability, 16% of the ensemble member trends over the satellite era are statistically indistinguishable from zero. Results from the CMIP5 models do not appear to have appreciably reduced uncertainty as to when a seasonally ice-free Arctic Ocean will be realized.***

The press and climate change enthusiasts have been hyping the loss of Arctic sea ice, but the models simulate it so poorly that the authors had to conclude that, as far as we know, natural variability causes the bulk of the ice loss.

GENERAL OVERVIEW OF MODELS

Let's return to Mauritsen, et al. (2012) "Tuning the Climate of a Global Model," [paywalled], which was mentioned in the introduction. (See the preprint edition here.) Mauritsen, et al. (2012) discuss in detail many of the problems, flaws, unknowns, etc., inherent in climate models and what modelers do to tune the models in light of those flaws. It is an eye-opening read.

MODEL BIAS

There is a remarkable paper that explains why the current generation of climate models (CMIP5) is in better agreement among themselves than the previous generation (CMIP3) but, as a result, they perform worse. See Swanson (2013) "Emerging Selection Bias in Large-scale Climate Change Simulations." The preprint version of the paper is here. In the Introduction, Swanson writes (my boldface):

> Here we suggest the possibility that a selection bias based upon warming rate is emerging in the enterprise of large-scale climate change simulation. Instead of involving a choice of whether to keep or discard an observation based upon a prior expectation, we hypothesize that this selection bias involves the 'survival' of climate models from generation to generation, based upon their warming rate. One plausible explanation suggests this bias originates in the desirable goal to more accurately capture the most spectacular observed manifestation of recent warming, namely the ongoing Arctic amplification of warming and accompanying collapse in Arctic sea ice. However, fidelity to the observed Arctic warming is not equivalent to fidelity in capturing the overall pattern of climate warming. **As a result, the current generation (CMIP5) model ensemble mean performs worse at capturing the observed latitudinal structure of warming than the earlier generation (CMIP3) model ensemble. This is despite a marked reduction in the inter-ensemble spread going from CMIP3 to CMIP5, which by itself indicates higher confidence in the consensus solution. In other words, CMIP5 simulations viewed in aggregate appear to provide a more precise, but less accurate picture of actual climate warming compared to**

CMIP3.

In other words, the current generation of climate models (CMIP5) agrees better among themselves than the prior generation (CMIP3), i.e., there is less of a spread between climate model outputs, because they are converging on the same results. Overall, however, the CMIP5 models perform worse than the CMIP3 models at simulating global temperature. "[M]ore precise, but less accurate."

What I found remarkable about Swanson (2013) was that it explained **why**, **not if**, model performance had grown worse. Apparently, it is common knowledge among the climate science community that CMIP5 models perform worse than the prior generation, CMIP3.

Climate models are growing by leaps and bounds, but in the wrong direction.

CHAPTER 1.2 SUMMARY

Climate models are portrayed by political entities and the media as splendid tools for forecasting future climate. The climate science community, however, is well aware that climate models are deeply flawed. Rarely, if ever, are the models' chronic problems presented to the public and policymakers. In this chapter, I cited scientific studies that showed that the models are flawed at simulating, for example:

- The coupled **ocean-atmosphere processes** of El Niño and La Niña, the world's largest drivers of global temperature and precipitation.
- Responses to **volcanic eruptions**, sometimes powerful enough to counteract the effects of even strong El Niño events.
- **Sea surface temperatures**
- **Precipitation**—globally or regionally
- **Clouds**
- Influence of El Niño events on **hurricanes**
- The **coupled ocean-atmosphere processes** associated with decadal and multidecadal variations is sea surface temperatures, which strongly impact land surface temperatures and precipitation on those timescales.

I'll close with a quote from climate scientist Dr. Judith Curry, who is the chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. As Wikipedia notes:

> *Her research interests include hurricanes, remote sensing, atmospheric modeling, polar climates, air-sea interactions, and the use of unmanned aerial vehicles for atmospheric research. She is a member of the National Research Council's Climate Research Committee.*

Dr. Curry is also the proprietor of the very popular blog Climate Etc. Her recent post, Climate Model Simulations of the AMO, discusses two papers. The first, also discussed in this chapter, is Ruiz-Barradas, et al. (2013) "The Atlantic Multidecadal Oscillation in Twentieth Century Climate Simulations: Uneven Progress from CMIP3 to CMIP5." The second was the recent scientific study by Von Storch, et al. (2013) "Can Climate Models Explain the Recent Stagnation in Global Warming?" Dr. Curry concludes her blog post with the following:

> ***Fitness for purpose?***
>
> *While some in the blogosphere are arguing that the recent pause or stagnation is coming close to 'falsifying' the climate models, this is an incorrect interpretion of these results. The issue is the fitness-for-purpose of the climate models for climate change detection and attribution on decadal to multidecadal timescales. In view of the climate model underestimation of natural internal variability on multidecadal time scales and failure to simulate the recent 15+ years 'pause', the issue of fitness for purpose of climate models for detection and attribution on these time scales should be seriously questioned. And these deficiencies should be included in the 'expert judgment' on the confidence levels associated with the IPCC's statements on attribution.*

That is, to paraphrase Dr. Curry, it is highly questionable whether climate models are able to tell whether any given indicator of climate change is due to natural or to human causes on decadal to multidecadal timescales. Apparently, the climate science community, with their much-trumpeted numerical models, is no closer than they were decades ago at being able to detect any human fingerprint in global warming or climate change.

Chapter 1.3 – Overview of Climate Model Outputs

In this chapter, I'll discuss ensembles, ensemble members, and ensemble mean.

In the Introduction, I quoted the NCAR (National Center for Atmospheric Research) webpage (here):

> *Climate models are an imperfect representation of the earth's climate system and climate modelers employ a technique called ensembling to capture the range of possible climate states.*

That statement, originally part of an NCAR Frequently Asked Question webpage, was removed from their website. The in-depth discussion accompanying it was excellent, so I have no idea why it was removed. The old website address was:

http://www.gisclimatechange.org/faqPage.do

For those who want to confirm the following quotes, that webpage can still be accessed through the internet archive called the WaybackMachine. Simply cut and paste the above address into the appropriate field at the WaybackMachine and hit "Enter". Then, select the February 2, 2012 capture. One of the FAQs on the old NCAR webpage reads:

> *What is the meaning of the numbers within the data sets names, such as 2, 3, 5, 6, and 7? Are these indicating any simulation parameter, or set of parameters applied to run the simulation model? Should I focus on just one data set? If so, which one and what would be the rationale behind it?*

And the answer:

> *Climate models are an imperfect representation of the earth's climate system and climate modelers employ a technique called ensembling to capture the range of possible climate states. A climate model run ensemble consists of two or more climate model runs made with the exact same climate model, using the exact same boundary forcings, where the only difference between the runs is the initial conditions. An individual simulation within a climate model run ensemble is referred to as an ensemble member. The different initial conditions result in different simulations for each of the ensemble members due to the nonlinearity of the climate model system. Essentially, the earth's climate can be considered to be a special ensemble that consists of only one member. Averaging over a multi-member ensemble of model climate runs gives a measure of the average model*

> *response to the forcings imposed on the model. Unless you are interested in a particular ensemble member where the initial conditions make a difference in your work, averaging of several ensemble members will give you best representation of a scenario.*

To put that quote in non-technical terms: Climate models simulations cannot duplicate how Earth's climate actually works. Because all models are wrong, climate modelers use multiple computer runs, and the collection of those model runs is called an ensemble. The individual runs are called ensemble members. The climate modelers believe that (1) if they perform multiple runs with the same inputs (2) but with different initial (starting) conditions for each run and (3) average the outputs, then the average will provide a good measure of how the Earth's climate responds to the forcings that the modelers use as inputs to the models. Their main assumption is that the model responds to the modelers forcings in the same way that the Earth responds to them.

In Chapter 1.2 – "Scientific Papers Critical of Climate Models," however, you saw that climate models cannot accurately simulate climate on Earth. That is, the average of a bunch of wrong models is still wrong.

That aside, look now at an example (Figure 1-1) of an ensemble of climate model outputs showing each of the ensemble members. These are the CMIP5-archived outputs of NCAR's CCSM4 climate model-based simulations of sea surface temperature anomalies of the Pacific Ocean starting in January 1994.

More specifically, Figure 1-1 shows the simulated monthly sea surface temperature anomalies for the Pacific Ocean (60S-65N, 120E-80E) from the 6 NCAR CCSM4 ensemble members, for the period of January 1994 to June 2013. Shown in red is the ensemble mean. The model outputs through December 2005 are hindcasts. The outputs from January 2006 forward are projections (based on the RCP6.0 Representative Concentration Pathways scenario). For further information about Representative Concentration Pathways scenarios, see the Wikipedia webpage here. I use RCP6.0 in this book because it is the closest to the A1B scenario which was popular in past IPCC reports. The ensemble member numbering (EM-0, EM-1, etc.) in the graph is as provided by the KNMI Climate Explorer, the source of the model outputs. That numbering system may not be the same one used by NCAR. Note, the graph also includes the linear trends for the individual ensemble members and the CCSM4 model mean.

I've used the coordinates for the Pacific Ocean and presented the model outputs starting in January 1994 for a very specific reason, as you will discover.

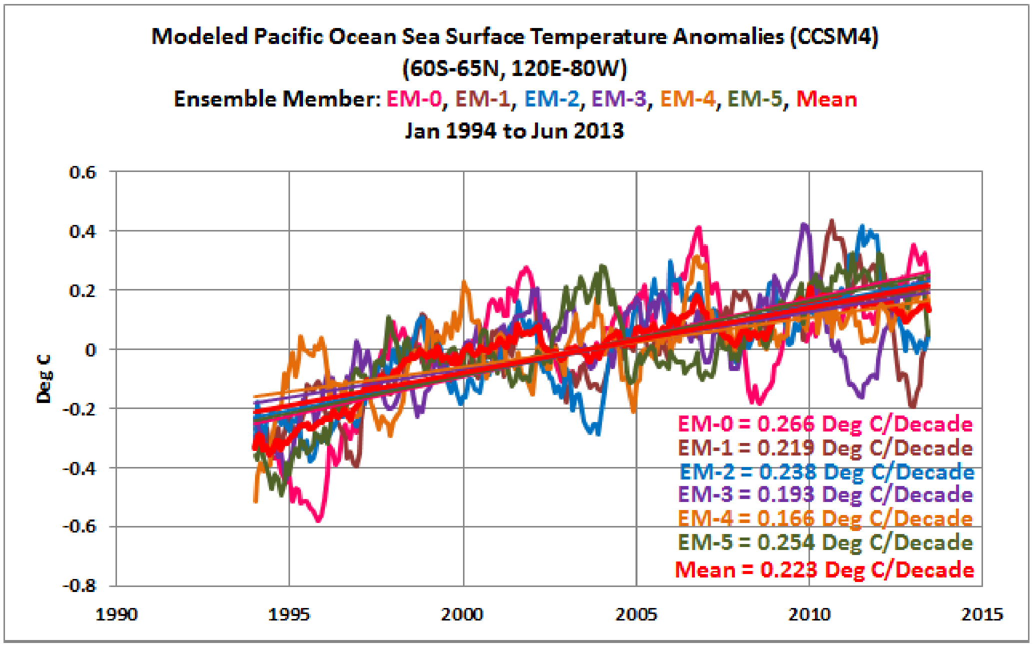


Figure 1-1

Figure 1-1 reveals the wide variations in the modeled sea surface temperature anomalies of the Pacific Ocean. That variability probably results from the modelers' attempts to simulate El Niño and La Niña events. The differences may also result from other noise inherent in that model and from the initial conditions used at the start of each run. There are major differences in the simulated rates of warming. The lowest rate is about 0.1 deg C/decade less than the highest rate. One thing is certain: all of the models show a relatively high warming trend since January 1994. The modeled warming rates range from 0.166 deg C/decade to 0.266 deg C/decade, for an average of 0.223 deg C/decade.

The observed temperatures say otherwise. Unfortunately for the models, the data show that sea surface temperature anomalies of the Pacific Ocean have not warmed in almost 2 decades.

Figures 1-2 through 1-7 illustrate the observed sea surface temperature anomalies for the Pacific Ocean since January 1994, using the Reynolds OI.v2 data. Each of those graphs also includes an individual NCAR CCSM4 ensemble member. Figure 1-8 compares the data to the NCAR CCSM4 model mean. Note that the annual variations in the sea surface temperature anomalies of the individual ensemble members do not match the data. One wouldn't expect them to because: (1) the modeled timings, strengths, and durations of El Niño and La Niña events do not coincide with reality; and (2) the models do not simulate El Niño and La Niña processes accurately. (See Guilyardi, et al. (2009) "Understanding El Niño in Ocean-Atmosphere General Circulation Models: Progress and Challenges." (I'll link that paper as a reminder a number of times in this book.) If the climate models were fit for purpose, the modeled warming rates would be similar to those observed, but all of the individual ensemble members show warming rates that are too high. The data show the sea surface temperature anomalies of the Pacific Ocean have not warmed in almost 20 years.

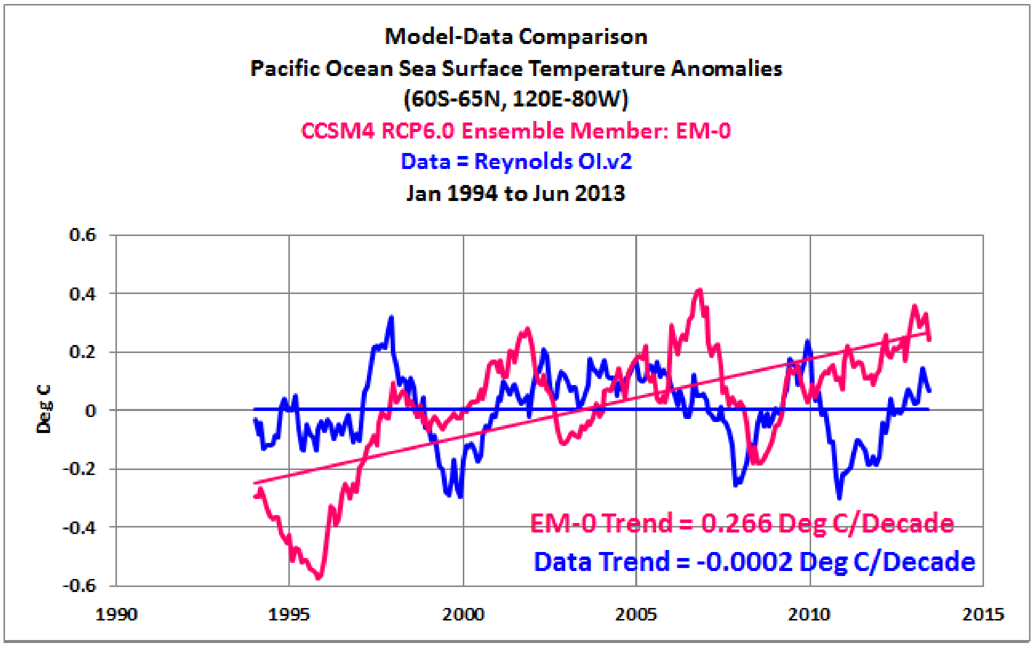


Figure 1-2

# # #

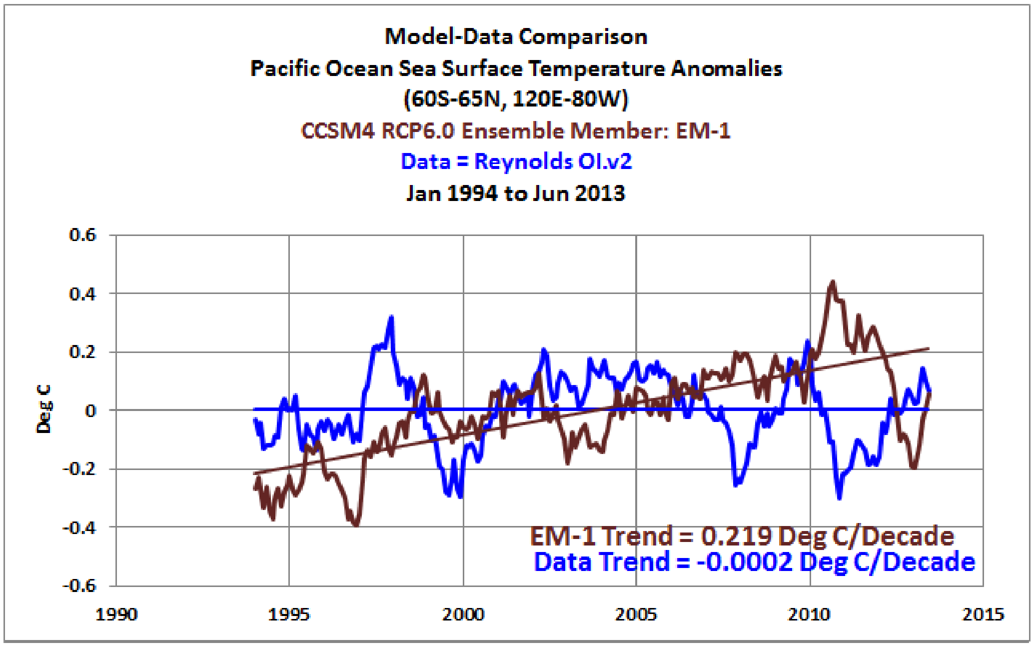


Figure 1-3

# # #

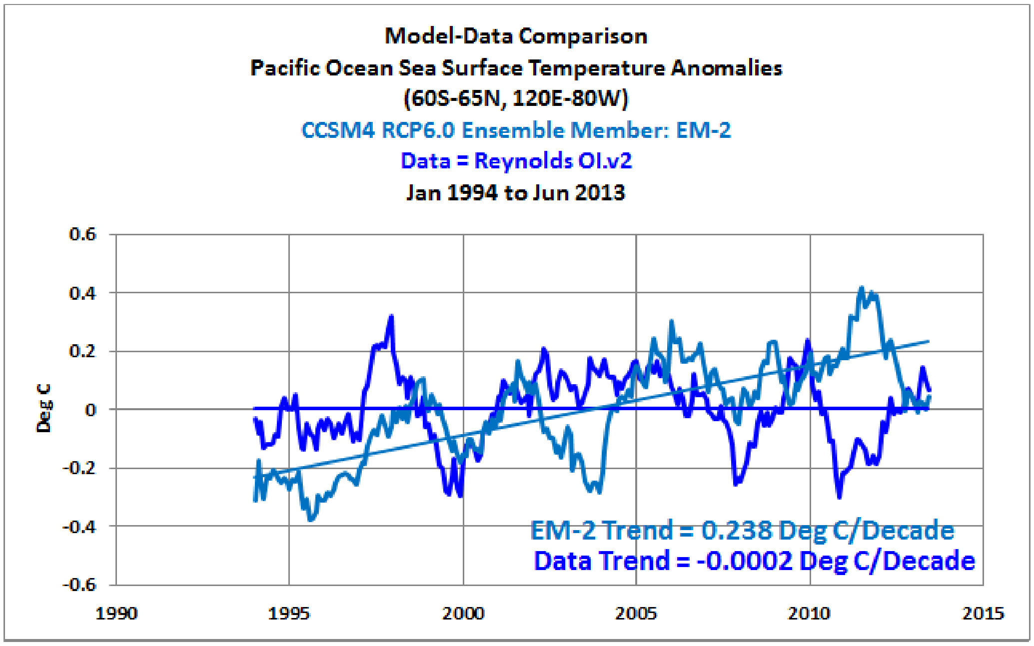


Figure 1-4

# # #

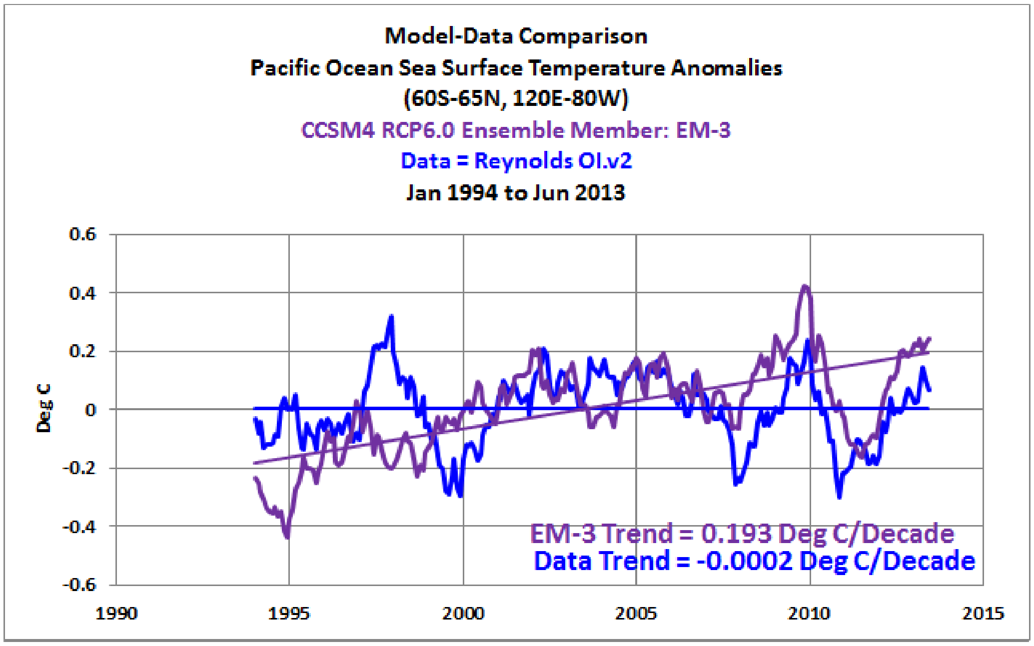


Figure 1-5

# # #

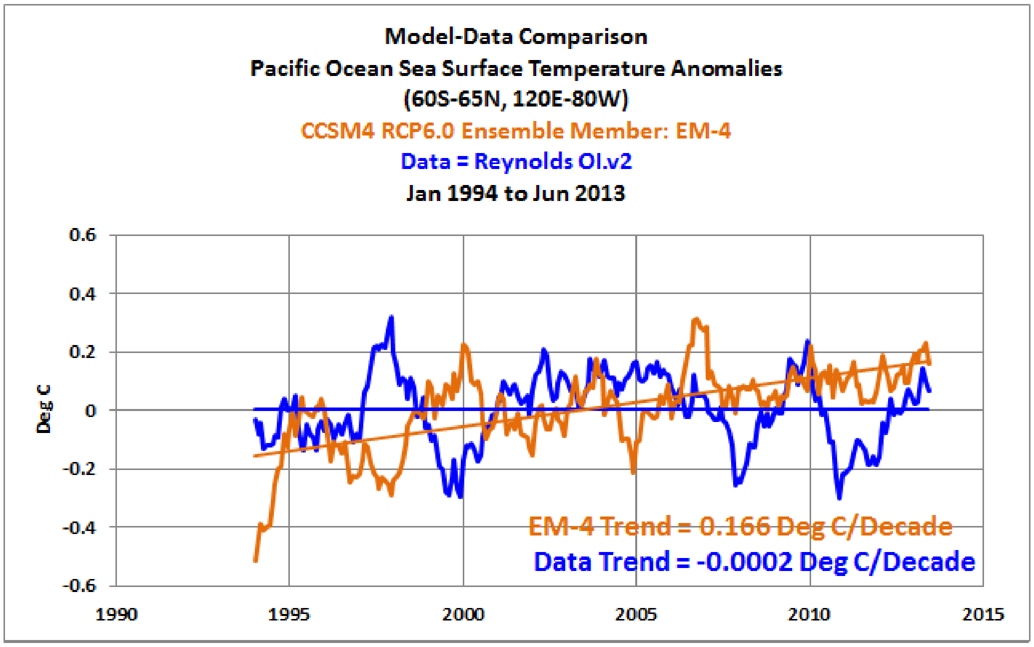


Figure 1-6

# # #

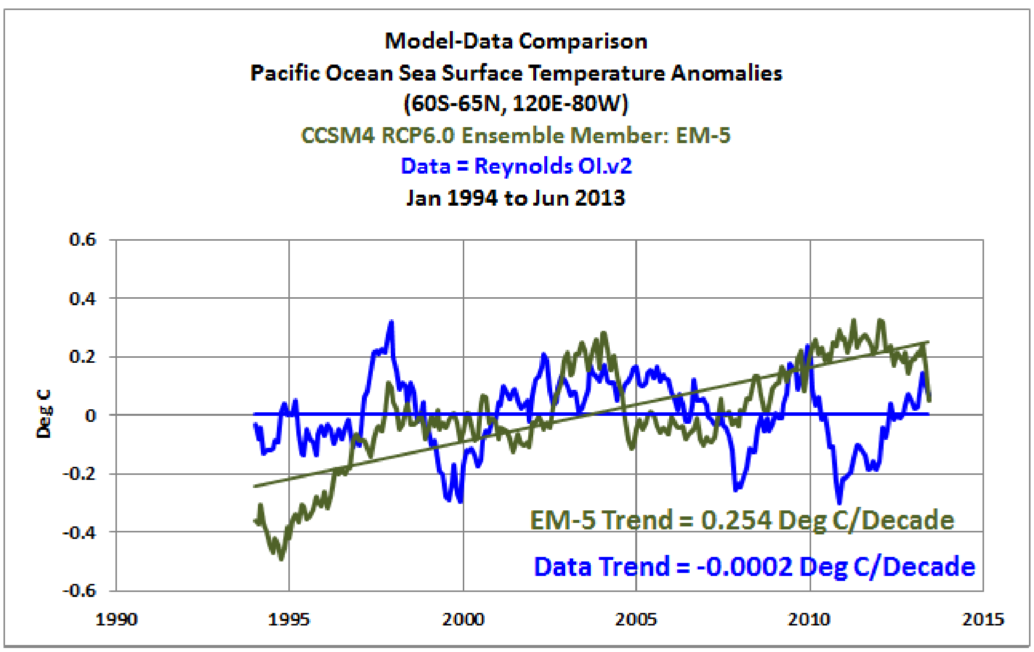


Figure 1-7

# # #

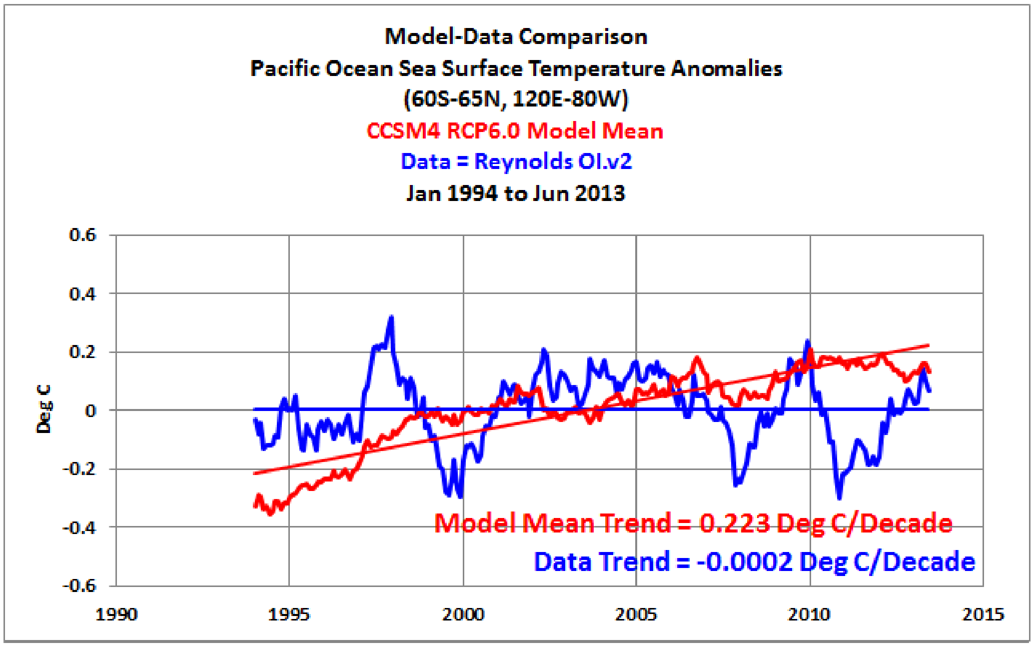


Figure 1-8

Note also how much smoother the model mean in Figure 1-8 is than the individual ensemble members. The reason: the large variations in the ensemble members occur randomly, and when we average the ensemble members (represented by the model mean), those random components tend to cancel one another.

Bear in mind that the NCAR CCSM4 is only one of the 48 different climate models stored in the CMIP5 archive that are available through the KNMI Climate Explorer, and that many of the models have multiple ensemble members; i.e. they include multiple runs.

How do the above CCSM4 simulations of the Pacific Ocean sea surface temperature anomalies compare to all of the other climate models stored in the CMIP5 archive?

Not all of the modeling groups provided sea surface temperature outputs for their models using the RCP6.0 scenario. The average warming rate of all of the ensemble members of all of the climate models stored in the CMIP5 archive that provided simulations of sea surface temperature anomalies, however, was 0.205 deg C/decade (for the Pacific Ocean, for the same time period). The average warming rate of NCAR's CCSM4 model simulations was about 0.223 deg C/decade or about 10% higher.

But the data show the Pacific hasn't warmed since January 1994.

CHAPTER 1.3 SUMMARY

Each of the individual climate model runs is called an ensemble member. A group of them is called an ensemble, and the average is called the ensemble mean.

Ensembling is used by climate modelers to try to correct model imperfections. Climate modelers claim that performing multiple runs of their imperfect models will “capture the range of possible climate states.” Unfortunately for the modelers, the average of multiple poor simulations of climate is still a poor simulation of climate. The average of the individual simulations does have a use, however. I’ll discuss that in the next chapter.

Chapter 1.4 – On the Use of the Multi-Model Mean

Climate models are consistently wrong. In the examples of their failed attempts to simulate sea surface temperatures of the Pacific Ocean for the past two decades, the magnitude of their errors was exposed in Chapter 1.3.

For the purpose of analyzing the models' performance, there are sound reasons for using the model mean instead of the oodles of ensemble members:

First, in the words of a prominent climate scientist, Gavin Schmidt: (Dr. Gavin Schmidt is a climatologist and climate modeler at the NASA Goddard Institute for Space Studies—GISS. He is also one of the regular contributors at the website Real Climate. As they say in their header, "RealClimate, Climate science from climate scientists.")

The following question was asked on the thread of the RealClimate post, **Decadal predictions**:

> *If a single simulation is not a good predictor of reality how can the average of many simulations, each of which is a poor predictor of reality, be a better predictor, or indeed claim to have any residual of reality?*

Gavin Schmidt replied (See "Comment 46 and his answer at 30 Sep 2009 at 6:18 AM):

> *Any single realisation can be thought of as being made up of two components – a forced signal and a random realisation of the internal variability ('noise'). By definition the random component will uncorrelated across different realisations and when you average together many examples you get the forced component (i.e. the ensemble mean).*

Gavin Schmidt used "noise" to describe the random internal variations (chaotic weather) created within the model. He also used "realisation" in place of "ensemble member." The "forced component", which is very important to this discussion, represents how the model responds to the inputs used to drive the models, like manmade greenhouse gases.

To paraphrase Gavin Schmidt, the individual ensemble members contain random noise that is inherent in each model. That noise limits the value of each individual ensemble member. The model mean, through averaging, minimizes model noise, revealing the "forced component". In other words, the model mean is the best-guess approximation of the modelers' assumptions about how climate on Earth is supposed to respond to human-induced global warming.

That's what we're after: how the Earth is supposed to respond to human-induced global warming.

Second, is a quote from obsolete NCAR FAQ webpage discussed in Chapter 1.3:

> ***Averaging over a multi-member ensemble of model climate runs gives a measure of the average model response to the forcings imposed on the model****. Unless you are interested in a particular ensemble member where the initial conditions make a difference in your work,* ***averaging of several ensemble members will give you best representation of a scenario****.*

Because we're examining historic model simulations (hindcasts), "scenario" is the past climate on Earth. The model mean is being presented because it gives the best representation of Earth's climate, as measure by the average model response to the historic forcings (anthropogenic CO2, etc.) imposed on the models.

CHAPTER 1.4 SUMMARY

The outputs of individual ensemble members (single computer runs) contain noise that is inherent to the models and those outputs are determined by the initial conditions of the simulation. That noise obscures the modeler's assumptions.

The model mean, exposes the modelers' assumptions about how global temperatures, precipitation, sea ice, etc., are supposed to have responded to human-induced climate change.

Chapter 1.5 – Additional Climate Model Failings

Many peer-reviewed scientific studies are critical of climate models (See Chapter 1.2). The following paper needs its own chapter: Trenberth and Fasullo (2012) "Climate Extremes and Climate Change: the Russian Heat Wave and Other Climate Extremes of 2010." This paper is an example of modern climatologists performing climate research as it was done in the days before climate models. The researchers examined data and used it, not model outputs, to explain the causes of the 2010 Russian heat wave and the other extreme weather events of that year. Except for the anthropogenic global warming conjecture, it was a **brilliant** investigation of weather events.

Why didn't Trenberth and Fasullo use climate models for the study of extreme weather events?

Trenberth and Fasullo briefly explain in the last sentence of the abstract:

> *Attribution is limited by shortcomings in models in replicating monsoons, teleconnections and blocking.*

Monsoons of course relate to seasonal changes in atmospheric circulation and precipitation. Teleconnections are mechanisms through which the weather events in one part of the globe are related to the weather in another part even though the two regions may be separated by thousands of kilometers. Blocking refers to a stationary large-scale atmospheric pattern that causes regional weather to remain fixed for long time periods—days, weeks, months. You've likely heard your local weatherperson mention "blocking highs."

In the last paragraph of their Introduction (my boldface), Trenberth and Fasullo expand on why they could not use models to study extreme weather events:

> *While relevant, this study is not about attribution but rather it explores aspects of the physical environment in which the extremes occurred.* ***Central to the analysis here is the question as to whether models are capable of depicting the modes of variability associated with the extremes generally. Our analyses suggest that they are not.***

And Trenberth and Fasullo conclude in the final paragraph of their paper:

> *It remains a challenge for climate models to correctly simulate mean rainfall distributions, and as a result it is even more of a challenge to reproduce anomalies and associated teleconnections [Yang and DelSole, 2012], such as*

> *those observed in 2010. However, unless the diabatic heating, mainly from latent heating in precipitation linked to SST [sea surface temperature] anomalies, is possible to simulate, predict, or fully attribute blocking events and climate anomalies such as observed.*

Trenberth and Fasullo don't seem to be very optimistic about the future abilities of climate models.

So we can add monsoons, teleconnections, and blocking to the list of climate model failings. Because the models cannot simulate those phenomena, the models cannot be used in attribution studies of extreme weather events nor can they be used to predict how extreme weather will change in the future.

Another reason Trenberth and Fasullo (2012) is worth discussing: it is a prime example of the typical peer-reviewed paper written in alarmist terms. Just look at the title "Climate Extremes and Climate Change: The Russian Heat Wave and Other Climate Extremes of 2010." "Extremes" appears twice in 15 words. "Record" as in "highest on record" or "record breaking" appears more than 25 times throughout the paper, and "extreme" more than 15 times. For most readers, such repeated magnification tells them that the main intent of the paper is climate extremist propaganda. Thus, the largest coverage of that paper came from the political website ThinkProgress and enthusiastic anthropogenic global warming promoter, Joe Romm's, post "Must-Read Trenberth: How To Relate Climate Extremes to Climate Change."

Trenberth and Fasullo (2012) did not succeed in linking climate extremes to human-induced climate change. They tried, but failed. The abstract of the paper asserts:

> *Natural variability, especially ENSO, and global warming from human influences together resulted in very high sea surface temperatures (SSTs) in several places that played a vital role in subsequent developments.*

ENSO stands for El Niño-Southern Oscillation, the term climate scientists use for the coupled ocean-atmosphere processes associated with El Niño and La Niña events. In that sentence, Trenberth and Fasullo acknowledged that El Niño and La Niña contributed to the warming in 2010 and that they are naturally occurring processes. They also, nevertheless, speculate that humans can significantly alter sea surface temperatures.

Later in the paper, Trenberth and Fasullo say:

> *In part the high SSTs in the Indian and Atlantic sectors were a consequence of the previous El Niño [Trenberth et al., 2002], however, there is also a significant global warming component [Gillett et al., 2008]. The human influence is*

> *systematic and persistent and can be thought of as the underlying warming of order 0.6 deg C since the 1950s while there are large regional and temporal fluctuations superposed on this warming by natural variability.*

It is worth repeating that Trenberth and Fasullo noted El Niño events are natural phenomena. They discuss how El Niño-driven high sea surface temperatures in four specific regions (See Figure 1-9) caused the Russian heat wave and other extreme weather events in 2010. Figure 1-9 is Figure 2 from Trenberth and Fasullo (2012), but I've circled and named the four regions. The sea surface temperature anomalies of the fifth region, NINO3.4, are a commonly used index for the timing, strength, and duration of El Niño and La Niña events.

Annotated Figure 2 from Trenberth and Fasullo (2012)
(Lower Panel Only)

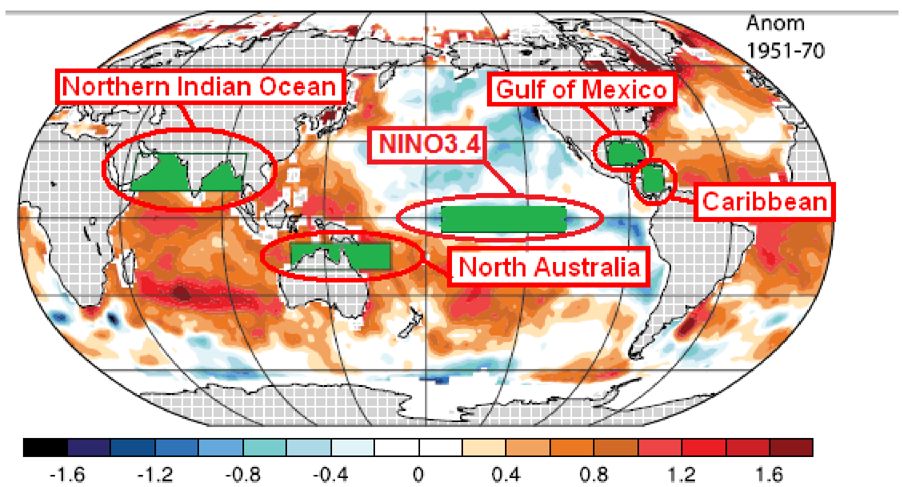


Figure 2. Seasonal Jun–Jul–Aug 2010 mean SSTs and their anomalies relative to 1951–70, based on HADISST data. Dark green boxes on the lower panel indicate the regions discussed in the text for, from left to right, the Northern Indian Ocean, North Australia, Niño 3.4, Gulf of Mexico, and Caribbean.

Figure 1-9

As you'll note in the caption for their Figure 2, Trenberth and Fasullo used the UK Met Office HADISST sea surface temperature reconstruction. I will also use that dataset. Trenberth and Fasullo noted that sea surface temperatures warmed globally since 1950 and then made the grandiose claim that the "human influence is systematic and persistent and can be thought of as the underlying warming."

"Systematic and persistent"?

To confirm (or contradict) the claim by Trenberth and Fasullo, the sea surface temperature anomalies for the Indian and Pacific Oceans, and a small part of the Atlantic Ocean need to be examined, but as a whole. (See Figure 1-10). The coordinates of 90S-90N, 20E-70W capture all five of the regions discussed by Trenberth and Fasullo, and they include the related parts of the Arctic and Southern Oceans. I call this area "The Indian & Pacific Oceans Plus."

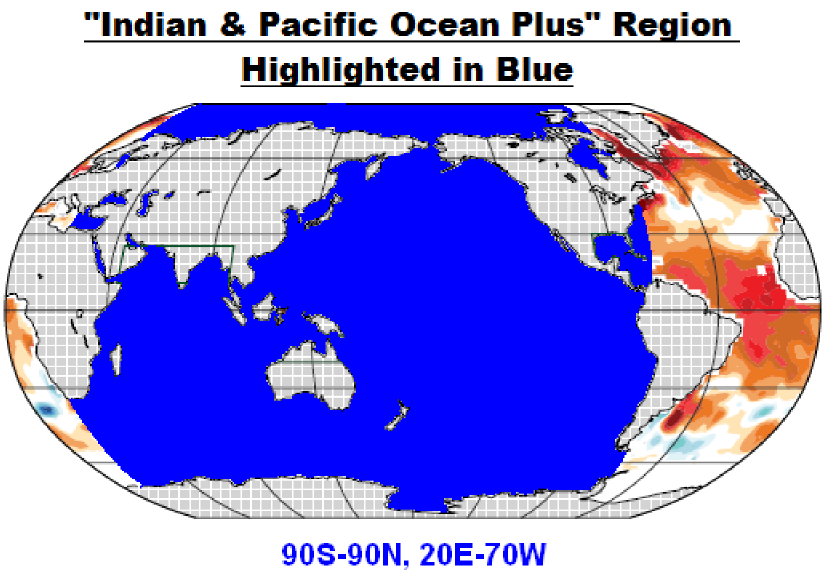


Figure 1-10

The only ocean basins excluded from this region are the North and South Atlantic and the corresponding portions of the Arctic and Southern Oceans.

Recall that Trenberth and Fasullo said:

> *The human influence is systematic and persistent and can be thought of as the underlying warming of order 0.6 deg C since the 1950s while there are large regional and temporal fluctuations superposed on this warming by natural variability.*

What Trenberth and Fasullo failed to tell their readers was that the sea surface temperatures for the oceans that encompass that area have warmed at an extremely slow rate over the past 20 years. (See Figure 1-11). The observed warming rate of the sea surface temperatures of the Indian & Pacific Ocean Plus subset, using HADISST data, is only 0.013 deg C/decade since January 1993. That's only **13 one-thousandths of a deg C per decade**, so low that it is negligible. On the other hand, the climate models estimated that anthropogenic greenhouse gas emissions would warm the sea surface temperature anomalies for the Indian & Pacific Ocean Plus region more than 0.4 deg C over those 2 decades.

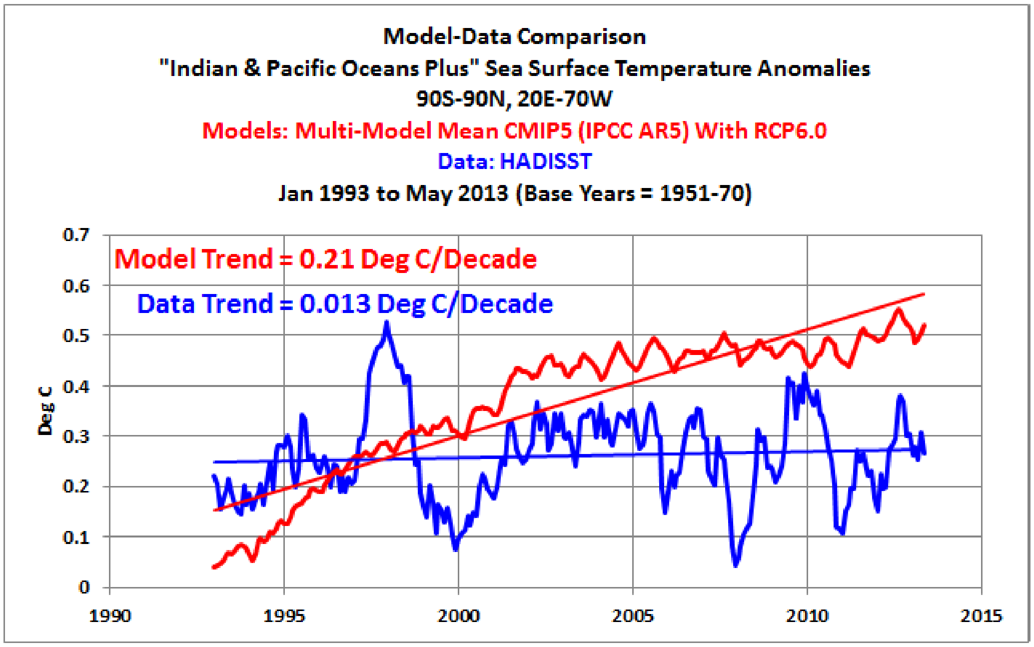


Figure 1-11

Trenberth and Fasullo looked at the atmospheric responses to the seasonal sea surface temperatures for 5 regions in 2010. Because the sea surface temperatures for the oceans that surround those 5 regions haven't warmed in over 20 years, Trenberth and Fasullo's claim that there is a human-induced global warming component in the extreme weather events is not supported by data.

CHAPTER 1.5 SUMMARY

Global sea surface temperatures warmed about 0.6 deg C since the 1950s, so what Trenberth and Fasullo had written was, in general, realistic. However, unless a reader is intimately familiar with the sea surface temperature data, that reader will likely accept at face value whatever the authors say. That reader will thus fail to understand that, based on the HADISST dataset, the warming of a major portion of the global oceans stopped two decades ago. The regions examined by Trenberth and Fasullo (2012) lie within that no-warming ocean area; the authors failed to attribute the extreme weather events to man.

I have presented two papers above that discuss how climate models cannot properly simulate El Niño and La Niña processes. According to Trenberth and Fasullo (2012), the El Niño of 2009/10 and the immediately trailing La Niña were the primary causes of the extreme weather events of 2010. They noted that El Niño and La Niña events are "natural variability."

Additionally, Trenberth and Fasullo stated quite emphatically that climate models cannot be used to diagnose the causes of extreme weather events because climate models cannot simulate precipitation (monsoons), teleconnections, or blocking patterns.

Note: Kevin Trenberth was a lead author of the 2^{nd}, 3^{rd} and 4^{th} Assessment Reports by the IPCC.

Section 2 – Additional Preliminary Discussions

This section contains topics for those who are new to the presentation of climate data and model outputs. I discuss why anomalies and not absolutes are presented, the impacts of the base years chosen for the anomalies, data suppliers and their products, the sources of the data and model outputs, and data smoothing. I also discuss zonal-mean graphs and provide an introduction to polar amplification. I conclude with a note about the dips and rebounds caused by volcanic aerosols.

Chapter 2.1 – The Use of Temperature and Precipitation Anomalies

With rare exceptions, the surface temperature, precipitation, and sea ice area data and model outputs in this book are presented as anomalies, not as absolutes. To see why anomalies are used, take a look at global surface temperature in absolute form. Figure 2-1 shows monthly global surface temperatures from January, 1950 to October, 2011. As you can see, there are wide seasonal swings in global surface temperatures every year.

The three producers of global surface temperature datasets are the NASA GISS (Goddard Institute for Space Studies), the NCDC (NOAA National Climatic Data Center), and the United Kingdom's National Weather Service known as the UKMO (UK Met Office). Those global surface temperature products are only available in anomaly form. As a result, to create Figure 2-1, I needed to combine land and sea surface temperature datasets that are available in absolute form. I used GHCN+CAMS land surface air temperature data from NOAA and the HADISST Sea Surface Temperature data from the UK Met Office Hadley Centre. Land covers about 30% of the Earth's surface, so the data in Figure 2-1 is a weighted average of land surface temperature data (30%) and sea surface temperature data (70%).

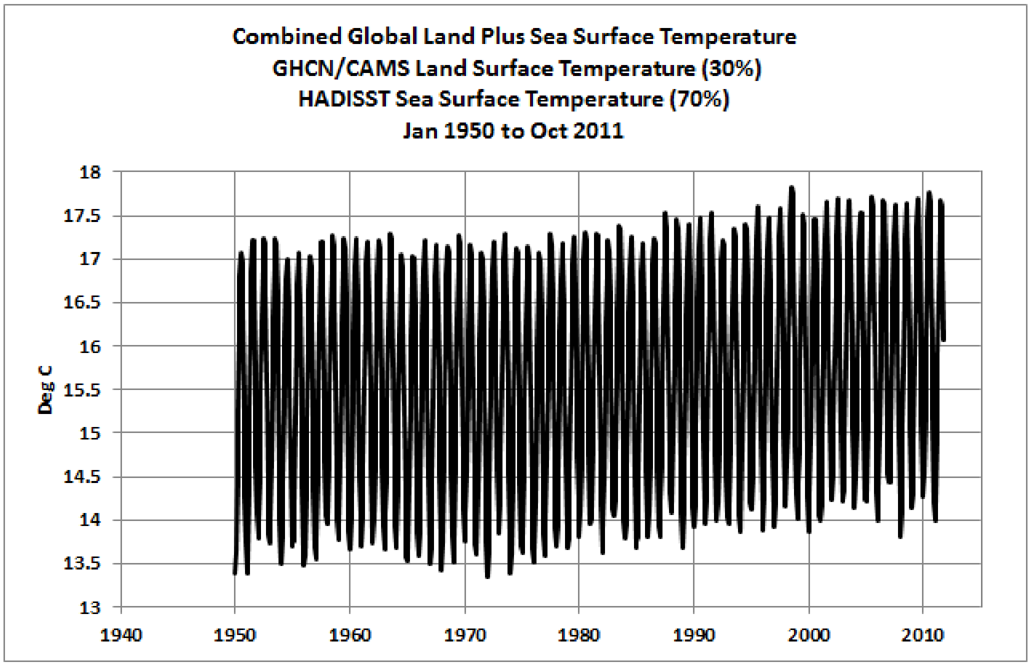


Figure 2-1

When looking at absolute surface temperatures (Figure 2-1), it's really difficult to determine if there are changes in global surface temperatures from one year to the next; the annual cycle is so large that it limits one's ability to see when there are changes. And note that the variations in the annual minimums do not always coincide with the variations in the maximums. You can see that the temperatures have warmed, but you can't determine the changes from month to month or year to year.

Take the example of comparing the surface temperatures of the Northern and Southern Hemispheres using the satellite-era sea surface temperatures in Figure 2-2. The seasonal signals in the data from the two hemispheres oppose each other. When the Northern Hemisphere is warming as winter changes to summer, the Southern Hemisphere is cooling because it's going from summer to winter at the same time. Those two datasets are 180 degrees out of phase.

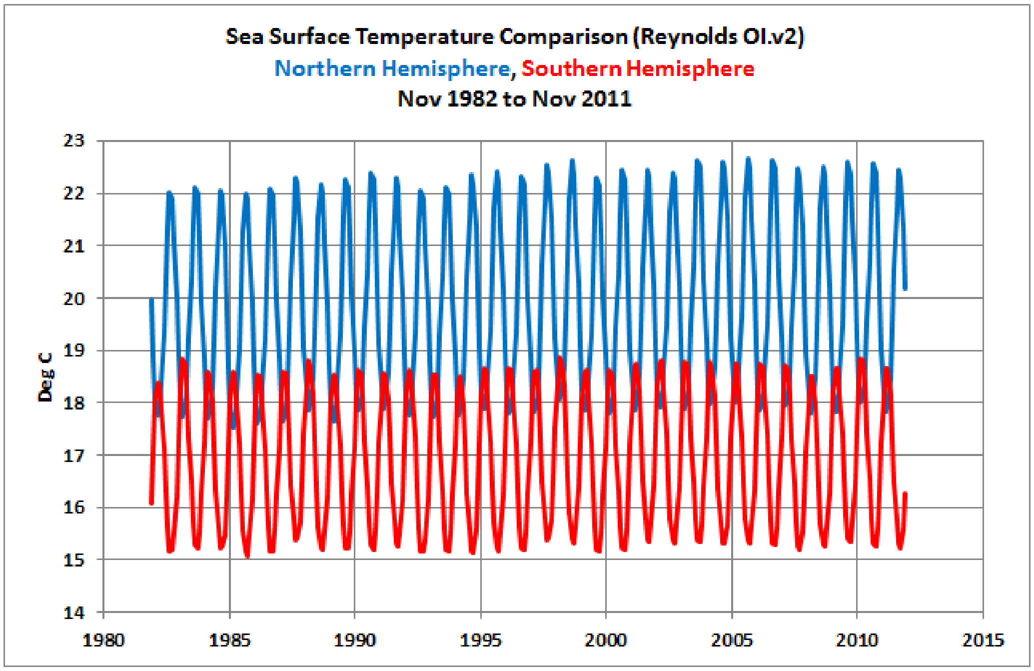


Figure 2-2

After converting that data to anomalies (Figure 2-3), the two datasets are easier to compare.

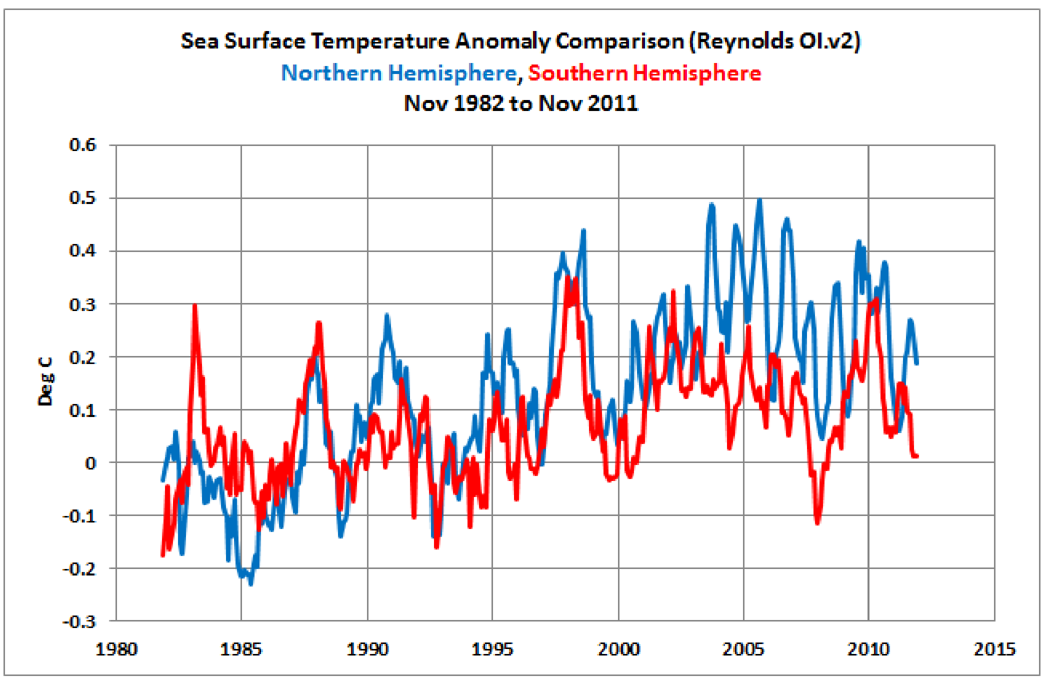


Figure 2-3

Returning to the global land-plus-sea surface temperature data, once you convert the same data to anomalies, as was done in Figure 2-4, you can see that there are significant changes in global surface temperatures that aren't related to the annual seasonal cycle. The upward spikes every couple of years are caused by El Niño events. Most of the downward spikes are caused by La Niña events. (I discuss El Niño and La Niña events a number of times in this book. They are parts of a very interesting process that nature created.) Some of the drops in temperature are caused by the aerosols ejected from explosive volcanic eruptions. Those aerosols reduce the amount of sunlight that reaches the surface of the Earth, cooling it temporarily. Temperatures rebound over the next few years as volcanic aerosols dissipate.

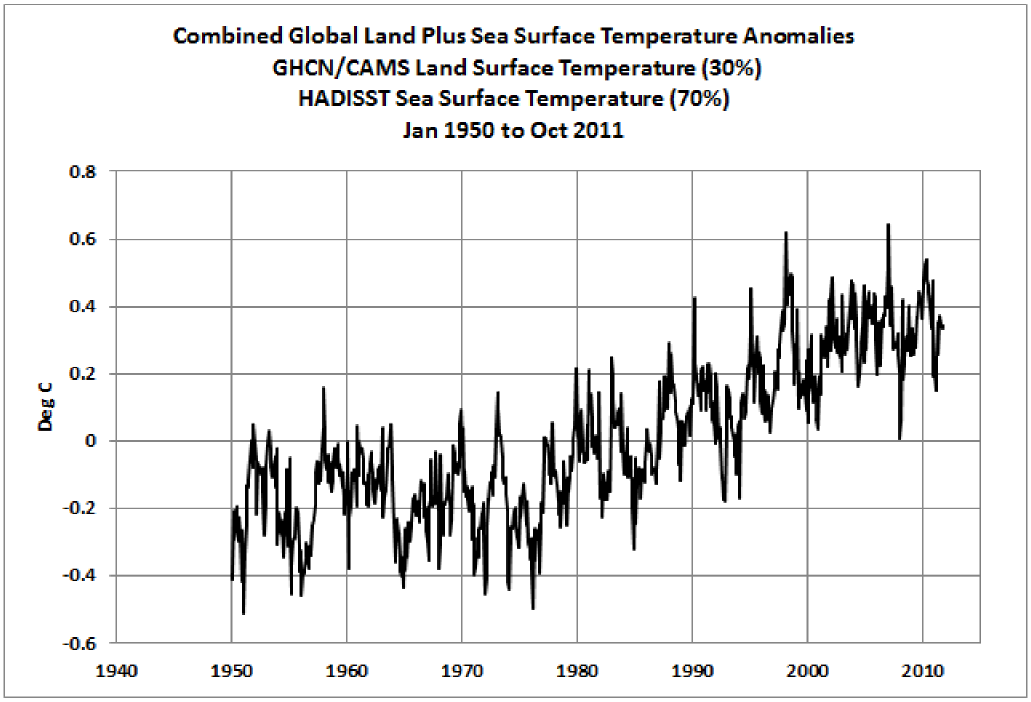


Figure 2-4

HOW TO CALCULATE ANOMALIES

For those who are interested: To convert the absolute surface temperatures shown in Figure 2-1 into the anomalies presented in Figure 2-4, you must first choose a reference period. The reference period is often referred to as the “base years.” I use the base years of 1950 to 2010 for this example.

The process: First, determine average temperatures for each month during the reference period. That is, average all the surface temperatures for all the Januaries from 1950 to 2010. Do the same thing for all the Februaries, Marches, and so on, through the Decembers during the reference period; each month is averaged separately. Those are the reference temperatures. Second, determine the anomalies, which are calculated as the differences between the reference temperatures and the temperatures for a given month. That is, to determine the January, 1950 temperature anomaly, subtract the average January surface temperature from the January, 1950 value. Because the January, 1950 surface temperature was below the average temperature of the reference period, the anomaly has a negative value. If it had been higher than the reference-period average, the anomaly would have been positive. The process continues as February, 1950 is compared to the reference-period average temperature for Februaries. Then March, 1950 is compared to the reference-period average temperature for Marches, and so on, through the last month of the data, which in this example was October 2011. It's easy to create a spreadsheet to do this, but, thankfully, data sources like the KNMI Climate Explorer website do all of those calculations for you, so you can save a few steps.

CHAPTER 2.1 SUMMARY

Anomalies are used instead of absolutes because anomalies remove most of the large seasonal cycles inherent in the temperature, precipitation, and sea ice area data and model outputs. Using anomalies makes it easier to see the monthly and annual variations and makes comparing data and model outputs on a single graph much easier.

Chapter 2.2 – The Subtle Differences Due to the Base Years Used for Anomalies

Reference periods (the base years for anomalies) are a subtle feature of data presentation.

For example, the IPCC used 1901 to 1950 as the base-year period for the surface temperature data in Figure 9.5 of their 4th Assessment Report. (See the IPCC webpage here.) At first glance, if you're familiar with surface temperature data, those base years appear to be an odd choice, because the three producers of Global Surface Temperature data don't use them. GISS uses 1951-1980 as base years, the NCDC uses 1901-2000 for graphs and 1971-2000 for maps, and the UK Met Office-Hadley Centre uses 1961-1990. Thus, for a moment you'd wonder, "Why did the IPCC use that early time period for their anomalies?" Then, it dawns on you. They used that period because 1901 to 1950 was cooler than the second half of the 20th century. Using those early base years makes the later years' data look hotter. This is illustrated in Figure 2-5.

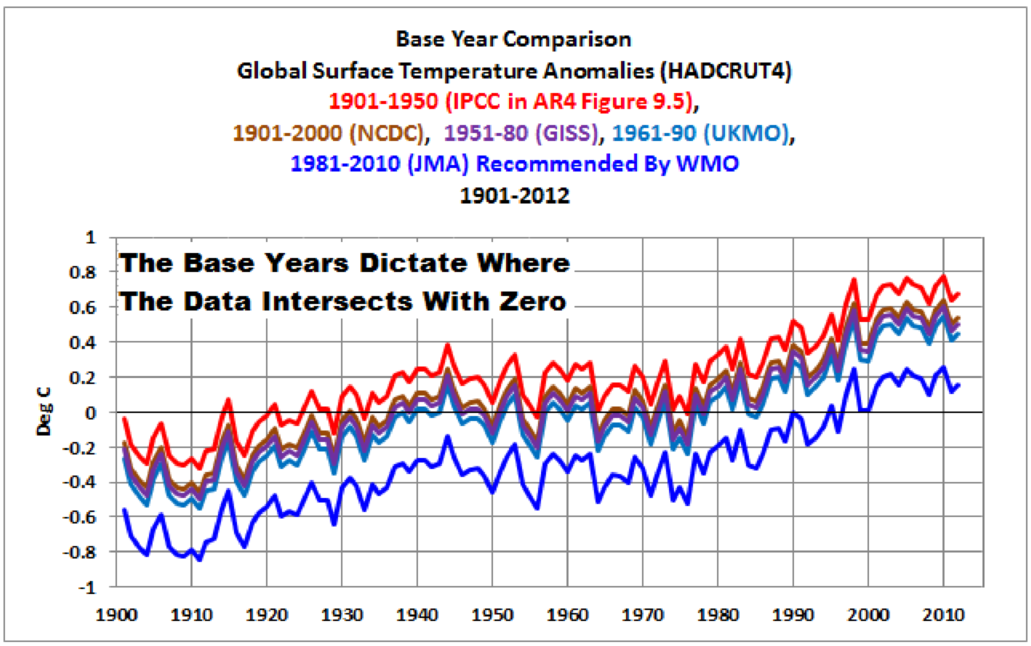


Figure 2-5

All of the data in Figure 2-5 are based on the HADCRUT4 global surface temperature data from the UK Met Office. Only the reference periods (base years) used for the anomalies are different.

Note: that I present the above for the purpose of illustration only. The UKMO HADCRUT4 data wasn't available at the time of the IPCC's AR4. They used the earlier

UKMO product, HADCRUT3, in their Figure 9.5.

The IPCC's choice of 1901-1950 for base years doesn't have an impact on the shape of the curve or the warming **rate** of the data; using those early base years simply makes the data appear warmer. With respect to the base years used by the three data suppliers, the IPCC's choice of 1901-1950 shifts the data: 0.14 deg C higher than it would have been using the NCDC base years; about 0.17 deg C higher than with the GISS base years; and about 0.23 deg C higher than with the UK Met Office base years.

You noticed, no doubt, that my graph in Figure 2-5 also includes the base years of 1981-2010. Those are the base years recommended by the WMO (World Meteorological Organization). Only one global temperature data supplier uses those recommended base years, the JMA (Japanese Meteorological Agency). Even though the WMO recommends the use of 1981-2010 for base years, GISS, NCDC, and UKMO continue to use the base years they selected for one simple reason: those base years make the data appear hotter.

Which sounds more alarming: A. "Global surface temperatures were 0.54 deg C warmer than the reference period of 1951-80; or B. "Global surface temperatures were 0.16 deg C warmer than the reference period of 1981-2010"?

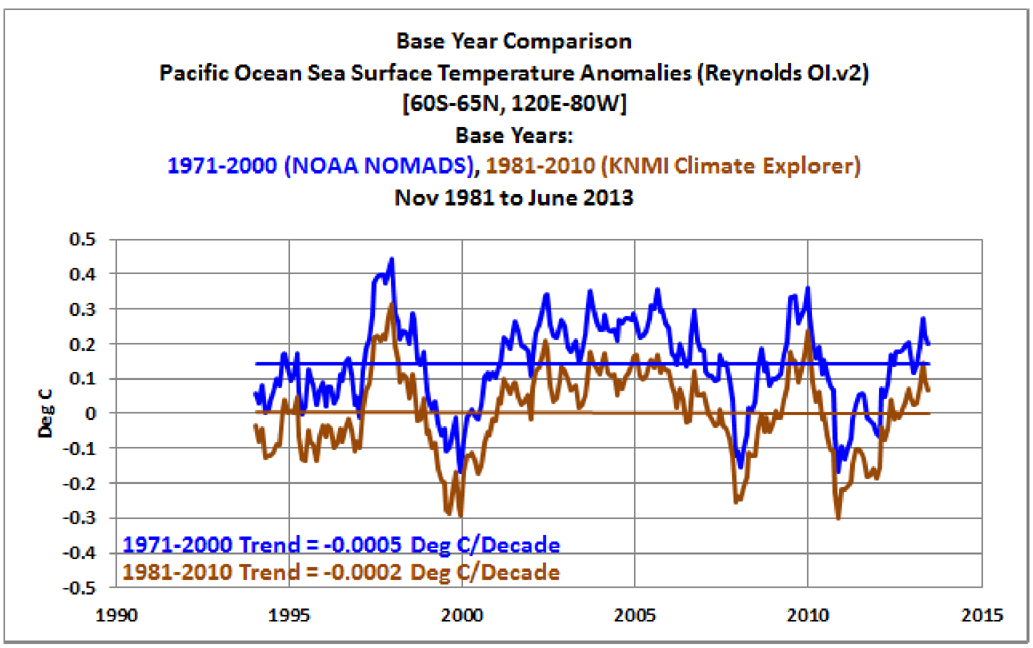


Figure 2-6

For another example of how base years impact the presentation of data, look at the sea surface temperatures of the Pacific Ocean using different base years. I compare two sets of temperature anomalies in Figure 2-6, along with their estimated linear trends. I use two different suppliers for the Reynolds OI.v2 data, and their default base years for anomalies differ. The data with anomalies mostly above zero was downloaded from the NOAA NOMADS website. NOAA uses the base years of 1971-2000 for their Reynolds OI.v2 sea surface temperature data. The Pacific sea surface temperature data with more anomalies below zero was downloaded from the KNMI Climate Explorer. The default base years at the KNMI Climate Explorer are 1981 to 2010, as recommended by the WMO.

The overall annual variations in Figure 2-6 are the same for both sets of base years, but some of the monthly wiggles are slightly different. The reason: the annual cycle in the base years of 1971-2000 is slightly different then the annual cycle for the base years of 1981-2010.

You'll also notice that the trends of the two datasets are essentially the same. I show **way** too many significant figures to be realistic. Both trends can only be meaningfully described as 0.0 deg C/decade. A difference of 3 **ten-thousandths** of a deg C/decade is trivial — especially in view of the fact that the difference between the models and the real world observations for the Pacific is about 0.2 deg C/decade.

CHAPTER 2.2 SUMMARY

The base years used for anomalies dictate where the data intersect with zero on a graph, and they can also significantly impact how people perceive global warming.

Next, a few more background discussions before I illustrate and discuss how poorly the climate models simulate 20th century global surface temperatures.

Chapter 2.3 – Where the Data and Model Outputs Intersect

The appearance of a model-data comparison graph is up to whoever is preparing the presentation. Some prefer to have the data (or trend lines of the data) and model outputs intersect at the first data point. In Figure 2-7, for example, where I compare observed satellite-era global sea surface temperature anomalies with the climate model simulations of those same sea surface temperature anomalies, I've shifted the data and the model output (a multi-model ensemble mean) so that their trend lines intersect at zero at the first month, November, 1981. (Note: modelers refer to sea surface temperatures as "TOS", presumably for Temperature of Ocean Surface.)

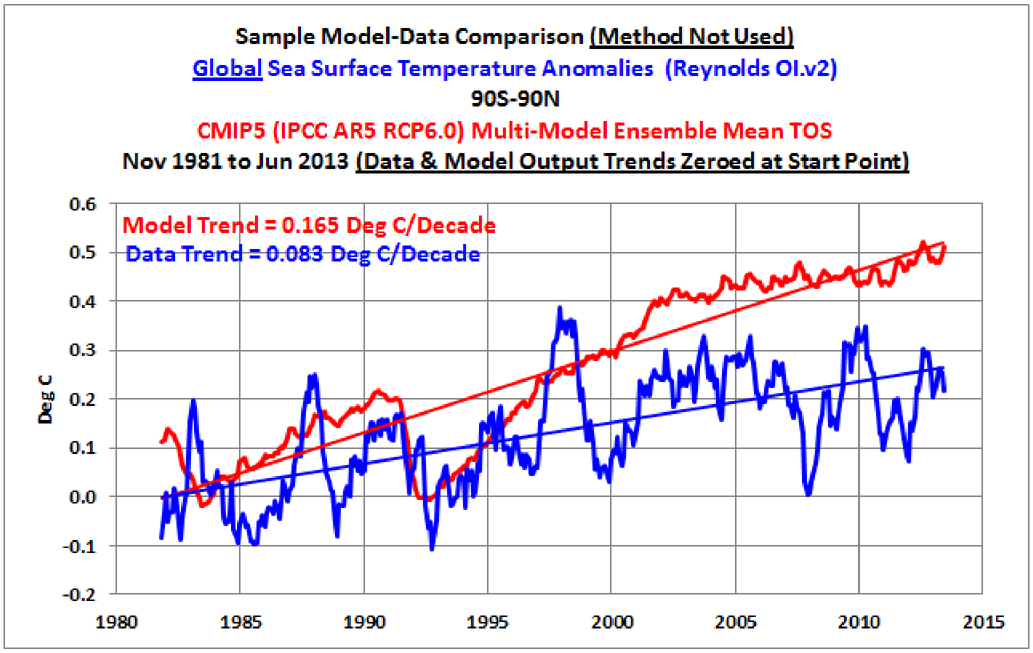


Figure 2-7

Shifting the data and model outputs doesn't change the variations within the two datasets nor their linear trends; it simply impacts where the two trend lines cross one another.

Again, while some prefer to create graphs in the manner shown in Figure 2-7, it requires more work for no meaningful gain in understanding. It is the modeled and observed warming **rates** that are of interest—not where the trend lines intersect.

Figure 2-8 is my presentation of the global sea surface temperature anomalies and the model outputs from a later chapter.

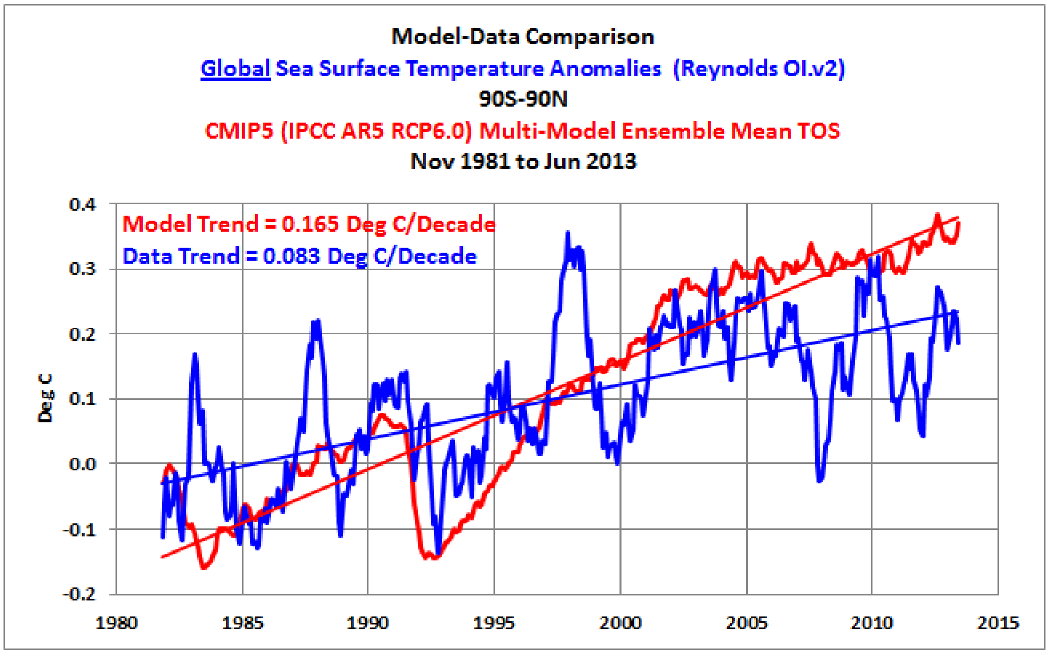


Figure 2-8

Whichever way the comparison is presented, it is clear that while the models estimated that global sea surface temperatures should have warmed at a rate of 0.165 deg C/decade over the past 31 years, but satellite-era sea surface temperatures actually warmed at half that rate, i.e., 0.083 deg C/decade. In other words, the models estimated how sea surface temperatures would have warmed based on the assumption that they were warmed by manmade greenhouse gases. According to the programmers' assumptions, the surface of the global oceans should have warmed at twice the observed warming rate. Looks like the modelers made an incorrect assumption or two.

CHAPTER 2.3 SUMMARY

I have taken no extraordinary steps in preparing the graphs in this book. The climate models have failed abysmally. Therefore, it takes no special effort on my part to make them look bad.

Chapter 2.4 – Dataset Overviews

The following are general overviews of the main datasets that are used in the model-data comparisons, and in general discussions. I also used a few other datasets as references and, in those cases, during those discussions, the data source is identified and links to the main page for the dataset are provided.

Note: I've provided links to the dataset webpages during the overviews in this chapter. The attached webpages should include references to the peer-reviewed papers upon which the datasets are based, if you're interested.

I. GLOBAL COMBINED LAND AIR PLUS SEA SURFACE TEMPERATURE ANOMALIES

I use GISS (Goddard Institute for Space Studies) LOTI (Land-Ocean Temperature Index) data in Section 4. A detailed overview can be found here. Starting with their January, 2013 update, the GISS dataset uses NCDC ERSST.v3b sea surface temperature data. The impact of GISS's recent change in sea surface temperature data suppliers is discussed here. GISS adjusts GHCN and other land surface temperature data using a number of different methods; when any data is missing, they simply fill it in (infill it) using 1200km smoothing. (See the GISS description here.) Unlike the UK Met Office and NCDC products, GISS masks sea surface temperature data at the poles where seasonal sea ice exists, then, they extend **land** surface temperature data **out over the oceans** in those locations. (See discussions here and here.)

Some background information before I explain why I've used GISS LOTI data for the global surface temperature model-data comparisons:

Always remember this: surface temperatures are not sampled uniformly around the globe. Figure 2-9 shows the grids where temperature data exists in May 2013 and May 1913 as examples. Even today, there are few grids with land surface air temperature data in Africa, Antarctica, Greenland, and in the Amazon basin of South America. As for the oceans, there are few samples south of 45S latitude. And the farther you travel back in time, the fewer samples there are.

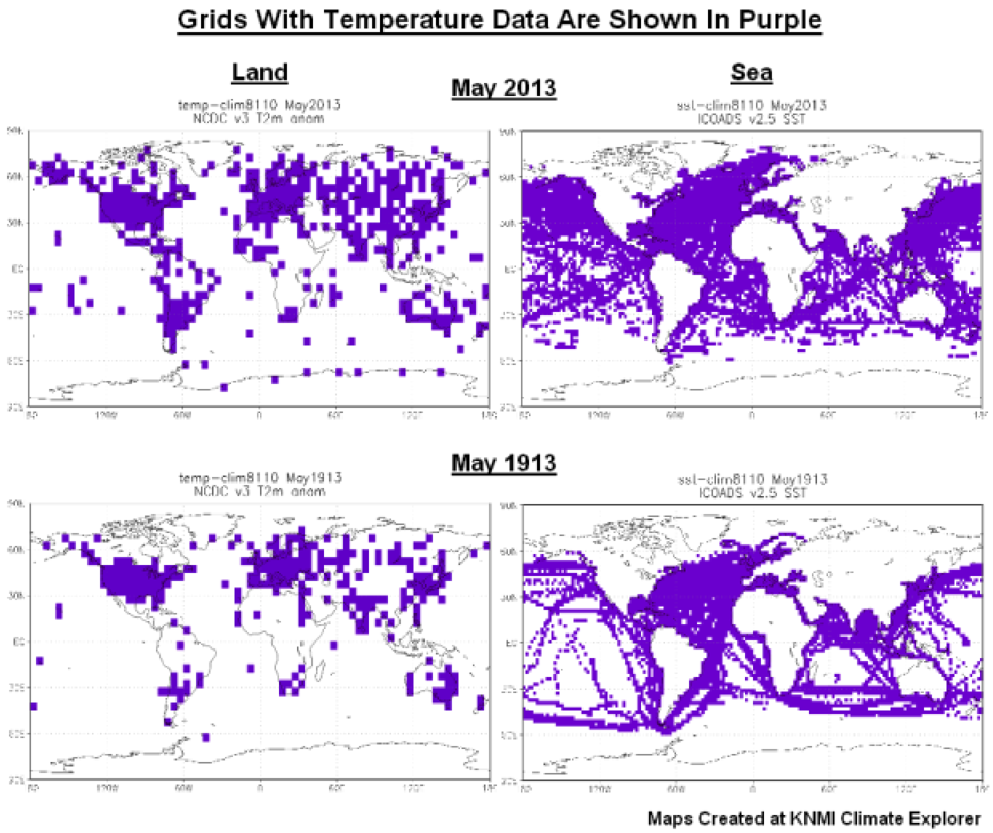


Figure 2-9

The land surface air temperature measurements in Figure 2-9's two left-hand maps are based on the NOAA/NCDC GHCN (Global Historical Climatology Network) dataset. That dataset serves as the source of most of the land surface air temperature data for the surface temperature products from GISS, NCDC, and UKMO. GISS and NCDC fill in missing data using different statistical techniques. The UKMO does not infill missing data. In Figure 2-9's right-hand maps, the sea surface temperature measurements are based on the ICOADS (International Comprehensive Ocean-Atmosphere Data Set). The NCDC adjusts and infills missing data using statistical methods to create their ERSST.v3b (Extended Reconstructed Sea Surface Temperature) product. And both GISS and NCDC use the ERSST.v3b sea surface temperature data for their combined land-plus-ocean surface temperature products. The UKMO does not fill in missing sea surface temperature data (just as it does not fill in its land surface data).

Due to infilling, GISS and NCDC global temperature anomaly products give a false impression of being datasets with good global coverage. In Figure 2-10 are maps of the GISS LOTI temperature anomalies for May 1913 and May 2013, for a visual comparison with the maps of the source data shown in Figure 2-9. As shown, most of the areas with no source data, now have data. GISS and NCDC have made great efforts to fill in the data. There is a drawback to the infilled data. The infilled data is statistically created data, i.e., it's make-believe data. One must take into consideration where they did the infilling. For example, the sea surface temperature data in the Southern Ocean surrounding Antarctica appears to be complete, yet the vast majority of it is **infilled**, i.e., **pretend**. Thus, any study of it would be, primarily, an analysis of the infilling methods and not of observations-based data.

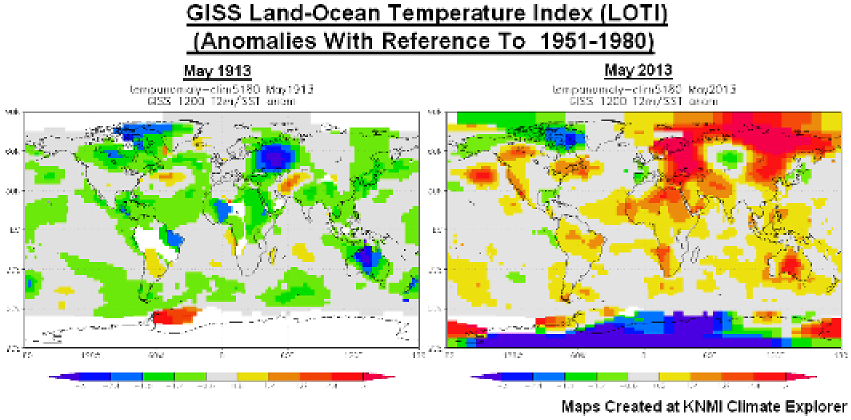


Figure 2-10

Even with the infilling used by the GISS and NCDC, their long-term global temperature data are remarkably similar to the UKMO data, which does not infill missing data. (See Figure 2-11.) They should be similar, because they all rely on the same source data.

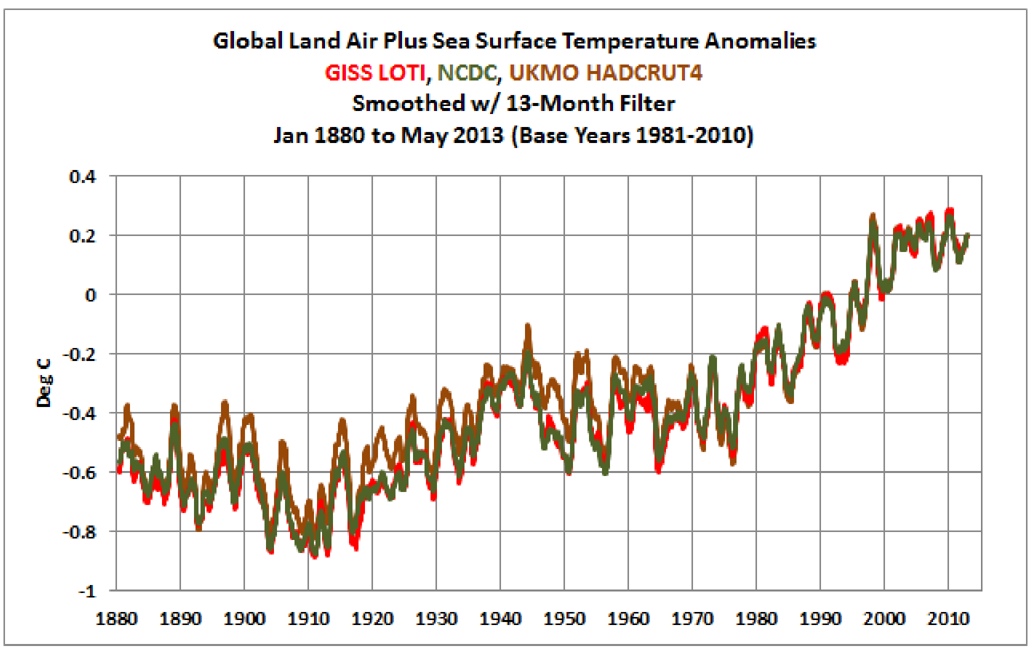


Figure 2-11

The vast majority of the differences between the UKMO HADCRUT4 data and the other two products result from the differences in the sea surface temperature reconstructions. The UKMO revised how they reconstruct (adjust/correct) sea surface temperature data recently with their new HADSST3 data and they are using it in the HADCRUT4 combined land plus ocean data.

Back to the use of the GISS product in this book: For the model-data comparisons of global surface temperatures, I present maps of modeled and observed temperature trends for specific periods. The GISS LOTI (Land-Ocean Temperature Index) data provided the most complete trend maps at the KNMI Climate Explorer. (See Figure 2-12.)

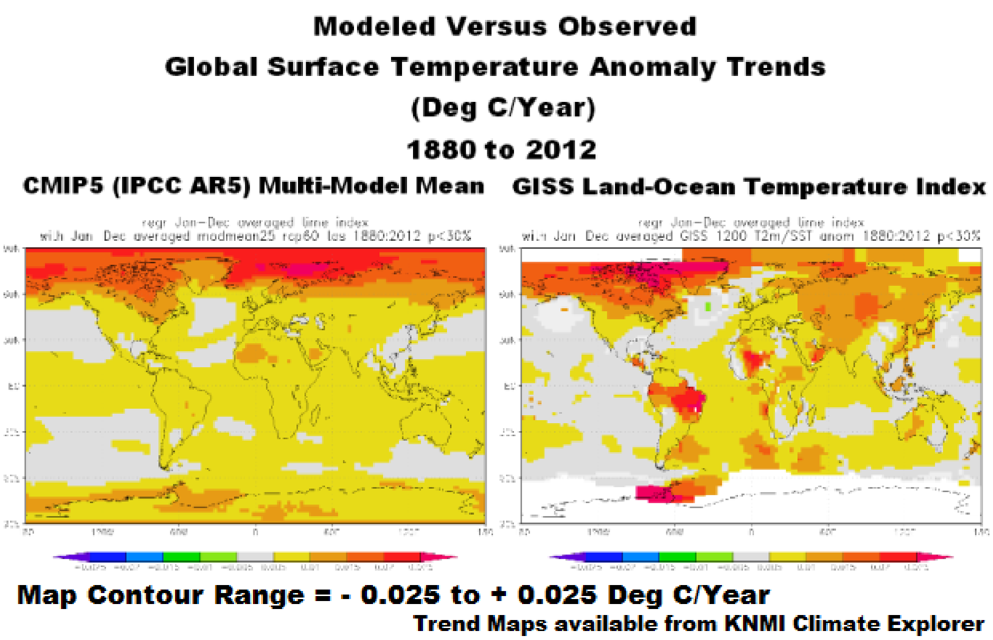


Figure 2-12

The trend maps for the NCDC and UKMO global land-ocean temperature products, on the other hand, have large gaps where the data was incomplete. In other words, I use the GISS LOTI data because the maps of that dataset look more complete (more complete looking than those of NCDC and UKMO data).

II. LAND SURFACE AIR TEMPERATURE ANOMALIES

In Section 5, I use the UKMO CRUTEM4 dataset for the comparisons of modeled and observed land surface air temperature anomalies. It's the land surface air temperature component of the UKMO's combined HADCRUT4 product. As noted above, the UKMO surface temperature products are **not infilled**, while the GISS and NCDC products are infilled with statistically created data.

I will not be looking at land surface temperature anomalies on a global basis in Chapters 5.1 through 5.4. I include the land-only data and model outputs for only a couple of continents and a few regions. At those low levels of data, statistical infilling could play too large a role in both the long- and short-term trends. I do not want the infilling methods to influence the comparisons. In other words, in these relatively small areas of the globe, the goal is to examine **data**, not “make believe” infilled data.

In Chapter 5.5, I use the BEST (Berkeley Earth Surface Temperature) dataset to present daily minimum and maximum temperatures and of the difference between them, known as the “diurnal temperature range.”

III. SEA SURFACE TEMPERATURE ANOMALIES

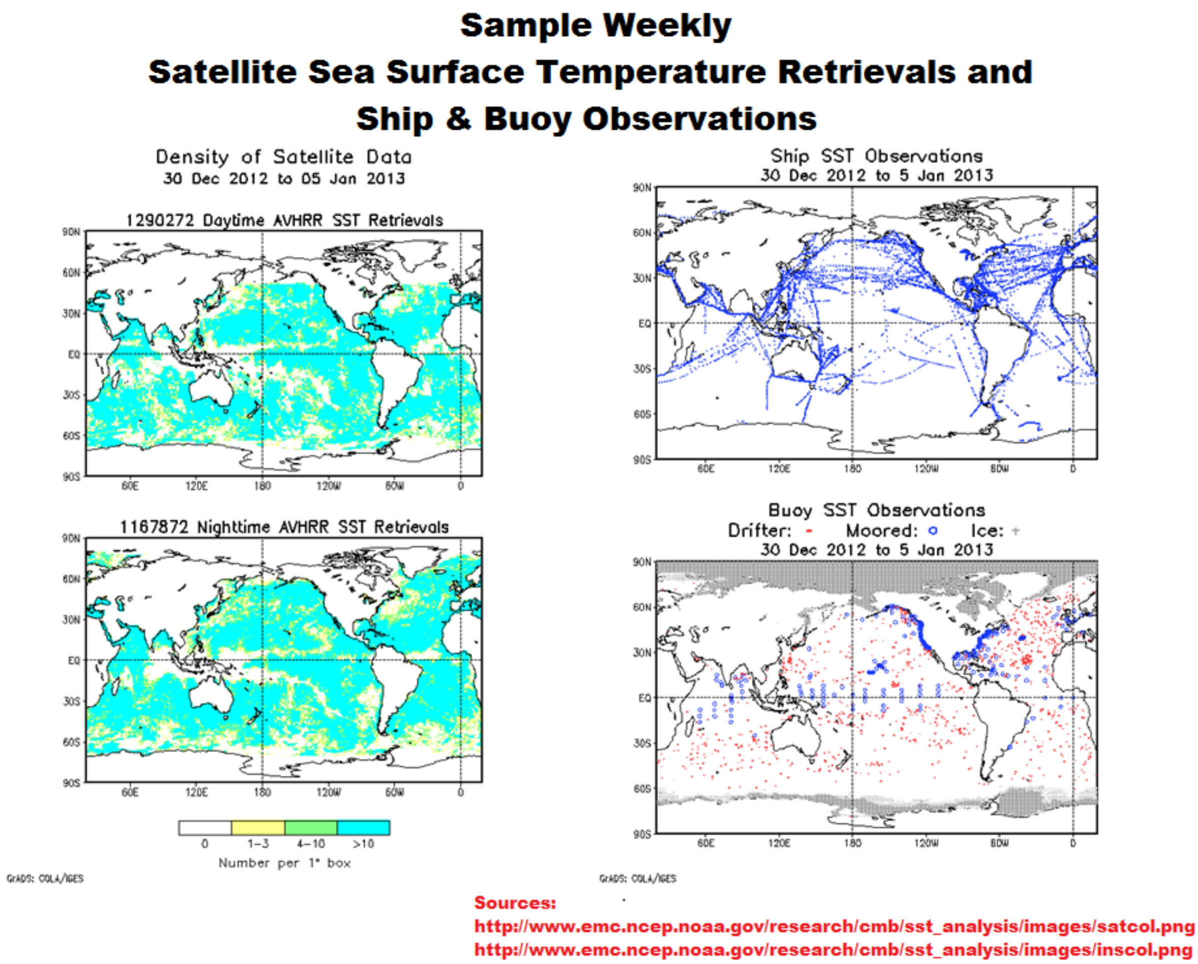


Figure 2-13

The majority of the sea surface temperature data presented for comparison is the NOAA Optimum Interpolation Sea Surface Temperature Analysis, also known as

Reynolds OI.v2. The satellite era of sea surface temperature data begins in late 1981. Satellite-era sea surface temperature data are not based solely on satellite-derived data. They are also based on *in situ* samples from ship inlets and from fixed and drifting buoys. (See Figure 2-13.)

Satellite-based sea surface temperature datasets have much better coverage of the global oceans than datasets that exclude the satellite data, especially in the polar oceans where sea ice reduces ship travel. The satellite-based data are corrected for biases as outlined in Reynolds, et al. (2002) An Improved In Situ and Satellite SST Analysis for Climate.

In a 2004 peer-reviewed paper, Smith and Reynolds called the Reynolds OI.v2 data sea surface temperature dataset "a good estimate of the truth." (See page 10 of the paper.) And the truth is what we're looking for. Bottom line: The Reynolds OI.v2 dataset is the best sea surface temperature data available.

Also when looking at long-term sea surface temperature data without the land surface temperature data, in most cases, I use the UKMO HADISST product. At other times, I present the NOAA ERSST.v3b data. Both datasets rely on the same ICOADS source data, and the both infill missing data. What are the differences? HADISST incorporates satellite-based data starting in the early 1980s (satellite data is excluded from ERSST.v3b). The UKMO reinserts observations-based data into the statistically infilled HADISST data (as far as I know, NOAA does not take this additional step with the ERSST.v3b data). These differences in methodology create subtle differences in the datasets. Some researchers prefer HADISST and others prefer ERSST.v3b. Both of those long-term reconstructions are available through the KNMI Climate Explorer if you'd like to examine the differences.

IV. SATELLITE-ERA PRECIPITATION DATA

There are a wide variety of precipitation datasets available at the KNMI Climate Explorer. The first set of model-data precipitation comparisons use global data (land and ocean), and for the oceans, satellite-based data are required. There are three global precipitation datasets (land plus ocean) available at the KNMI Climate Explorer that are based on a combination of satellite and rain gauge measurements. They start in 1979. I use all three in this book: 1) NOAA's CAMS-OPI data, where the acronyms stand for Climate Anomaly Monitoring System ("CAMS") and OLR Precipitation Index ("OPI"); 2) GPCP v2.2 (Global Precipitation Climatology Project version 2.2); and 3) CMAP (CPC Merged Analysis of Precipitation).

The CAMS-OPI data continues to be updated, while it appears that NOAA stopped updating the GPCP v2.2 precipitation data with the January 2013 data. CMAP data have not been updated at the KNMI Climate Explorer since November, 2011, as of this writing.

A benefit to the GPCP v2.2 data at the KNMI Climate Explorer is that land and ocean masks are provided; thus, you can download precipitation data for land and oceans separately. That option is not available for the CAMS-OPI or CMAP data.

V. LONG-TERM (RAIN GAUGE-BASED) LAND PRECIPITATION DATA

For the longer-term model-data comparisons of land (only) precipitation, I use three rain gauge-based datasets: 1) CRU TS 3.10, a product of the Climatic Research Unit (CRU) at the University of East Anglia; 2) NOAA/NCDC's GHCN Version 2 (part of its GHCN (Global Historical Climatology Network); and 3) GPCC (Global Precipitation Climatology Centre) product.

Note: There are two versions of the rain gauge-based precipitation data from the third supplier GPCC. It comes with and without computer model enhancement. Global Precipitation Climatology Centre (GPCC) has created a reanalysis of precipitation called the GPCC Version 6. (A reanalysis is basically a computer model that includes data as one of the inputs, so it's a computer-modified data analysis.) The GPCC also make the rain gauge-based data available without the model enhancement. I use the data, not the reanalysis, in this book.

VI. SEA ICE AREA ANOMALIES

For hemispheric sea ice area anomalies, I use the data from NSDIC (National Snow & Ice Data Center) to simply show whether climate models can accurately simulate growth or loss in sea ice area for the Northern and Southern Hemispheres.

VII. OCEAN HEAT CONTENT

The climate model outputs of ocean heat content are not available through the KNMI Climate Explorer. So there are no model-data comparisons presented in this book.

However, KNMI does include an ocean heat content dataset that covers the top 700 meters of the global oceans. It is the ocean heat content data from the NODC (National Oceanographic Data Center). I use the NODC's ocean heat content data for the depths of 0-700 meters during discussions of El Niño and La Niña processes and ocean warming in general.

Chapter 2.5 – Data and Model Output Sources

I have used two sources of data and climate models in this book. Both provide data in easy-to-use formats, with the format from the KNMI Climate Explorer easier to use than the format from the NOAA NOMADS website.

I only use readily available data and climate model outputs so that anyone could download it and confirm the results presented herein. All you need is internet access and spreadsheet software.

I. PRIMARY SOURCE

The primary source of data and climate model outputs used in this book is the KNMI Climate Explorer. KNMI stands for the Royal Netherlands Meteorological Institute. (See also the KNMI About webpage.)

KNMI provides an Introduction to their Climate Explorer at their Starting Point webpage here, and a Help page here, which covers a number of topics.

I prepared a Very Basic Introduction to the KNMI Climate Explorer a couple of years ago. The opening paragraph says:

> Dr. Geert Jan van Oldenborgh of the Royal Netherlands Meteorological Institute (KNMI) created and maintains (in addition to all of his research endeavors) the web application called the KNMI Climate Explorer. It allows users to perform statistical analysis of climate data. There are a multitude of datasets and analyses available, and any attempt on my part to describe what is available would not do justice to the efforts that have gone into the tool. Many of the datasets are updated monthly. Some are not. And for some datasets, the source may not update the data for a month or two. HADISST always lags the other SST datasets by a month. You can even investigate some of the climate model outputs used for the IPCC AR4.

Over the past year or more, the climate models stored in the CMIP5 archive have also been added to the KNMI Climate Explorer. See the Monthly CMIP5 scenario runs webpage. As you'll recall, the CMIP5 archive is being used by the IPCC for their 5th Assessment Report (AR5).

EXAMPLES OF LOCATING THE MODELS AT THE KNMI CLIMATE EXPLORER

1) For the multi-model ensemble mean of the simulations of Global Surface

Temperature Anomalies, I use “tas” (assumedly for Temperature of the Air at the Surface). The RCP6.0 scenario is being used. It also includes the historic model simulations. See the selection in the 3rd column and 3rd row of the Surface Variables, in my Figure 2-14 below.

Screen Capture of CMIP5 Model "Surface Variables" Selections
At KMNI Climate Explorer

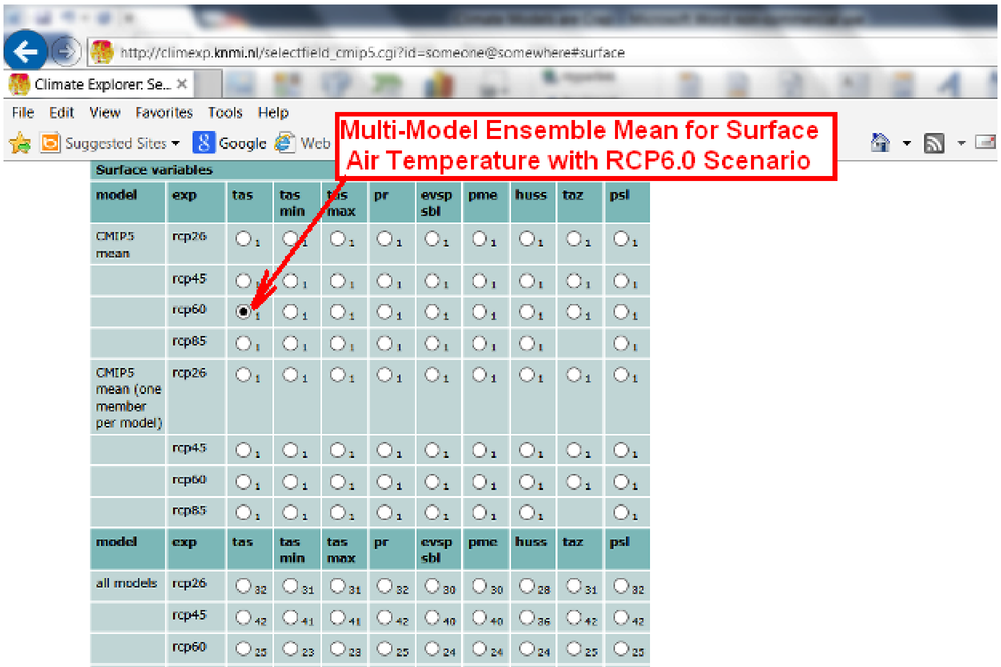


Figure 2-14

(Note the headings of “tas min” and “tas max” in Figure 2-14, to the right of “tas.” Those are the selections for “Daily Minimum Near-Surface Air Temperature” and “Daily Maximum Near-Surface Air Temperature”. I use those to discuss daily maximum and minimum land surface air temperatures and the difference between the maximums and minimums, which is called the “diurnal temperature range.”)

2) For model simulations of only land surface air temperature anomalies (no sea surface data), to isolate the land surface temperature portions of the simulations, select the “land points” option on the Field webpage, shown in my Figure 2-15 below — the “Field” webpage appears after you select the type of model output from the “Monthly CMIP5 scenario runs” page. Selecting “land points” masks the surface temperature outputs for the oceans; the default selection is “Everything” so **you must select “land points**” for land surface variables **only**. (Obviously, you can’t select land surface temperatures from model outputs of sea surface temperatures.)

Screen Capture of "Field" Webpage
At KMNI Climate Explorer

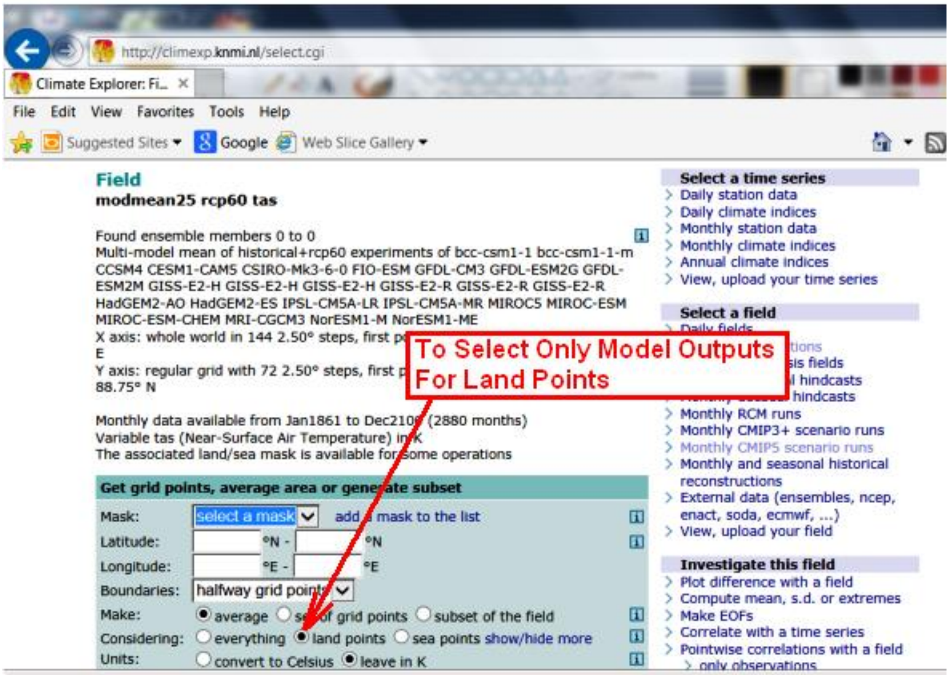


Figure 2-15

3) The multi-model ensemble mean for sea surface temperature simulations is available under "Land, ocean, sea ice variables". (See my Figure 2-16.) Sea surface temperatures are identified as "tos", assumedly for Temperature of the Ocean Surface.

Screen Capture of CMIP5 Model "Land, Ocean, Sea Ice Variables" Selections At KMNI Climate Explorer

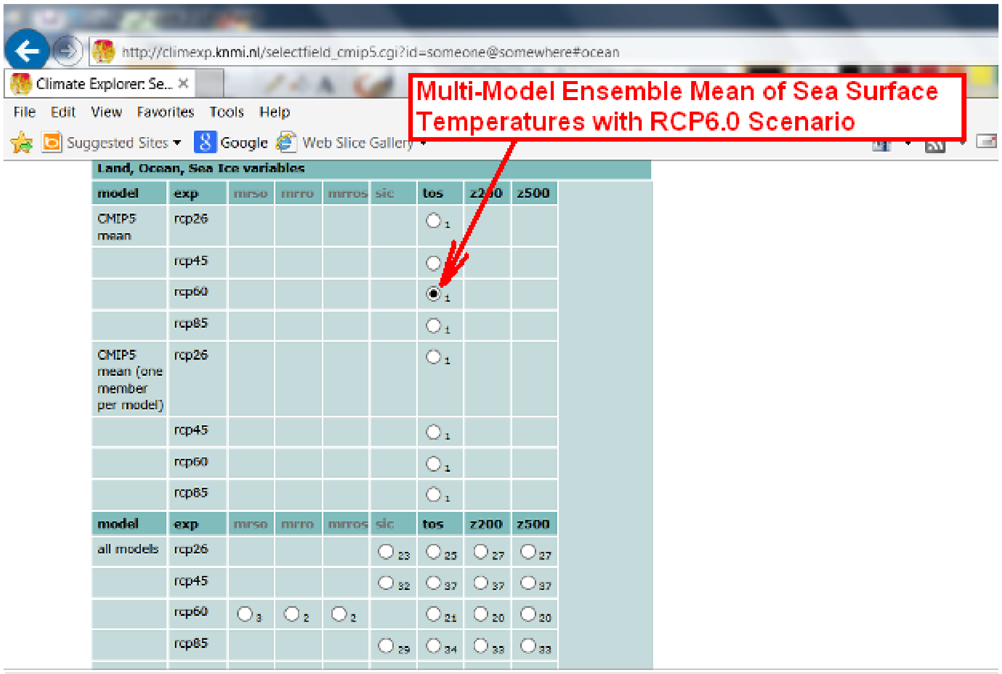


Figure 2-16

EXAMPLES OF LOCATING OBSERVATIONS-BASED DATA

1) The monthly surface temperature and precipitation data at the KNMI Climate Explorer is found at their "Monthly observations" webpage — the GISS LOTI (Land-Ocean Temperature Index) data is found under the "Temperature" heading and called "1880-now anomalies: GISS 1200km". GISS LOTI data is used in comparisons of global land-plus-ocean surface temperature anomalies.

2) I use UKMO CRUTEM4 for most of the model-data comparisons of land surface air temperature anomalies — under the KNMI heading of "Land", you'll find the "1850-2010 anomalies: CRUTEM4.2.0.0" selection").

3) For the BEST (Berkeley Earth Surface Temperature) dataset (I use this in my discussion of daily maximum and minimum temperatures and the difference between the two, the "diurnal temperature range"), select KNMI Climate Explorer "Monthly observations" under the headings of "Tmax" and "Tmin" (the link under "Tmax" is "1750-2012: Berkeley 1°" and for "Tmin" it is "1750-2012: Berkeley 1°").

4) For long-term sea surface temperature anomaly comparisons, i.e., the NOAA/NCDC ERSST.v3b data and the UKMO HADISST data, look under the heading "SST" (sea

surface temperature), ERSST.v3b is "1854-now: NCDC v3b ERSST reconstruction" and HADISST is "1870-now: HadISST1 1° reconstruction".

5) The three satellite- and rain gauge-based precipitation datasets are under "Precipitation". The CAMS-OPI dataset is "1979-now: CAMSOPI", the CMAP precipitation data are listed as "1979-now: CPC Merged Analysis of Precipitation", and GCPC v2.2 precipitation data is "1979-now: GPCP v2.2 analysis".

(Note 1: there are land and ocean masks for GCPC. Unfortunately, there are no land and ocean masks for the CAMS-OPI or CMAP data.

(Note 2: To create a model-data comparison, see link to a blog post in Chapter 2-11, below, for a further instructions.)

II. THE SECOND SOURCE

The second source of sea surface temperature data used in this book is NOMADS (NOAA's National Operational Model Archive & Distribution System). I use it for the Reynolds OI.v2 sea surface temperature data in my monthly sea surface temperature updates (Example here). For consistency, I also present the data from NOMADS in my model-data comparisons of sea surface temperature anomalies. (See the NOMADS "time series" selection webpage for the Reynolds OI.v2 data here, and the corresponding main webpage here). To navigate NOMADS: select "anomalies" from the drop-down "Field" menu; enter the desired coordinates; then, click on "Plot" to see a graph of the desired data. Below that graph, on the left, is a link to "Download data file… ." Access the data through that link.

You will see only one column. That's the data. Other websites, such as the KNMI Climate Explorer, provide two columns, where the first column includes the corresponding months and the second column includes the data. In order to use the data from the NOAA NOMADS website, you must create a column for the months in numeric form on your spreadsheet. If you're new to plotting climate-related data, try using the Reynolds OI.v2 data via the KNMI Climate Explorer; it comes with the corresponding months.

As a reminder, NOAA uses a special climatology prepared for the Reynolds OI.v2 data at their NOMADS website. They created that climatology because they needed a reference for anomalies when they first started the satellite-based Reynolds OI.v2 data. The base years used in their climatology are 1971 to 2000. When you download anomaly data from the **KNMI Climate Explorer**, however, it uses the Reynolds OI.v2 data to create the base years, so the base years there start in 1982.

Chapter 2.6 – Data Smoothing

The data in some of the presentations are very volatile. For example, look at the land surface air temperature anomalies for Scandinavia since 1930. (See Figure 2-17.) That dataset will also appear later in this book. The title block lists the coordinates used for the data and for the multi-model mean of all of the climate model outputs: 55N-72N, 2E-30E. As you can see in the graph, the monthly variations can be quite large. It's tough to tell what's going on with all of that "weather noise." The model output is less volatile, due to the averaging of all of ensemble members included in the model mean. In Figure 2-17, I've also shown the linear warming trends for the models and for the data. The models estimated that Scandinavian land surface air temperatures should have warmed at a rate that was twice as fast as the observed warming rate. The models did not simulate the warming rate of Scandinavian surface temperatures very well.

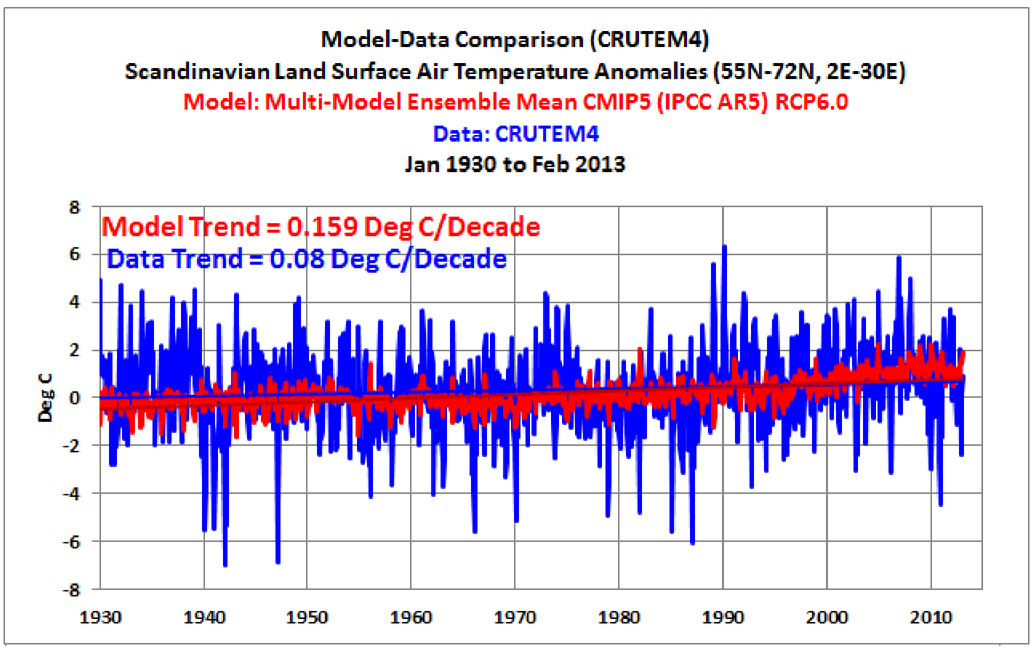


Figure 2-17

Where the data is highly volatile, I smooth the data and the model outputs with 13-month running-average filters. If you smooth one dataset in a comparison, you must smooth them all. The smoothing drastically reduces weather noise and minimizes any seasonal component in the data. (See Figure 2-18.) To create that filter, each data point in the curve is made to represent a 13-month average that is centered on the 7th month. The first data point in this example is at July, 1930 and it represents the average surface temperature anomalies from January, 1930 to January, 1931. The next data point is in August, 1930 and it shows the average for the period of February, 1930 to February, 1931, and so on, until the final data point in August, 2012 for the 13-month period of February, 2012 to February, 2013. With this simple type of smoothing, the graph begins six months after the start month of the monthly data and ends six months before the last month of the data.

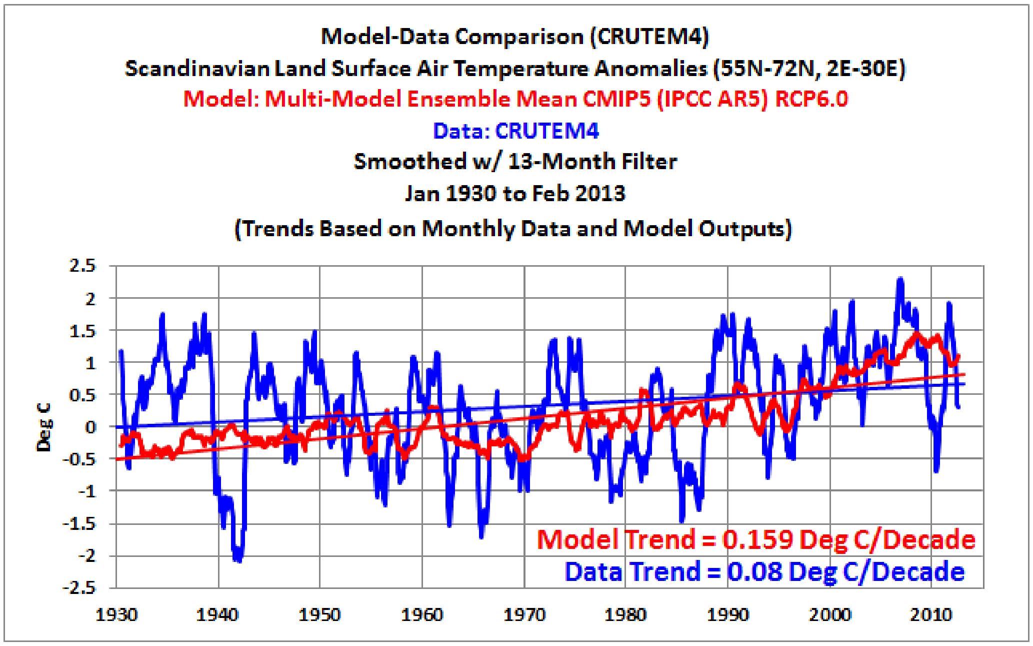


Figure 2-18

The data in Figure 2-18 still shows lots of variability, but at least with the smoothing, one can see what's taking place from year to year. The smoothing also lets you see other things that are taking place in the data. Notice the climate shift in the Scandinavian land surface temperature anomalies in the late 1980s. That is, from the 1930s until the late 1980s, Scandinavian land surface air temperatures cooled quite rapidly, then, they abruptly shifted upwards within about one year. After the upward shift, Scandinavian surface temperatures again cooled until the mid-1990s and then warmed until the late 2000s. I've highlighted that abrupt climate shift in Figure 2-19.

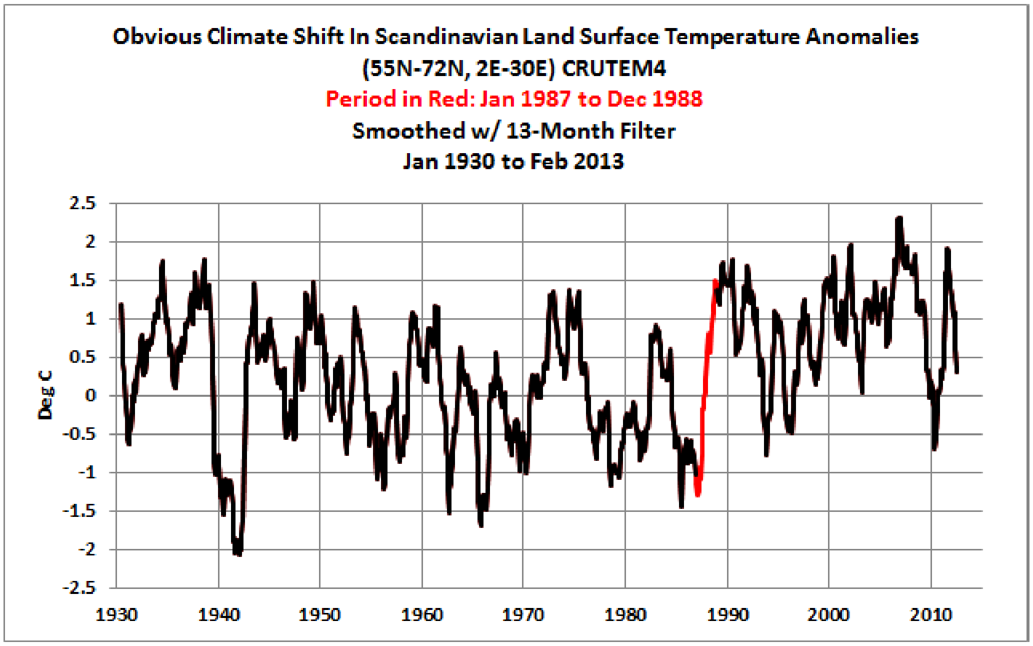


Figure 2-19

It's difficult to see that upward shift in the raw data. (See Figure 2-17.) But, with the smoothed data, it stands out like a sore thumb. In that later chapter, I compare the modeled and observed warming rates before and after that obvious climate shift. If you thought the models' estimates looked bad from 1930 to the end of the data in 2013, they look even worse when the models and data are compared before and after that shift.

The climate science community would like you to believe that the long-term warming over the past century and a half was caused by manmade greenhouse gases. But, their models cannot explain why Scandinavian land surface temperatures cooled from the 1930s to the late 1980s. And they also can't explain why land surface air temperatures, based on the linear trend, haven't warmed since the late 1980s.

It is also obvious that the long-term warming in Scandinavia (since 1930) depended on 1 year of data. That is, if you were to remove the 12 months of data corresponding to the abrupt shift, Scandinavian land surface air temperatures would show long-term cooling, not warming. But, I'm getting ahead of myself.

Chapter 2.7 – Zonal-Mean Graphs

In addition to time-series graphs, I use graphs that present variables on a zonal-mean basis. "Zonal-mean" means latitude average. In this book, the variable for zonal mean graphs is shown in the (vertical) y-axis. In Figure 2-20, for example, the variable is sea surface temperature, with the units in deg C. The (horizontal) x-axis is latitude. Figure 2-20, as noted in its title, shows the average (or mean) sea surface temperatures (**not** anomalies) of the Pacific Ocean for the period of January, 1982 to April, 2012 in 5-degree latitude increments. The average sea surface temperatures are much warmer in the tropical Pacific than they are toward the poles.

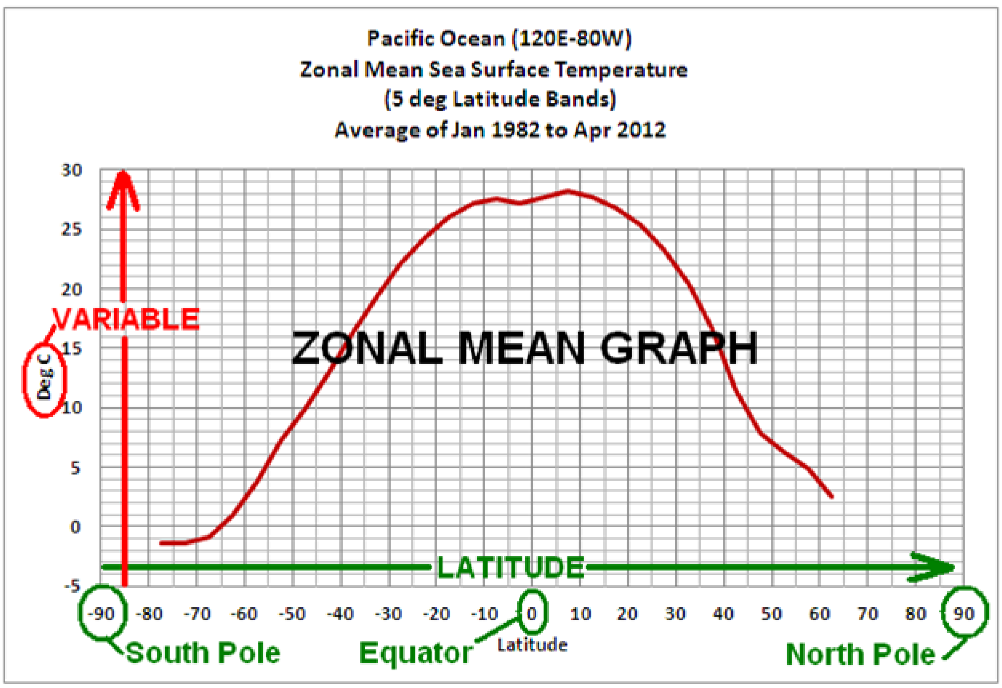


Figure 2-20

Figure 2-21, below, illustrates what a zonal-mean graph represents. That graph shows the average zonal-mean sea surface temperature for the year 2011 in the Pacific Ocean; that is, it's the average of the monthly data from January to December, 2011, for the longitudes of 120E-80W, in 5-degree latitude increments. Below it is the corresponding sea surface temperature map. The graph starts on the left with the 2011 average sea surface temperatures in the Southern Ocean, south of the Pacific and north of Antarctica. The average temperatures of the waters at those latitudes in 2011 were below zero deg C. On the right, it ends at the latitude band of 60N-65N, at the Bering Strait. The average sea surface temperatures near the Bering Strait for 2011 were approximately 2.5 deg C. Near the equator, the sea surface temperatures are much warmer, with highest sea surface temperatures about 28 deg C at the latitude band of 5N-10N.

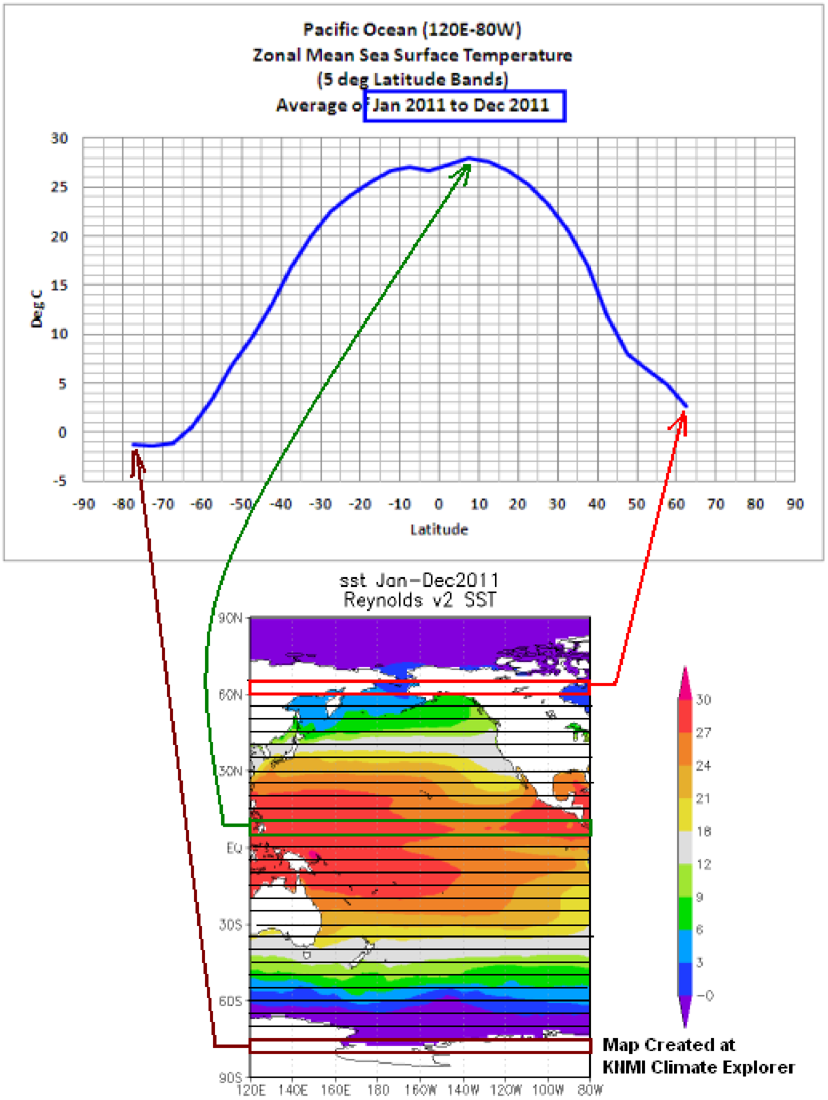


Figure 2-21

In the map in Figure 2-21, I include horizontal lines in increments of 5-degrees latitude. To create the zonal-mean graph, I downloaded the sea surface temperature data for each of those segments, using the longitudes of 120E-80W for all of them. For instance, the data point at 82.5 S on the graph represents the average sea surface temperature (January to December, 2011) for the slice with the coordinates of 85S-80S, 120E-80W. The next data point, at 77.5S, shows the average sea surface temperature for 80S-75S, 120E-80W. The process is repeated in 5 degree increments moving northward until the last point on the graph to the right at 62.5N shows the average sea surface temperature for 60N-65N, 120E-80W.

I use the zonal-mean graphs later to compare modeled and observed warming and cooling rates (Yes, cooling rates!) in sea surface temperatures and land surface air temperatures. The sea surface temperatures for a large portion of the global oceans have cooled in the last 3 decades and another very large portion shows no warming or cooling, based on linear trends, in that time. Of course, climate models estimated that they should have warmed, if manmade greenhouse gases warmed the surface of the oceans.

Sorry, I've gotten ahead of myself once again.

Chapter 2.8 – On Polar Amplification

I discuss modeled and observed global surface temperature trends on a zonal-means (latitude-average) basis in Chapters 4.2 and 4.3. The phenomenon of polar amplification is easily seen in those graphs. Wikipedia describes Polar Amplification as:

> *Polar amplification, also referred to as Arctic amplification, is the greater temperature increases in the Arctic compared to the earth as a whole as a result of the effect of feedbacks and other processes. It is not observed in the Antarctic, largely because the Southern Ocean acts as a heat sink and the lack of seasonal snow cover.*

Figure 2-22 illustrates the warming rates (trends in deg C/decade) in global surface temperatures since 1914 using the GISS LOTI (Land-Ocean Temperature Index) data on a zonal mean (latitude average) basis. The data were first divided into three periods: 1914-1945, 1945-1975, and 1975-2012. Polar (Arctic) amplified warming occurred during the two warming periods since 1914 (1914-1945 and 1975-2012). Polar amplification also works in the other direction, too. That is, it can exaggerate the **cooling** trends in the Northern Hemisphere, as seen during the period of 1945-1975.

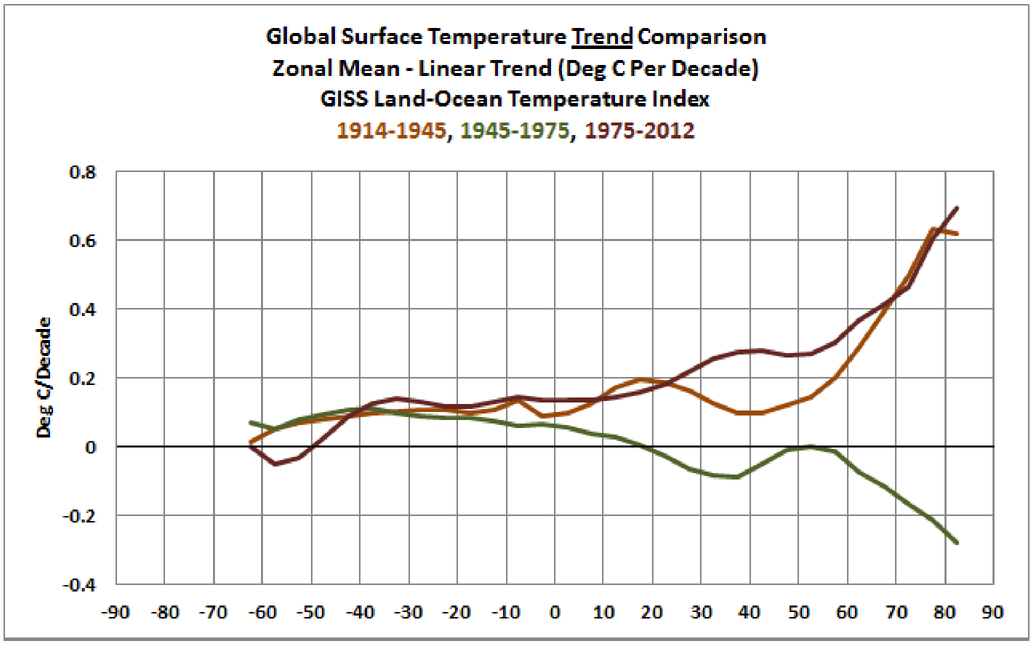


Figure 2-22

As you'll note, I have not presented trends for Antarctica and for most of the Southern Ocean that surrounds it. Land surface temperature data for Antarctica does not begin until the 1950s, and there is too little sea surface temperature source data in the Southern Ocean before the satellite era to show the trends there.

POLAR AMPLIFICATION IS A PHENOMENON THAT PRESENTS ITSELF IN LAND SURFACE AIR TEMPERATURE DATA, NOT SEA SURFACE TEMPERATURE DATA

An important point occurred to me as I was about to publish *Climate Models Fail*.

Figure 2-22-S compares warming rates on a zonal-means basis for two datasets: 1) Reynolds OI.v2 sea surface temperature data and 2) CRUTEM4 land surface air temperature data. The time period extends from the start of the Reynolds OI.v2 data (November, 1981) to July, 2013.

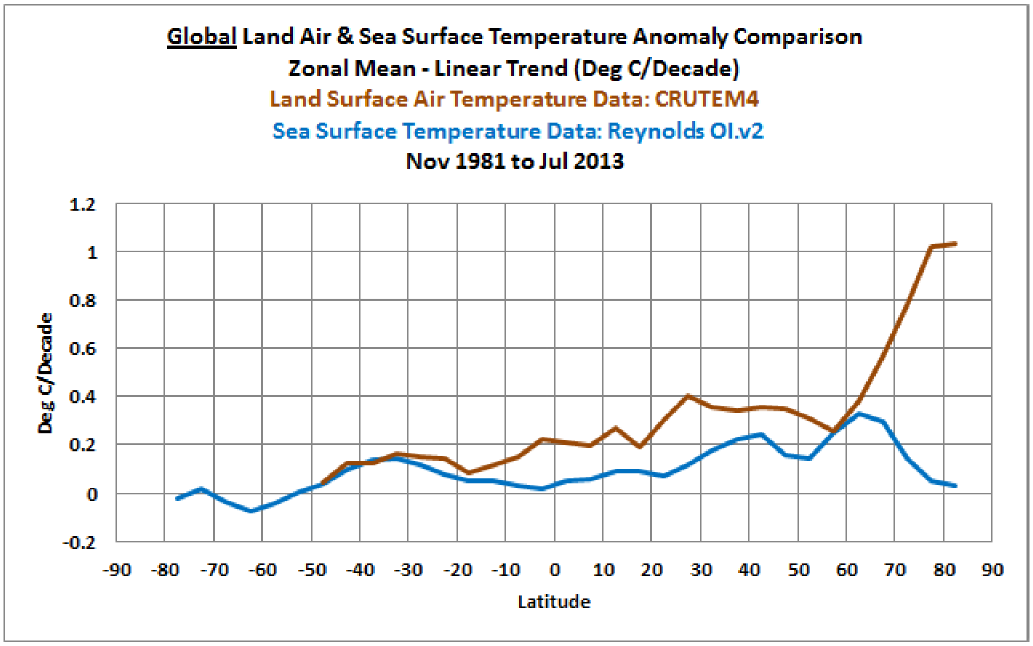


Figure 2-22-S

Note how the two datasets diverge greatly starting at about 60N to 65N. The warming rates of land surface air temperature skyrocket as they approach the North Pole, but the warming rates of the sea surface temperature data drops to almost zero.

Sea surface temperature data only exists in the polar oceans when there is open ocean. It does not exist when sea ice is present. When and where sea ice exists, NOAA uses the freezing point of sea water for the temperatures. Then, for example, when the ice melts to a new seasonal low that exposes new areas of open ocean, the measured sea surface temperatures for those new areas are compared to the freezing temperature of the sea water for anomalies. Open ocean exists in the polar oceans for only part of the year. Therefore, the warming rates in the Arctic are dampened by the existence of the sea ice during the other times of the year.

That does not mean that polar amplification of marine air temperatures over sea ice does not exist when sea ice covers the polar oceans. Those temperatures are simply not included in land surface temperature datasets, because they occur over the oceans. And they are not included in sea surface temperature datasets, because sea surface temperature datasets do not represent marine air temperatures. Last, very little marine air temperature data exists for the polar oceans, especially when sea ice is present.

GISS tries to accommodate for this by masking sea surface temperature data anywhere sea ice has existed since 1880 and then extending land surface air temperature anomalies out over the polar oceans. Unfortunately, GISS does not use sea surface temperature data when it is available in the polar oceans — they continue to use land surface temperature data over the open oceans when sea ice melts seasonally. This creates a warm bias in the GISS product, because the other global temperature data suppliers (NCDC and UKMO) do not use those techniques.

Chapter 2.9 – A Note About Volcanic Aerosols

The temperature dips and rebounds associated with volcanic eruptions appear in many of the time series graphs in this book. Explosive volcanic eruptions impact the amount of sunlight that reaches the surface of the Earth. It is often said that the aerosols spewed into the stratosphere by explosive volcanic eruptions act as an umbrella, shading the Earth's surface. The dips and rebounds shown in the models and in the data indicate that surface temperatures (observed and simulated) are impacted by the temporary drop in sunlight (**shortwave** radiation) reaching the surface. Note: correctly simulating those dips and rebounds does not mean that the models accurately handled manmade greenhouse gases, because anthropogenic CO2 would impact **longwave** (infrared) radiation.

Figure 2-23 is a replica of the IPCC's Figure FAQ 8.1 from their 4th Assessment Report. (It appeared in the Introduction here as Figure I-1). In Fig. 2-23, I highlight and identify the responses to four strong eruptions: Santa Maria in 1902, Mount Agung in 1963/64, El Chichon in 1982 and Mount Pinatubo in 1991.

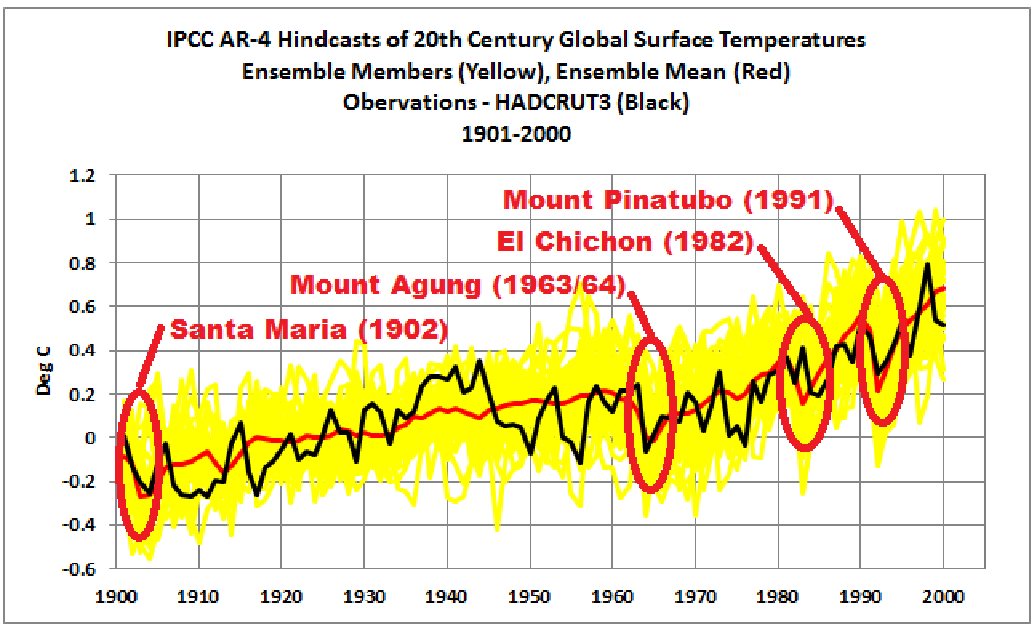


Figure 2-23

Some people believe the climate models perform well in general because they can show the dips and rebounds associated with volcanic eruptions. Those people are mistaken. It is only because climate models are **forced** to simulate those volcano-induced dips that they show up at all. Climate scientists created a dataset called stratospheric aerosol optical thickness or aerosol optical depth to make their models respond accordingly. (See the GISS webpage Forcings in GISS Climate Model - Stratospheric Aerosol Optical Thickness — the papers linked at the bottom of that GISS webpage describe how the modelers **estimated** that data; that is, for most of the time period of the dataset, the data are not based on direct measurements.)

In Figure 2-24 are the monthly GISS aerosol optical thickness data from January, 1901 to October, 2012. I use the global data presented by GISS here. Each of the large spikes is associated with a powerful explosive volcano.

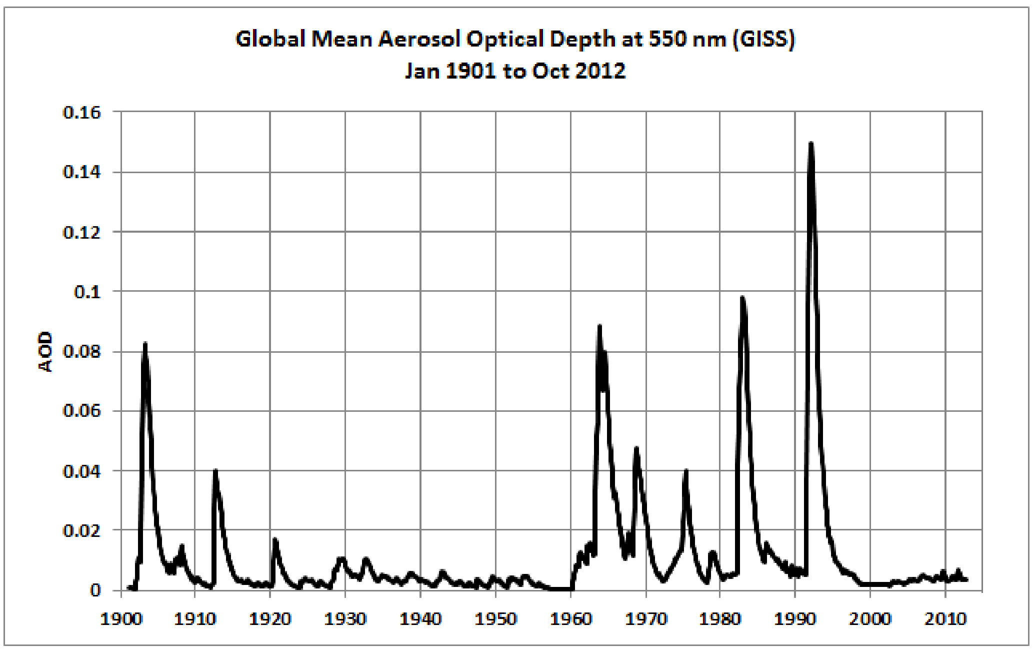


Figure 2-24

Climate modeling groups then convert the above "data" into watts/m^2. (See the GISS Forcings in GISS Climate Model webpage.) The GISS stratospheric aerosol forcing data (from the GISS webpage here) for 1901 to 2011 is shown in Figure 2-25.

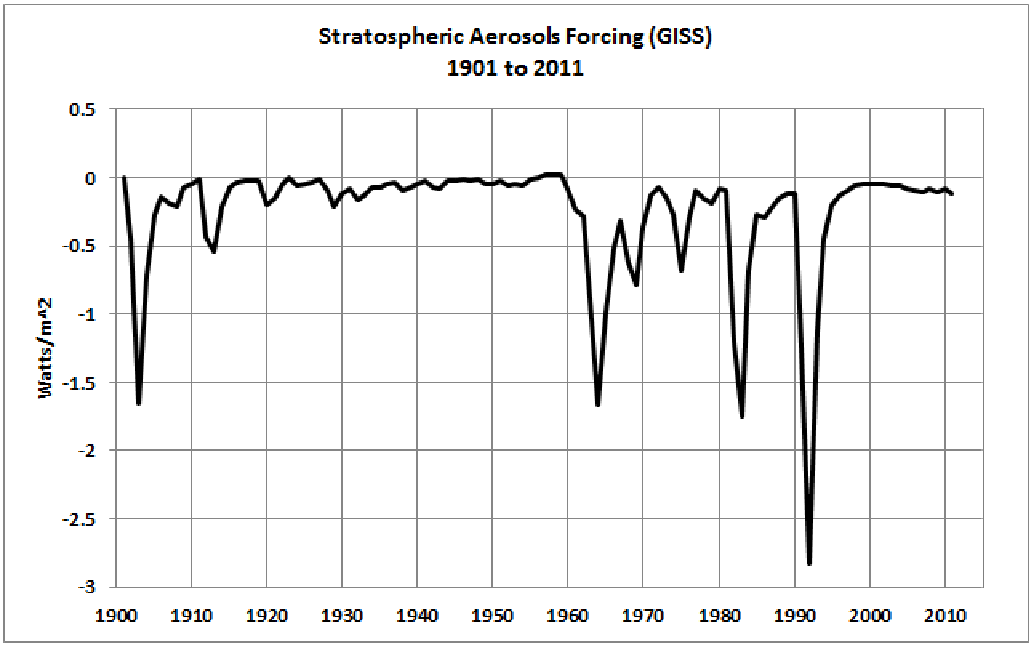


Figure 2-25

As noted earlier, stratospheric aerosols from explosive volcanic eruptions impact the amount of sunlight (downward **shortwave** radiation) that reaches and warms the surface of the planet. However, the hypothesis of human-caused global warming is not based on sunlight, so the fact that the models can mimic the dips and rebounds from volcanic eruptions does not mean the models have anything meaningful to say about climate responds to anthropogenic greenhouse gases. The hypothesis of anthropogenic global warming is based on downward **longwave** (infrared) radiation, and this book establishes the models show **no skill** at simulating the warming patterns that have actually taken place on Earth.

Additionally, sunlight has a significantly different impact on the oceans than would infrared radiation from manmade greenhouse gases. Infrared radiation can only penetrate the top few millimeters of the ocean surface — where evaporation takes place. Sunlight (downward shortwave radiation), on the other hand, penetrates the oceans to depths of about 100 meters, but most is absorbed in the first 10 meters. That's ten meters for sunlight versus a few millimeters for infrared radiation caused by manmade greenhouse gases.

A final comment on volcanic aerosols: in chapter 1.2, I cited papers that discuss the numerous flaws in climate models. One of those papers was Driscoll, et al. (2012) "Coupled Model Intercomparison Project Phase 5 (CMIP5) Simulations of Climate Following Volcanic Eruptions." Their abstract reads (my boldface):

> *The ability of the climate models submitted to the Coupled Model Intercomparison Project 5 (CMIP5) database to simulate the Northern*

> *Hemisphere winter climate following a large tropical volcanic eruption is assessed. When sulfate aerosols are produced by volcanic injections into the tropical stratosphere and spread by the stratospheric circulation, it not only causes globally averaged tropospheric cooling but also a localized heating in the lower stratosphere, which can cause major dynamical feedbacks. Observations show a lower stratospheric and surface response during the following one or two Northern Hemisphere (NH) winters, that resembles the positive phase of the North Atlantic Oscillation (NAO). Simulations from 13 CMIP5 models that represent tropical eruptions in the 19th and 20th century are examined, focusing on the large-scale regional impacts associated with the large-scale circulation during the NH winter season.* ***The models generally fail to capture the NH dynamical response following eruptions. They do not sufficiently simulate the observed post-volcanic strengthened NH polar vortex, positive NAO, or NH Eurasian warming pattern, and they tend to overestimate the cooling in the tropical troposphere.*** *The findings are confirmed by a superposed epoch analysis of the NAO index for each model.* ***The study confirms previous similar evaluations and raises concern for the ability of current climate models to simulate the response of a major mode of global circulation variability to external forcings.*** *This is also of concern for the accuracy of geoengineering modeling studies that assess the atmospheric response to stratosphere-injected particles.*

CHAPTER 2.9 SUMMARY

Climate models show a dip and rebound in response to volcanic eruptions. Those dips and rebounds do not mean the models are accurately simulating observed responses of the Earth's climate to explosive eruptions. It only means that models follow their programmers' instructions. Further, by no stretch of the imagination, do those simulated dips and rebounds mean that the models will ever be able to simulate any of the hypothetical impacts of anthropogenic greenhouse gases on climate.

Chapter 2.10 – Data Detrending

I present detrended data a number of times in this book. In this chapter, I discuss how it's commonly used, why it's used, and how to detrend data.

I briefly mentioned the AMO (Atlantic Multidecadal Oscillation) in Chapter 1.2, during the discussion of papers that are critical of climate models. The AMO (Atlantic Multidecadal Oscillation) was the subject of the paper by Ruiz-Barradas, et al. (2013) titled "The Atlantic Multidecadal Oscillation in Twentieth Century Climate Simulations: Uneven Progress from CMIP3 to CMIP5." Further information about the AMO (Atlantic Multidecadal Oscillation) can be found at the NOAA AOML (Atlantic Oceanographic and Meteorological Laboratory) "Frequently Asked Questions" webpage here, and at my blog post here and at my "Introduction to the Atlantic Multidecadal Oscillation" here.

The NOAA/ESRL created an AMO (Atlantic Multidecadal Oscillation) Index to illustrate the multidecadal variability of the sea surface temperatures of the North Atlantic. While there are many ways to present the Atlantic Multidecadal Oscillation, the simplest way, and a very logical way, is simply to detrend the sea surface temperature anomalies of the North Atlantic. Let me borrow a discussion from my book ***Who Turned on the Heat?*** It has been edited for this book.

> First, a quick introduction: The Atlantic Multidecadal Oscillation, or AMO, is a natural mode of climate variability that occurs in the North Atlantic Ocean. The Atlantic Multidecadal Oscillation was first identified in the mid-1990s. As Wikipedia notes on its **Atlantic Multidecadal Oscillation webpage**:
>
> > *The AMO signal is usually defined from the patterns of SST [Sea Surface Temperature] variability in the North Atlantic once any linear trend has been removed.*
>
> The easiest way to explain that sentence is to first show a graph of the sea surface temperature anomalies of the North Atlantic since 1900, along with the linear trend of the data, Figure 2-26. As shown, North Atlantic sea surface temperature anomalies have warmed at a rate of 0.053 deg C per decade since 1900 based on the linear trend. In addition to the overall warming, there is an additional long-term variation that caused North Atlantic sea surface temperatures to warm much faster than the long-term trend from 1900 to the late 1930s. Then, the sea surface temperature anomalies were relatively flat (not warming or cooling other than the yearly variations) until the early 1960s. Sea surface temperatures cooled quite rapidly from the early 1960s until the mid-1970s. They've then warmed since the mid-1970s. The length of the cycle since

1900 appears to be nearly 60 years. Paleoclimatological studies have shown the cycle varies in frequency with a range of 50 to 80 years.

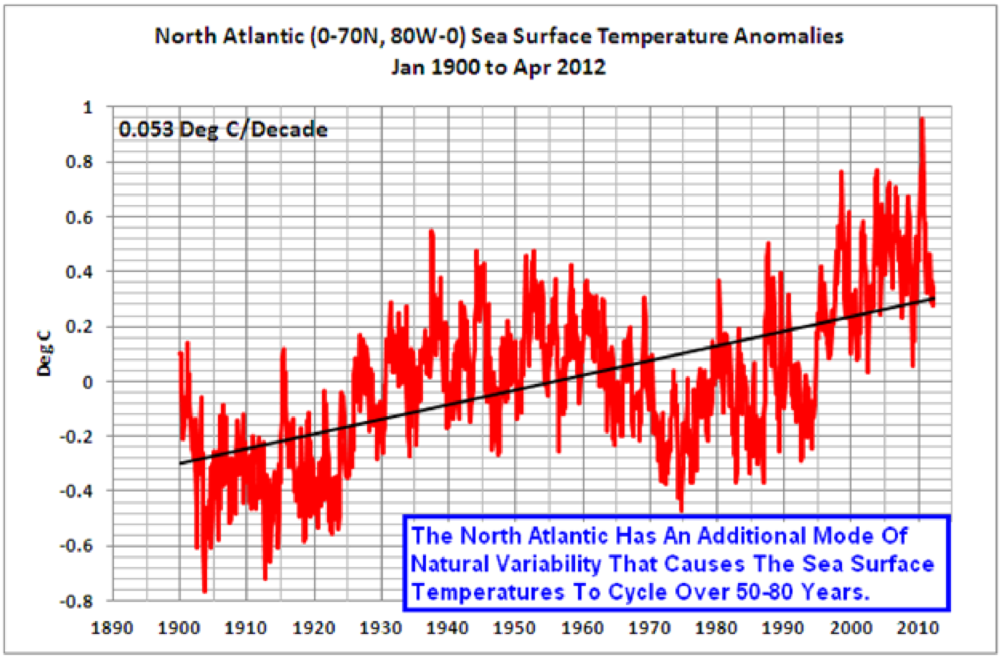


Figure 2-26

To remove the linear trend from the data, i.e., to detrend it, first, the monthly values of the linear trend line are determined. Then, those values are subtracted from, in this example, the monthly North Atlantic sea surface temperature anomalies. (See Figure 2-27.) The black line at zero degrees C is the actual linear trend of the detrended data. It is flat. In other words, the detrended North Atlantic sea surface temperature anomalies no longer have a trend.

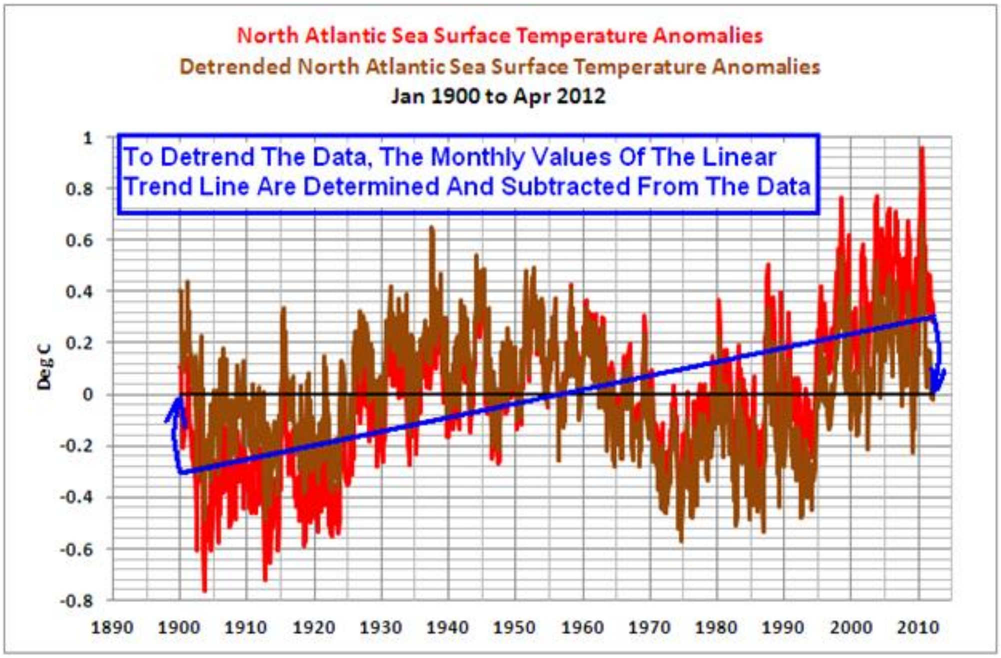


Figure 2-27

NOAA calls the detrended North Atlantic sea surface temperature anomaly data the AMO **(Atlantic Multidecadal Oscillation) Index**. The monthly variations in the data in Figure 2-27 are quite large. As a result, NOAA uses a 121-month running-average filter to show the underlying multidecadal variations. I've smoothed the data with a 121-month filter in Figure 2-28. The first warming period in the detrended data peaks in the early 1940s then cools slowly until the late 1950s. From the late 1950s until the mid-1970s, the detrended North Atlantic sea surface temperature anomalies cooled rapidly. They warmed slowly until the late 1980s, then much more quickly through the end of the dataset. If history repeats itself, the multidecadal cycle in the detrended North Atlantic sea surface temperature anomalies should peak and then start to cool in the not-too-distant future.

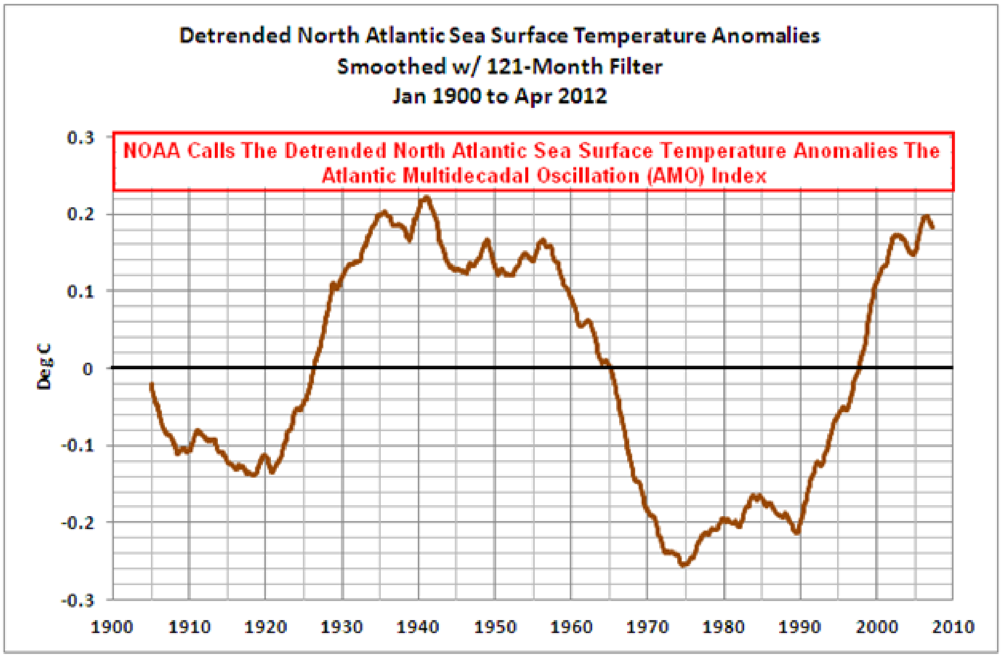


Figure 2-28

[End of reprint from ***Who Turned on the Heat?*** **By Bob Tisdale**]

In Figure 2-28, it is obvious that once the data have been detrended and smoothed, there are very strong multidecadal variations in the sea surface temperature anomalies of the North Atlantic.

In short, detrending helps to show the timing, magnitude, and frequency of the multidecadal variations in a dataset — smoothing helps, too.

The sea surface temperatures of the North Pacific also have strong multidecadal variations. I've illustrated and discussed this in numerous blog posts — most recently in Multidecadal Variations and Sea Surface Temperature Reconstructions. (See Figure 2-29 which compares the detrended sea surface temperatures of the North Atlantic (0-70N, 80W-0) and the extratropical North Pacific (20N-65N, 100E-100W) using NOAA's ERSST.v3b data. As illustrated, the multidecadal variations in the North Pacific sea surface temperature anomalies run both in and out of sync with those of the North Atlantic.)

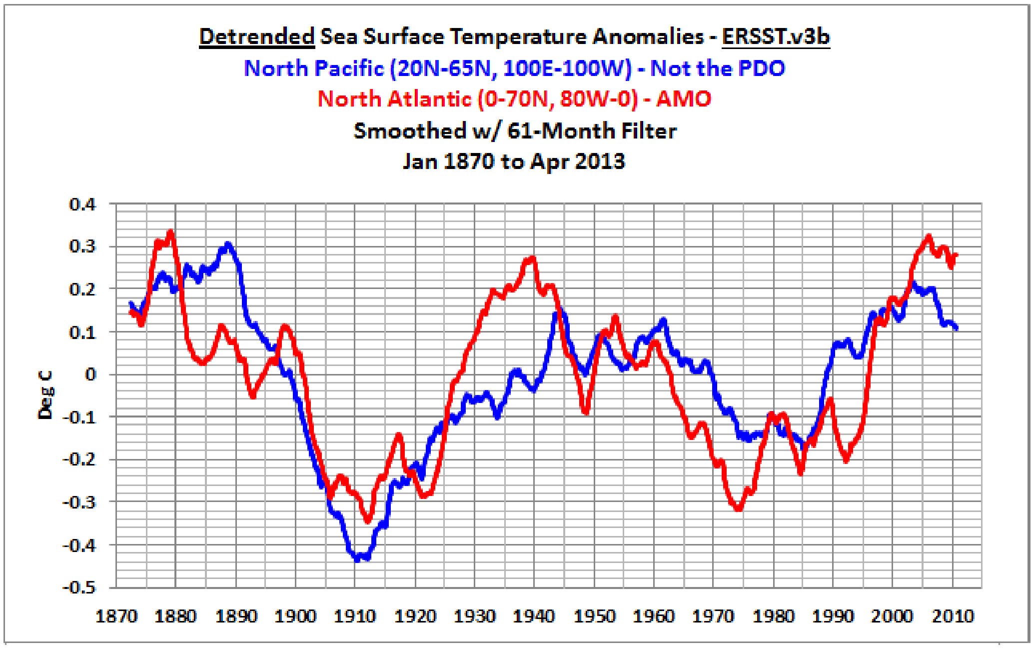


Figure 2-29

[NOTE: The North Pacific data presented in Figure 2-29 is NOT the PDO (Pacific Decadal Oscillation) Index data created and maintained by JISAO. The North Pacific data in Figure 2-29 has simply been detrended and smoothed. The PDO index, on the other hand, is a statistically created dataset that is **inversely** related to the multidecadal variations in the sea surface temperatures of the North Pacific. As a result, the PDO only adds confusion to discussions of surface temperatures. The PDO basically represents how closely the spatial pattern of the sea surface temperature anomalies of the North Pacific (north of 20N) matches the spatial pattern created by El Niño and La Niña events. Once again, **the PDO index does not represent the sea surface temperatures of the North Pacific**. The PDO index, therefore, cannot be compared to surface temperatures. For further information about the PDO, what it represents, and what it does not represent see the posts here, here, and here.]

Back to detrending: I detrend and standardize a couple of datasets in this book. An example is shown in Figure 2-30, using Arctic land surface air temperature data, and Northern Hemisphere sea surface temperature data, both of which all have similar multidecadal variations.

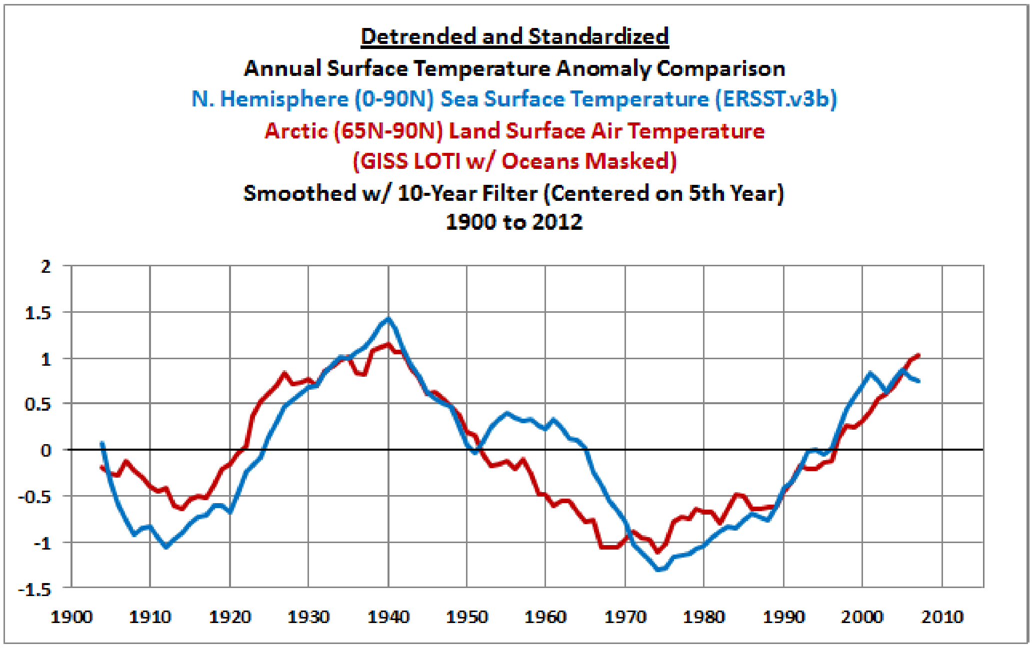


Figure 2-30

Due to polar amplification, the variations in Arctic land surface air temperatures are much greater than the variations in Northern Hemisphere sea surface temperatures. Thus, in order to see how similar they are, the data need to be detrended, standardized (divided by their standard deviations), and smoothed.

# # #

Earlier, I noted that the Atlantic Multidecadal Oscillation may soon reach the peak of its current “cycle”. Figure 2-31 show the satellite-era sea surface temperature anomalies for the North Atlantic (based on the Reynolds OI.v2 data). I divided the data into two periods and presented the linear trends for each: November, 1982 to December, 2002 and January, 2003 to July, 2013.

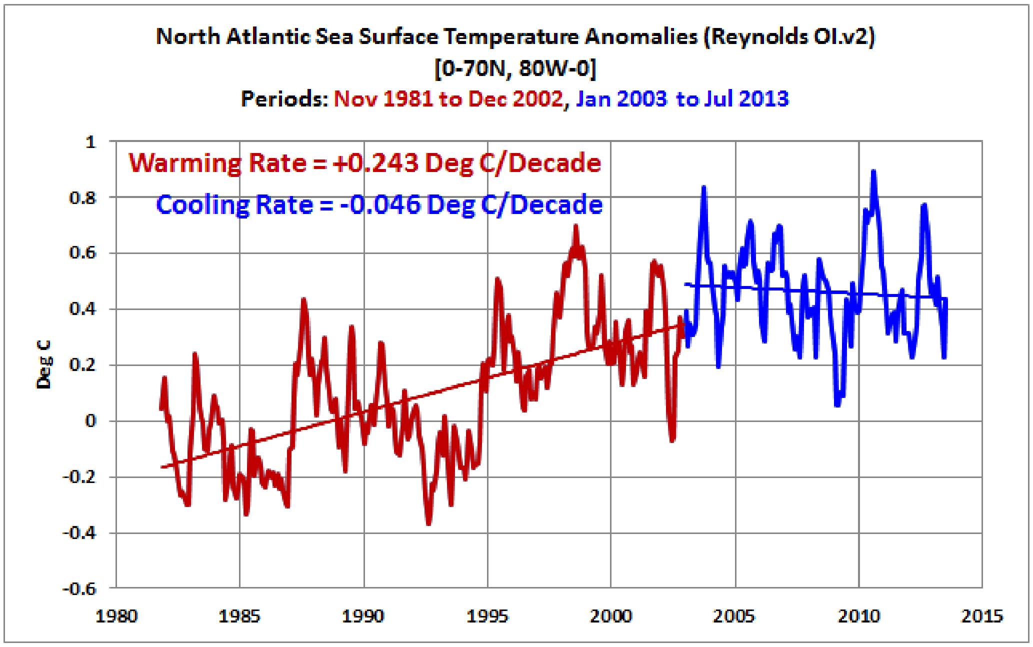


Figure 2-31

The period from 1991 to 1994 was strongly impacted by the volcanic aerosols emitted by the eruption of Mount Pinatubo, so that explains the dip and rebound in North Atlantic sea surface temperatures then. Without that dip and rebound, North Atlantic sea surface temperature anomalies would have shown a relatively continuous warming until 2003. Based in the trend for the last 10 years, it appears the sea surface temperature anomalies of the North Atlantic may have reached their peak.

Chapter 2.11 – A Blog Post that Shows You How to Create a Model-Data Comparison Graph

Suppose you see a model-data comparison graph and you just can't believe the models performed that poorly. (See the example in Figure 2-32.) The models estimated that the surface temperatures of the Pacific Ocean should have warmed at about 0.17 deg C/decade over the past 31 years, but the observed warming rate was half what the models guessed.

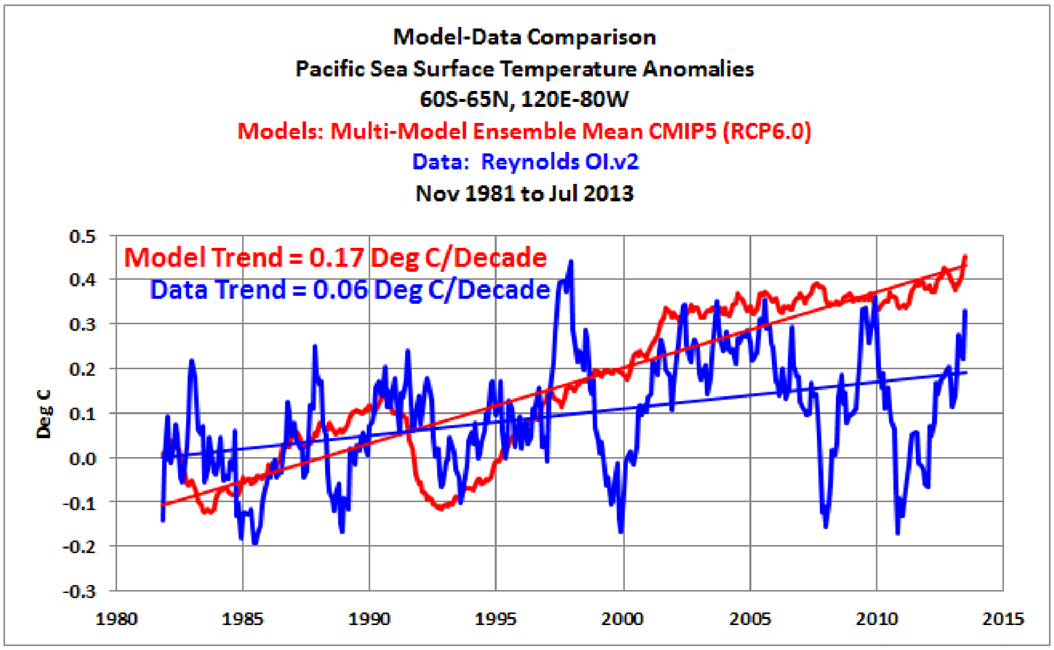


Figure 2-32

To allow you to answer such questions for yourself, I've prepared a blog post that uses screen captures to run you through the process of creating a model-data comparison graph from start to finish. The post is "Step-By-Step Instructions for Creating a Climate-Related Model-Data Comparison Graph."

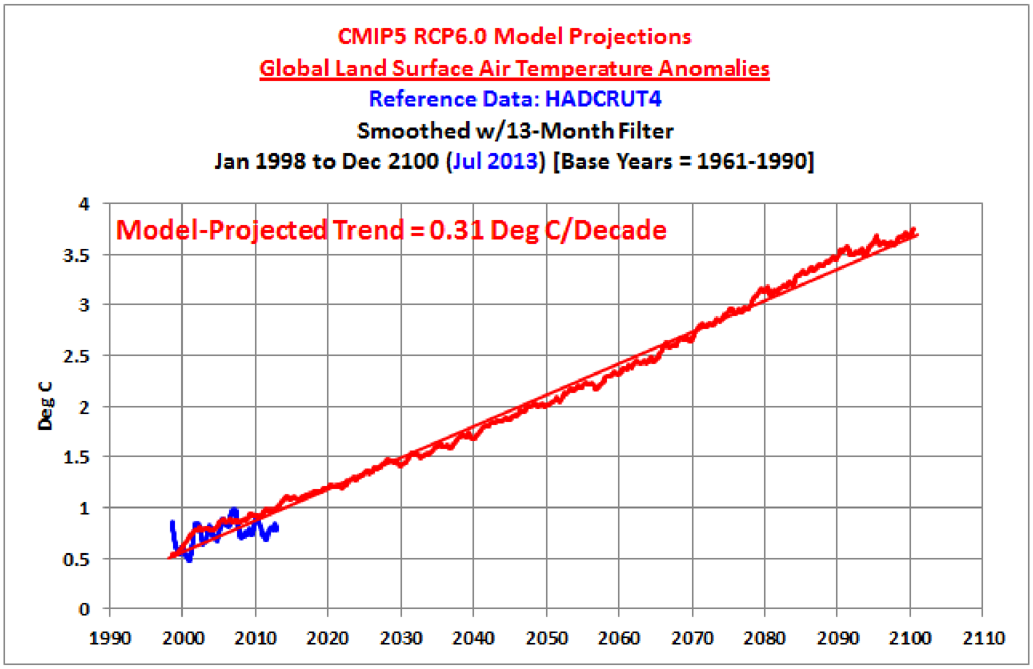
I had originally wanted to include that discussion in this book. It included a reference graph and 35 annotated screen captures. Then I noticed how big this book had grown. This book includes more than 200 illustrations, but adding those 35 color screen captures almost doubled the size of the book's file. Because ebook pricing depends on the file size, I saw no reason to add that much cost to the book, solely for the few persons who might want to verify the model outputs and the data. Thus, the blog post.

Chapter 2.12 – IPCC AR5 (CMIP5 RCP6.0) Surface Temperature Projections Through 2100

The graphs in this chapter illustrate the IPCC's projections of surface temperature anomalies from the start of the current warming halt through to December, 2100. Included are: global land air surface, global sea surface, and global combined surface, temperature anomalies. The CMIP5-based multi-model ensemble mean is presented. The model forcings are based on the RCP6.0 scenario which is similar to the A1B scenario from past IPCC reports. I use 1998 as the start of the global warming stoppage period because it was used by Von Storch, et al. (2013). Also included are the surface temperature anomalies as portrayed by the UKMO products. I smoothed the monthly data and model outputs with 13-month filters, and use the UKMO standard base years of 1961-1990 for the anomalies. The trends illustrated are based on the monthly, not smoothed, model outputs.

After that, I discuss the HADCRUT global surface temperature anomaly data starting in 1861 and the multidecadal variations that are blatantly obvious in them.

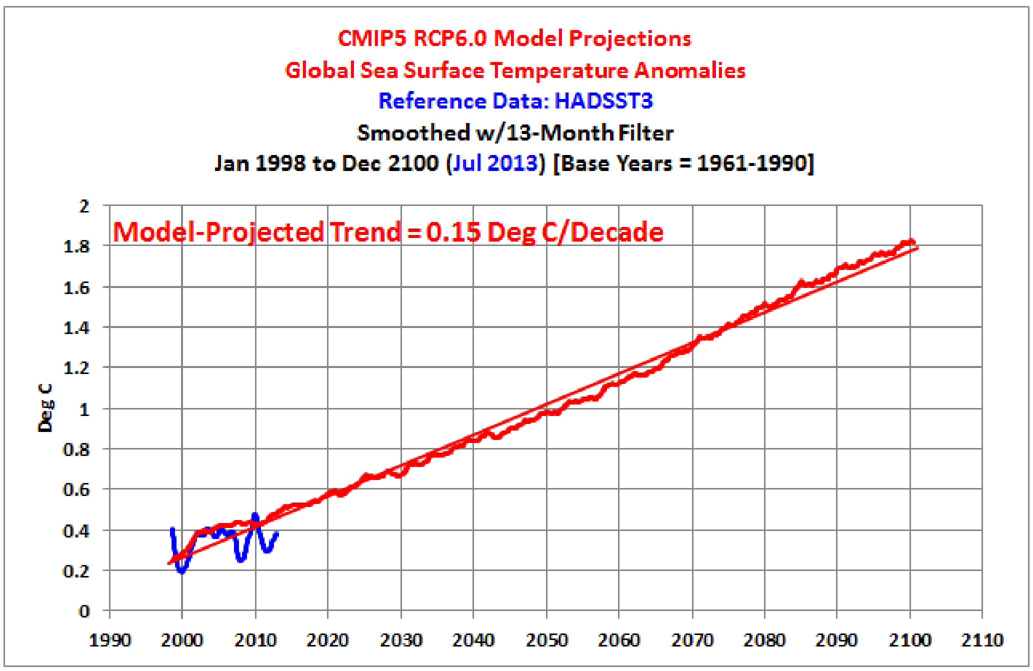
MODEL PROJECTIONS OF FUTURE SURFACE TEMPERATURE WARMING



Trend is Based on Monthly Model Output, Not Smoothed Version

Figure 2-33

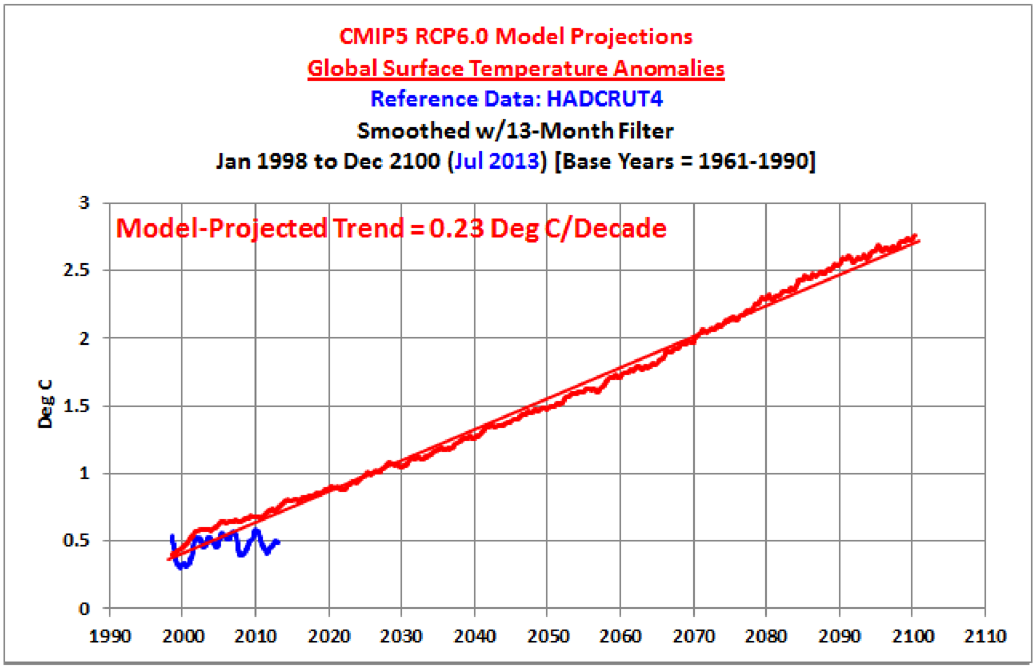
Figures 2-33 and 2-34 illustrate projections of the global land surface air temperature and the global sea surface temperature anomalies, respectively, for the period of 1998 to 2100. The models projected a warming rate for land surface air temperature anomalies, based on the RCP6.0 scenario, of 0.31 deg C/decade, or over 3 deg C in 100 years. They projected a warming rate for sea surface temperatures of about half that at 0.15 deg C/decade, or about 1.5 deg C in 100 years.



Trend is Based on Monthly Model Output, Not Smoothed Version

Figure 2-34

The modeled projection of global surface temperature (land plus ocean) is shown in Figure 2-35. Using the RCP6.0 scenario, the models prepared for IPCC's 5th Assessment Report are projecting a warming rate of about 0.21 deg C/decade or a warming of about 2.0 deg C over the 21st Century.



Trend is Based on Monthly Model Output, Not Smoothed Version

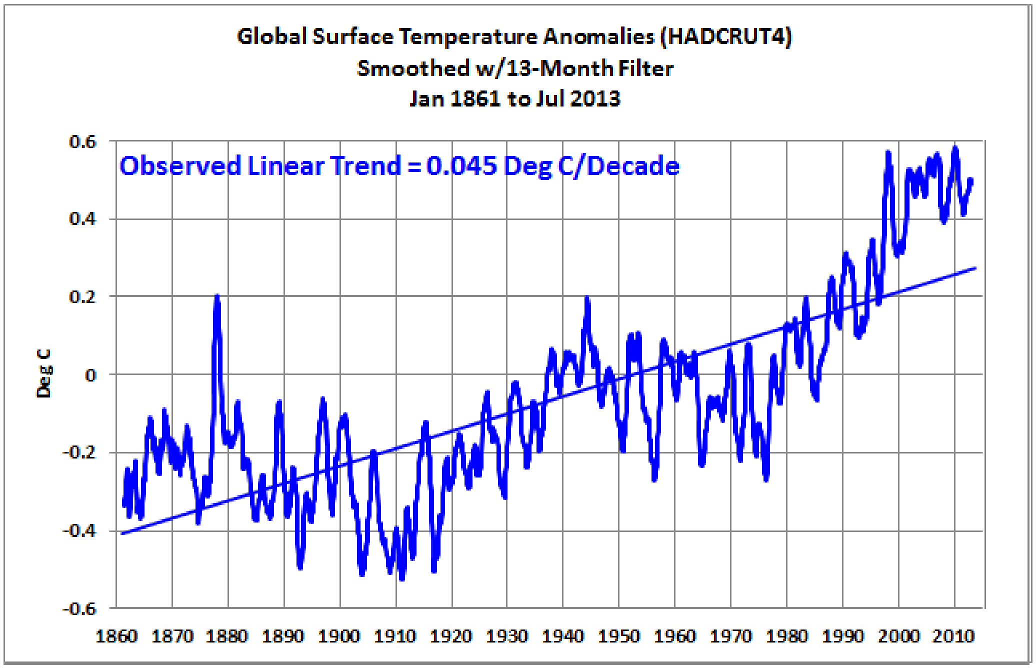
Figure 2-35

Those are easy-to-remember warming estimates for the next 100 years:

- 3.0 deg C for global land surface air temperatures
- 1.5 deg C for global sea surface temperatures
- 2.0 deg C for global combined surface (land plus ocean) temperatures

THE SURFACE TEMPERATURE RECORD SINCE 1861 INCLUDES 2 HALT PERIODS BEFORE THE CURRENT LACK OF WARMING

The observed HADCRUT4-based global surface temperature anomalies (land plus ocean), starting in 1861, are shown in Figure 2-36. The year 1861 was chosen by the IPCC for the start year of its historic (hindcast) modeling efforts. It's a good year to start such a presentation, because it wasn't long after 1861 that the first of 2 warming cessation periods began. Surface temperatures did not warm from about 1880 to 1910. A second halt in warming started in the 1940s and extended to the 1970s. And now, based on climate scientists' discussions and all of the recent papers, it is accepted that we are currently in (and have been for up to 16 years, depending on the metric) yet another period when global warming has stopped.



Trend is Based on Monthly Data, Not Smoothed Version

Figure 2-36

Note also that the warming rate is only 0.045 deg C/decade, for a period that includes 2 stoppage periods and 2 warming periods and that began with a stoppage period.

The periods when warming ceased stand out plain as day. They're tough to miss. Yet, there are **no** multi-decadal periods without warming in the model projections as presented with the multi-model mean. A few of the modeling groups **claim** their models have simulated decade-long periods without warming, but I do not believe that any models are projecting multidecadal (30-year) periods of no warming.

CHAPTER 2.12 SUMMARY

Over the 21st Century, based on the RCP6.0 scenario, the models are projecting about a 3.0 deg C warming of land surface air temperatures, that sea surface temperatures will warm about 1.5 deg C, and that global combined (land plus ocean) surface temperatures will warm about 2.0 deg C.

But, the multi-model mean shows no multidecadal halt periods in their projections.

If we detrend the HADCRUT global land air plus sea surface temperature anomalies and smooth them with a 121-month filter, Figure 2-37, the multidecadal (about 30 year) warming and cooling/cessation periods are even more pronounced.

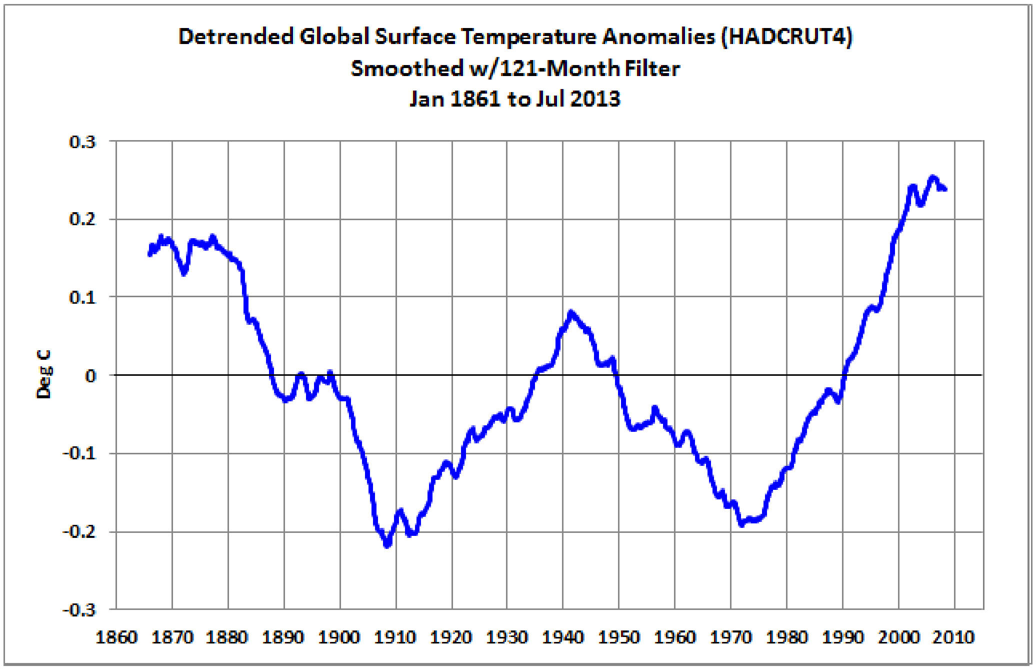


Figure 2-37

I suspect that if the IPCC fails to acknowledge:

- The current 12-to-16-year cessation of warming; and
- that the current halt in warming could very likely extend for another 15 to 20 years; and
- that the next multidecadal warming period could very plausibly be followed by yet another multidecadal cessation of warming…

…then the public will forever dismiss the IPCC's projections.

Section 3 – Model-Data Comparisons – Hemispheric Sea Ice and Global Precipitation

In this section, I compare model outputs to observations for a couple of different climate-related variables: hemispheric sea ice area and global precipitation. Climate models show **no skill** at being able to simulate those variables over the past few decades. And that generates a question: if climate models can't simulate the past, why should we have any confidence in their ability to predict the future?

That's a question you'll likely ask yourself as you view the comparisons in the remaining chapters of this book.

Chapter 3.1 – Climate Models Can't Simulate Hemispheric Sea Ice Area

It seems that Arctic sea ice is in the news almost every week, accompanied by dire predictions of gloom and doom.

Sea ice loss outpaced past model forecasts. (See Stroeve, et al. (2007) "Arctic Sea Ice Decline: Faster Than Forecast".) Alarmists and mainstream media took that ball and ran with it, gleefully announcing it with headlines like "Arctic Sea Ice Melting Faster Than Expected". Ponder that for a moment. It's odd that global warming enthusiasts would rejoice in the models' shortcomings — heralding the models' failures — but that's what they did.

In a follow-up paper, Stroeve, et al. (2012) "Trends in Arctic Sea Ice Extent from CMIP5, CMIP3 and Observations" found some improvement in the current generation of models but not enough for the models to have any value. Their abstract concludes:

> *Trends from most ensemble members and models nevertheless remain smaller than the observed value. Pointing to strong impacts of internal climate variability, 16% of the ensemble member trends over the satellite era are statistically indistinguishable from zero. Results from the CMIP5 models do not appear to have appreciably reduced uncertainty as to when a seasonally ice-free Arctic Ocean will be realized.*

The current generation of models may be said to perform better, but, the models are clearly having difficulty simulating Arctic sea ice loss.

Maybe the overall plan of focusing on the Arctic was to draw attention from an even greater model failure at the other end of the globe, the sea ice surrounding Antarctica.

In presenting model-data comparisons, I typically compare model outputs and observations directly. With sea ice area, I varied my usual practice, because the model outputs and data are in different formats. The NSIDC (National Snow and Ice Data Center) through the KNMI Climate Explorer presents its sea ice area data in millions of square kilometers, while the CMIP5-archived model outputs there are presented as a fraction of sea ice area. For a direct comparison, the fraction of sea ice area presented by the models would have to be converted to area expressed in millions of square kilometers. That, of course, would involve approximations and assumptions. But, the models fail so greatly in estimating Southern Hemisphere sea ice that there's no need to go to all that trouble.

I take a simpler approach with sea ice area — showing only whether the models accurately simulate a gain or a loss in each hemisphere. Yes, the models are that bad.

Thus, the oceans have been losing sea ice in the Arctic during the satellite era of sea ice monitoring, since November, 1978, and they've been gaining sea ice area around Antarctica. (See Figure 3-1.)

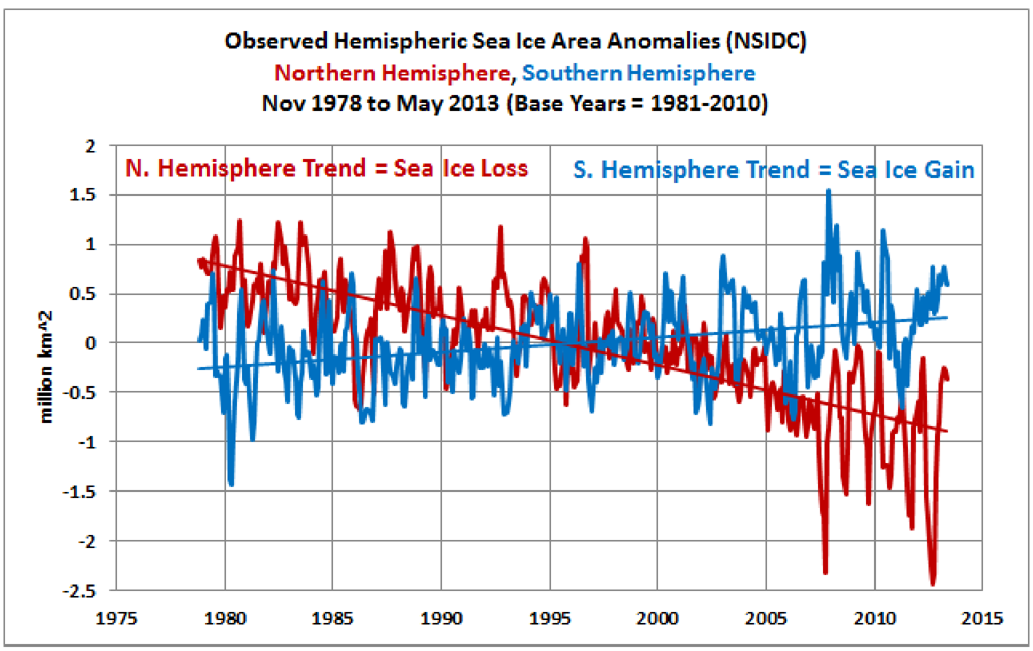


Figure 3-1

Then there are the oodles of climate models stored in the CMIP5 archive. They're the models being used by the IPCC for the upcoming 5th Assessment Report. Would you like to guess whether they show the Southern Hemisphere gaining or losing sea ice area over the same time period?

The multi-model ensemble mean shows that the models estimated that the Southern Ocean surrounding Antarctica should have lost sea ice from November, 1978 to May, 2013. (See Figure 3-2.) But, the data (Figure 3-1) show Antarctic sea ice area is increasing. The models also estimated that the Southern Hemisphere would lose sea ice **faster** than the Northern Hemisphere.

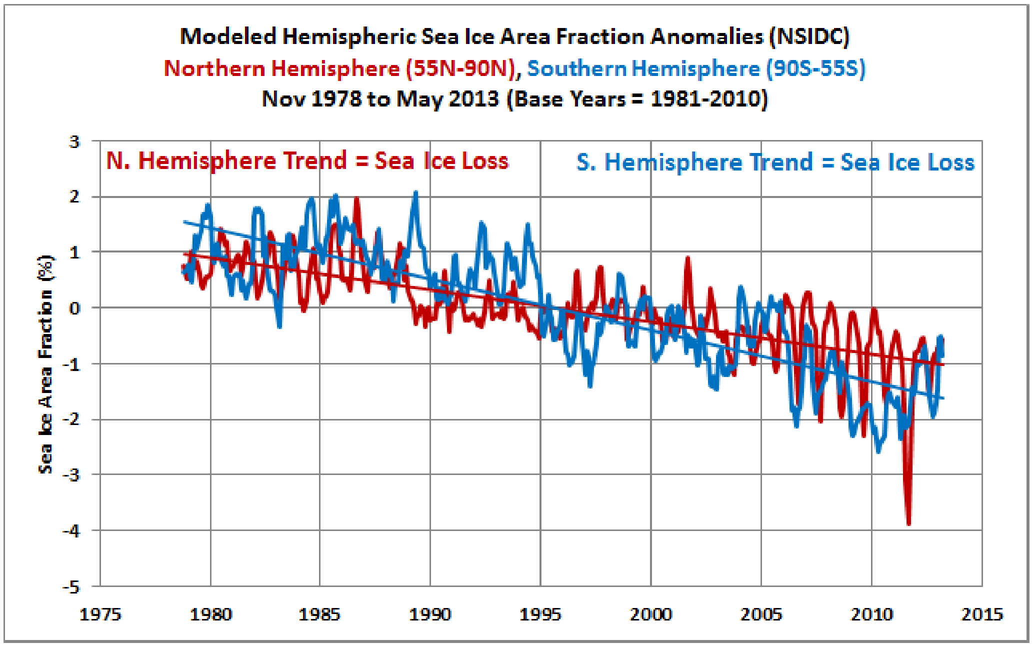


Figure 3-2

Climate models still have significant failings in their attempts to simulate sea ice loss in the Arctic. This led Stroeve, et al. (2012) to conclude:

> *CMIP5 models do not appear to have appreciably reduced uncertainty as to when a seasonally ice-free Arctic Ocean will be realized.*

Stroeve, et al. (2012) also suggest that natural, weather-related, factors continue to have a major effect:

> *Pointing to strong impacts of internal climate variability, 16% of the ensemble member trends over the satellite era are statistically indistinguishable from zero.*

Compounding the models' problems is their complete failure at modeling Southern Hemisphere sea ice. There, climate models, laboring under the assumption that anthropogenic greenhouse gases cause reductions in sea ice area, also guessed incorrectly that the Southern Hemisphere would lose sea ice faster than the Arctic.

Further, as noted in Chapter 1.2, improvements in the newer (CMIP5) models' (over the older generation of models (CMIP3)) ability to project re: the Arctic came at a cost of overall accuracy. Their already dubious ability to predict other, non-sea ice, variables around the globe grew worse. For your convenience, the paper cited earlier in Chapter 1.2 is: Swanson (2013) "Emerging Selection Bias in Large-scale Climate Change Simulations". The preprint version of the paper is here. In his Introduction, Swanson writes (my emphasis):

> Here we suggest the possibility that a selection bias based upon warming rate is emerging in the enterprise of large-scale climate change simulation. Instead of involving a choice of whether to keep or discard an observation based upon a prior expectation, we hypothesize that this selection bias involves the 'survival' of climate models from generation to generation, based upon their warming rate. One plausible explanation suggests this bias originates in the desirable goal to more accurately capture the most spectacular observed manifestation of recent warming, namely the ongoing Arctic amplification of warming and accompanying collapse in Arctic sea ice. However, fidelity to the observed Arctic warming is not equivalent to fidelity in capturing the overall pattern of climate warming. A**s a result, the current generation (CMIP5) model ensemble mean performs worse at capturing the observed latitudinal structure of warming than the earlier generation (CMIP3) model ensemble. This is despite a marked reduction in the inter-ensemble spread going from CMIP3 to CMIP5, which by itself indicates higher confidence in the consensus solution. In other words, CMIP5 simulations viewed in aggregate appear to provide a more precise, but less accurate picture of actual climate warming compared to CMIP3.**

Chapter 3.2 – Global Precipitation – There's Little Agreement Among Three Global Precipitation Datasets, but the Models Aren't Even Close

Global precipitation is a crucial part of our understanding of the global Water Cycle of which the oceans are an essential part. We can't hope to predict future precipitation without knowing how precipitation has varied in the past. From the webpage "The Water Cycle: The Oceans":

> *It is also estimated that the oceans supply about 90 percent of the evaporated water that goes into the water cycle.*

NOAA presents three satellite-and-rain-gauge-based precipitation datasets that start in 1979, giving more than 3 decades data. They are:

- CAMS-OPI, the Climate Anomaly Monitoring System ("CAMS") and OLR Precipitation Index ("OPI")
- GCPC v2.2, the Global Precipitation Climatology Project version 2.2
- CMAP, the PC Merged Analysis of Precipitation.

Amazingly, there are few to no agreements among the three datasets when looking at the global data. Each shows different annual variations. (See Figure 3-3.) Only one of the three datasets is updated regularly at the KNMI Climate Explorer (CAMS-OPI), thus, the different end dates of the data.

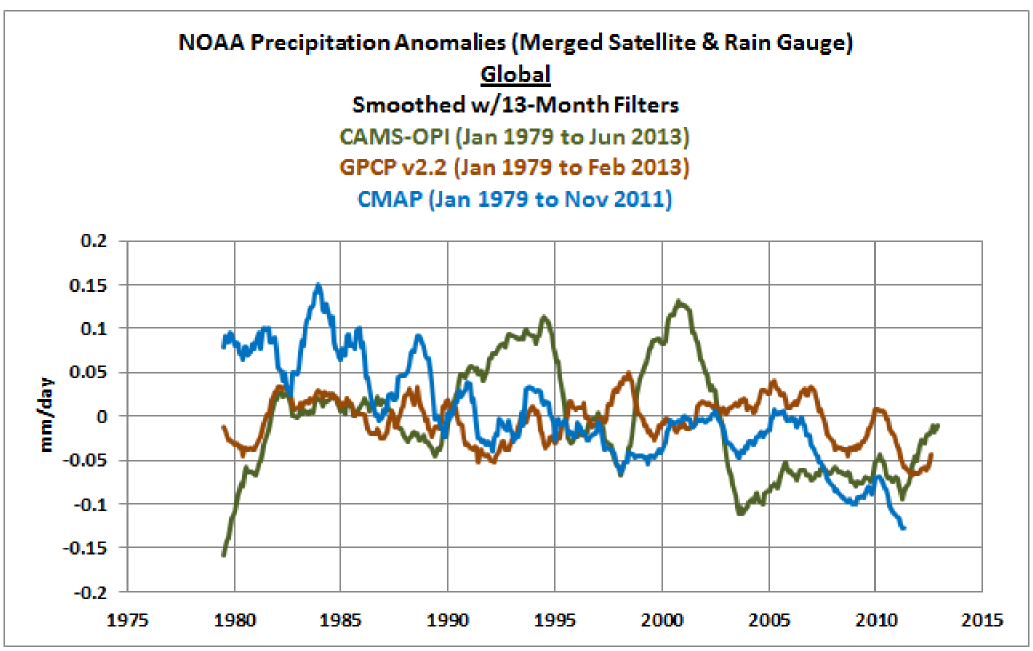


Figure 3-3

And their trends are very different. (See Figure 3-4.)

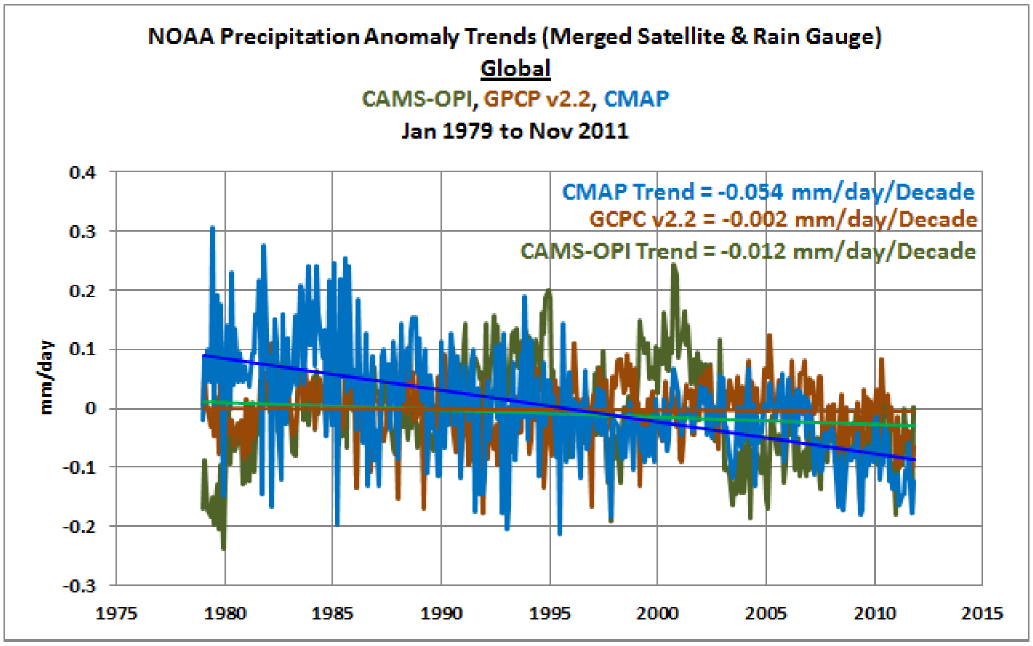


Figure 3-4

The CMAP data shows a large decrease in the global precipitation anomalies from 1979 to 2009. The CAMS-OPI also shows a decrease, but it's not nearly as great as the CMAP data. And the GCPC v2.2 data shows basically no trend, especially when compared to the other two.

IS ONE OF THE DATASETS CLOSE TO BEING RIGHT?

Looking at the global combined land-plus-ocean data, one would be hard pressed to determine which if any of the three global precipitation datasets are close to being correct. There is a place, however, to look for some insight. El Niño and La Niña events make precipitation in the tropical Pacific highly volatile, but it does follow a pattern: precipitation there increases during El Niños and decreases during La Niñas. And some El Niños have stronger impacts on precipitation in the tropical Pacific than others.

Figure 3-5 presents the CAMS-OPI, CMAP and GCPC v2.2 precipitation anomalies for the tropical Pacific. Again, the three datasets have been smoothed.

Before 1987 and during the 1988/89 La Niña, the CMAP data is the outlier. On the other hand, the CAMS-OPI data diverges from the other two during the early 1990s and from 1998 to 2003. That leaves the GCPC v2.2 precipitation data.

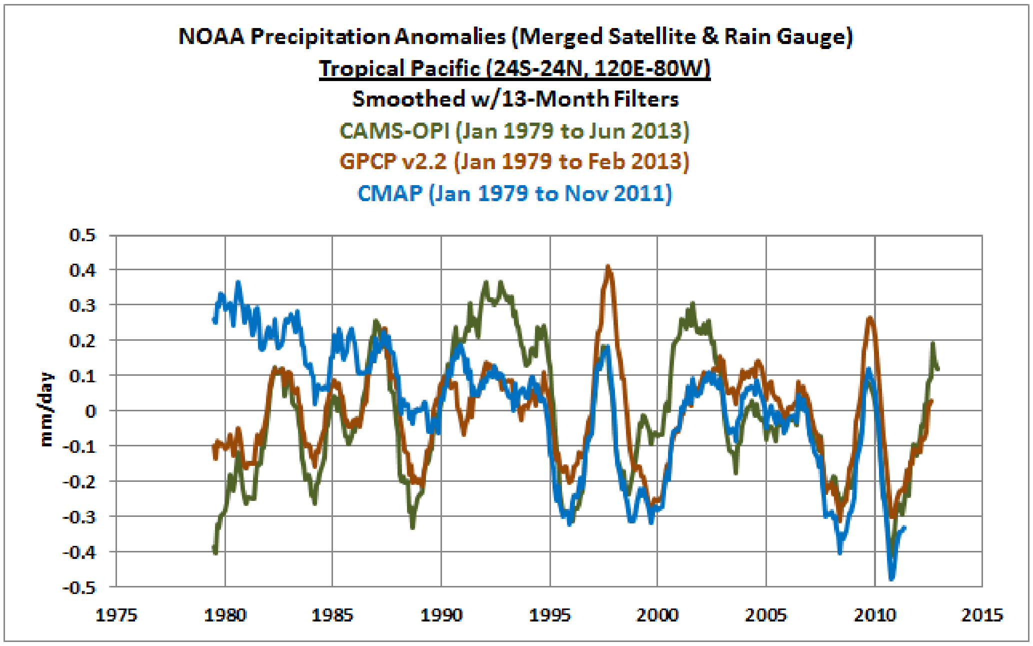


Figure 3-5

In figure 3-6, I compare the GCPC v2.2 precipitation anomalies for the tropical Pacific to NINO3.4 sea surface temperature anomalies. I standardized both datasets (divided the data by their standard deviations). The NINO3.4 data reflect the impacts of El Niño and

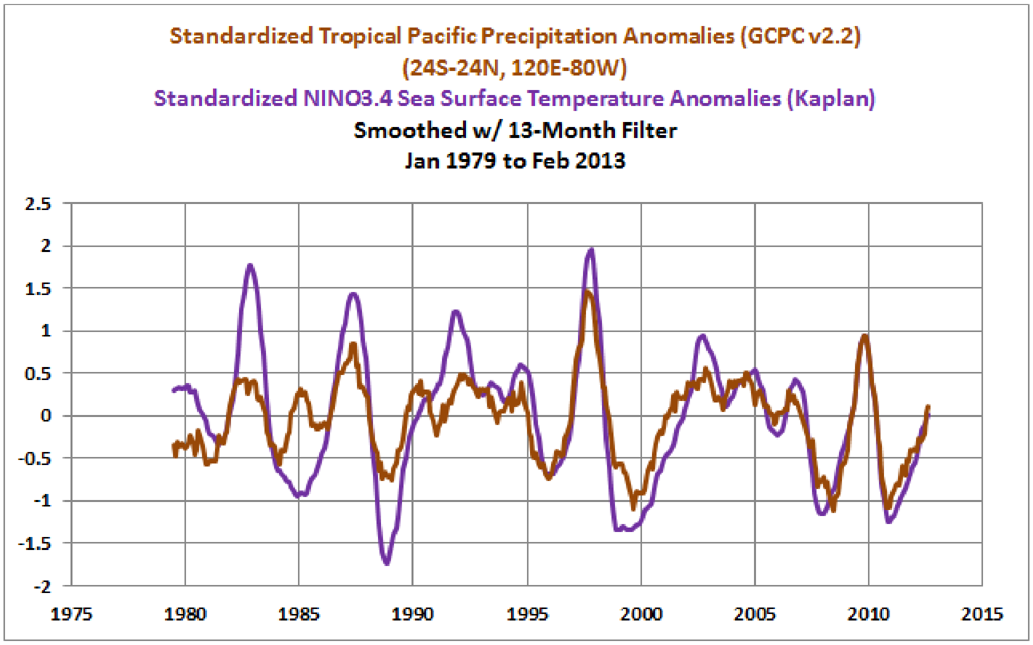


Figure 3-6

La Niña events on the sea surface temperature anomalies of a region along an east-central portion of the equatorial Pacific; they are a commonly used index for the timing, strength, and duration of El Niños and La Niñas. The major warming events are El

Niños and the cooling events are La Niñas. As shown, the GCPC v2.2 precipitation anomalies for the tropical Pacific closely mimic the variations in the NINO3.4 region sea surface temperature anomaly data. There are differences, but the tropical Pacific precipitation data consistently increase during El Niños and decrease during La Niñas.

Explanation: During El Niño events, a massive volume of naturally created warm water is released from below the surface of the western tropical Pacific. It then floods across the surface of the central and eastern tropical Pacific, where sea surface temperatures are normally cooler than in the west. Evaporation increases in the tropical Pacific during an El Niño because of all of that additional warm water on the surface. The resulting additional warm moist air rises. As it rises into cooler air at higher elevations, the moisture condenses, forms clouds, and eventually falls as rain. Those El Niño-caused increases in precipitation are reflected in the GCPC v2.2-based tropical Pacific precipitation data above in Figure 3-6.

During La Niña events, precipitation in the tropical Pacific decreases for some very basic reasons. Trade winds are stronger than normal during La Niñas. The stronger trade winds cause more cool water than normal to be upwelled (drawn to the surface) along the central and eastern equatorial Pacific. The cooler water at the surface results in less evaporation, fewer clouds, and less precipitation over the tropical Pacific. That is precisely what the GCPC v2.2-based tropical Pacific precipitation data above shows.

Those ENSO-related variations are also reflected in the GCPC v2.2 precipitation data globally, but to see it one must first isolate the precipitation data for the land and oceans. (See Figure 3-7, from my post [Models Fail: Global Land Precipitation & Global Ocean Precipitation].) As I noted in that post:

> *Looking at the global ocean precipitation anomalies (red curve), it's blatantly obvious that the primary causes of annual precipitation variations are El Niño and La Niña events. The 1982/83, 1986/87/88, 1997/98 and 2009/10 El Niño events are plainly visible, and you can also make out the lesser El Niños in the early 1990s and mid-2000s. The trailing La Niñas are also evident.*
>
> *The opposing relationship between ocean precipitation and land surface precipitation is also obvious. Land surface precipitation generally drops in response to El Niños and increases during La Niñas. There is also a strong dip and rebound in the land surface precipitation data starting about 1991. In some respects, it appears it could be a response to the eruption of Mount Pinatubo in 1991 and the strong El Niño that occurred then. However, why then did the combined effects of the 1982/83 El Niño and the eruption of El Chichon not create a similar effect in the land precipitation data? Additionally, the precipitation data over the oceans do not show a similar response. Curious.*

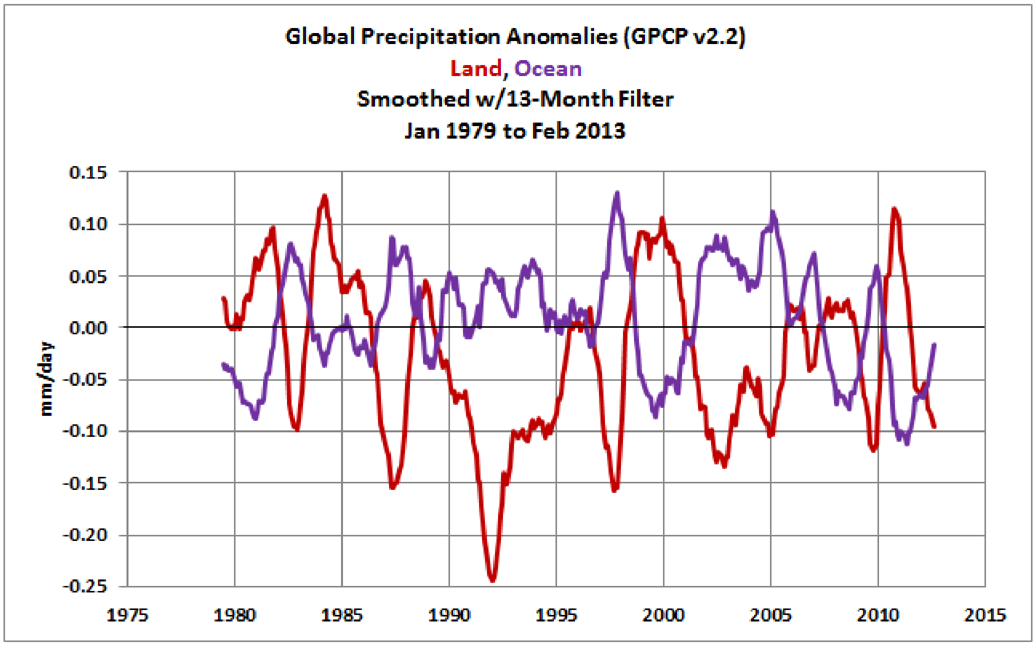


Figure 3-7

Unfortunately, there are no land and ocean masks at the KNMI Climate Explorer for the CAMS-OPI and CMAP precipitation data, so we can't isolate land data from sea data to see how those two datasets respond.

HOW DO THE MODELS COMPARE TO THE THREE GLOBAL PRECIPITATION DATASETS?

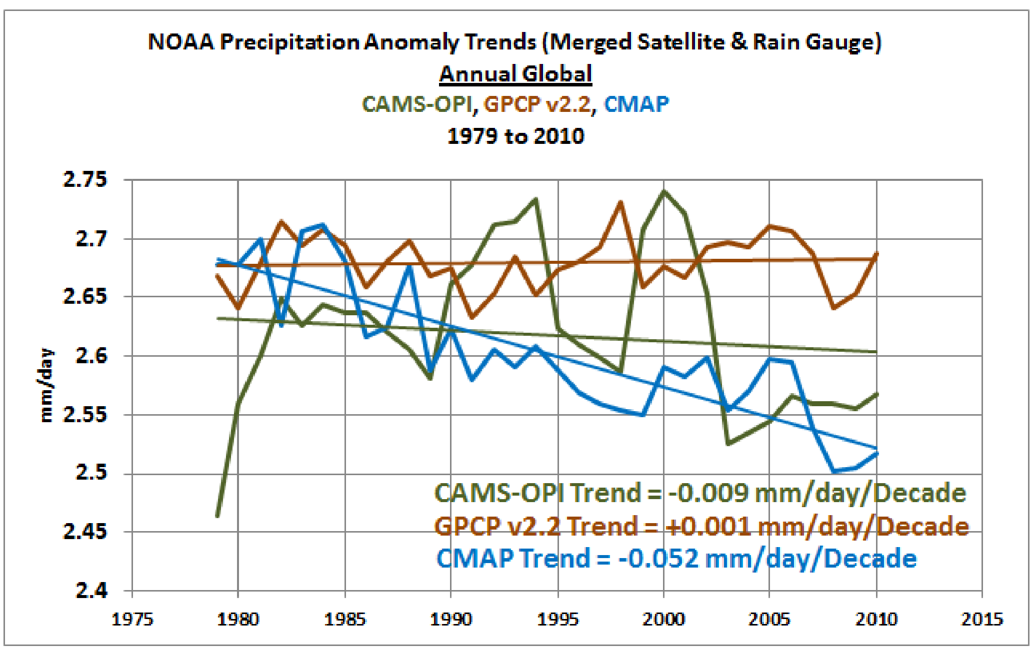


Figure 3-8

In Figure 3-8 are the annual CAMS-OPI, CMAP, and GCPC v2.2 precipitation data on a global basis from 1979 to 2010. Note also that the data are presented as absolutes, not as anomalies. That gives us an idea of how much precipitation falls daily when averaged over a year, and how much it changed from 1979 to 2010. Using the annual data gives slightly different trends than the monthly data shown in Figure 3-4, but that's to be expected.

In Figure 3-9, I add the multi-model ensemble mean of the climate models stored in the CMIP5 archive. The models estimated way too much precipitation globally and, even worse, they had it increasing from 1979 to 2010, while two of the observations datasets show a decrease in precipitation and the third shows little to no long-term change.

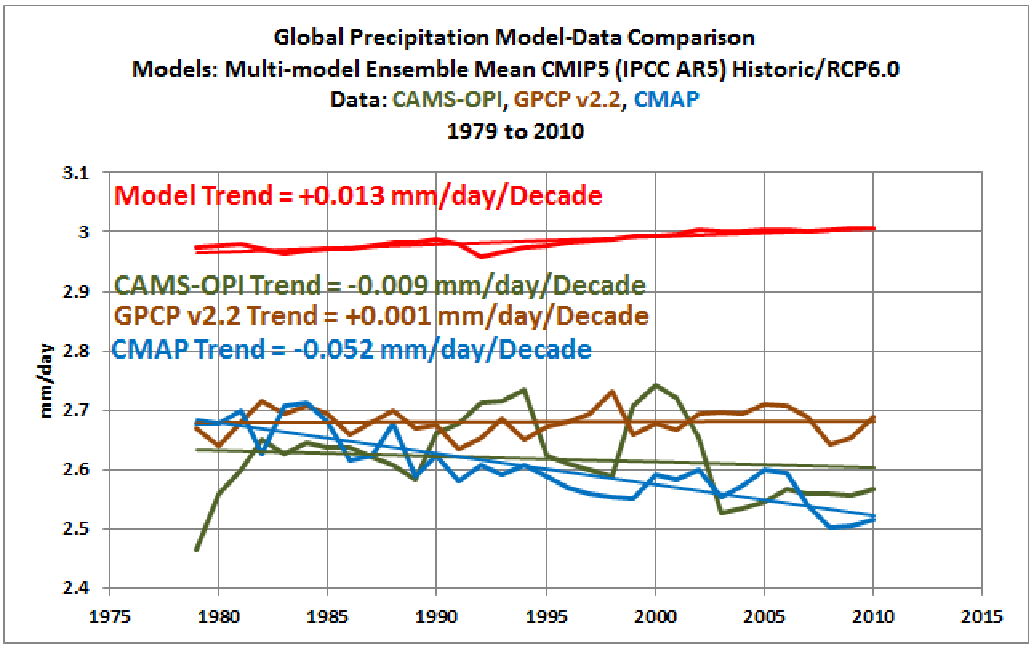


Figure 3-9

Climate models obviously cannot accurately simulate global precipitation during the satellite era.

CHAPTER 3.2 SUMMARY

For global land-plus-sea surface temperatures, there is a reasonably close agreement among the datasets. No such agreement exists for global land-plus-ocean precipitation data.

Without knowing how precipitation has varied in the past, how in the world can climate modelers hope to be able to correctly project changes in the future? Some people assert the empty argument that modelers present the theoretical changes in precipitation, and yet, underscoring the silliness of this assertion: (1) the modelers presented a theoretical loss of sea ice in the Southern Ocean surrounding Antarctica even though sea ice area is increasing there; and (2) the modelers presented a theoretical warming of the Pacific Ocean for the past 2 decades even though the sea surface temperatures there did not warm.

Because global precipitation is heavily dependent on El Niño and La Niña events, climate models, to have any value, must be able to simulate the processes of ENSO. After decades of trying, however, the model programmers still cannot simulate the El Niño-La Niña processes. (See Guilyardi, et al. (2009) "Understanding El Niño in Ocean-Atmosphere General Circulation Models: Progress and Challenges" and Bellenger, et al. (2013) "ENSO Representation in Climate Models: from CMIP3 to CMIP5".

The bottom line: as shown in Figure 3-9, the climate models estimate way too much precipitation globally and, moreover, they say it has increased. Contradicting the models, two of the observations-based datasets show that global precipitation decreased and the third shows little change.

Climate models show **no skill** at being able to simulate past global precipitation since 1979. Why would anyone believe climate models can project/predict future precipitation?

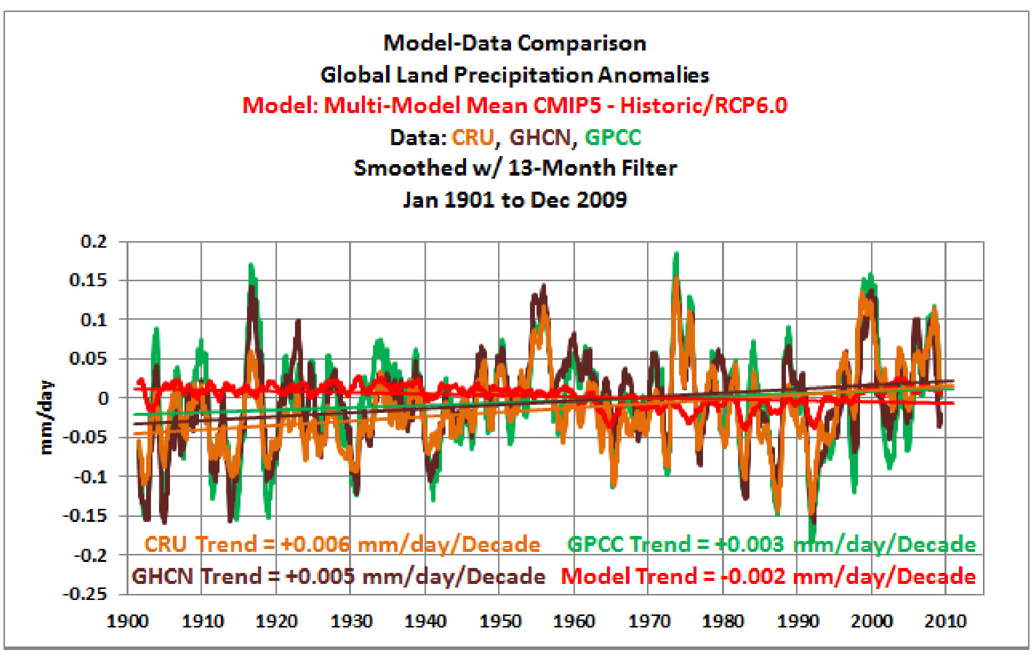
Chapter 3.3 – Long-Term Global Land Precipitation

In this chapter, I compare climate model simulations of global land precipitation anomalies with rain gauge-based global precipitation data starting in 1901. The models' poor performance during the satellite era does not bode well for their being able to simulate precipitation since the beginning of the 20th century.

Included below are 3 long-term, rain gauge-based precipitation datasets available through the KNMI Climate Explorer:

- CRU TS 3.10, a product of the Climatic Research Unit (CRU) at the University of East Anglia.
- GHCN Version 2, produced by NOAA/NCDC, as part of its GHCN (Global Historical Climatology Network) data.
- GPCC Version 6, while this is part of a reanalysis of rain gauge data from the GPCC (Global Precipitation Climatology Centre), the GPCC also makes the rain gauge-based data available; I use the **data**, not the reanalysis, in this presentation.

The CRU TS 3.1 data ends in December, 2009, so, for comparison purposes, I end all of the data and model outputs at the same time.



Trends Are Based on Monthly (Not Smoothed) Data & Model Outputs

Figure 3-10

I smoothed the three global land-only precipitation datasets in Figure 3-10 with 13-month filters to reduce the visual "noise" caused by the volatility of the data. Notice how the timing of the large short-term changes agree quite well, but the magnitudes of the variations are at times quite different. Note also that while the data trends are all positive, indicating that precipitation over land has increased, the trend of the CRU precipitation data is twice that of the GPCC data.

The majority of those short-term wiggles are responses to El Niño and La Niña events. Recall that global land precipitation drops during El Niños and increases during La Niñas. This is seen in the satellite-and-rain-gauge-based data in the previous chapter. Examples in Figure 3-10, working backward in time: 1) the spike from 1998 to 2000 occurred during the 1998-01 La Niña; 2) the two spikes in 1973 and 1975 happened during the 1973-76 La Niña; 3) the prolonged spike in the mid-1950s coincides with the 1954-56 La Niña; and 4) the large but temporary increase in precipitation in 1917 took place during the 1916/17 La Niña.

The strength of the El Niño events' effect on precipitation appears to be skewed in the precipitation data. Examples: The precipitation decline in response to the 1991/92 El Niño is much greater than the response to the 1997/98 El Niño, but, measured by most other variables, the 1997/98 El Niño dwarfed the one in 1991/92. The El Niño of 1997/98 is considered a super El Niño, and the 1991/92 El Niño is merely a strong event (and the 1991/92 event was counteracted by the eruption of Mount Pinatubo).

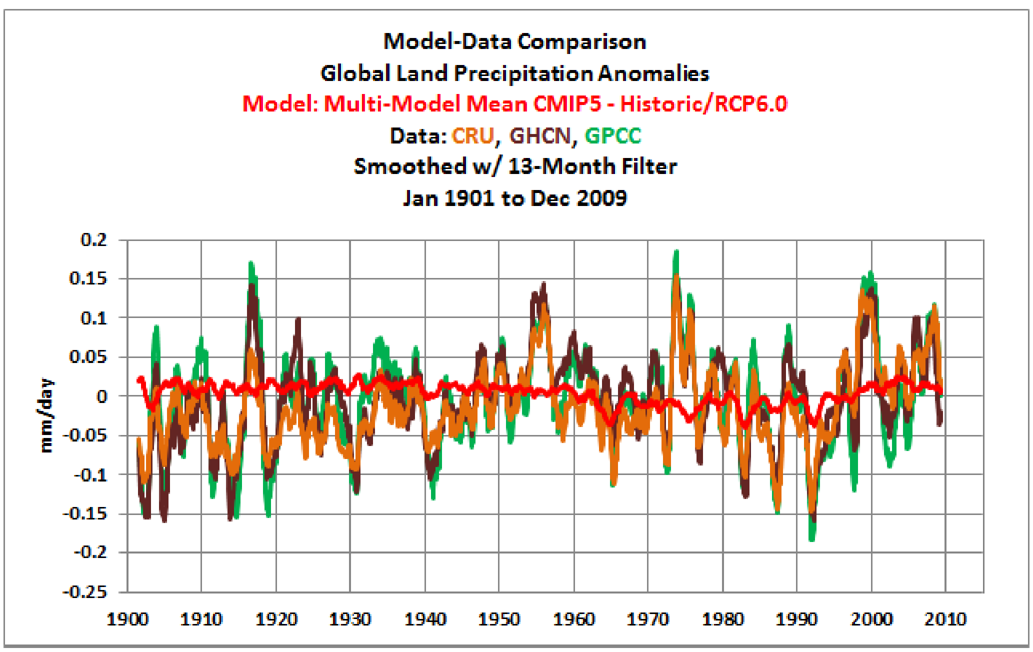


Figure 3-11

In direct opposition to the observations-based data, the climate models estimated, according to their carbon dioxide-dependent programming, that global precipitation would decrease from 1900 to 2009.

In Figure 3-11, I eliminated the trend lines for a clearer view of the data and model output curves.

And it gets even worse for the models. In Figure 3-12, I smoothed the data and model outputs with 121-month. That filter is commonly used by the climate science community to bring out the decadal and multidecadal variations in datasets. (In fact, the NOAA/ESRL uses the same smoothing for their Atlantic Multidecadal Oscillation (AMO) Index.)

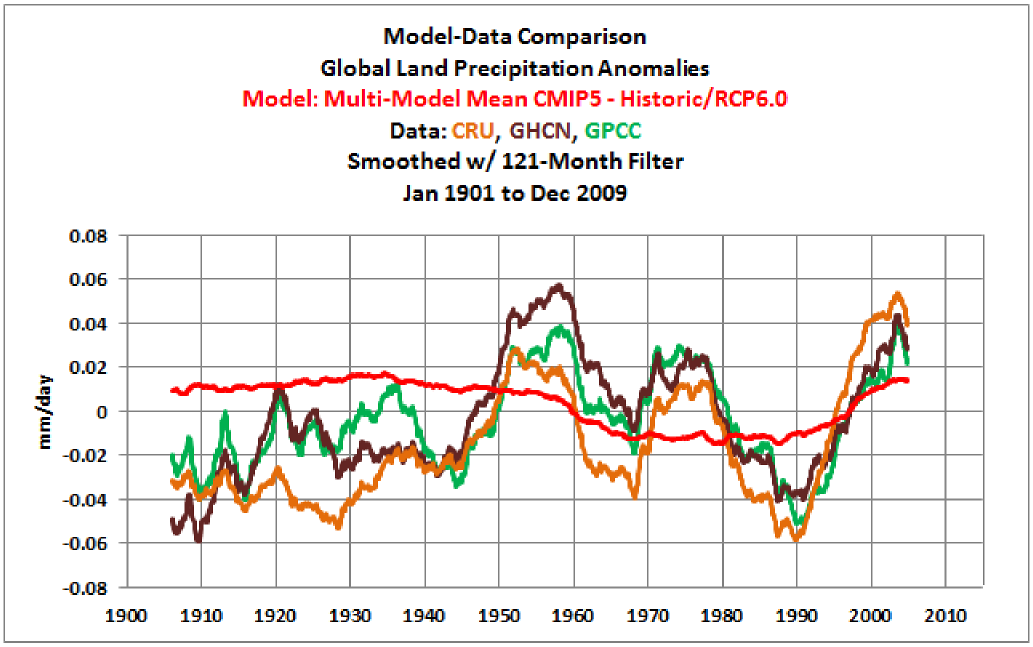


Figure 3-12

All three of the global land precipitation datasets in Figure 3-12 show decadal and multidecadal variations. Since the mid-1940s, the timings of the variations coincide closely, but, the magnitudes of the variations differ significantly between the datasets. Before the mid-1940s, the timings of the decadal variations do not coincide as well. That is normal for long-term datasets, especially considering the sparseness of the source data and the adjustments made by the data producers.

Notice that the model mean in Figure 3-12 did not accurately reproduce the decadal and multidecadal variations in land precipitation. While, yes, I use the average of all of the ensemble members of all of the climate models stored in the CMIP5 archive that produced precipitation outputs, thus dampening any possible multidecadal variations, that's exactly what I want to show. I'm interested in finding out what the modelers assumed about the response of precipitation to manmade greenhouse gases, not the "noise" the models create. (See Chapter 1.4 for why the multi-model ensemble mean best represents how the models respond to the assumptions of their programmers.) Briefly, the multi-model mean represents how the models say global land precipitation would respond if anthropogenic forcings caused the variations in precipitation.

Apparently, some cause other than people is responsible for the multidecadal variations in precipitation over land. The most plausible candidates are El Niño and La Niña events which clearly have decadal and multidecadal variations. Some decadal and multidecadal periods are dominated by El Niño events; during those periods, we would expect global precipitation over land to be lower than normal. When La Niña events dominate, the other side of the coin, we would expect global land precipitation to be above normal.

The vast majority of the **data**-based scientific studies on global land precipitation discuss regional precipitation as a response to El Niños and La Niñas. In fact, regional responses to El Niño and La Niña events are very well understood. They have been the subjects of dozens of data-based papers since the 1980s, largely because that knowledge helps with weather forecasts. Unfortunately, while there are numerous data-based studies of ENSO effects on **regional** land precipitation, there are few data-based studies of the effects of ENSO on **global** precipitation.

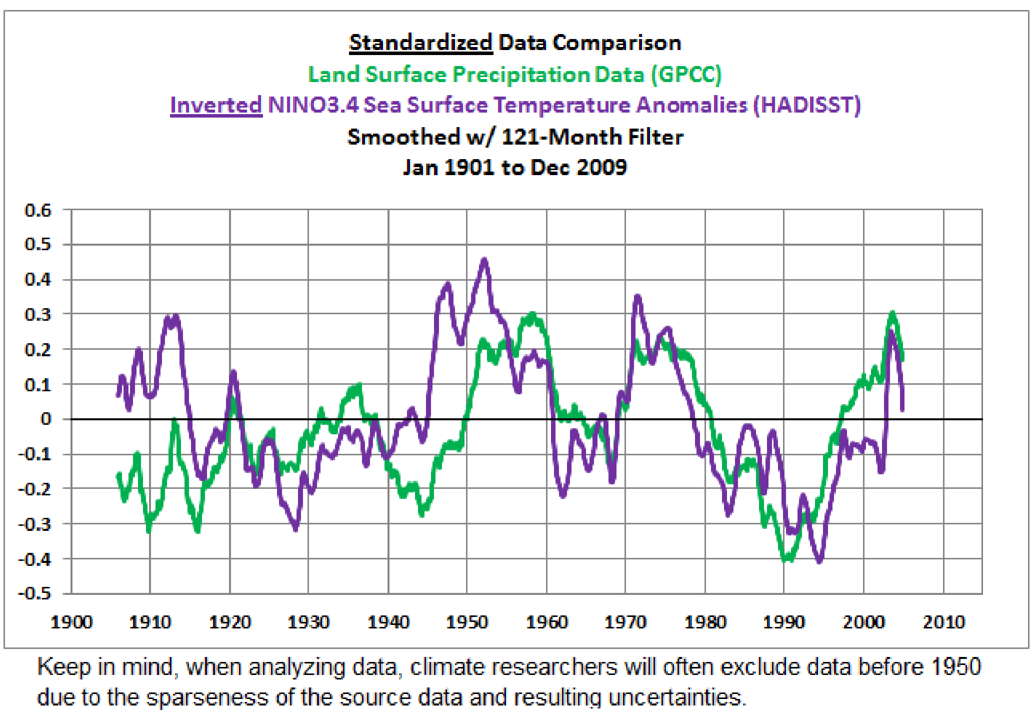


Figure 3-13

In Figure 3-13, I compare an ENSO index to one of the land precipitation datasets presented in this chapter (GPCC). I standardized both datasets (divided them by their standard deviations) and smoothed them with 121-month filters. Additionally, I inverted the ENSO index (NINO3.4 sea surface temperature anomalies) by multiplying that data by -1.0. There appears to be a rough relationship between the two datasets, starting in the mid-1950s. During the period from the late 1960s to the late 1970s, La Niña events dominated (the positive anomalies of the purple curve) and global land precipitation was above normal. The relationship between the datasets isn't as well-defined after the precipitation anomalies rose above zero again in the late 1990s. But, when El Niño events began to dominate in the late 1970s, global precipitation soon dropped to below normal.

The two datasets suggest a relationship between the decadal variations in ENSO and the decadal variations in land precipitation. There are, nevertheless, many other natural factors that are known to influence land precipitation, e.g., the Atlantic Multidecadal Oscillation, the Pacific Decadal Oscillation (an aftereffect of El Niño and La Niña), the North Atlantic Oscillation, the Indian Ocean Dipole, etc.

(See chapter 1.2 for peer-reviewed papers that detail how climate models cannot simulate the AMO (Atlantic Multidecadal Oscillation) or the processes that drive El Niño and La Niña events.)

CHAPTER 3.3 SUMMARY

Global precipitation over land increased from 1901 to 2009 according to three rain gauge-based precipitation datasets. Climate models, on the other hand, based on their programmers' assumption that global land precipitation is driven by human activity, estimated that global land precipitation would decrease over that time period.

One of the natural factors that clearly contributes powerfully to the annual variations in land precipitation is ENSO. El Niño and La Niña (i.e., ENSO) likely also contribute to the decadal and multidecadal variations in global land precipitation, because land precipitation and ENSO show similar decadal and multidecadal variability since the 1950s. It is well understood by the climate science community that **climate models cannot simulate ENSO** — or other natural coupled ocean-atmosphere processes like the Atlantic Multidecadal Oscillation and the Pacific Decadal Oscillation, which impact regional precipitation. Thus, at this time, climate modelers can in **no way** accurately forecast what regional or global precipitation will be decades and centuries into the future.

In short, climate models cannot simulate past precipitation over global land surfaces because climate models cannot simulate the natural coupled ocean-atmosphere processes that drive global precipitation on annual, decadal, and multidecadal bases. There is presently no reason to have confidence in any single model's projections or in any combination of climate model projections of future precipitation, globally or regionally. Until the climate models used by the IPCC can simulate those powerful natural factors, including the Atlantic Multidecadal Oscillation, the Pacific Decadal Oscillation, the Arctic Oscillation, the Indian Ocean Dipole, and, most importantly, the coupled ocean-atmosphere processes that drive El Niño and La Niña events, they should be ignored.

Section 4 – Global Land Plus Sea Surface Temperature Anomalies Since 1880

This section includes a much-expanded and edited (for ease of reading) version of a model-data comparison which I first presented in my blog post "Model-Data Comparison: CMIP5 (IPCC AR5) Models vs New GISS Land-Ocean Temperature Index". In that post, I divide the GISS Land-Ocean Temperature Index data from 1880 to 2012 into the two warming periods and the two periods where global surface temperatures leveled off or cooled slightly. My analysis showed how well and, even more, how poorly the models simulated the warming or cooling rates during those periods. **In this expanded version, however, the periods have been altered slightly to avoid claims that the start and end years were "cherry picked"**. In addition to time-series graphs and linear trend comparisons, I also include trend maps of surface temperature anomalies. In this section, I also present the modeled and the observed warming and cooling rates during those 4 periods using zonal-mean (latitude average) graphs and discuss how the models fail to accurately simulate polar amplification. I also present the difference between the models and observations (that's easily done by subtracting the data from the model outputs). The final two topics of discussion are: 1) the observed versus the modeled warming rates during last century's two warming periods; and 2) why the models' failure to accurately simulate the warming during the first warming period is important.

NOTE 1: For the trend maps in Figures 4-7, 4-10, 4-13, and 4-16, I use a different range for the contour levels than those used in Figure 4-3. The contour range in Figure 4-3 is -0.025 to +0.025 deg C/year to accommodate the lower long-term trend. Because the short-term trends are higher, for Figures 4-7, 4-10, 4-13, and 4-16, the contour range is -0.05 to +0.05 deg C/year.

NOTE 2: For the temperature anomaly comparisons, I use the base period of 1961-1990 for anomalies. Those are the base years used by the IPCC in their model-data comparisons in its Figure 10.1 from the Second Order Draft of AR5.

NOTE 3: The data and models in this section are presented on an annual basis. The last full year of data is 2012 — thus, 2012 is the end year of the model-data comparisons in this section. 2012 is also used as the end year of the recent warming period because the climate models estimate a continued warming through 2012.

Chapter 4.1 – The Long-Term Model-Data Comparison and How the 4 Periods Since 1880 Were Determined

I compare the new GISS LOTI (Land-Ocean Temperature Index) data and the multi-model ensemble mean of the CMIP5-archived models prepared for the IPCC's upcoming AR5. Recently, GISS revised their surface temperature dataset. GISS changed from a combination of HADISST and Reynolds OI.v2 sea surface temperature data to NOAA's ERSST.v3b data. (See my post here for more information.) In Figure 4-1, I compare the old and new versions of the GISS LOTI data from 1880 to 2011. The trend increased slightly with the change.

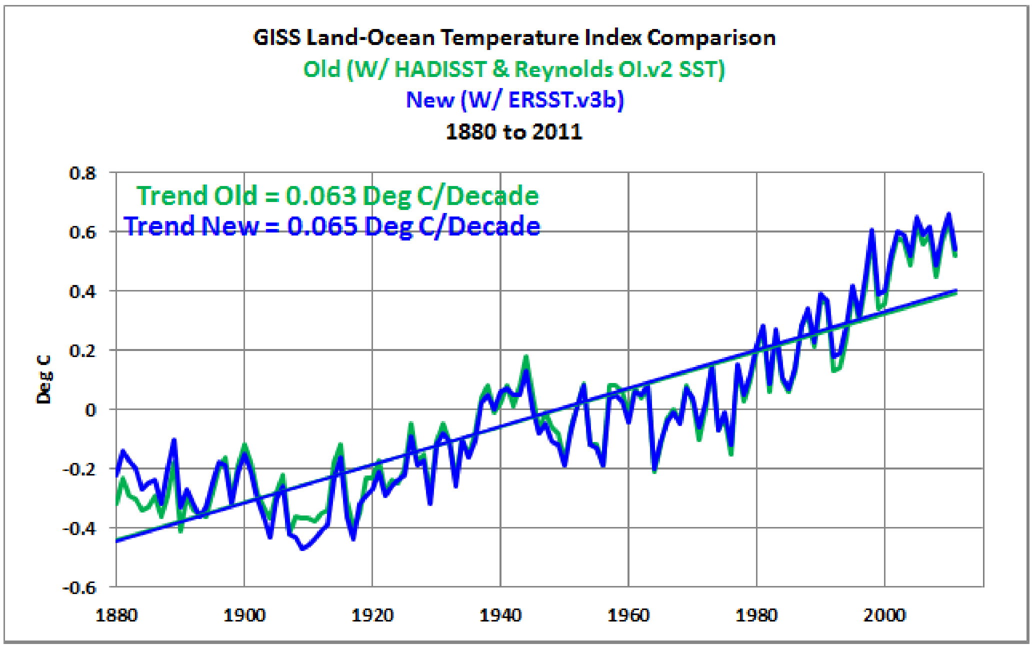


Figure 4-1

Global surface temperature anomalies have clearly warmed since 1880. Based in the linear trend, global surface temperatures have warmed about 0.85 deg C from 1880 to 2012. You may believe a rise in temperature of that magnitude is insignificant, but that's the primary metric used to present global warming. Climate models that were prepared for the IPCC's upcoming 5th Assessment Report appear to do a reasonable job of simulating historic global surface temperatures over that time period (1880 to 2012). In Figure 4-2, I compare the GISS LOTI data to the multi-model ensemble mean of simulations of global surface temperatures. The model mean consists of historic simulations combined with model projections for the last few years using the RCP6.0 scenario. The simulated and observed warming rates are reasonably close over the full term of the GISS Land-Ocean Temperature Index data. What stands out, though, is the divergence in recent years. The models continue to show warming, while the data shows surface temperatures leveling off.

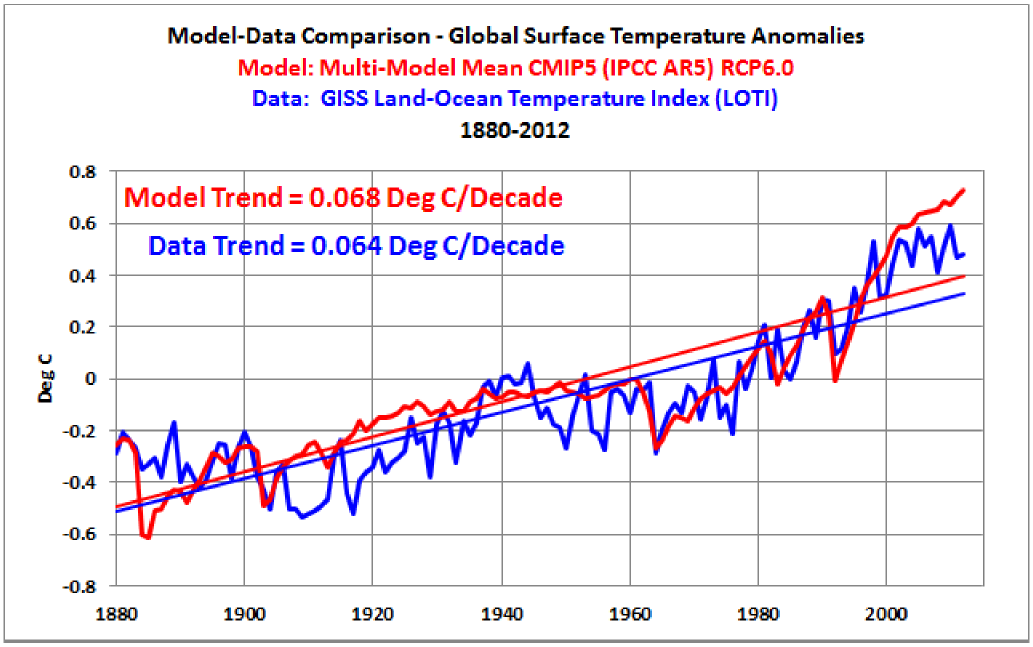


Figure 4-2

(See Fyfe, et al. (2013) "[Overestimated Global Warming Over the Past 20 Years]" [paywalled]. See also the PCIC (Pacific Climate Impacts Consortium) science brief about the Fyfe paper [here] [300 KB pdf].)

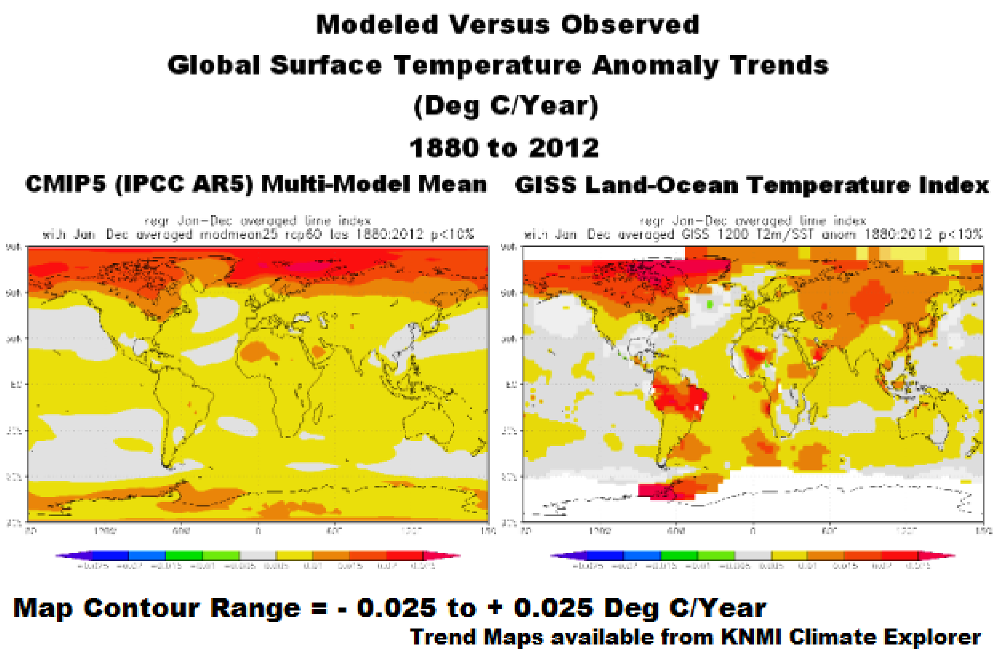


Figure 4-3

In Figure 4-3 are global maps of the modeled and observed warming trends from 1880 to 2012. The CMIP5-archived simulations estimated there would be stronger-than-observed, polar-amplified, warming at high latitudes in the Northern Hemisphere, but then, strangely, underestimated the warming over much of central Asia. The models also estimated that there would be more warming of the tropical Pacific, when the observations show little warming there. There are a number of other regional modeling problems over the long-term.

Note: the trend map for the GISS data leaves a blank in Antarctica and in parts of the Southern Ocean surrounding it. Land surface air temperature measurements did not begin in Antarctica until the late 1940s, so the KNMI Climate Explorer does not have sufficient data to determine trends. The same problem exists for part of the Arctic above Canada, Alaska, and the Chukchi Peninsula in far eastern Siberia.

The trends when presented over the full term of the GISS data, Figures 4-2 and 4-3, tend to make the models seem as though they might perform reasonably well. But, it's well known that global surface temperatures did not warm continuously from 1880 to 2012. The IPCC acknowledges this in their 4th Assessment Report. (See "Chapter 3 Observations: Surface and Atmospheric Climate Change" of the IPCC's 4th Assessment Report. Under the heading of "3.2.2.5 Consistency Between Land and Ocean Surface Temperature Changes.") With respect to the surface temperature variations over the period of 1901 to 2005 (page 235) [The Figure and FAQ referenced below are theirs, not the ones in this book.], the IPCC states:

> *Clearly, the changes are not linear and can also be characterized as level prior to about 1915, a warming to about 1945, leveling out or even a slight decrease until the 1970s, and a fairly linear upward trend since then (Figure 3.6 and FAQ 3.1).*

When I break the observations and model outputs into the 4 periods shown in Figure 4-4, the models do not fare as well. In fact, the trend maps in the following chapters of this section will help to show just how poorly the models simulated observed temperature trends during the early cooling period (1880 to 1915), the early warming period (1915 to 1945), the mid-20th century flat temperature period (1945 to 1975), and the late warming period (1975 to 2012).

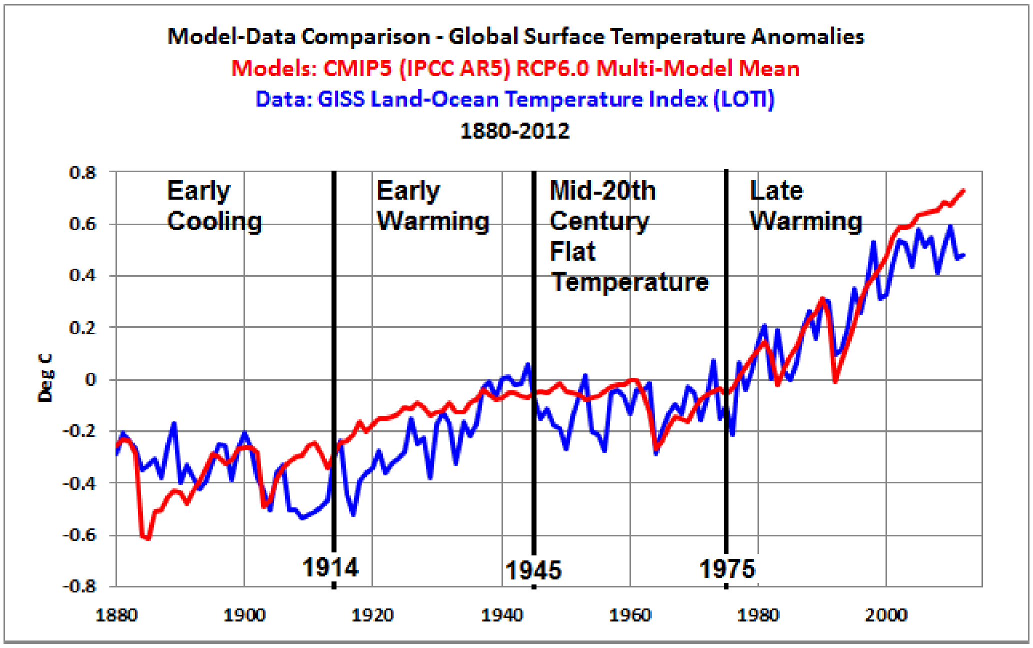


Figure 4-4

It's important to break the data down into the 4 periods. In this way, one can determine if the climate models accurately simulate the warming that occurred during the periods when surface temperatures have warmed and determine if the models accurately simulate the lack of warming during those periods when warming stops.

NOTES ABOUT THE BREAK POINTS

The model-data comparisons in this section may look familiar to some readers. I prepared a similar discussion in my post "Model-Data Comparison with Trend Maps: CMIP5 (IPCC AR5) Models vs New GISS Land-Ocean Temperature Index". In that post, I use 1917, 1944, and 1976 as the years for the break points, keying off of peak minimum and maximum years.

That post was also cross posted at WattsUpWithThat here. There, Dr. Leif Svalgaard of Stanford University, one of the world's leading solar physicists, commented:

> *I have a problem with the start and end points in Figures 3, 5, 7, and 9: They are generally chosen to be near extremes, that is to start at a low point and end at a high point for warmings and to start at a high point and end at a low point for coolings. Such cherry picking is skewing the 'trends'.*

Dr. Svalgaard then very kindly calculated the break points of 1914 and 1945 using a statistical technique called segmented regression. He describes that technique and the results here and here. For the 1975 break year, I relied on the analysis by the blogger "Tamino" (statistician Grant Foster) here.

Let’s start with the time period when the models perform best, the most recent warming period. Then, we’ll work our way back in time.

Chapter 4.2 – Modeled and Observed Trends During the Warming and Cooling (Flat Temperature) Periods

I'll compare models and data during the most recent warming period (1975 to 2012), the mid-20th century flat temperature period (1945 to 1975), the early warming period (1914 to 1945), and the early cooling period (1880 to 1914). I'll use time-series graphs, trend maps, and trend comparisons on a zonal-mean (latitudinal) basis.

RECENT WARMING PERIOD – 1975 TO 2012

In Figure 4-5, I compare the observed and modeled linear trends in global land-plus-sea surface temperature anomalies for the period of 1975 to 2012. The models overestimated the warming by about 25%. The divergence between the models and the data in recent years is evident.

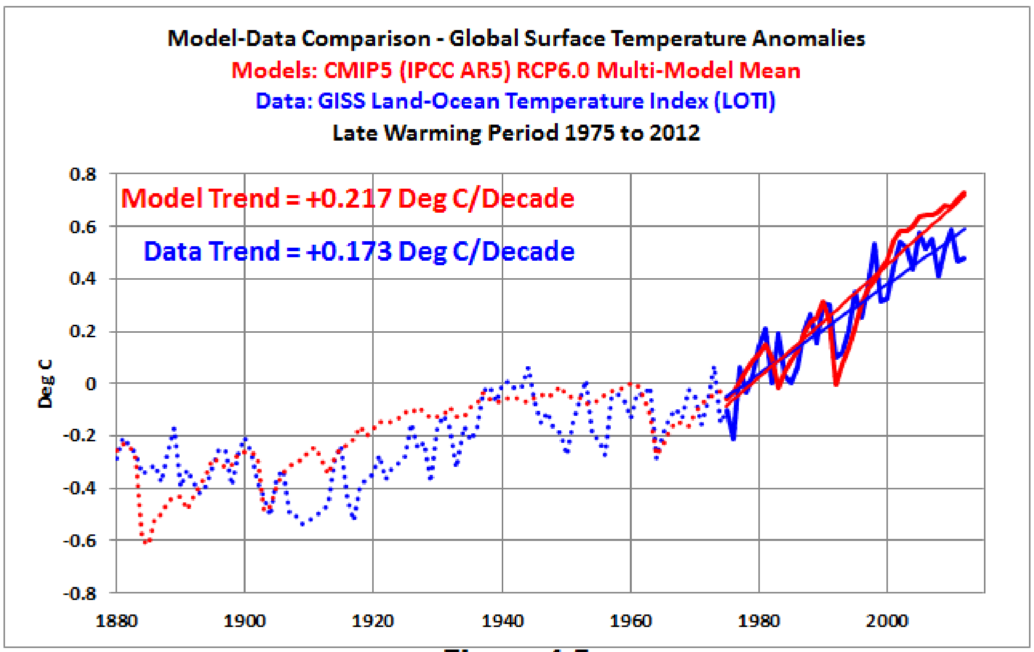


Figure 4-5

In Figure 4-6, I compare the trends on a latitudinal (zonal mean) basis. The models appear to simulate the warming rates of surface temperatures reasonably well at the mid-to-high latitudes of the Northern Hemisphere for the period of 1975 to 2012. In the tropics, however, the simulated warming rate is about 35% too high. Then, toward the high latitudes of the Southern Hemisphere (as far as 65S), the models simulate way too much warming. In fact, the Southern Ocean surrounding Antarctic has **cooled** over this period, while the models said it would warm.

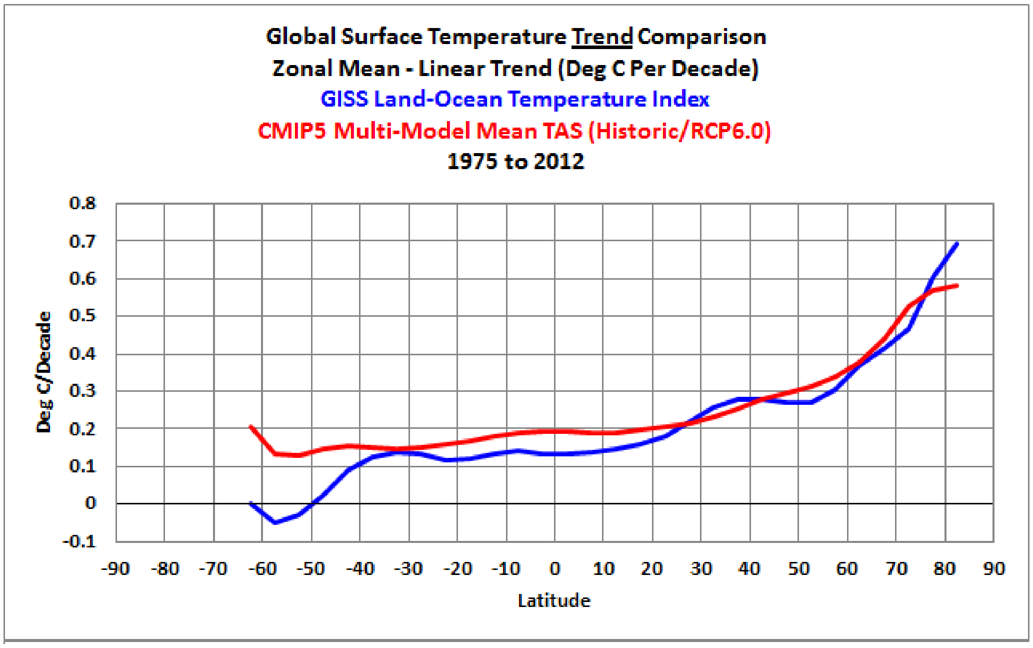


Figure 4-6

The zonal-mean graph in Figure 4-6 **excludes Antarctica**. While there is Antarctic data during this period, it is not available during the two periods before 1944. To keep the illustrations consistent, I excluded it in the two periods after 1944.

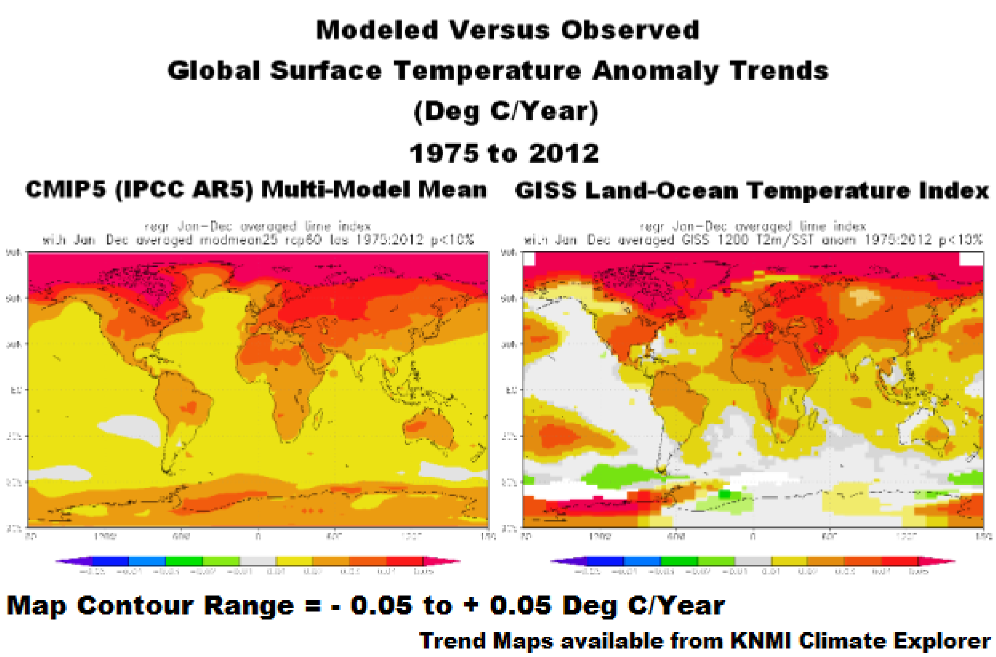


Figure 4-7

In Figure 4-7, I compare the modeled and observed surface temperature trend maps for 1976 to 2012. The models estimated that the vast majority of the East Pacific would warm, while the data indicates little to no warming there. For the western and central longitudes of the Pacific, the models failed to show the ENSO-related warming of the Kuroshio-Oyashio Extension (KOE) east of Japan and the warming in the South Pacific Convergence Zone (SPCZ) east of Australia and New Zealand. The models also underestimated the warming in the mid-to-high latitudes of the North Atlantic. The anomaly trends of modeled land surface temperature also have low validity on a regional basis, but that's not surprising since the models simulate the sea surface temperature trends so poorly. (I show how poorly the models simulate sea surface temperatures in Section 7 of this book.)

MID-20th CENTURY FLAT TEMPERATURE PERIOD – 1945 to 1975

Compared to the trends for the warming periods of 1914-1945 and 1975-2012, surface temperatures warmed at a much lower rate during the period of 1945 to 1975. (See Figure 4-8.) Programmed by their modelers to respond to the volcanic aerosols from the eruption of Mount Agung in 1963/64, the model outputs have a dip and rebound then which causes them to have a cooling trend during this time period. The difference between modeled and observed trends, however, is more than 0.05 deg C, a sizable difference. It is pretty obvious that the modelers do not fully understand why the warming of global surface temperatures slowed during this period.

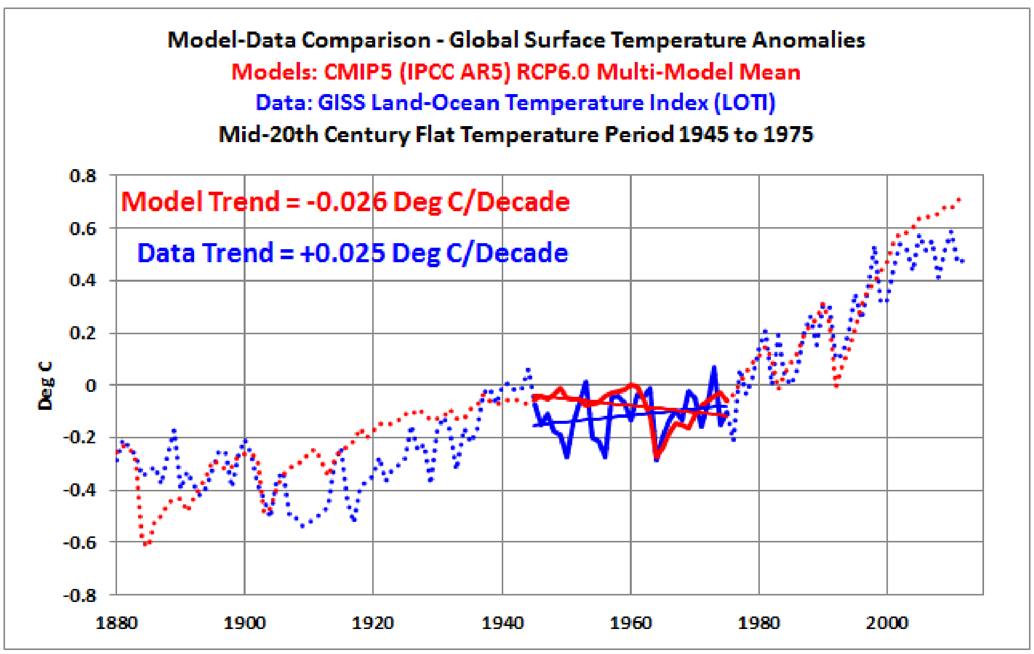


Figure 4-8

The models look even worse when we look at the trends for the period of 1945 to 1975 on a zonal-means basis, Figure 4-9. It is patently obvious that the models cannot simulate the polar-amplified cooling that took place. The models also miss the warming in Southern Hemisphere. The only region where the models appear to have made a fairly good guess was in the low-to-mid latitudes of the Northern Hemisphere, but even that could simply have been a lucky coincidence for the models, considering how poorly they simulated the trends everywhere else.

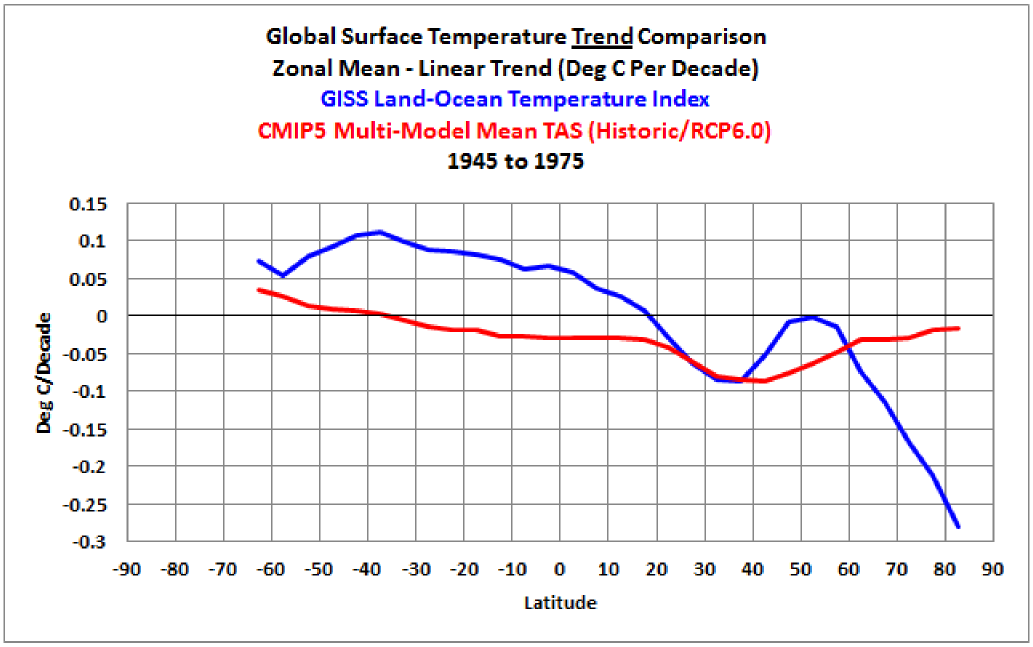
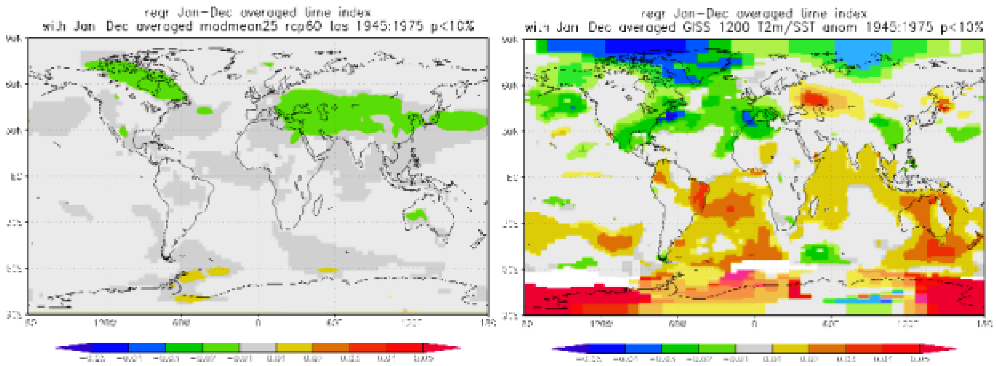


Figure 4-9

# # #

Modeled Versus Observed
Global Surface Temperature Anomaly Trends
(Deg C/Year)
1945 to 1975

CMIP5 (IPCC AR5) Multi-Model Mean | **GISS Land-Ocean Temperature Index**



Map Contour Range = - 0.05 to + 0.05 Deg C/Year

Trend Maps available from KNMI Climate Explorer

Figure 4-10

In the trend maps in Figure 4-10, it is clear that the climate models failed to simulate the polar amplified cooling that happened from 1944 to 1975 in the Arctic. The climate models also failed to simulate the cooling in the mid-to-high latitudes of the North Atlantic and in a few regions in the North Pacific. Further, the climate models failed to simulate the warming of sea surface temperatures in the Southern Hemisphere and they completely missed the warming of Antarctica.

EARLY WARMING PERIOD – 1914 TO 1945

Atrocious, horrible, and horrendous describe the performance of the CMIP5-archived climate models during the early warming period of 1914 to 1945. (See Figure 4-11.) According to the models, with their unsupported assumption that human greenhouse gases cause global warming, global surface temperatures should have warmed at a rate of about +0.06 deg C/decade from 1914 to 1945. BUT, according to the new and improved GISS LOTI (Land-Ocean Temperature Index) data, global surface temperatures actually warmed approximately 2.3 times faster than that or about 0.138 deg C/decade. That difference presents a number of problems for the hypothesis of human-induced, greenhouse gas-driven global warming, which I discuss later, in Chapter 4.4.

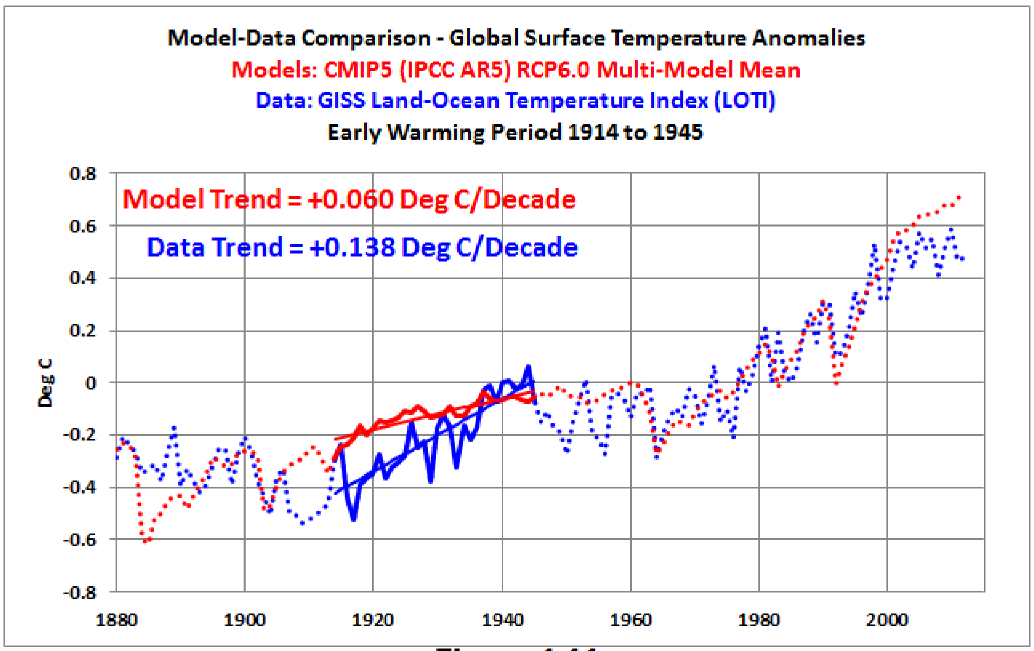


Figure 4-11

You may be looking at the trends in Figure 4-11 and thinking that the models do a pretty good job during the early warming period — that they have, in fact, been modest in their estimate of the warming rate. That's the problem. They've underestimated the warming during the early warming by a factor of 2.3. That suggests that surface temperatures are capable of warming at a higher rate without being forced to do so by manmade greenhouse gases. We'll discuss that at length in Chapter 4.4.

The models do not improve when we compare trends on a zonal mean basis. (See Figure 4-12) The data show polar-amplified warming during this period. The models severely underestimate the warming that took place at all latitudes and they failed to show **any** significant polar amplification.

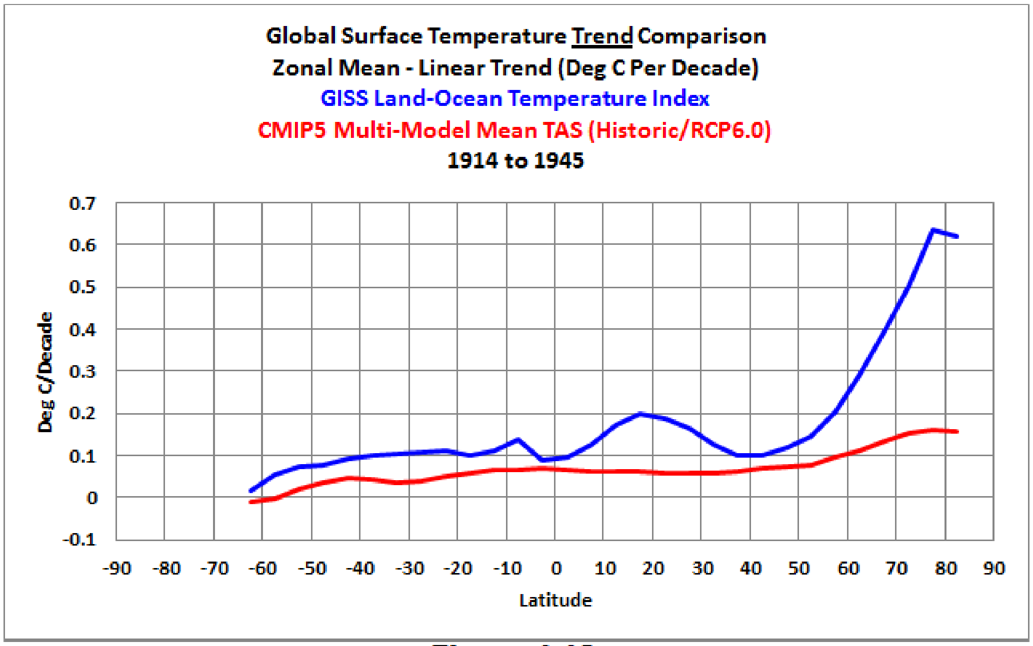


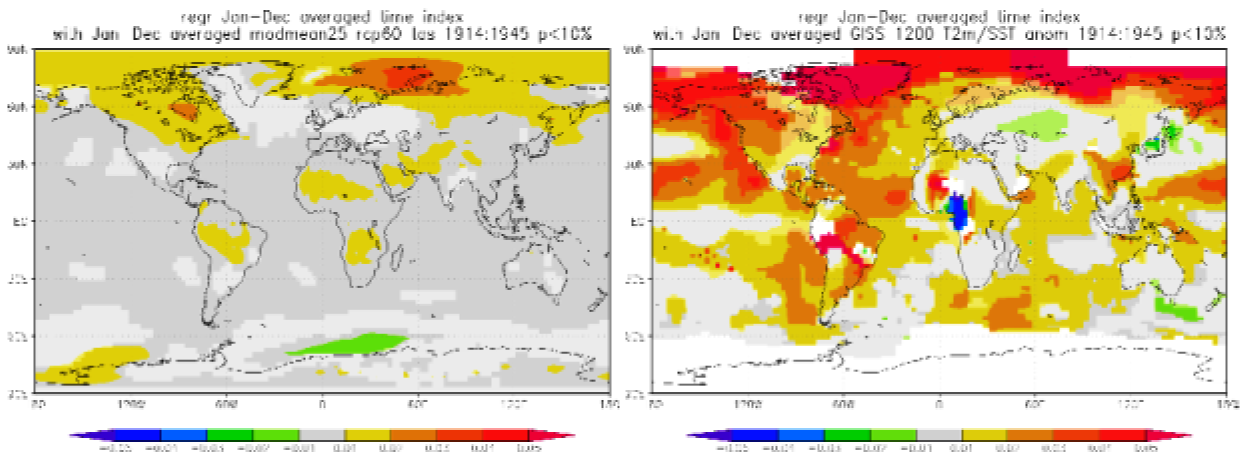
Figure 4-12

In the maps of modeled and observed trends, Figure 4-13, it is easy to see that the models failed to simulate the general warming of sea surface temperatures from 1914 to 1945 and that they completely failed to capture the polar amplified warming at high latitudes of the Northern Hemisphere.

Modeled Versus Observed
Global Surface Temperature Anomaly Trends
(Deg C/Year)

1914 to 1945

CMIP5 (IPCC AR5) Multi-Model Mean **GISS Land-Ocean Temperature Index**



Map Contour Range = - 0.05 to + 0.05 Deg C/Year

Trend Maps available from KNMI Climate Explorer

Figure 4-13

Land surface temperatures warm in response to the warming of sea surface temperatures. (Again see Compo and Sardeshmukh (2009) "Ocean Influences on Recent Continental Warming.") Thus, if the models can't simulate the natural variations in the warming rates of sea surface temperatures, there is no way they will ever accurately simulate the warming of land surface temperatures.

EARLY COOLING PERIOD – 1880 TO 1914

If the data back this far in time can be believed (that's for you to decide), surface temperatures cooled. (See Figure 4-14.) The models, on the other hand, said they should have warmed.

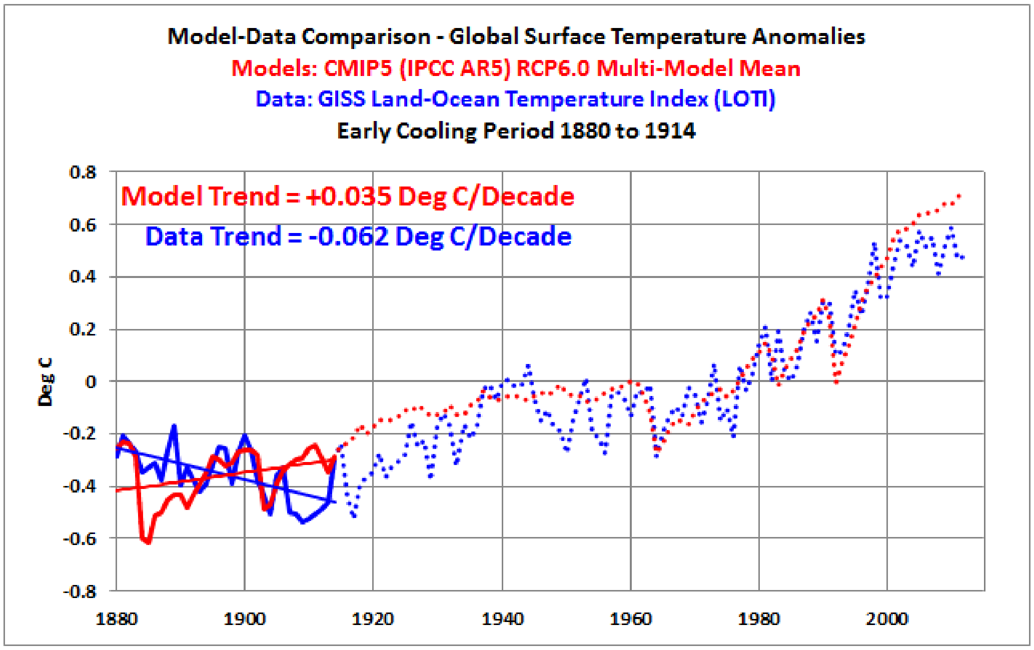


Figure 4-14

Once again, on a zonal-means basis, Figure 4-15, the models completely failed to simulate the observed warming and cooling rates for the period of 1880 to 1914.

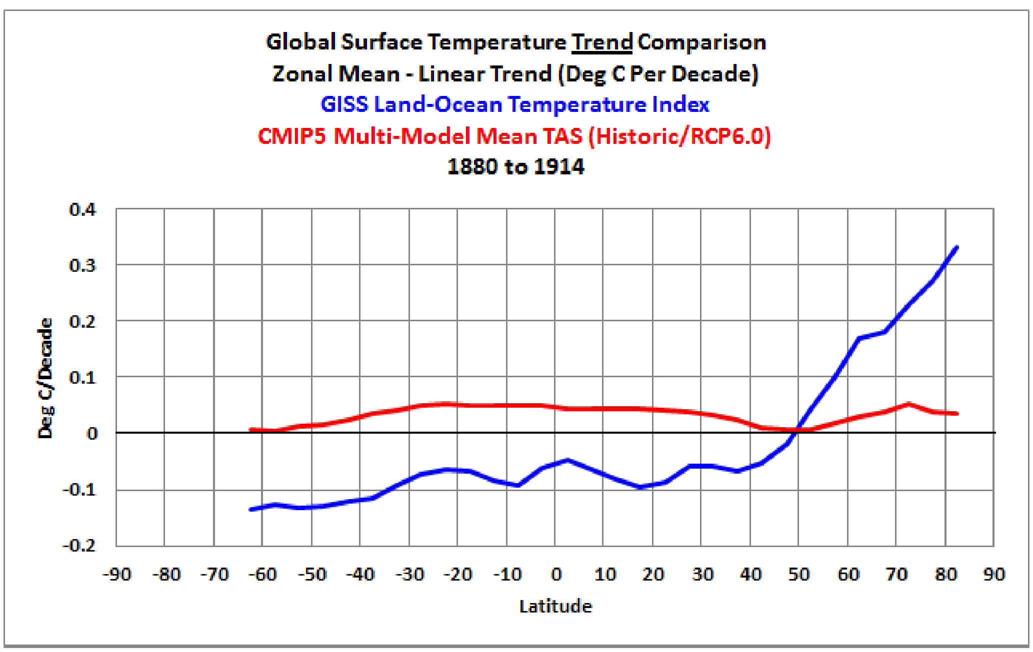


Figure 4-15

In the observations-based maps in Figure 4-16, the land surface and sea surface temperature trends appear to be out of sync during this period — sea surface temperatures cool while land surface temperatures warm in many areas. The models fail to capture either the warming on land or the cooling of ocean surfaces.

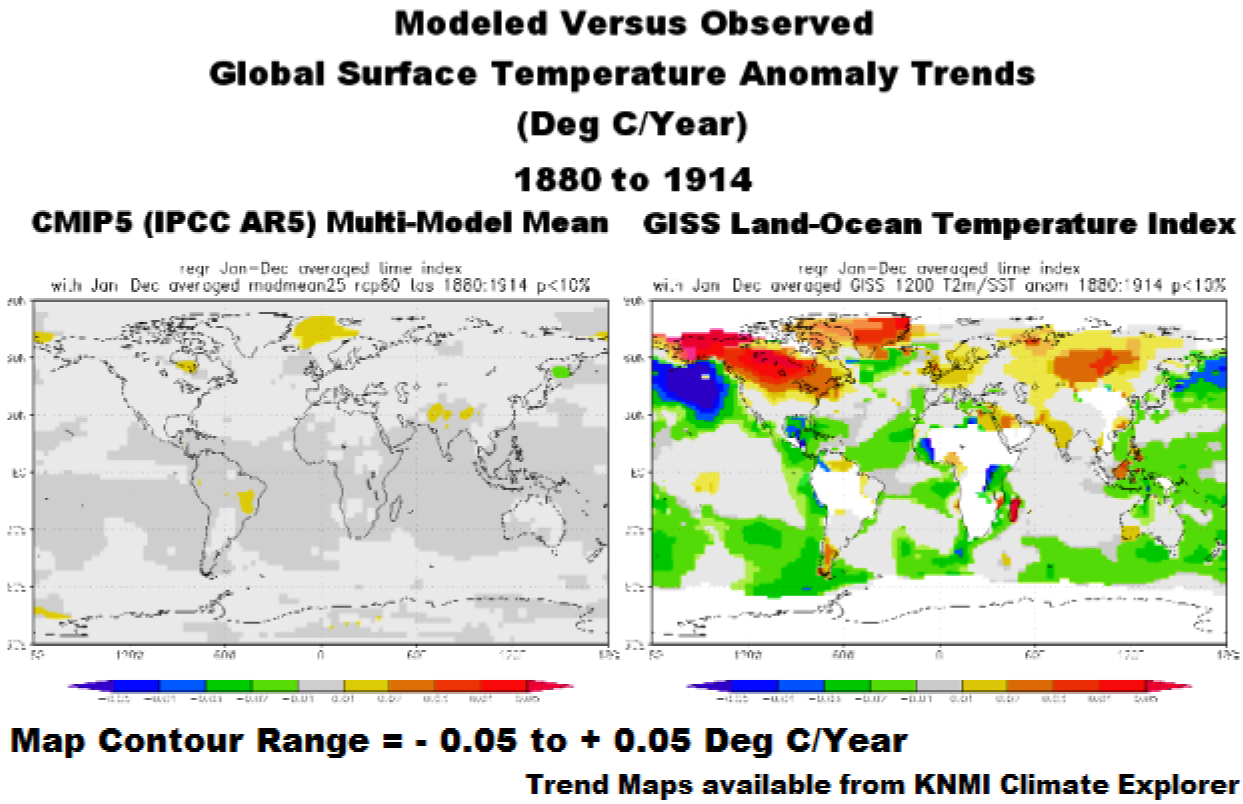


Figure 4-16

NOTE: If GISS had kept HADISST as their long-term sea surface temperature dataset, the disparity between trends would not have been as great during this period. The reason: the HADISST data do not show much cooling during this period compared to the ERSST.v3b data GISS is now using.

CHAPTER 4.2 SUMMARY

The climate models were tuned to mimic the global warming rate of the data in later years, thus, they perform best during the late warming period of 1975 to 2012. (See Mauritsen, et al. "Tuning the Climate of a Global Model" [paywalled]. (Preprint edition is here.)) They note as step 2 of their iterative process:

> *2. A longer simulation with altered parameter settings obtained in step 1 and observed SST's, currently 1976-2005 from the Atmospheric Model Intercomparison Project (AMIP), is compared with the observed climate.*

(Note: AMIP is a climate model experiment in which observed sea surface temperatures and sea ice were used as inputs to the models. The linked AMIP webpage notes that they start the experiment in 1979, but the actual start date appears to be left up to the various modeling groups, e.g., Mauritsen, et al. used 1976 as their start year.)

During the period of 1975 to 2012, the models only estimated well in the mid-to-high latitudes of the Northern Hemisphere. Even there, however, they failed to capture the regional warming rates of many locations.

The models show **no skill** at simulating the surface temperatures during: 1) the early cooling period of 1880 to 1914; or 2) the early warming period of 1914 to 1945; or 3) the mid-20th century flat temperature period of 1945 to 1975. That the models can't simulate the observed warming and cooling rates during these periods indicates that the forcings used by the modelers do not explain the long-term temperature variations. This strongly suggests that the multidecadal variations in global temperatures — including the warming during the most recent warming period — are not caused by the forcings that are used as inputs to climate models. More on this in Chapter 4.4.

Chapter 4.3 – Modeled versus Observed Polar Amplification

In this chapter, I again illustrate the polar amplification that exists in the data (warming and cooling) and the failure of the climate models to simulate it. I also discuss one of the very likely causes of those model failings.

MODELS FAIL TO SIMULATE THE OBSERVED POLAR AMPLIFICATION DURING THE EARLY WARMING PERIOD AND DURING THE MID-20th CENTURY FLAT TEMPERATURE PERIOD

The observations-based temperature trends in the zonal-mean plots in Chapter 4.2 show evidence of polar amplification. Figure 4-17 shows the trends in global surface temperatures (deg C/decade) for the periods of 1914-1945, 1945-1975, and 1975-2012, on a zonal-mean (latitude-average) basis. During the two warming periods of 1914 to 1945 and 1975 to 2012, the Arctic warmed at a much faster rate than that of the mid-latitudes of the Northern Hemisphere. Note just how similar those warming rates are in the Arctic. The polar amplified cooling in the Northern Hemisphere from 1945 to 1975 also stands out in Figure 4-17.

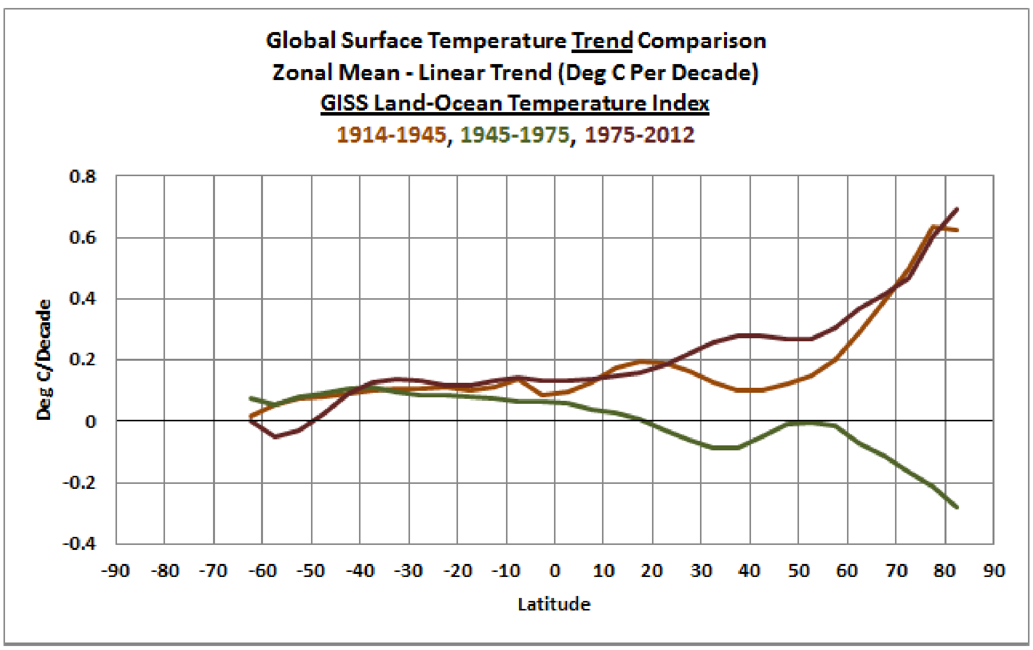


Figure 4-17

The climate models prepared for the IPCC's 5th Assessment report, on the other hand, only show polar amplification during the recent warming period of 1975 to 2012. (See Figure 4-18.) The models failed to capture 1) the polar-amplified cooling during the mid-20th century flat temperature period of 1945 to 1975 and 2) the polar-amplified warming during the early warming period of 1914 to 1945.

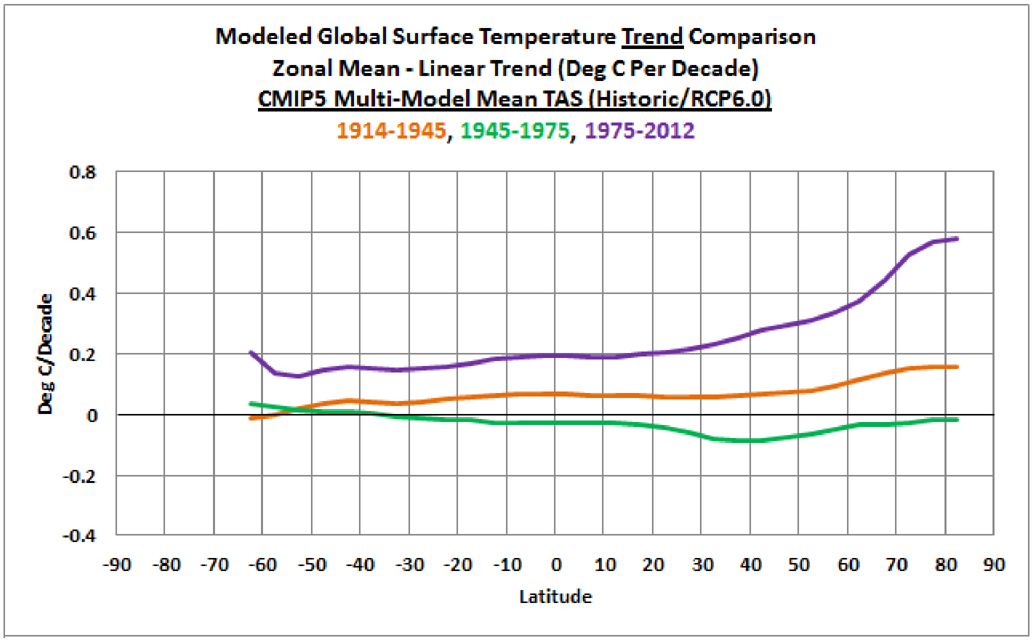


Figure 4-18

MULTIDECADAL TEMPERATURE VARIATIONS IN THE ARCTIC AGREE WITH MULTIDECADAL VARIATIONS IN NORTHERN HEMISPHERE SEA SURFACE TEMPERATURES

I discuss Ruiz-Barradas, et al. (2013) "The Atlantic Multidecadal Oscillation in Twentieth Century Climate Simulations: Uneven Progress from CMIP3 to CMIP5" in Chapter 1.2, re: scientific studies critical of climate models. (The full paper is here.) They conclude that climate models cannot simulate the processes associated with the multidecadal variations in the sea surface temperatures of the North Atlantic. In their "Concluding Remarks" they discuss why it is of vital importance that climate models accurately simulate the multidecadal variability of sea surface temperatures in the Northern Hemisphere:

> *If climate models do not incorporate the mechanisms associated to the generation of the AMO (or any other source of decadal variability like the PDO) and in turn incorporate or enhance variability at other frequencies, then the models ability to simulate and predict at decadal time scales will be compromised and so the way they transmit this variability to the surface climate affecting human societies.*

In Figure 4-19, I compare two surface temperature variables for the Northern Hemisphere. First, land-only GISS LOTI (Land-Ocean Temperature Index) data for the Arctic (65N-90N) — the oceans are masked — and, second, Northern Hemisphere sea surface temperature data included in the GISS LOTI data, i.e., NOAA's ERSST.v3b data. The multidecadal variations in the Arctic stand out. Plainly, there were two warming periods since 1900 in the Arctic data and they were separated by a cooling period. Unfortunately, the magnitudes of those variations in Arctic land surface air temperatures are so great that they mask any similarities with the sea surface temperature data for the Northern Hemisphere.

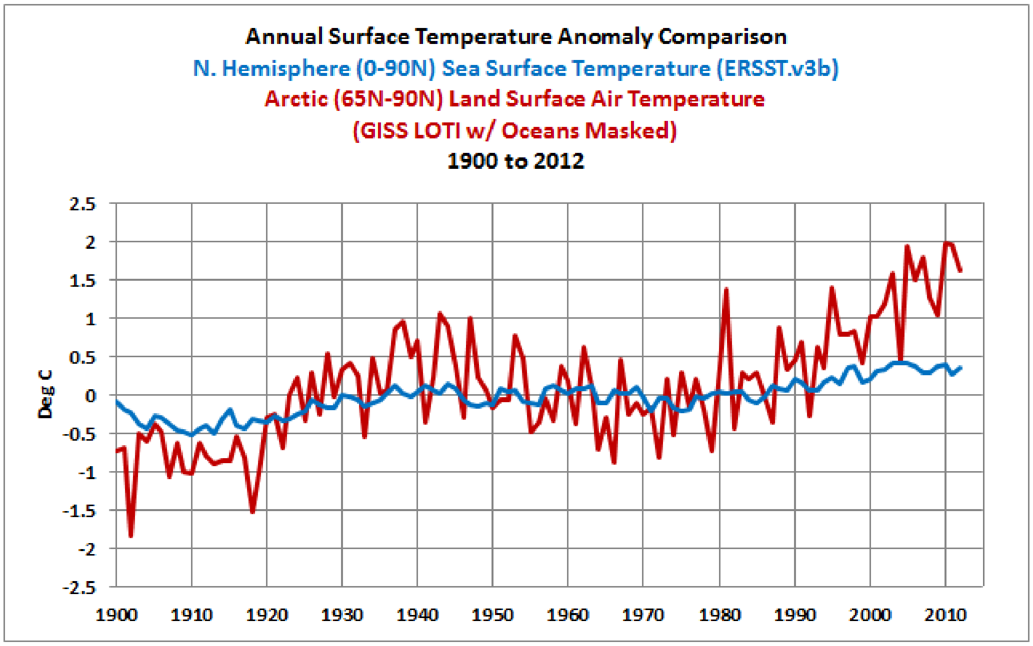


Figure 4-19

In Figure 4-20, I detrend and standardize (divide them by their standard deviations) the two datasets to eliminate the differences caused the scales of the variations and then smooth them with 10-year filters to help bring out the multidecadal variations. The multidecadal variations in the two datasets are very similar with a few differences from time to time. In view of the sparseness of source data (the actual observations), and that sparseness grows worse as we travel back in time, and in view of the fact that the infilling methods used by GISS for the land surface temperature data are different than those used by NOAA for the sea surface temperature data, the similarities between the two datasets are quite remarkable.

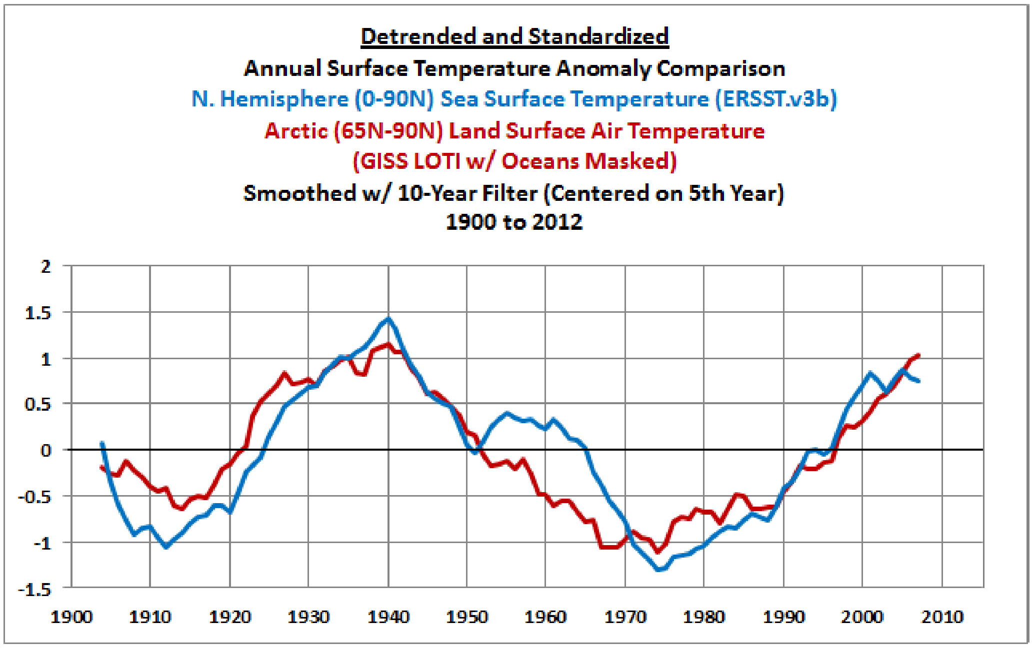


Figure 4-20

It is well understood by the climate science community that the vast majority of the variations in land surface temperatures are responses to the variations in sea surface temperatures. (See Compo and Sardeshmukh (2009) "Ocean Influences on Recent Continental Warming" cited earlier.) Also keep in mind that climate modelers use sea surface temperatures as inputs to climate models to force the models' responses during the model tuning processes; this was discussed in Mauritsen, et al. (2012) "Tuning the Climate of a Global Model" [paywalled]. (The preprint edition is here.) Land surface temperatures mimic and exaggerate the variations in sea surface temperatures. Polar amplification is the exaggeration of warming (and cooling) in the Arctic in response to the warming (and cooling) of sea and land surface temperatures.

The climate models' failure to accurately simulate the natural processes that cause multidecadal variations in sea surface temperatures in the Northern Hemisphere is likely why the models also cannot accurately simulate the multidecadal variations in polar-amplified warming and cooling seen since the start of the 20th century.

In other words, the climate models can't accurately simulate the variations in sea ice and polar amplification because they can't accurately simulate the multidecadal variations in sea surface temperatures of the Northern Hemisphere. And if climate modelers can't simulate sea surface temperatures, they cannot hope to simulate land surface temperatures.

CHAPTER 4.3 SUMMARY

Climate models cannot accurately simulate two critical components of climate on Earth:

1) the multidecadal variability of sea surface temperatures in the Northern Hemisphere; and 2) the multidecadal variations in polar amplified warming and cooling in the Arctic. It is highly likely that the models' failure to simulate polar amplification stems from their failure to simulate the multidecadal variations in sea surface temperatures.

Chapter 4.4 – A Major Flaw in the Hypothesis of Human-Induced Global Warming

In Chapter 4.2, I compared modeled and observed global surface temperatures during each of the four warming and cooling (or flat temperature) periods since 1880. In this chapter, I first compare the **observed** warming rates of the two warming periods with each other to show how similar they are, then, I compare the **modeled** warming rates for each of those same warming periods to highlight how different from each other they are. I also discuss how those respective differences between the warming rates of the models and between the rates of the observations strongly indicate that the climate models do not support (and even contradict) the hypothesis of human-induced global warming.

I use the same warming periods (1914 to 1945 and 1975 to 2012) I use throughout this section.

IMPORTANT PRELIMINARY POINT

Keep in mind, as discussed in Chapter 1.4, the model mean represents the models estimate of how surface temperatures would respond if their warming was indeed caused by anthropogenic forcings (primarily, manmade greenhouse gases) per the anthropogenic forcing assumptions programmed into the models. In other words, if manmade greenhouse gases did, indeed, cause the warming, the model mean is the models' best guess about how surface temperatures would have warmed.

GLOBAL LAND PLUS SEA SURFACE TEMPERATURES – MODELED AND OBSERVED WARMING RATES DURING THE TWO WARMING PERIODS

The **modeled** warming rates of global surface temperatures (land and ocean) during the two warming periods (1914 to 1945 and 1975 to 2012) are shown in Figure 4-21. If the hypothetical impacts of manmade climate forcings (including anthropogenic greenhouse gases) had actually caused the warming of global surface temperatures, the warming rate during the later warming period would have been about 3.6 times greater than it was during the earlier warming period.

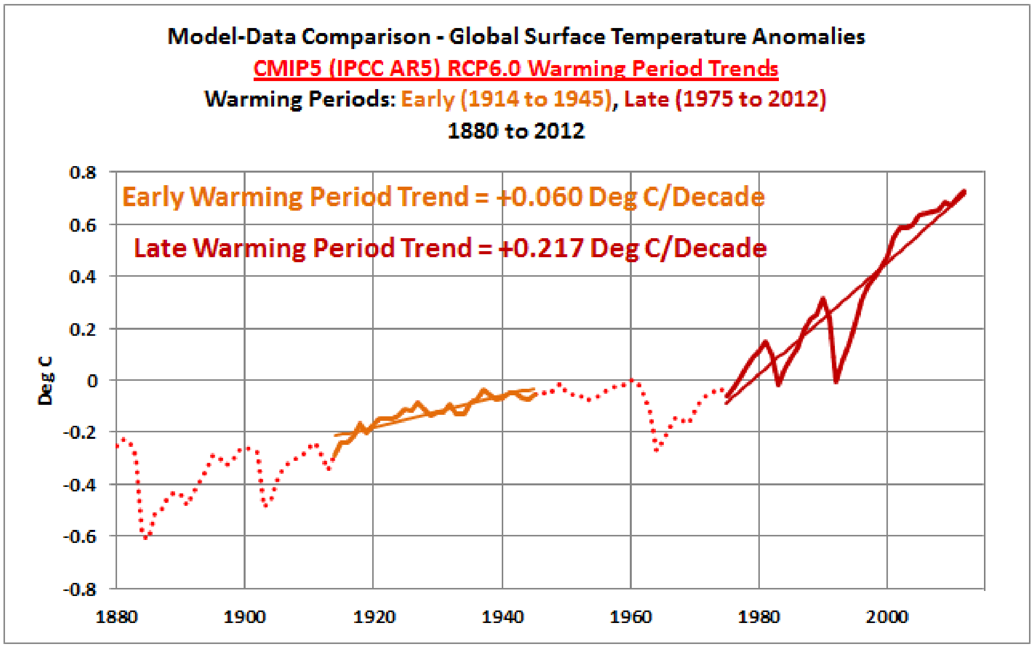


Figure 4-21

On the other hand, the **observed** warming rates during the early and late warming periods are remarkably similar to each other. (See Figure 4-22.) Using the global GISS Land-Ocean Temperature Index data, the observed warming rate during the later warming period is only 25% higher than the trend during the earlier warming period.

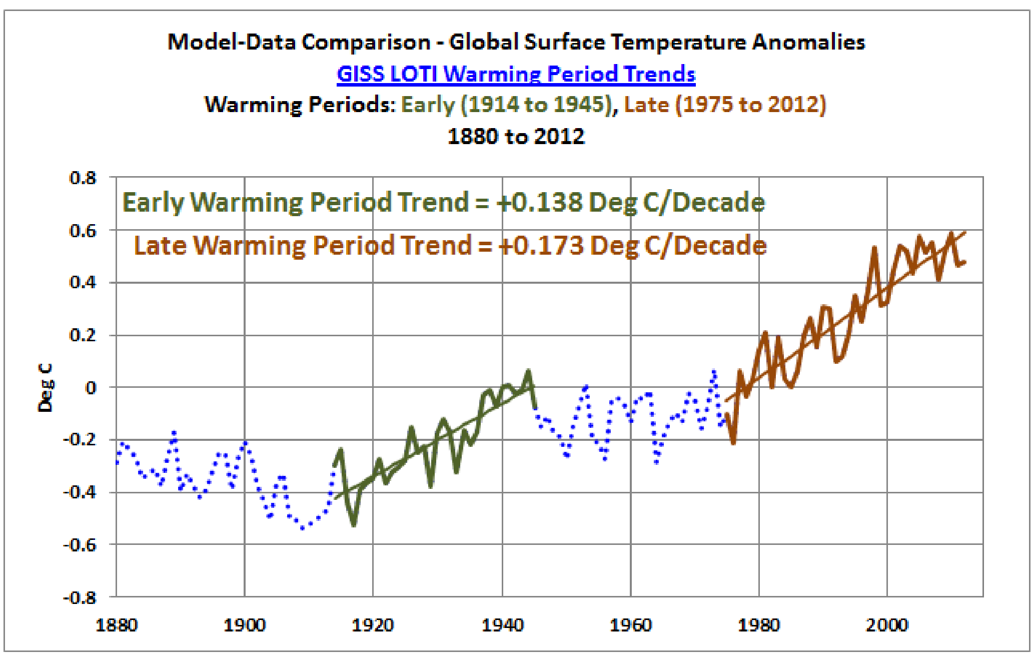


Figure 4-22

The internal inconsistency of the models' warming rates is one of the major failures of the global warming hypothesis. In other words, anthropogenic forcings are obviously not the dominant cause of the warming of global surface temperatures over the 20th century (or else the two modeled warming rates would be very similar to each other just as the actual data's rates are similar). That the models cannot hindcast the early (1914-1945) rise in global surface temperatures shows that global surface temperatures can warm due to causes other than the forcings (human and natural) programmed into the climate models.

THE DATA WARMING AT A HIGHER RATE DURING THE LATE WARMING PERIOD

Both the data and the model outputs warmed at higher rates during the later warming period than during the early warming period. Unfortunately for the models, the difference between the modeled warming rates for the two warming periods was way too high — about 0.16 deg C/decade. By contrast, the data's warming for the second period was only about 0.035 deg C/decade higher than the data's rate for the first period. Is that difference between the two observed warming rates an indication that greenhouse gases caused the additional warming?

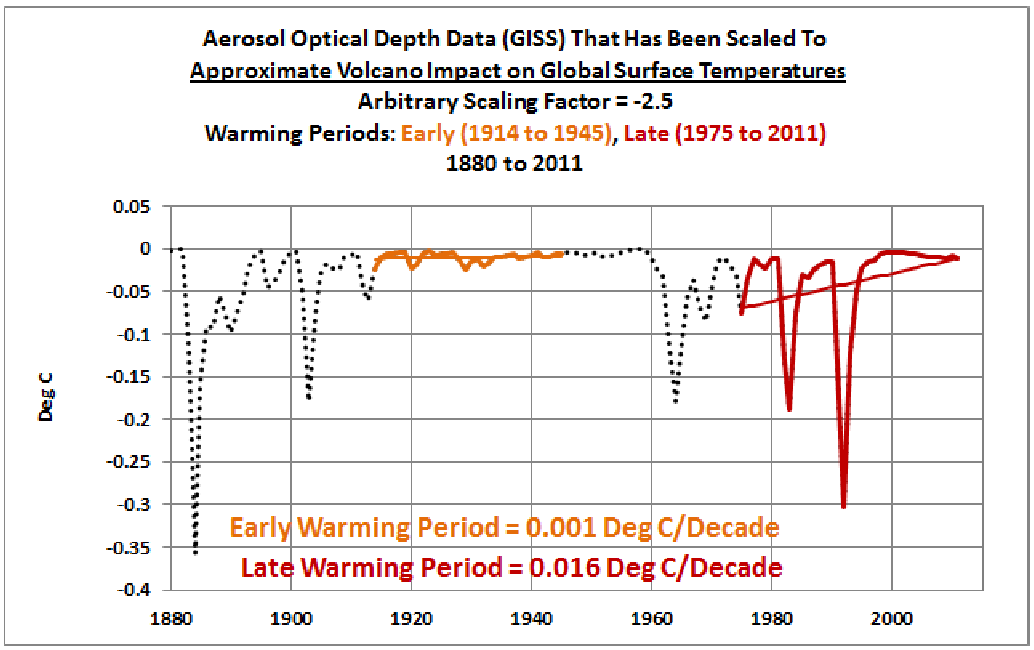


Figure 4-23

Not necessarily. One factor to consider is explosive volcanic eruptions. The eruption of Mount Pinatubo in 1991 temporarily cooled global surface temperatures. The estimates of the peaking cooling range from 0.2 deg C to 0.5 deg C during 1991 to 1992, the year following the eruption. The models estimated there would be about a 0.3 deg C drop in global surface temperatures in response to the eruption of Mount Pinatubo. (See Figure 4-21.) [Note: Figure 4-23 shows that GISS aerosol optical depth data has been scaled to produce about a 0.3 deg C drop in response to the eruption of Mount Pinatubo. That is roughly the same as what the models' estimated.] There was also the eruption of El Chichon in 1982. Both of those catastrophic eruptions occurred during the first half of the late warming period of 1975 to 2012. Thus, those two eruptions exaggerate the warming rate of the later period by biasing the first half of the data downward. During the early warming period, there were no large volcanic eruptions to downwardly bias the warming rates to that significant a degree.

As shown, the eruptions of El Chichon and Mount Pinatubo, by depressing the temperatures of first half of the late warming period, impose a slight warming trend on it. Thus, volcanoes account for part of the difference between the warming rates of observed global surface temperatures during the early and late warming periods shown in Figure 4-22.

Unfortunately for the modelers, the difference in warming rates caused by the volcanic eruptions is far too small to explain the big difference between their models' simulated trends for the early and late warming periods.

There are factors, other than CO2, that are likely contributing to the difference between the observed warming rates during the two warming periods. Examples are:

- urban heat island effect (See Wu and Yang (2013)),
- land use changes (See Pielke, et al. (2011)), and
- overzealous corrections to the instrument temperature record (See the difference between the raw and corrected USHCN surface temperatures—from the NOAA/NCDC webpage here.

CLIMATE MODEL FORCINGS DURING THE EARLY AND LATE WARMING PERIODS

GISS publishes the individual forcings that they use to drive their climate models. (See their Forcings in GISS Climate Model webpage. And see the data here.) In Figure 4-23 I illustrate the Net Forcings — the sum of all of the radiative forcings data — used by GISS for the period of 1900 to 2011. It is the same forcings data presented by GISS in their graph here. In Figure 4-24, I also include the linear trends for the Net Forcings for the periods of 1914 to 1945 and 1975 to 2011. According to the natural and anthropogenic forcings that are used as input to the GISS climate models, the rate at which the forcings increased during the late warming period was about 3.8 times faster than during early warming period.

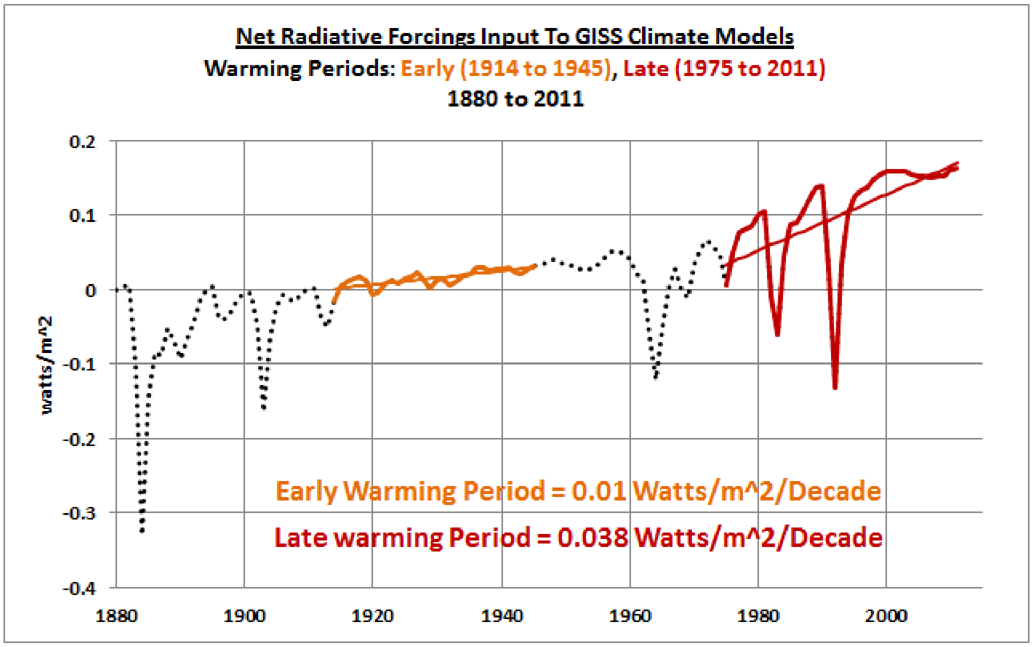


Figure 4-24

Yet, the observed warming rates in surface temperature for the early and late warming periods are actually similar.

As noted earlier, regarding the early warming period, this indicates that global surface temperatures can warm independent of human activity.

Another way to look at it: the data indicate that the much higher anthropogenic forcings for the latter warming period — compared to the earlier warming period — had little impact on the rate at which the observed temperatures actually warmed. In other words, the climate models and data do not support the hypothesis of anthropogenic forcing-driven global warming; they contradict it.

CHAPTER 4.4 SUMMARY

The fact that the models simulated the warming better during the more recent warming period does not mean that manmade greenhouse gases caused that warming — it simply reveals that the modelers managed to tune their models to perform better for the more recent warming period.

The climate models cannot simulate the observed rate of warming during the early warming period (1914-1945), which warmed at about the same rate as the recent warming period (1975-2012). This illustrates that global surface temperatures can warm without being forced — unlike climate models which must be driven by the natural and anthropogenic forcings used as inputs. And the similarities between the observed warming rates during the early and late warming periods indicate that the much higher anthropogenic forcings during the late warming period had little impact on the rate at which observed temperatures warmed.

In other words, the climate models and data do not support the hypothesis of anthropogenic forcing-driven global warming; they contradict it.

The world portrayed by all those number-crunching climate models is a fantasy world — with little or no relationship to the real world.

Section 5 – Land Surface Air Temperatures

One might have thought that modelers would have spent time in their tuning efforts to accurately simulate land surface air temperatures. We live on land. But, they appear to have overlooked two entire continents.

Another place the models fail is in the Arctic, where temperatures warm and cool in very specific time patterns. This is especially true in Alaska, Scandinavia, and the combined temperatures of Greenland and Iceland. The models fail to accurately simulate those warming and cooling periods.

Below, I compare the recently updated UKMO CRUTEM4 land surface air temperature anomalies with the multi-model ensemble mean of the CMIP5 climate model simulations of land surface temperature anomalies using the historic and the RCP6.0 scenarios. The data and model outputs are available through the KNMI Climate Explorer on a gridded basis. (Note: To reproduce the graphs, you must select "Land only" after entering the desired coordinates for the model outputs.)

Climate models also fail to accurately simulate daily maximum and minimum temperatures and their difference, which is called the diurnal temperature range. For this discussion, I use the Berkeley Earth Surface Temperature (BEST) data.

SPECIAL NOTE: In a few chapters, I compare models and data for regions and continents. To those who believe it would have been better to use the climate models that were prepared specifically for short-term regional analyses, I say that models that were fine-tuned to simulate a specific region over a specific time period are not helpful in this discussion. The relevant issue here is models that are used to make long-term hindcasts and projections. That is, the relevant models are those upon which the predictions of global gloom and doom are based. Thus, I use those models in this section.

Let's start with the two continents.

Chapter 5.1 – Climate Models Estimate Way Too Much Warming for Two Continents

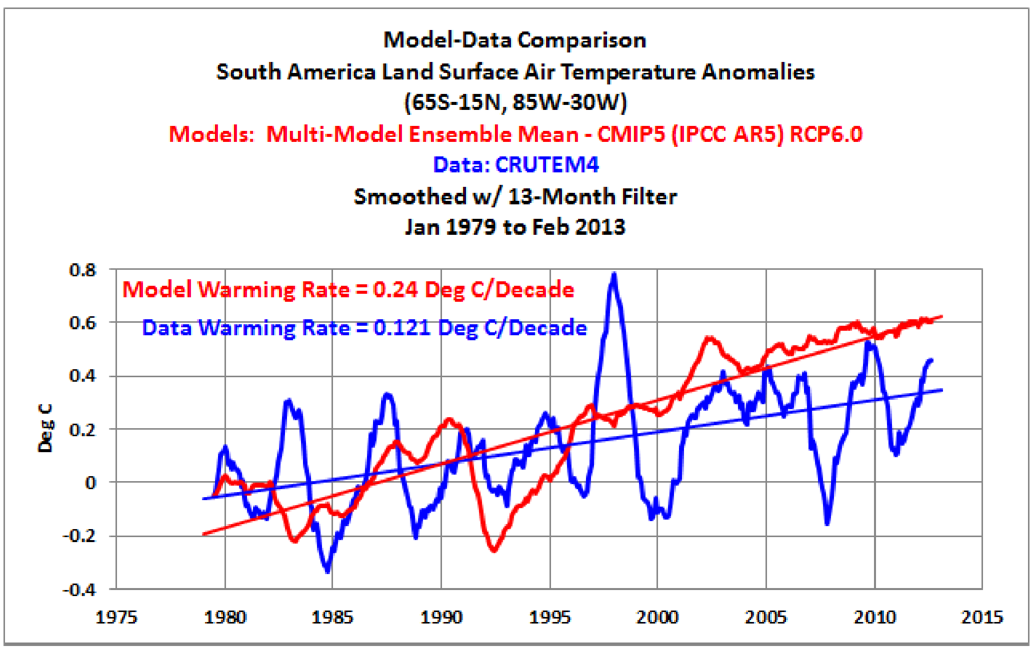
The Earth has seven continents. In primary school, we're taught their names and where to find them on maps. It's difficult to overlook two of the seven, but based on the warming rates of South America and of Australia, as simulated by the CMIP5 climate models, the modelers appear to have done just that. The simulated warming rates for those two continents are way too high.

For these two examples, I start the model-data comparisons in 1979. It's a commonly used start year for examinations of global temperature data because the satellite-based lower troposphere temperature datasets begin then. Because the data is somewhat noisy, I smoothed the data and model outputs with 13-month running-average filters.

As noted at the bottom of both graphs in this chapter, I calculated the linear trends from the monthly data and model outputs, not the smoothed versions. Performing a trend analysis on smoothed data can skew the results, sometimes, to an unacceptable degree.

SOUTH AMERICA

Figure 5-1 is my model-data comparison of South American land surface air temperature anomalies for the period of January, 1979 to February, 2013, using the coordinates: 65S-15N, 85W-30W. The data show that land surface air temperatures in South America warmed at a rate of 0.12 deg C/decade during this period. The models on the other hand, based on assumptions about manmade greenhouse gases, said that temperatures would warm twice as fast as they actually did.



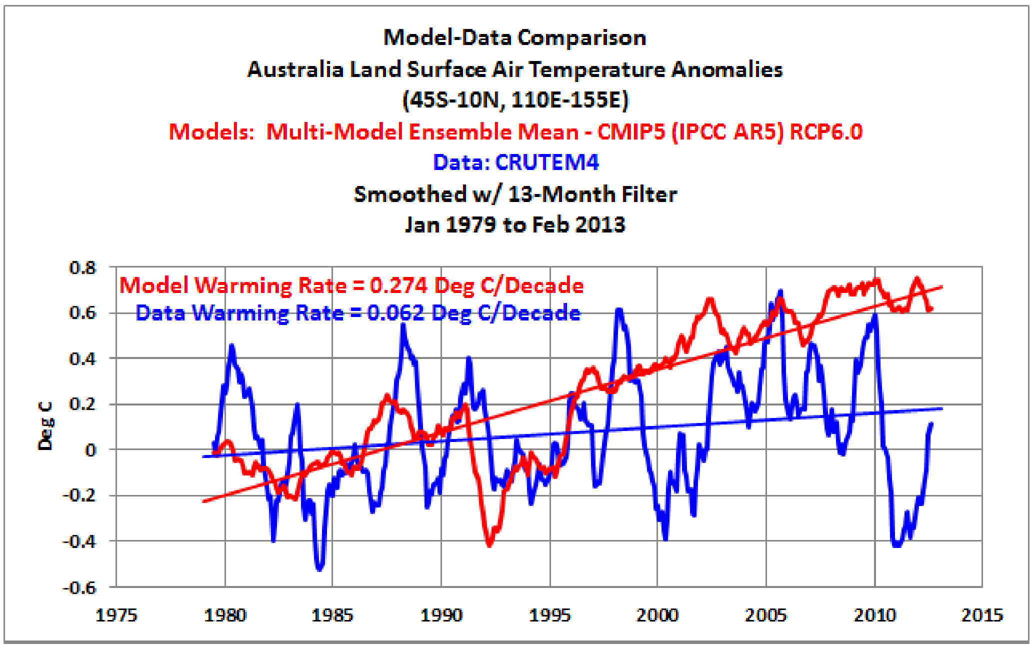
Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 5-1

The models doubled the observed warming rate in South America over the past 3+ decades. But that's nothing compared to Australia.

AUSTRALIA

For Australia, I use coordinates: 45S-10S, 110E-155E. Land surface air temperature anomalies in Australia since 1979 warmed at a sedate rate of 0.062 deg C/decade, according to the CRUTEM4 data. As shown in Figure 5-2, the CMIP5-archived climate models estimated a warming rate of 0.274 deg C/decade for Australia. Climate models, driven by the hypothetical effects of carbon dioxide, overestimated the warming rate in Australia by a factor of 4. A factor of 4 is a **massive** failure.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 5-2

CHAPTER 5.1 SUMMARY

The climate models prepared for the IPCC's 5th Assessment Report overestimated the warming since 1979 by a factor of 2 in South America and by a factor of 4 for Australia. Over much of that same time period, according to Mauritsen, et al. (2012), climate model simulations of land surface air temperatures were tuned from sea surface temperatures. Mauritsen, et al. describe the second step of their tuning process as:

> *A longer simulation with altered parameter settings obtained in step 1 and observed SST's [sea surface temperatures], currently 1976-2005 from the Atmospheric Model Intercomparison Project (AMIP), is compared with the observed climate…*

If the climate model programmers' assumption that anthropogenic greenhouse gases caused the warming of land surface air temperatures in South America and Australia had been correct, surface temperatures should have warmed at a rate of about 0.25 deg C per decade. But, according to the new-and-improved CRUTEM4 dataset, the land surface air temperatures warmed at significantly lower rates.

One of the possible causes of the model failures to properly simulate land surface temperatures may be based on their failure to simulate sea surface temperatures accurately. As you will see in Section 7, the models show no skill at simulating sea surface temperatures.

The abysmal model failures for those two continents call into question any successes the modelers claim they've had elsewhere around the globe. Carbon dioxide is a well-mixed greenhouse gas. Its effects simply cannot be present in some parts of the globe while virtually absent over two entire continents.

Chapter 5.2 – Regional Model Failure: Alaska Land Surface Air Temperature Anomalies

When and why Alaskan surface air temperatures warmed are well known to scientists. In fact, the Alaska Climate Research Center discusses it on their "Temperature Changes in Alaska" webpage. Below, I expand on their discussion and then compare the data with the model outputs.

THE 1976 PACIFIC CLIMATE SHIFT

In Figure 5-3 are the CRUTEM4 land surface temperature anomalies for Alaska smoothed with a 13-month filter. The coordinates: 57N-72N, 170W-140W. The data through 1975 are shown in blue and the data from 1977 to present are shown in dark red. The 1976 shift in surface temperatures stands out very clearly.

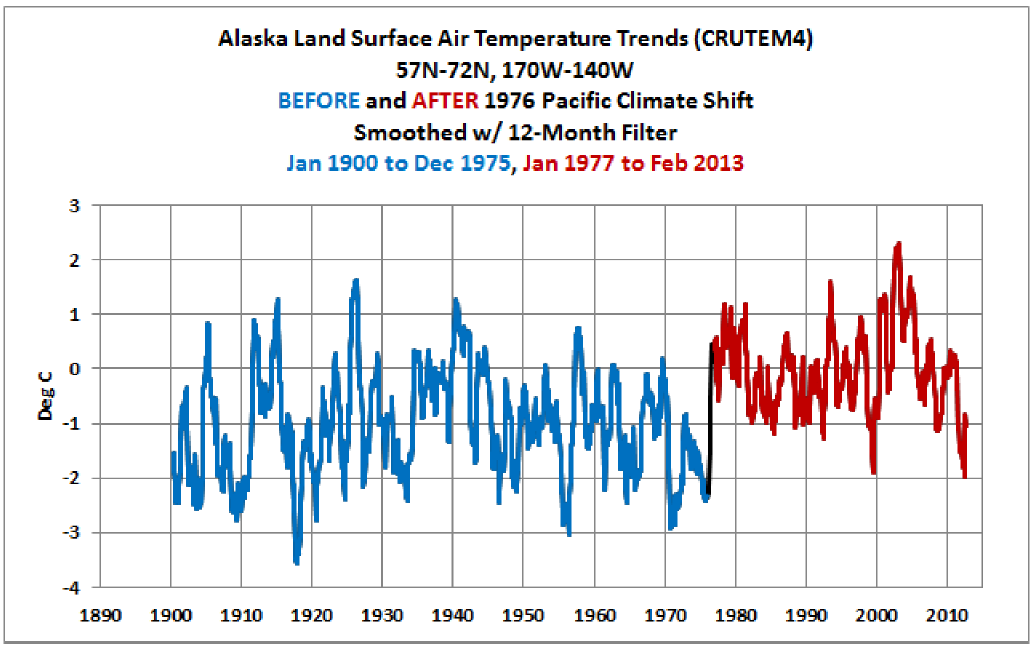


Figure 5-3

Figure 5-4 is the Alaska data since 1900 without smoothing, divided into the same two periods: before 1976 and after 1976. Based on their linear trends, land surface air temperatures were relatively flat in Alaska from 1900 to 1975, then, from 1977 to the present, they're flat again. Between those two periods was the Pacific Climate Shift of 1976, which, in effect, raised Alaska land surface air temperatures about 1 deg C. That shift can be seen as the difference between the two trend lines.

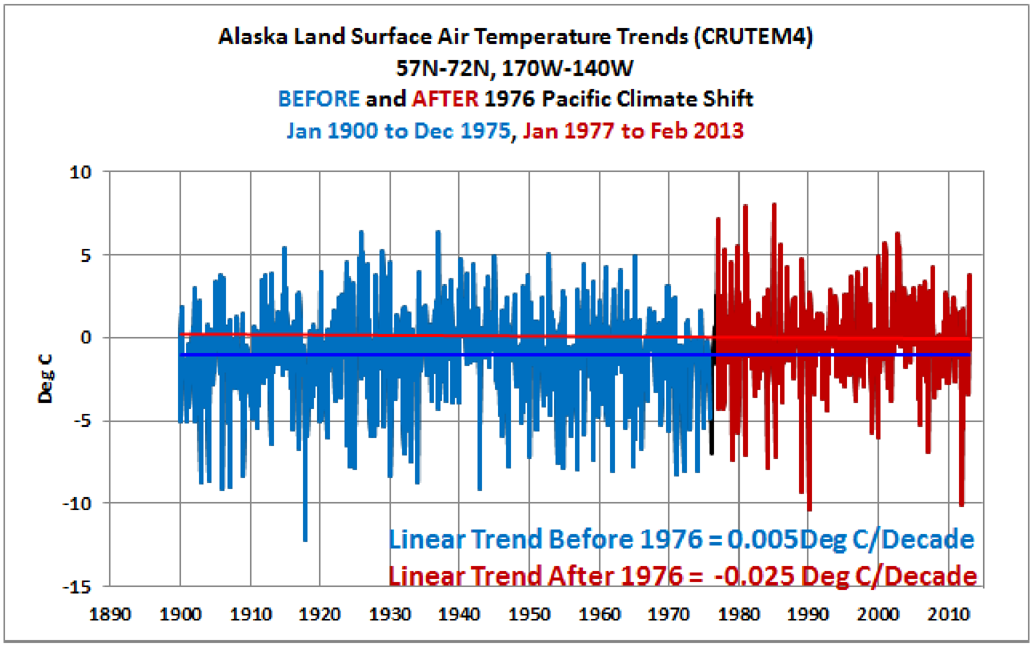


Figure 5-4

Obviously, there's a lot of yearly and decadal variability in Alaska surface temperatures. One more thing is also certain: surface temperatures there have slowly warmed since 1900, as is plainly seen in Figures 5-3 and 5-4. The long-term trend of the data would obviously show a positive warming rate. However, by breaking the data down into two subsets, before and after the 1976 Pacific Climate Shift, we can also see that, based on the linear trends, without that shift — without that one year of data — Alaska surface temperatures would not have warmed since 1900, based on the linear trends.

The Alaska Climate Research Center attributes the shift to the PDO (Pacific Decadal Oscillation):

> *The stepwise shift appearing in the temperature data in 1976 corresponds to a phase shift of the Pacific Decadal Oscillation from a negative phase to a positive phase. Synoptic conditions with the positive phase tend to consist of increased southerly flow and warm air advection into Alaska during the winter, resulting in positive temperature anomalies.*

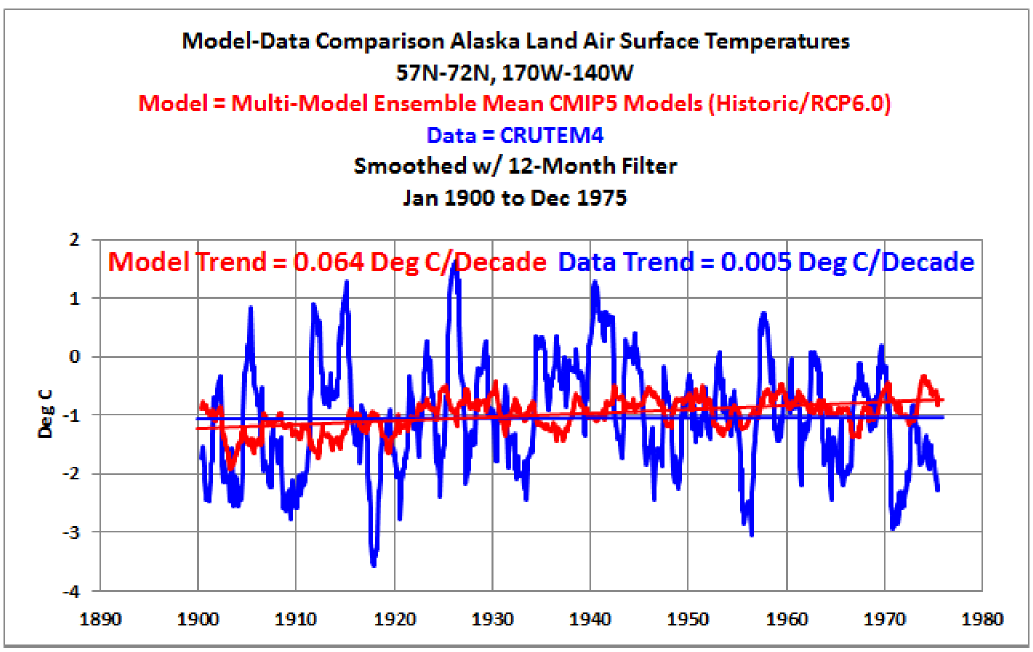
While the positive phase of the Pacific Decadal Oscillation does result in the winter conditions they described, the shift in temperatures is better explained as a response to the Pacific Climate Shift of 1976. The 1976 Pacific Climate Shift is a phenomenon that occurred across the entire East Pacific Ocean, effectively raising the sea surface temperatures of 33% of the global oceans almost 0.17 deg C — in one year. (See the graph here.) I discuss the impact of the 1976 Pacific Climate Shift in my blog post "On Hartman and Wendler 2005 'The Significance of the 1976 Pacific Climate Shift in the Climatology of Alaska'". In that post, I show that the Pacific Climate Shift raised sea surface temperatures of Alaskan coastal waters more than the average across the East Pacific as a whole.

Responding to the shift, land surface temperatures in Alaska exaggerated the warming as shown in Figures 5-3 and 5-4 above. The 1976 Pacific Climate Shift is well studied. There are numerous peer-reviewed papers about that shift, although few of them agree on its cause.

A NOTE ABOUT OTHER POSSIBLE SHIFTS

As you'll note in Figure 5-3, in addition to the one in 1976, there appear to be other shifts in the land surface air temperatures of Alaska, e.g., in 1911 and 1934, and possibly in 1957 and in 2001. Between the shifts, surface air temperatures decay, gradually cooling after each shift — except for the period after 2001, when surface temperatures were cooling quite drastically. Though not visible in Figure 5-3, there may also have been another surge in Alaska surface temperature in 2013. If history repeats itself, another gradual (or not so gradual) cooling will follow in the not-so-distant future.

MODEL-DATA COMPARISON



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 5-5

How well do climate models simulate Alaska land surface temperatures? For the period of 1900 to 1975, the climate model performance isn't too bad (relative to their poor performance for the most recent 35 years). (See Figure 5-5.) The difference in the observed trend in Alaska surface temperatures from 1900 to 1975 and the trend of all the ensemble members of the climate models stored in the CMIP5 archive (models used for the upcoming IPCC AR5) is only about 0.06 deg C per decade, with the models showing a slight warming and the data showing basically no warming.

According to the models, if manmade greenhouse gases caused global warming, Alaska land surface air temperatures warmed about 1.4 deg C since 1977, based on the linear trend. (See Figure 5-6.) Based on the linear trend of the data, however, land surface air temperatures in Alaska have not warmed since 1977. In fact, since the early 2000s, Alaskan surface air temperatures have cooled rapidly.

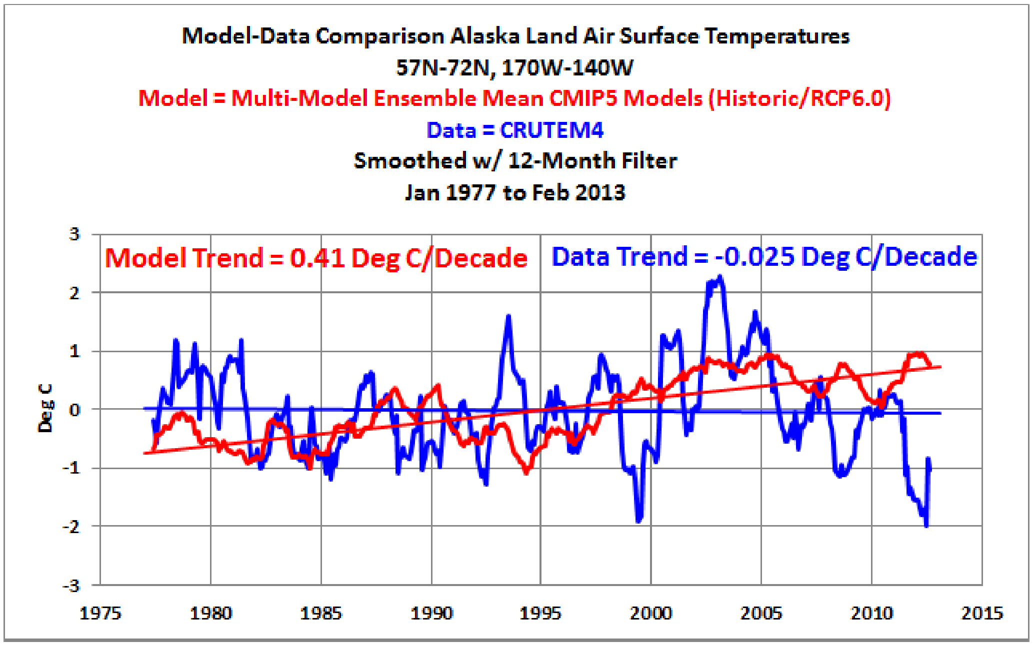


Figure 5-6

CHAPTER 5.2 SUMMARY

Surface temperature data in some parts of the globe may show a long-term warming trend. But long-term trends can mask the cause of the warming. The apparent long-term warming of Alaska surface temperatures depends on one year of data, when an upward step in surface temperatures occurred in response to the 1976 Pacific Climate Shift. If that one year of data were removed, Alaska surface temperatures would show no warming since 1900.

Climate models estimated that Alaska land surface air temperatures would warm about 1.4 deg C since 1977, but Alaska surface temperatures, based on the linear trend, show no warming in that 35+ year time period.

Climate models cannot simulate Alaska surface air temperatures.

Chapter 5.3 – Regional Model Failure: Greenland and Iceland Land Surface Air Temperature Anomalies

In this model-data comparison, I examine Greenland land surface air temperatures, using coordinates: 60N-85N, 75W-10W. Those coordinates also capture Iceland and parts of Canada's Ellesmere and Baffin Islands, but for the most part, it's Greenland data. The observations-based dataset is the UKMO CRUTEM4, and the models are represented by the multi-model ensemble mean of the models stored in the CMIP5 (IPCC AR5) archive.

This chapter is an expanded version of my blog post here.

INTRODUCTION

It always strikes me as odd that global warming enthusiasts announce that surface temperatures in some parts of the globe are warming faster than simulated by climate models. They're only advertising the fact that the models don't work well for those areas, thus affirming the failure of the models.

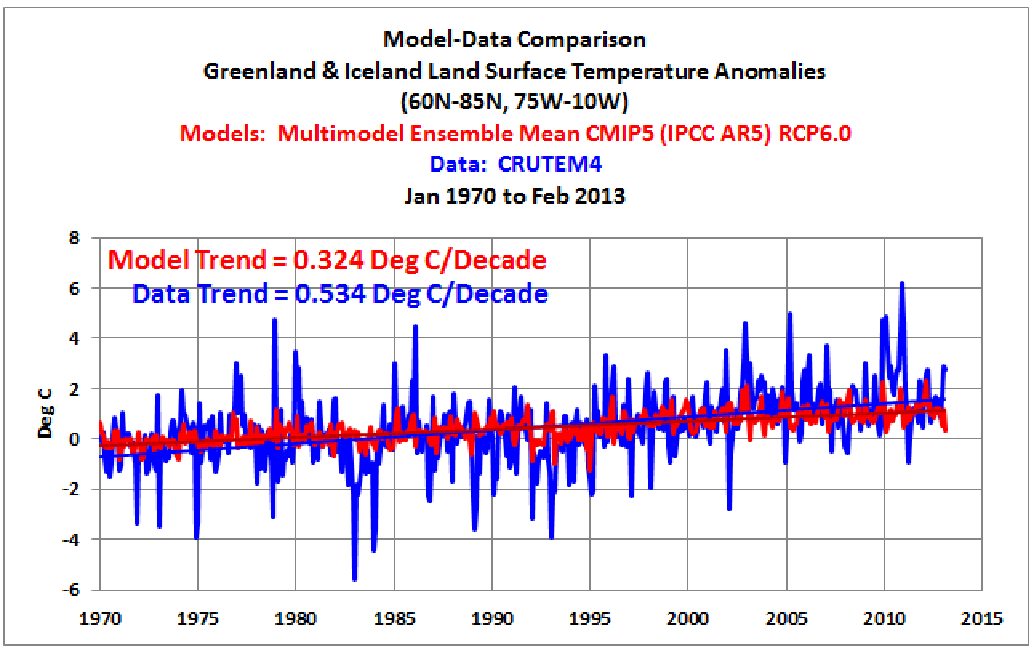


Figure 5-7

Greenland is a hotspot for climate alarmism in more ways than one. A monstrously large chunk of glacial ice sits atop Greenland. As it melts, it contributes to the rise in sea levels. The future warming rate of surface temperatures in Greenland (assuming they warm) will obviously impact glacial ice melt there. Greenland is also one of the locations around globe where land surface air temperatures in recent decades warmed faster than estimated by models. (See Figure 5-7.) Somehow, the Chicken Littles of the anthropogenic global warming movement twist those model failures into confident proclamations of doom, shouting that we're going to drown because rising sea levels.

Since 1970, based on the linear trends in Figure 5-7, Greenland and Iceland surface air temperatures warmed at a rate that's about 65% faster than predicted by the models. That's not a very good showing for the models.

And the disparity between the models and observations is even worse if we start the comparison in 1995, for example. (See Figure 5-8.) During the last 18 years, Greenland and Iceland land surface air temperatures warmed at a rate that's more than 2.5 times faster than the models hindcast. That's a **major** failure for the models. Obviously, the modelers have no clue about what causes land surface temperatures to warm there.

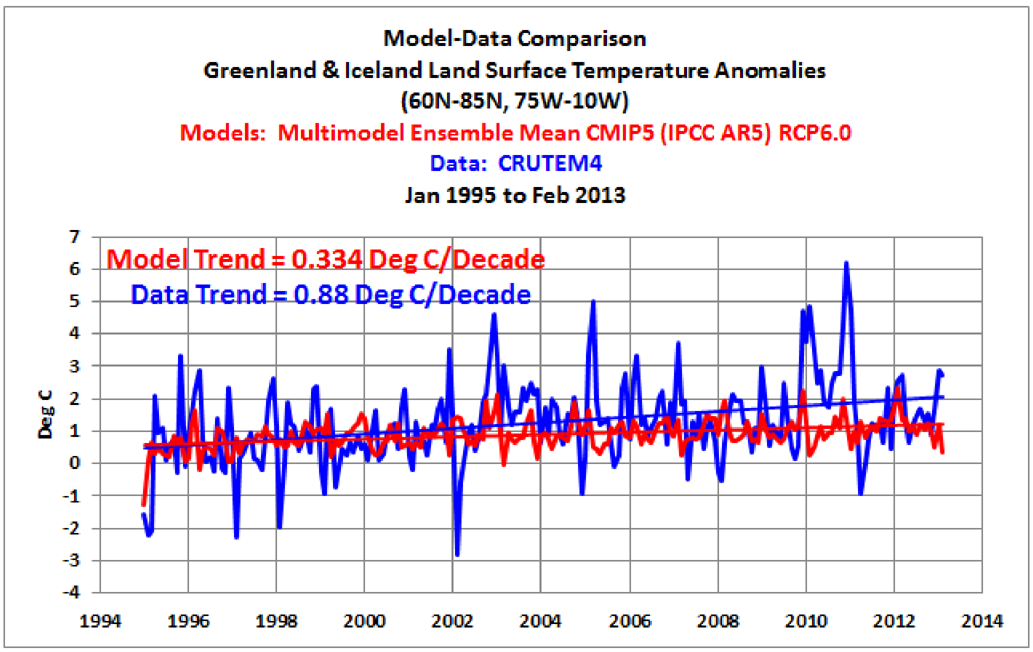


Figure 5-8

LOOKING AT THE RECENT WARMING PERIOD DOESN'T TELL THE WHOLE STORY

The data in Figure 5-7 cover a period of just over 40 years. Let's look at a model-data comparison for the 40-year period before that one, January, 1930 to December, 1969. (See Figure 5-9.) During that multidecadal period, land surface air temperature anomalies in Greenland and Iceland cooled, and they cooled quite **rapidly**, at a rate of about -0.28 deg C/decade. On the other hand, the models estimated there would be a miniscule long-term cooling from 1930 to 1969 (the trend is basically flat). Models fail again.

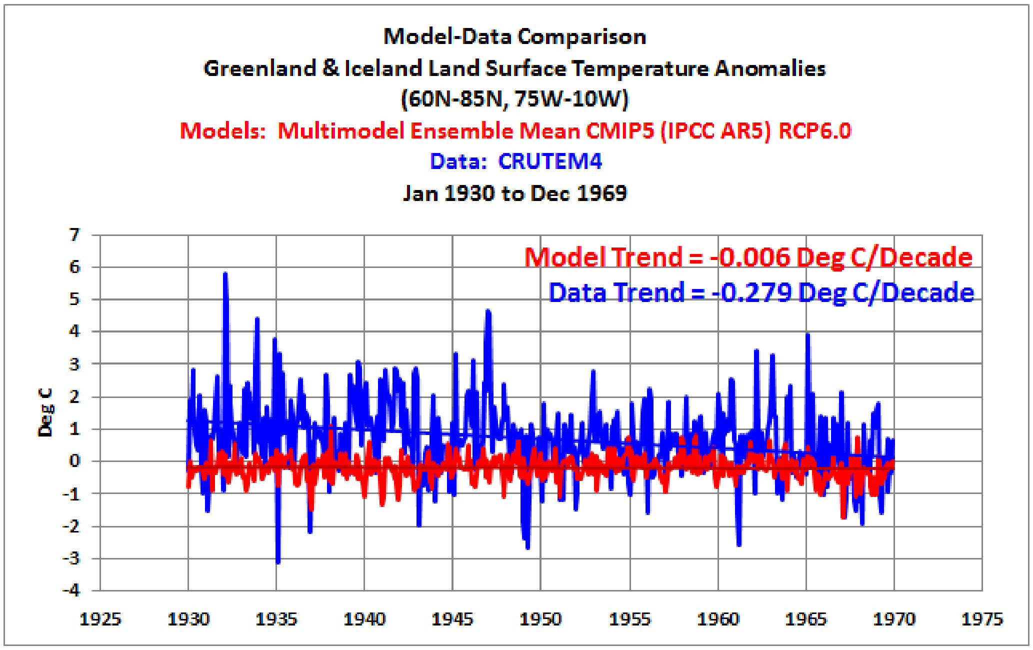


Figure 5-9

In Figure 5-8, I looked at the trends from 1995 to the present. In Figure 5-10, I compare the models and data from January, 1930 to December, 1994. The data show temperatures cooled at a fairly quick rate, about -0.25 deg C per decade, but, the models estimated they would warm. The models were off by almost 0.33 deg C/decade.

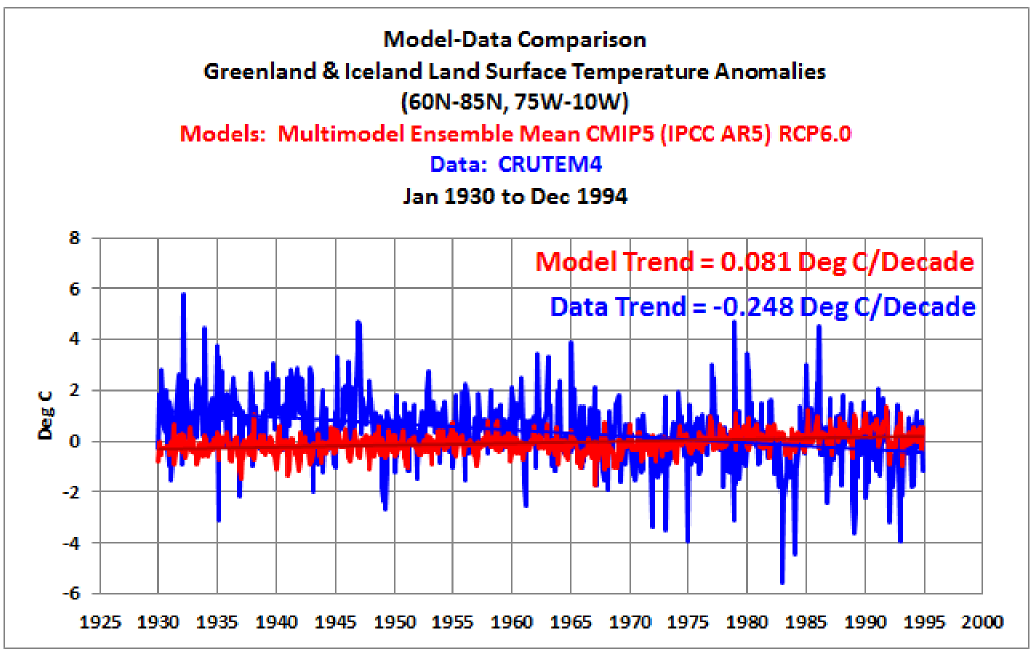


Figure 5-10

ANOTHER THING TO CONSIDER

In addition to demonstrating how poorly the models simulate the land surface temperatures of Greenland and Iceland, I want to make another point: you have to be wary of the start year of any model-based study of Greenland surface temperatures. In Figure 5-11, I compare the models and data for Greenland and Iceland from 1930 to the present. In it, I smoothed the data and model output with 13-month running-average filters to minimize the monthly variations. Greenland and Iceland cooled for much of the period since 1930. The precise break point between the cooling and warming may be debatable, but the most outstanding feature in the data is indisputable: the extreme dip and rebound in the early 1980s. That dip appears about the time of the eruption of El Chichon in Mexico. In 1991, there's another dip when Mount Pinatubo erupted. Mount Pinatubo was a stronger eruption, so the magnitude of the dip in 1982 is unusual. Bottom line: keep in mind that any study of Greenland and Iceland surface temperatures is **greatly** impacted by the start year, because, those dips in temperature during early years will significantly increase the warming trend of recent data.

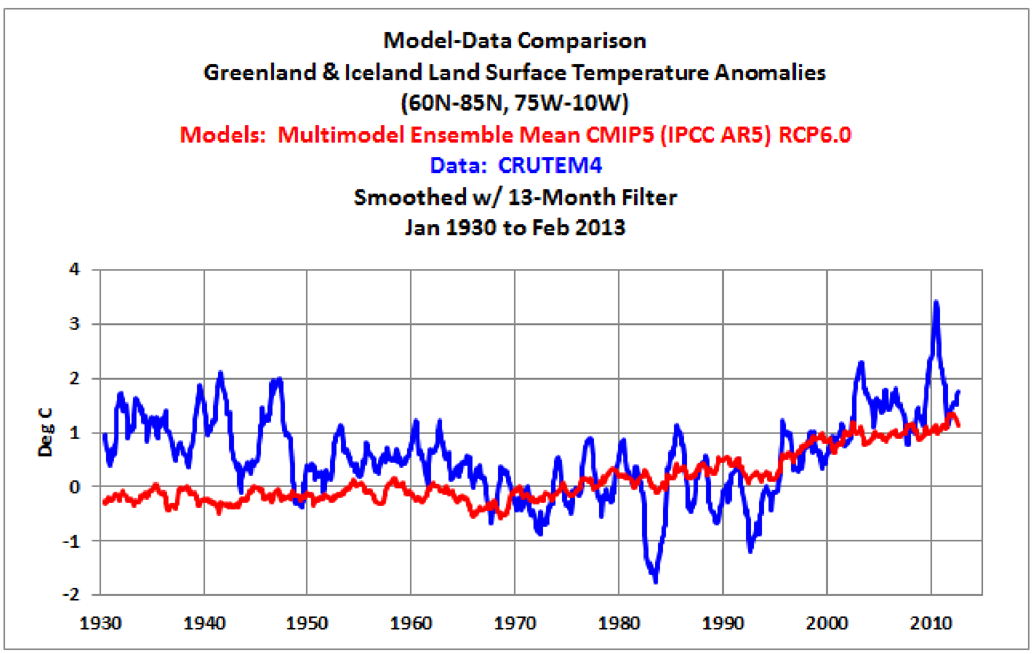
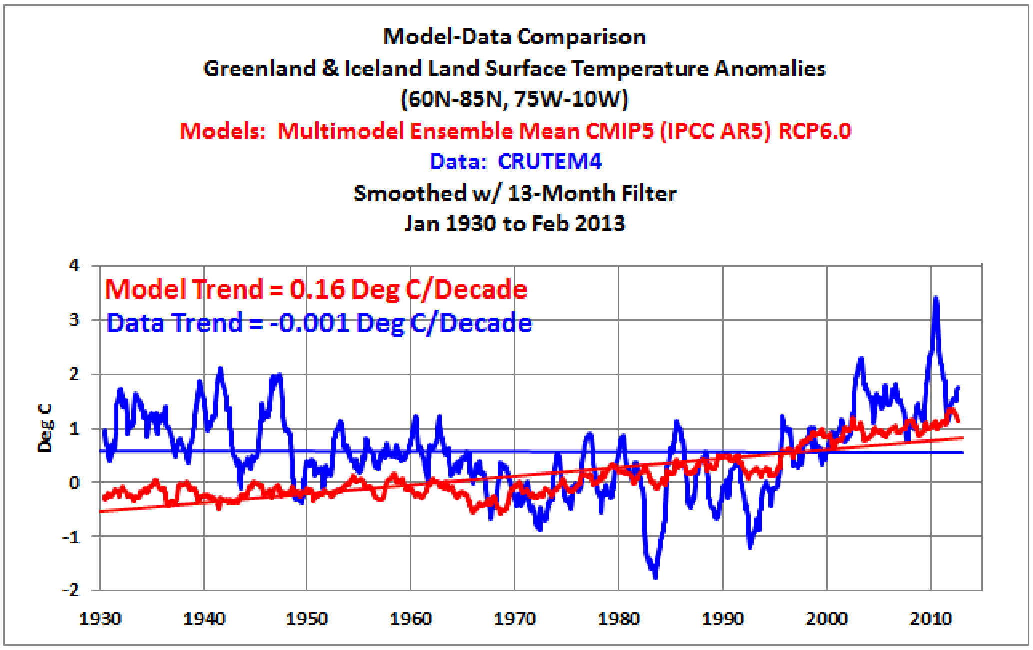


Figure 5-11

Based on the linear trends (of the monthly data, not the smoothed versions), land surface air temperature anomalies for Greenland and Iceland have not warmed since 1930. (See Figure 5-12.) But, the models estimated they would warm about 1.3 deg C. Granted, land surface temperatures now are warmer than then they were in the 1930s, but, the models can't explain the decade after decade of cooling that took place from the 1930s to the 1990s — and they definitely haven't explained the recent warming.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 5-12

CHAPTER 5.3 SUMMARY

Since 1930, land surface air temperatures for Greenland and Iceland varied in a very clear pattern. They cooled for the first several decades — until about 1990 (or until about 1970 — the break point is debatable). I compared models and data for the entire span of those two cooling periods. The models could not simulate the cooling of surface temperatures in Greenland and Iceland during either period.

After the above long-term cooling, land surface air temperatures in Greenland and Iceland warmed at a relatively high rate. The models could not simulate that rate of warming either.

The end result of the long-term cooling, followed by a shorter-term warming, is this: based on the linear trend, land surface air temperatures in Greenland and Iceland haven't warmed since 1930. The climate models prepared for the IPCC's 5th Assessment Report, flying in the face of reality, said that land surface temperatures there should have warmed about 1.3 deg C in that time.

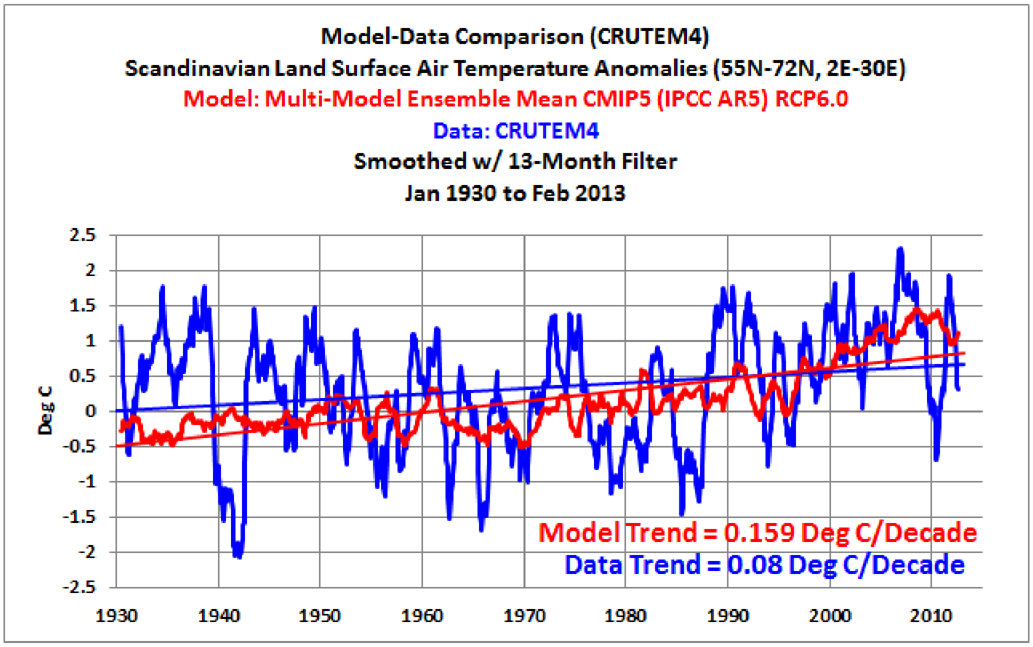
The models show **no skill** at being able to simulate the multidecadal or long-term (since 1930) surface temperatures in Greenland and Iceland. Therefore, what the models have to say about ice melt in Greenland is meaningless.

Chapter 5.4 – Regional Model Failure: Scandinavian Land Surface Air Temperature Anomalies

In the last two chapters, I illustrated how climate models cannot accurately simulate the surface temperatures in two Arctic regions, Alaska and Greenland-Iceland. Next, I look at Scandinavia.

I again use the UKMO CRUTEM4-based land surface air temperature anomaly data and the CMIP5-archived multi-model ensemble mean of the climate models prepared for the IPCC's 5th Assessment Report (AR5). The coordinates used for Scandinavia are: 55N-72N, 2E-30E. The climate model hindcasts are based on the historic forcings and the RCP6.0 scenario.

MODELED LONG-TERM TRENDS ARE TOO HIGH



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 5-13

Figure 5-13 is a model-data comparison of Scandinavian land surface air temperature anomalies, starting in 1930. I smoothed both the data and model outputs with 13-month running-average filters to reduce the monthly variations or "weather noise." Also, note that the spreadsheet software calculated the linear trends from the monthly data and monthly model outputs, not from the smoothed versions. According to the models, if manmade greenhouse gases were responsible for the warming of land surface air temperature anomalies in Scandinavia, they would have warmed about 2 times faster than they actually did. To put it another way, since 1930, Scandinavian land surface air temperatures warmed at half the rate estimated by the models. Not a very good showing on the part of the models.

IT GETS WORSE

Look closely at the surface temperature data in Figure 5-13. There's a very obvious upward shift in the data in the late 1980s. In Figure 5-14, I highlight that 2-year period of January, 1987 to December, 1988 and remove the model output.

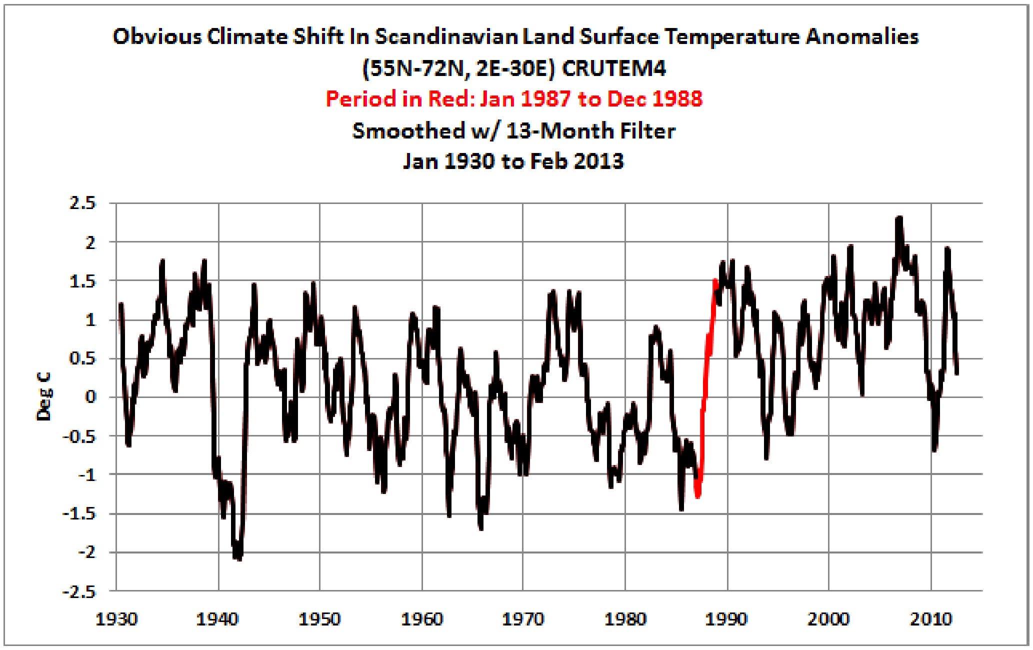
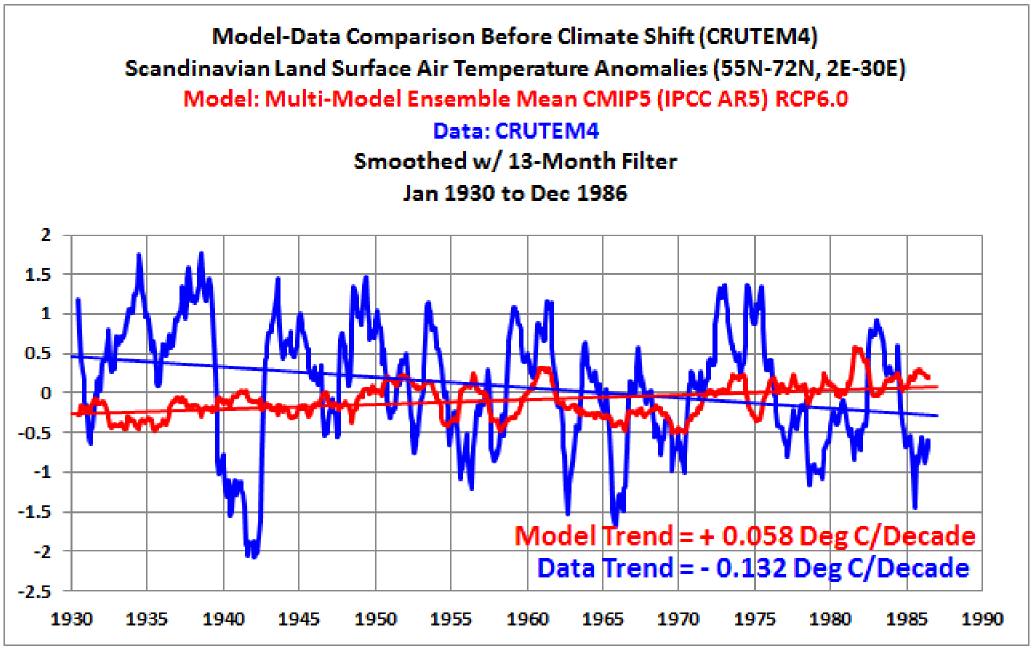


Figure 5-14

From 1930 through 1986, Scandinavian land surface air temperatures cooled. (Note the large dip and rebound at the time of World War II.) Then, there was a very strong warming surge in 1987 and 1988, followed by the period of 1989 to the present when surface temperatures don't appear to have warmed much at all. Next, I compare the models with the data for the periods before and after that big upward shift.

BEFORE THE BIG SHIFT

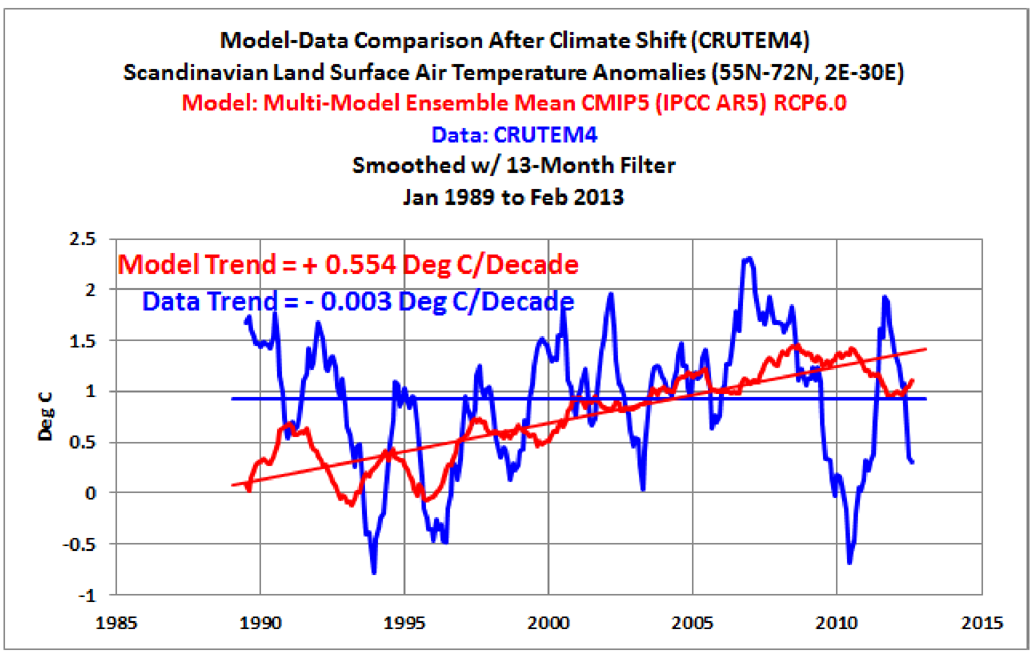
In Figure 5-15, I compare the modeled and observed Scandinavian land surface temperature anomalies for the period of January, 1930 to December, 1986. Scandinavian surface temperatures cooled at a rate of -0.132 deg C per decade, but the models said they warmed at a rate of +0.058 deg C per decade. The models missed the mark by 0.19 deg C per decade. That's a big difference. To put it another way, based on the linear trends, the models estimated that Scandinavian temperatures warmed about 0.33 deg C from 1930 to 1986, but surface temperatures there actually **cooled** approximately 0.75 deg C.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 5-15

AFTER THE BIG SHIFT

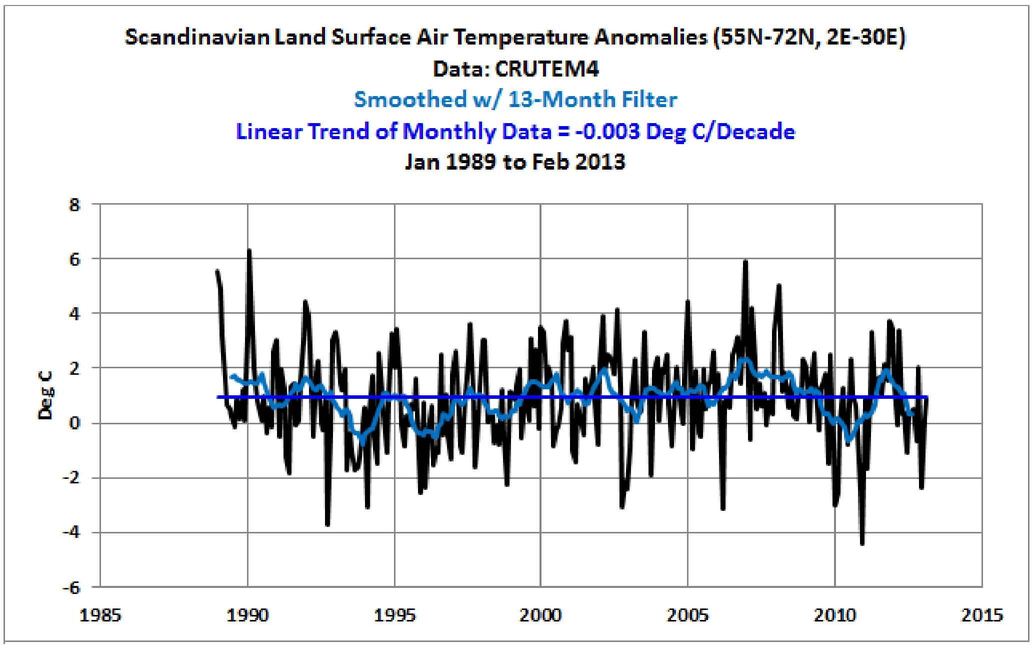


Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 5-16

Then, there's the period of January, 1989 to the present. (See Figure 5-16.) The climate models, following their programmer's beliefs about manmade greenhouse gases, said (based on the linear trend) that Scandinavian land surface temperature anomalies warmed about 1.3 deg C over the past 23+ years. However, based on the linear trend, the actual Scandinavian land surface air temperatures have not warmed.

NOTE: The model output and its steep trend in Figure 5-16 visually skew the graph. That is, the model output makes it appear as if the Scandinavian surface temperature data should also have a trend. In Figure 5-17, I plot the raw month Scandinavia surface temperature data along with a smoothed version and the linear trend (the trend is based on raw data). Without the graph-distorting model output, it is easily seen that the trend of the data is essentially zero.



Note: Trends are based on the monthly (not smoothed) data .

Figure 5-17

WHAT CAUSED THE BIG SHIFT?

Curious shifts exist in surface temperature data from around the globe. Yet, often, when one searches for scientific studies to explain a given shift, one can find no mention of it. The big shift in Scandinavia is one of those instances. I checked online and could find no mention of a late 1980's temperature shift in Scandinavian surface temperatures.

One of the many positive things about investigating climate-related data and presenting your findings on a blog is that sometimes one of your readers will know of or have written a scientific study about similar findings in a nearby or larger region. I originally presented a condensed version of the above discussion of Scandinavian surface temperatures in my blog post here. Shortly after I posted it, Marcel Crok, a science writer from the Netherlands, commented that he had recently co-authored a paper with

Jos de Laat of the Royal Netherlands Meteorological Institute (KNMI) about a similar shift in the surface temperatures of Europe, not only Scandinavia. (See De Laat & Crok (2013) "A Late 20th Century European Climate Shift: Fingerprint of Regional Brightening?") Marcel Crok presented their findings in a post at his blog here**.**

In my blog post, I wrote about a likely cause for the 1987/88 shift in Scandinavian surface temperatures:

> *It's probably a combination of a couple of natural factors. I did a quick search for papers that explained the shift but didn't find anything conclusive. Scandinavian visitors may know of some and hopefully they'll provide us with links.*
>
> *The Arctic Oscillation appears to have had a strong influence around that time. The Arctic Oscillation Index is based on sea level pressures north of 20N.* ***Wikipedia*** *has a good overview here. Also see the NOAA webpage here, and the Arctic Oscillation Index data here.*

I then went on in that post to illustrate the similar shifts in the annual Arctic Oscillation Index. (See Figures 5 through 10 of that post here.)

To explain the late 1980's shift in European temperatures, De Laat & Crok (2013) used a sea level pressure-based index closely related to the AO (Arctic Oscillation Index) called the NAO (North Atlantic Oscillation). (See the NOAA North Atlantic Oscillation webpage here.)

Regardless of the cause of the big shift, the climate models did not capture the cooling of Scandinavian land surface temperatures before the shift nor the flat temperatures after it.

CHAPTER 5.4 SUMMARY

Climate models double the observed warming rate of Scandinavian land surface air temperatures after 1930.

And the models failed in another big way. Scandinavian surface temperatures include a large shift in the late 1980s. Before the shift, Scandinavian surface temperatures had cooled at a quick rate. After the shift, the surface temperature data show no warming. That is, Scandinavian surface temperatures haven't warmed since 1989. Climate models, in contrast, estimated that surface temperatures in Scandinavia, both before and after the observed temperature shift, should have warmed at considerable rates.

Scandinavia is yet another of the regions in the high latitudes of the Northern Hemisphere where climate models cannot simulate the multidecadal changes in warming or cooling rates.

Chapter 5.5 – Daily Maximum and Minimum Temperatures and DTR (Diurnal Temperature Range)

This chapter was first presented in my blog post "Model-Data Comparison: Daily Maximum and Minimum Temperatures and Diurnal Temperature Range (DTR)". It was also cross posted at WattsUpWithThat here. It has been expanded and edited for readability in this book.

CHAPTER OVERVIEW

The temperature difference between daily maximum and minimum temperatures is called the "diurnal temperature range." Those promoting CAGW (Catastrophic Anthropogenic Global Warming) assert that the much-reported decrease in the diurnal temperature range is a "fingerprint" of human-induced global warming. As "proof," they cite climate models, of course. Then, along came the BEST (Berkeley Earth Surface Temperature) data, released to the public in October, 2011. That new dataset showed an increase in the diurnal temperature range since 1988, contradicting the models.

In this chapter, I compare the BEST dataset's daily maximum (Tmax) and minimum (Tmin) temperature anomalies with the multi-model ensemble mean of the climate models stored in the CMIP5 archive. The models did not perform well — and that's putting it nicely.

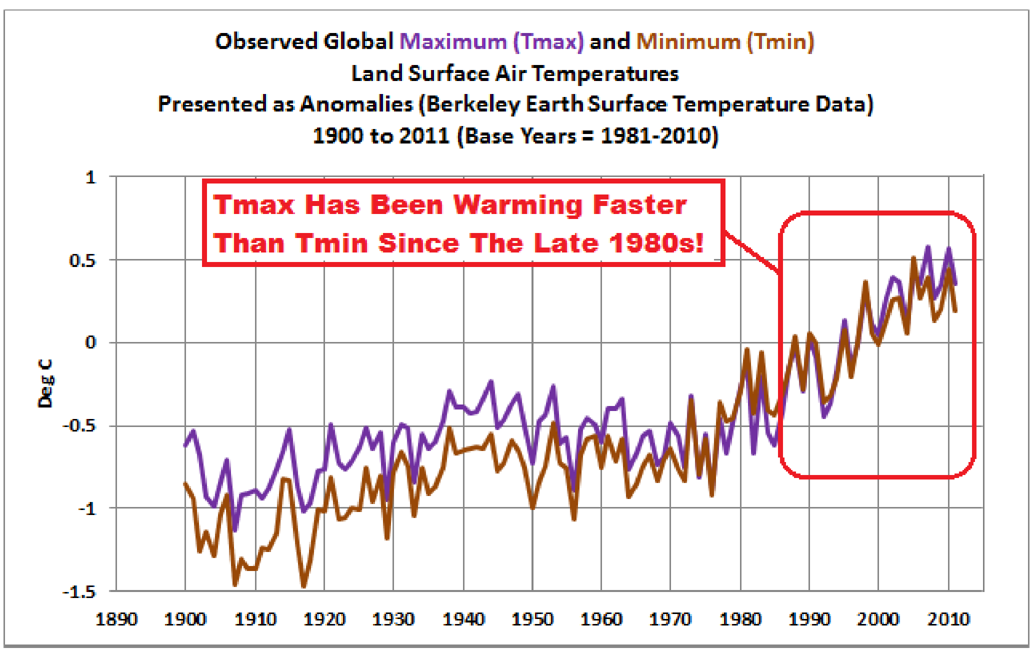


Figure 5-18

If they think there has been a decrease in diurnal temperature range and that the decrease is a "fingerprint" of human-induced global warming, climate scientists need a better AFIS.

INTRODUCTION

The following are examples of scientific studies whose authors blamed human-induced global warming for a narrowing of the diurnal temperature range.

Easterling, et al. (1997) "Maximum and Minimum Temperature Trends for the Globe": in their often-cited paper about the changes in the Daily Maximum (Tmax) and Minimum (Tmin) Temperatures and the daily differences between the two, the Diurnal Temperature Range (DTR), they examine data for the period of 1950 to 1993. The abstract begins:

> *Analysis of the global mean surface air temperature has shown that its increase is due, at least in part, to differential changes in daily maximum and minimum temperatures, resulting in a narrowing of the diurnal temperature range (DTR).*

Karl, et al. (1991) "Global Warming: Evidence for Asymmetric Diurnal Temperature Change" preceded Easterling, et al. The abstract in its entirety is interesting (my boldface):

> *Analyses of the year-month mean maximum and minimum surface thermometric record have now been updated and expanded to cover three large countries in the Northern Hemisphere (the contiguous United States, the Soviet Union, and the People's Republic of China). They indicate that most of the warming which has occurred in these regions over the past four decades can be attributed to an increase of mean minimum (mostly nighttime) temperatures. Mean maximum (mostly daytime) temperatures display little or no warming. In the USA and the USSR (no access to data in China) similar characteristics are also reflected in the changes of extreme seasonal temperatures, e.g., increase of extreme minimum temperatures and little or no change in extreme maximum temperatures. The continuation of increasing minimum temperatures and little overall change of the maximum leads to a decrease of the mean (and extreme) temperature range, an important measure of climate variability.*
>
> *The cause(s) of the asymmetric diurnal changes are uncertain, but there is some evidence to suggest that changes in cloud cover play a direct role (where increases in cloudiness result in reduced maximum and higher minimum temperatures). Regardless of the exact cause(s), these results imply that either: (1) climate model projections considering the expected change in the diurnal temperature range with increased levels of the greenhouse gases are*

> *underestimating (overestimating) the rise of the daily minimum (maximum) relative to the maximum (minimum), or (2)* ***the observed warming in a considerable portion of the Northern Hemisphere landmass is significantly affected by factors unrelated to an enhanced anthropogenically-induced greenhouse effect****.*

More recently, there's Braganza, et al. (2004) "Diurnal Temperature Range as an Index of Global Climate Change During the Twentieth Century." Their abstract begins (my boldface):

> *The usefulness of global-average diurnal temperature range (DTR) as an index of climate change and variability is evaluated using observations and climate model simulations representing unforced climate variability and anthropogenic climate change. On decadal timescales, modelled and observed intrinsic variability of DTR compare well and are independent of variations in global mean temperature.* ***Observed reductions in DTR over the last century are large and unlikely to be due to natural variability alone.***

For James Hansen fans, there's Hansen, et al. (2005) "Long-term Changes of the Diurnal Temperature Cycle: Implications About Mechanisms of Global Climate Change," a model-based study. This paper attributes the decrease in the diurnal temperature range to anthropogenic factors. Its abstract starts (my boldface):

> *We use a global climate model to investigate the impact of a wide range of radiative forcing and feedback mechanisms on the diurnal cycle of surface air temperature. This allows us not only to rule out many potential explanations for observed diurnal changes, but to infer fundamental information concerning the nature and location of the principal global climate forcings of this century. W****e conclude that the observed changes of the diurnal cycle result neither from natural climate variability nor a globally-distributed forcing, but rather they require the combination of a (negative) radiative forcing located primarily over continental regions together with the known globally-distributed forcing due to anthropogenic greenhouse gases.***

And, of course, there's Jones, et al. (1999) "Surface Air Temperature and Its Changes Over the Past 150 Years." Its abstract includes:

> *The twentieth-century warming has been accompanied by a decrease in those areas of the world affected by exceptionally cool temperatures and to a lesser extent by increases in areas affected by exceptionally warm temperatures. In recent decades there have been much greater increases in night minimum temperatures than in day maximum temperatures, so that over 1950–1993 the diurnal temperature range has decreased by 0.088C per decade.*

The authors of those papers could form the charter membership of a Who's Who of climate science. Just look at a few of the lead authors. The lead author of Jones et al. (1999) is Phil Jones, Director of the Climatic Research Unit of the University of East Anglia. Jones played a dominant role in Climategate. James Hansen, lead author of Hansen, et al. (2005), was the head of the Goddard Institute for Space Studies in New York. Alice Bell's article in "The Guardian" "James Hansen Retires from Science to Spend More Time with His Politics," explains that Hansen intends to spend more time as a climate activist. That's not too surprising because he was an activist while he was still the head of GISS. And the lead author of Karl, et al. (1991) is Thomas R. Karl, Director of NOAA's NCDC (National Climatic Data Center). The above studies, along with those of Braganza, et al. (2004), found that the diurnal temperature range was decreasing, that climate models confirmed the physics of that phenomenon, and called the decrease in the diurnal temperature range a "fingerprint" of human-induced global warming.

THE FINDINGS OF THE BEST TEAM

Then, in 2011, along came the latest and greatest land surface air temperature dataset from the BEST (Berkeley Earth Surface Temperature) team. The BEST data was released to the public before the supporting papers were published in peer-reviewed journals.

In Figure 5-18 above, the BEST Daily Maximum (Tmax) and Minimum (Tmin) Temperature data make it obvious that the diurnal temperature range has been **increasing** over the past 2+ decades, not decreasing. That doesn't speak too highly of the "physics" in the climate models used to study diurnal temperature range.

The BEST team address this in their Rohde, et al. (2012) paper "A New Estimate of the Average Earth Surface Land Temperature Spanning 1753 to 2011." There, under the heading of "Diurnal Range," they write:

> *Some of the climate models predict that the diurnal temperature range, that is, the difference between Tmax and Tmin, should decrease due to greenhouse warming. The physics is that greenhouse gases have more impact at night when they absorb infrared and reduce the cooling, and that this effect is larger than the additional daytime warming. This predicted change is sometimes cited as one of the "fingerprints" that separates greenhouse warming from other effects such as solar variability. Previous studies [15-18] reported significant decreases in the diurnal temperature range over the period 1948 to 1994. Jones, et al. [18] for example described the decrease as 0.08°C per decade for the period 1950 to 1993.*

Rohde, et al. (2012) presented the Diurnal Temperature Range in their Figure 4, which

I've included here as my Figure 5-19.

Figure 4 from Rohde et al (2012)

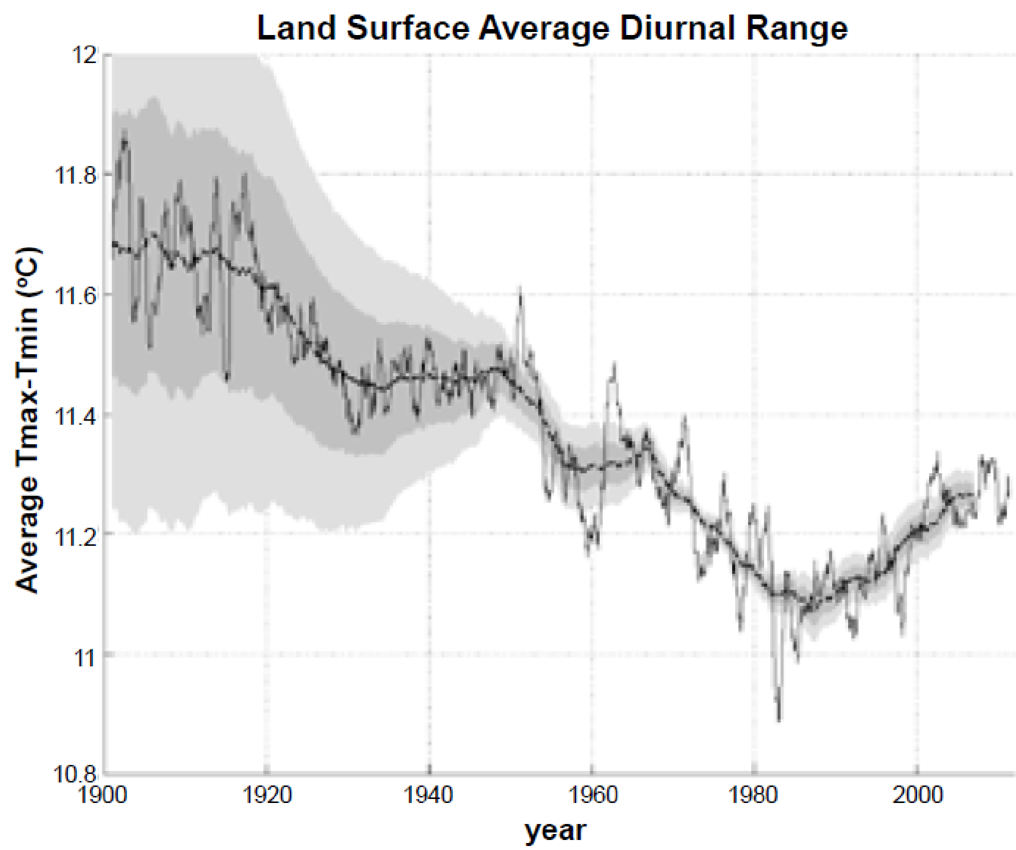


Figure 4: Earth average diurnal range, calculated from records of $D=T_{max}-T_{min}$ using the Berkeley Average estimation program. Shown are both the yearly averages and the 10-year averages, and the 1- and 2-standard deviation uncertainty estimates for the 10-year averages.

Figure 5-19

About their illustration, Rohde, et al. write (my boldface):

> *The result of this calculation is shown in figure 4. The solid line represents the annual average of the diurnal range, and the dashed line shows the 10-year running average. The 1- and 2-standard deviation error uncertainties are shown with the two grey bands for the 10-year average. The behavior of the diurnal range is not simple; it drops from 1900 to 1987, and then it rises. The rise takes place during a period when, according to the IPCC report, the anthropogenic effect of global warming is evident above the background variations from natural causes.*

> *Although the post-1987 rise is not sufficient to undo the drop that took place from 1901 to 1987,* ***the trend of 0.86 ± 0.13°C/century is distinctly upwards with a very high level of confidence****. This reversal is particularly odd since it occurs during a period when the rise in Tavg was strong and showed no apparent changes in behavior.*

Rohde, et al. seem to be throwing a few jabs at the IPCC and the previous papers. Let's see if those jabs are deserved.

MODEL-DATA COMPARISON OVERVIEW

As noted in the CHAPTER OVERVIEW, above, in this chapter of the book, I compare the BEST (Berkeley Land Surface Air Temperature) data to the multi-model ensemble mean of the climate models prepared for the upcoming 5th Assessment Report of the IPCC (Intergovernmental Panel on Climate Change). Below, I compare the daily maximum and minimum temperature data and the differences between the two on a global basis. The source of the data and model outputs, once again, is the KNMI Climate Explorer where the BEST daily minimum and maximum data are presented only as anomalies, not in absolute form. As a result, I cannot present the modeled and observed diurnal temperature ranges in time-series graphs. That's fine. I will simply present instead the differences in the **trends** of modeled and observed daily maximums and minimums.

I break the comparisons into two parts, based on the dividing year identified by Rohde, et al. (2012). The first group of global data comparisons is for the period of 1988 to 2011, which is the period over which Rohde, et al. found an increase in the diurnal temperature range. (Note: 2011 is the last full year of the BEST land surface air temperature dataset.) For the second group, ending in 1987, I use the start year of 1950. I use 1950 for two reasons: 1) based on Rohde, et al.'s Figure 4 (my Figure 5-19), the data uncertainties are quite large before 1950; and 2) so that the mid-20th century cooling period would be a significant portion of the time period.

I use the WMO-recommended base years of 1981-2010 for anomalies in the time-series graphs. (See Chapter 2.2 – The Subtle Differences Due to the Base Years Used for Anomalies, presented earlier, for information about WMO base years.)

Because the IPCC will be presenting regional climate projections in AR5, I also compare the modeled and data linear trends on zonal-mean (latitude average) bases. With these trend comparisons, the fact that data is presented as anomalies becomes a moot point. As a result, I can meaningfully present the trends in the diurnal temperature ranges.

MODEL-DATA COMPARISON – TIME SERIES – 1988 TO 2011

Figure 5-20 is a time-series graph of the BEST global maximum and minimum temperature anomalies for the period of January, 1988 to December, 2011. My analysis confirms the findings of Rohde, et al. (2012). Daily maximum temperatures are warming at a faster rate than the minimums. Based on the differences in the linear trends, the diurnal temperature range increased at a rate of about 0.09 Deg C/decade from 1988 to 2011 (Rohde, et al.'s range: 0.86 ± 0.13°C/century).

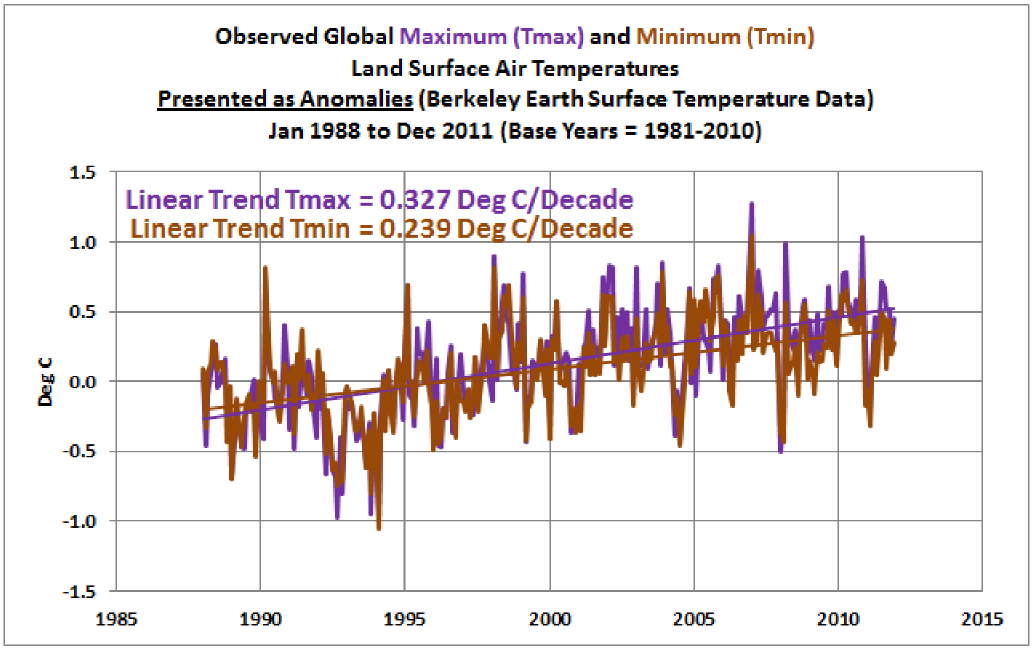


Figure 5-20

The multi-model mean of the CMIP5-archived models, on the other hand, estimated that the global daily minimum and maximum land surface air temperatures each warmed at basically the same rate from 1988 to 2011, with minimums warming at a slightly higher rate. (See Figure 5-21.) In other words, according to the models, if anthropogenic greenhouse gases and aerosols were the cause of the trends in the diurnal temperature range, there should have been minor decrease, when there was actually a significant increase, during this period.

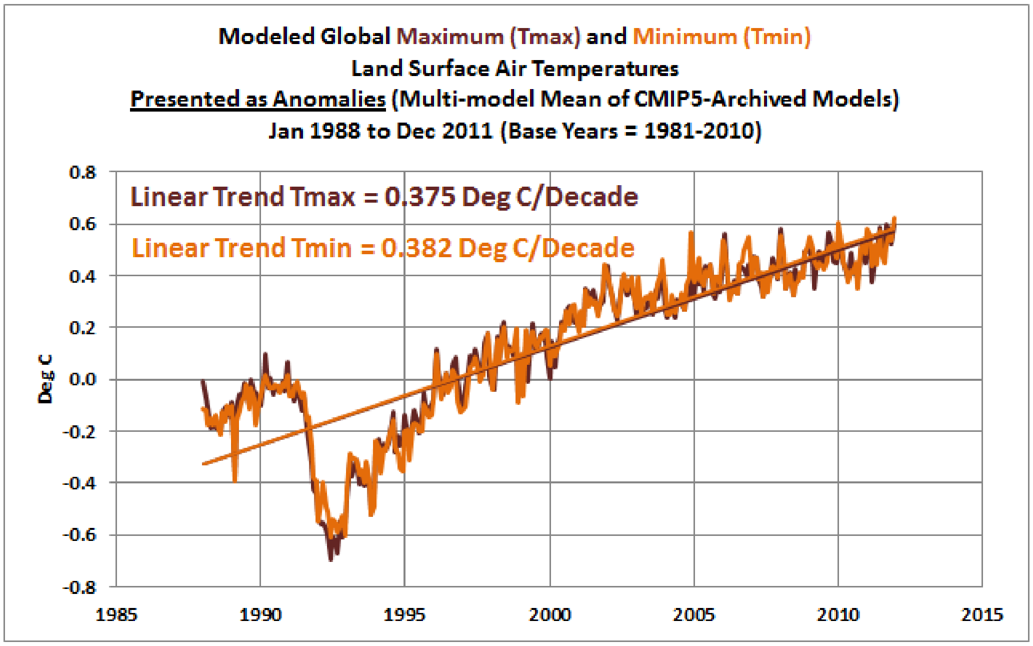


Figure 5-21

MODEL-DATA COMPARISON — TRENDS ON A ZONAL-MEANS BASIS — 1988 TO 2011

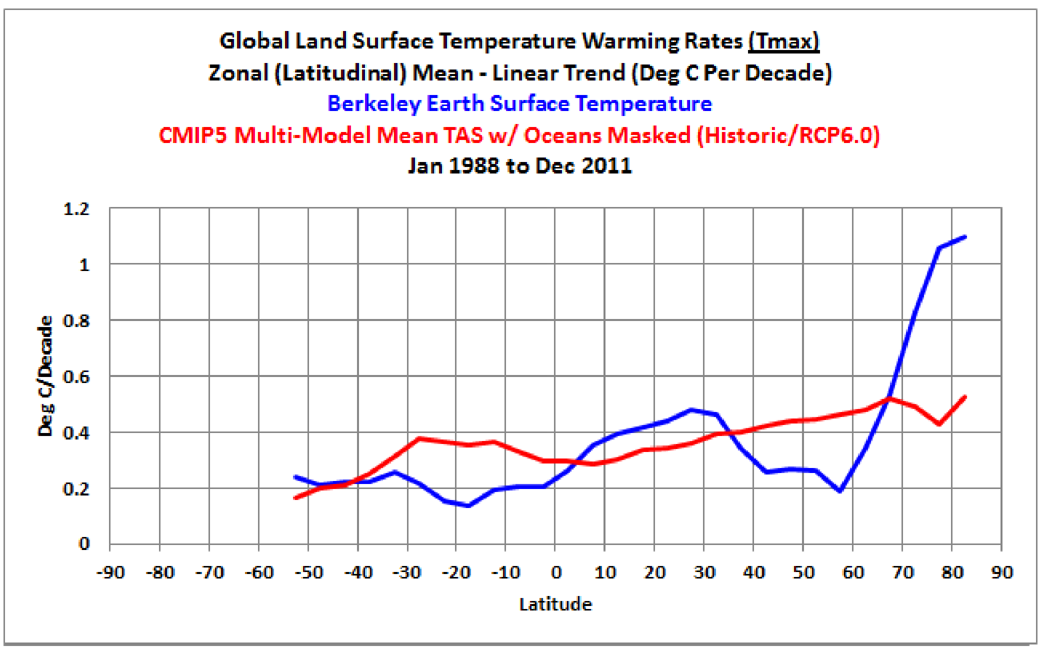


Figure 5-22

In the graphs under this heading, I present the global warming rates based on linear trends for the period of January, 1988 to December, 2011, using zonal-means (latitude average) graphs. Note: in the y-axis (vertical), the warming (and cooling) rates or trends, is scaled in deg C/Decade. The x-axis (horizontal) is scaled in degrees latitude: "-90" (90S) on the left is the South Pole; "0" is the equator; and "90" (90N) is the North Pole. In Figure 5-22, the model-mean output of 0.3 deg C/decade at zero latitude shows that the models estimated that the daily maximum temperatures at the equator should have warmed at a rate of 0.3 deg C per decade from 1988 to 2011.

I'll now discuss the Figure 5-22 differences between the models and the observations. The models overestimated the rate of warming of daily **maximum** temperatures from about 40S to 5N and from about 35N to 65N. The models underestimated the rate of warming slightly from 5N to 35N, but **grossly underestimate the polar-amplified warming** in the Arctic (70N - 82N). Anthropogenic warming proponents continually assert that climate model projections are consistent with polar amplification data. The truth is, the multi-model mean shows ridiculously little polar amplification compared to the data. Some readers might conclude that this is another indication of flaws in the underlying physics programmed into the climate models.

The failure of the models to simulate the polar amplified warming of the daily maximum temperatures is not surprising. As I discussed in Chapter 2.8, models failed to simulate the polar-amplified warming of average surface temperatures in the Arctic during the more recent warming period. The models also completely failed to simulate the polar-amplified cooling in the Arctic during the cooling period from the mid-1940s to the mid-1970s.

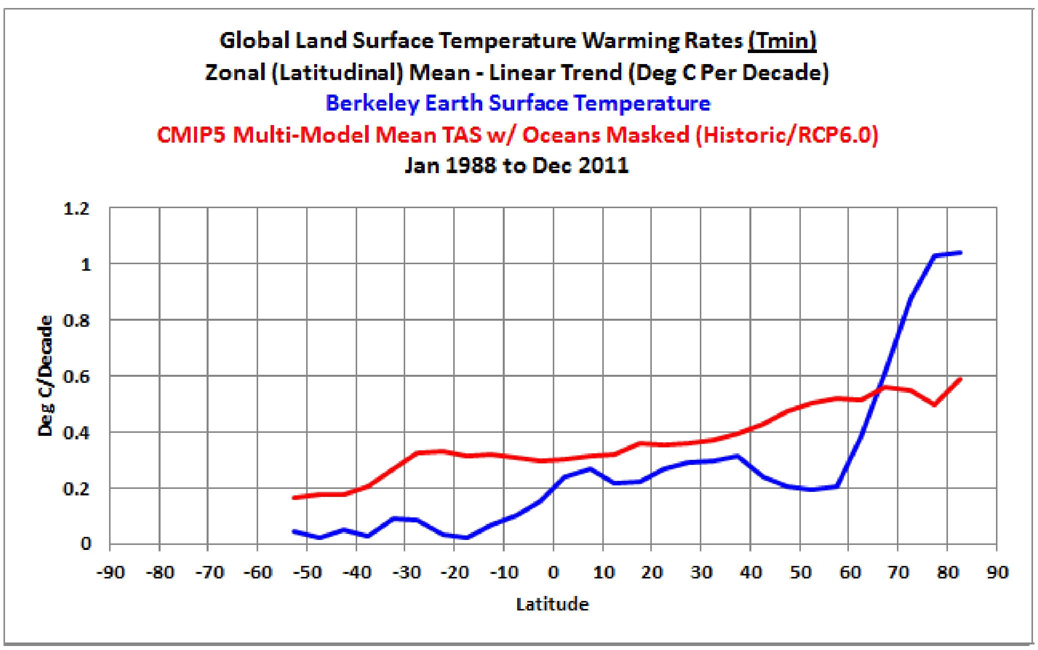


Figure 5-23

In Figure 5-23, I illustrate the modeled and observed warming rates of global daily **minimum** temperatures from 1988 to 2011. The models overestimated the warming rates of minimum temperatures from South America to the Arctic, and then, once again, completely fail to capture the polar-amplified warming in the Arctic. Note also that the observed minimum temperatures show little warming in the extra-tropics of the Southern Hemisphere. The observed warming rates of the minimums increase gradually until just north of the equator, then remain relatively constant until about 57N, where polar amplification kicks in.

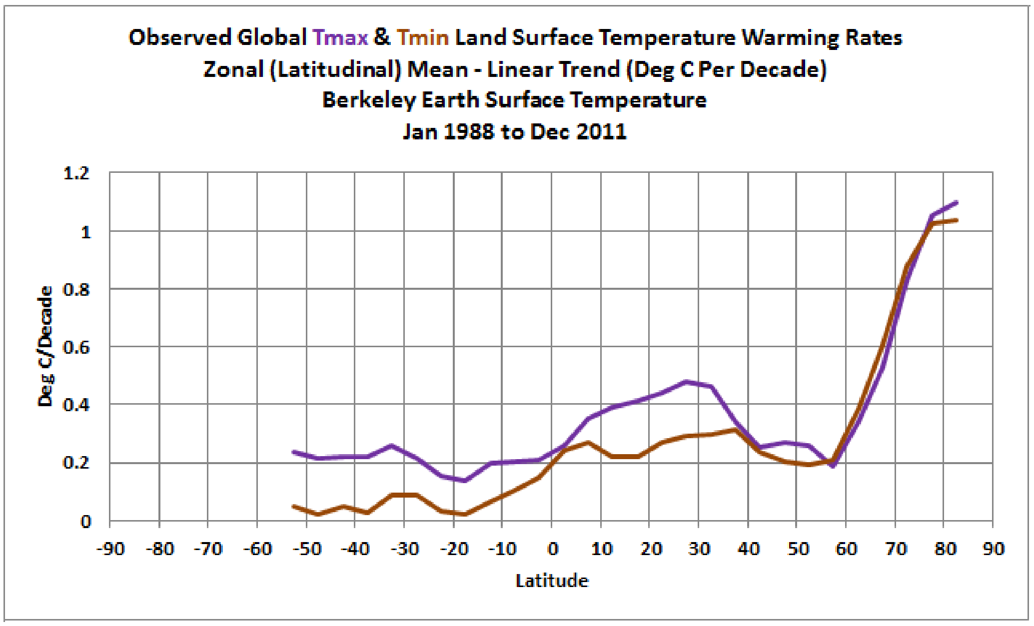


Figure 5-24

Figures 5-24 and 5-25 are background information for Figure 5-26. Figure 5-24 compares the **observed** warming rates in maximum and minimum temperatures from 1988 to 2011, while Figure 5-25 compares the **modeled** maximum and minimum warming rates.

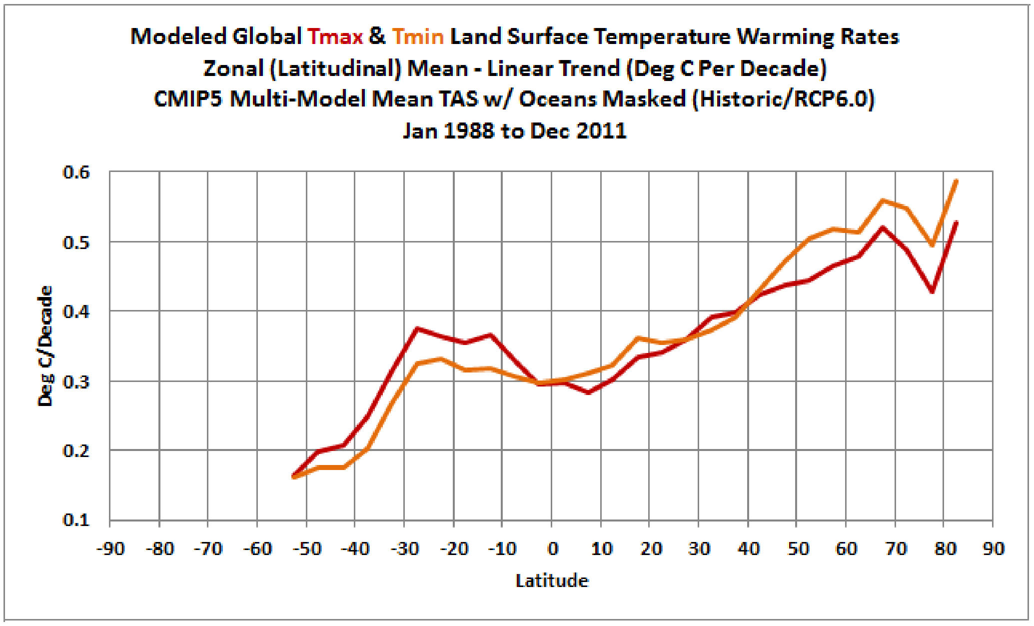


Figure 5-25

In Figure 5-26 are the observed and modeled trends in the diurnal temperature ranges on zonal-mean bases. I calculated them as the differences between the observed and modeled trends in the daily maximum and minimum temperatures. Contrasting Figure 5-20 (actual trends) with Figure 5-21 (modeled trends), it is clear that the models failed to simulate the observed rates of warming. The purpose of Figure 5-26 is to show that trends in observed diurnal temperature ranges are not the same around the globe. Remember: a positive trend in the diurnal temperature range indicates that the maximum temperatures are warming faster than the minimums—and a negative trend in the diurnal temperature range indicates that the minimum temperatures are warming faster than the maximums.

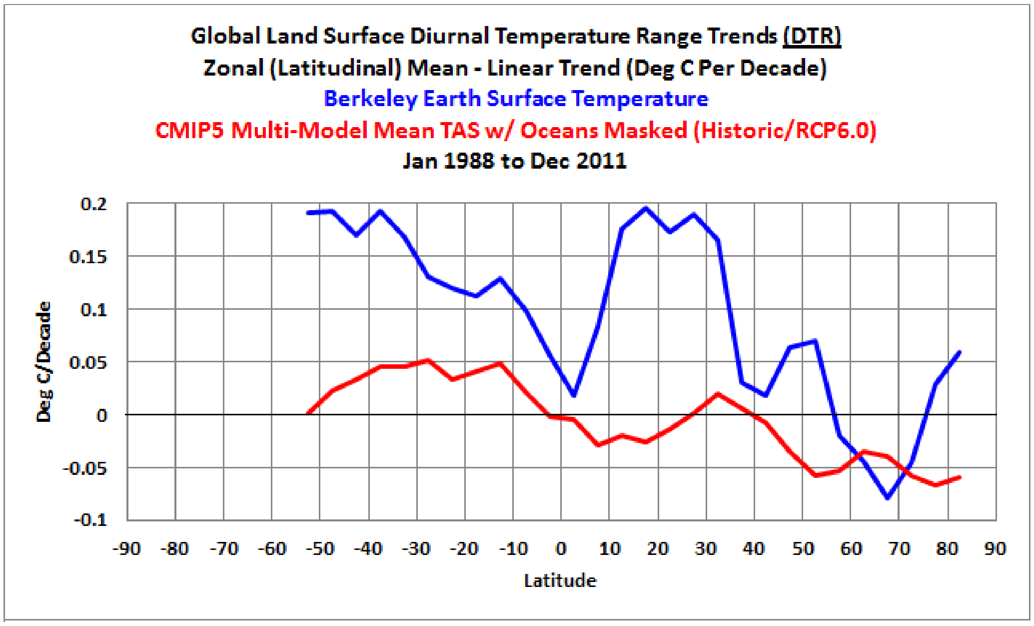


Figure 5-26

MODEL-DATA COMPARISON – TIME SERIES – 1950 TO 1987

In Figures 5-27 and 5-28, I present the observed and modeled global daily maximum and minimum temperatures (as anomalies) for the period of 1950 to 1987. Both the models and observations show that the minimums warmed faster than the maximums. The **observations** show that the minimums warmed 0.11 deg C/Decade faster than the daily maximums. The **models**, on the other hand, show that the minimums warmed only 0.02 deg C/decade faster than the maximums. That is, the models estimated that the decrease in the diurnal temperature range (Tmax minus Tmin) would be less than 20% what actually happened.

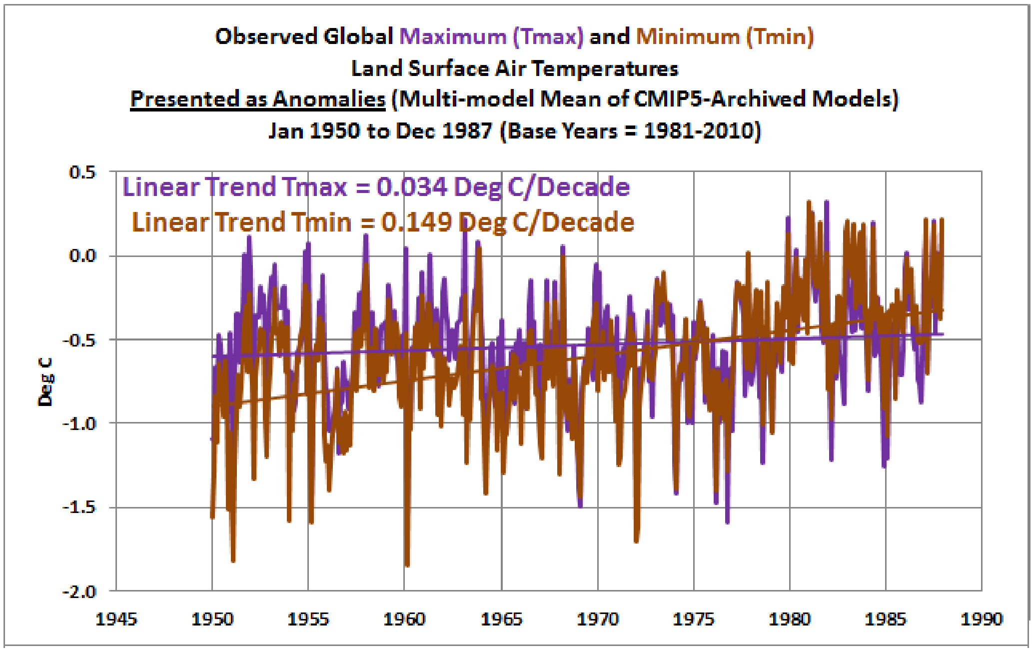


Figure 5-27

# # #

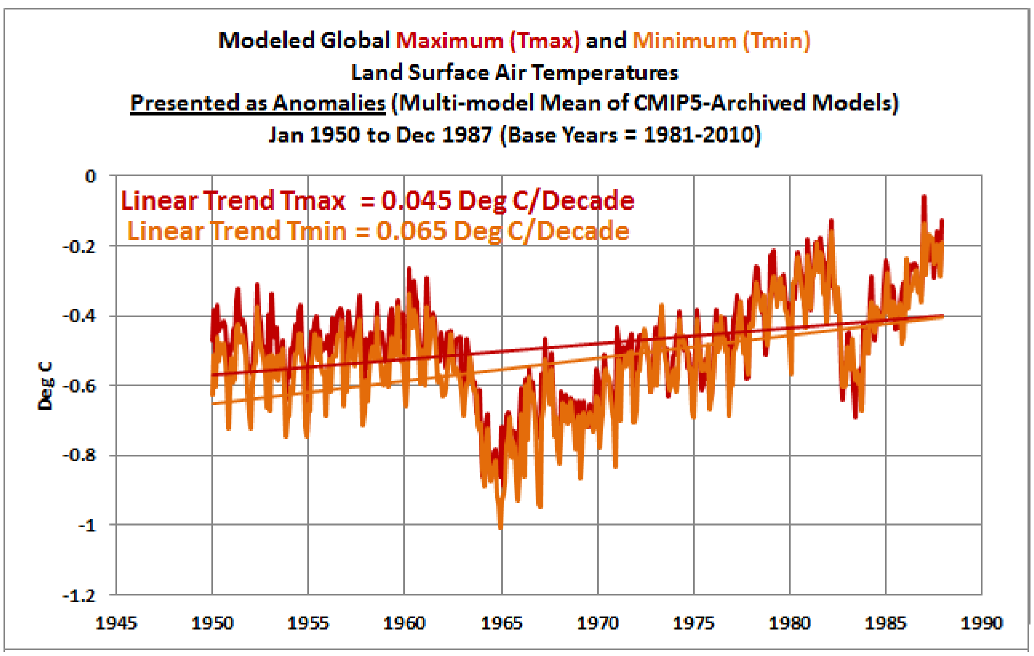


Figure 5-28

MODEL-DATA COMPARISON – TRENDS ON ZONAL MEAN BASIS – 1950 TO 1987

In Figure 5-29, I present the trends in the maximum temperatures from 1950 to 1987 on a latitudinal basis. The models performed reasonably well until the extreme high latitudes of the Northern Hemisphere, where daily maximum temperatures cooled during this period.

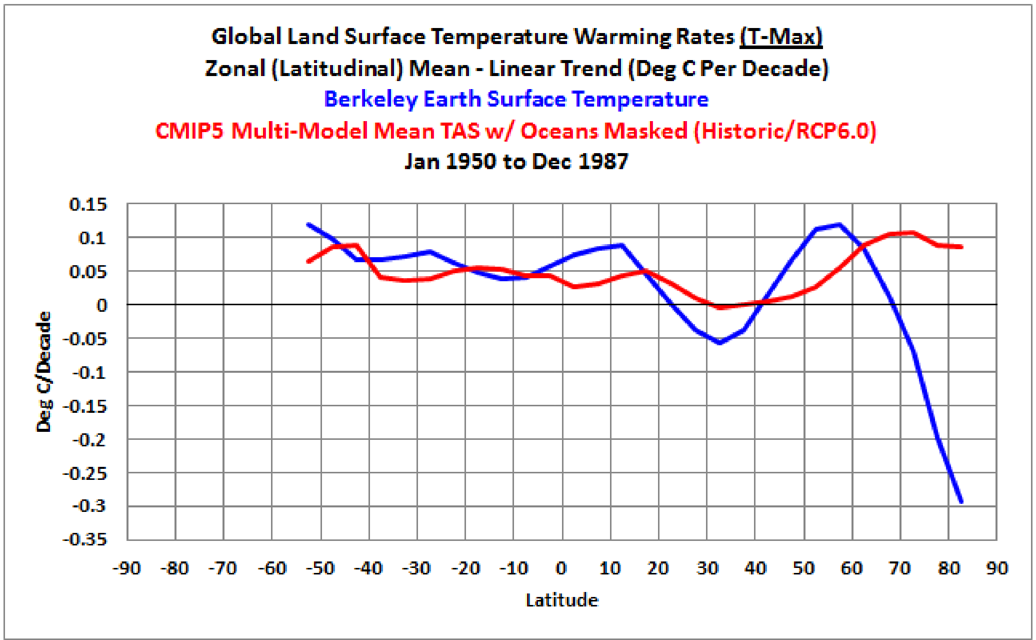


Figure 5-29

The modeled warming rates for the minimum temperatures from 1950 to 1987, Figure 5-30, were consistently lower than the observed trends — until they reach the Arctic, where, once again, observed minimum temperatures cooled drastically while the models say they should have warmed.

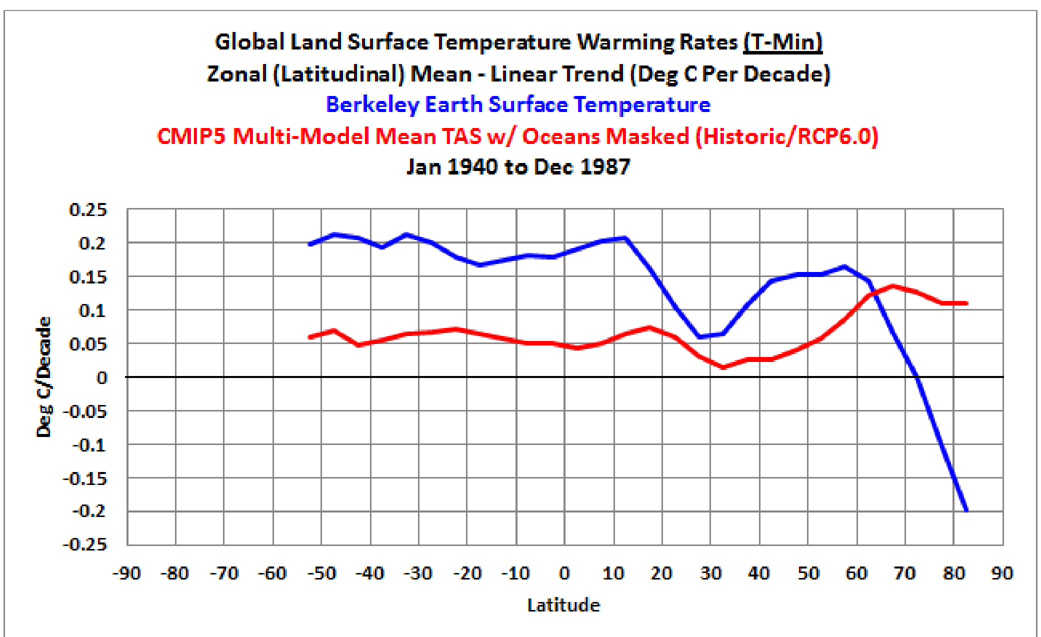


Figure 5-30

Figures 5-31 and 5-32 are background information for Figure 5-33. Figure 5-31 compares the **observed** warming rates in maximum and minimum temperatures from 1950 to 1987, while Figure 5-32 compares the **modeled** maximum and minimum warming rates.

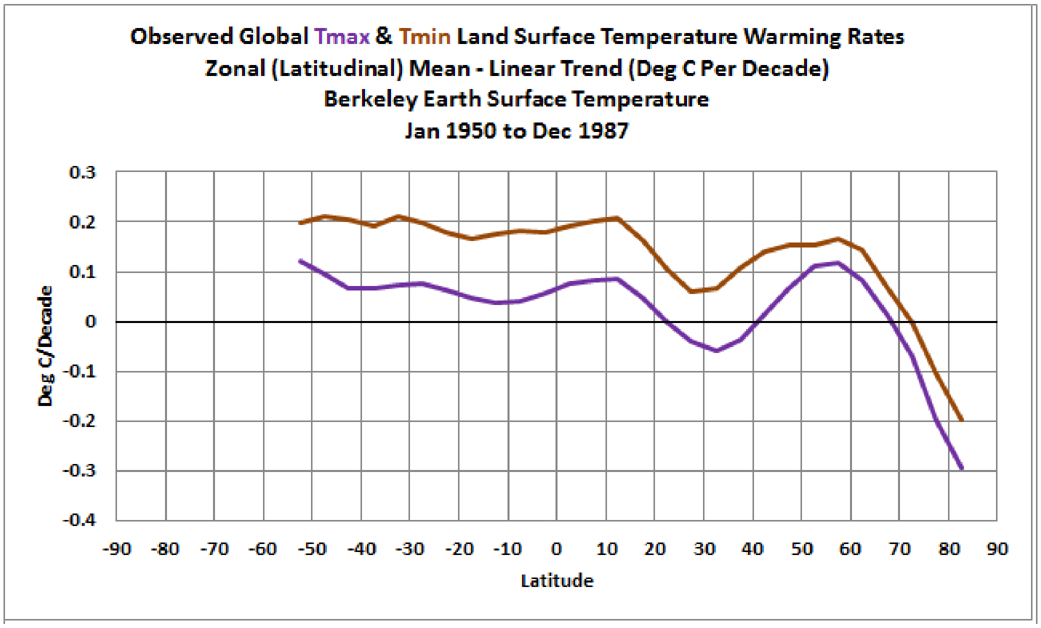


Figure 5-31

# # #

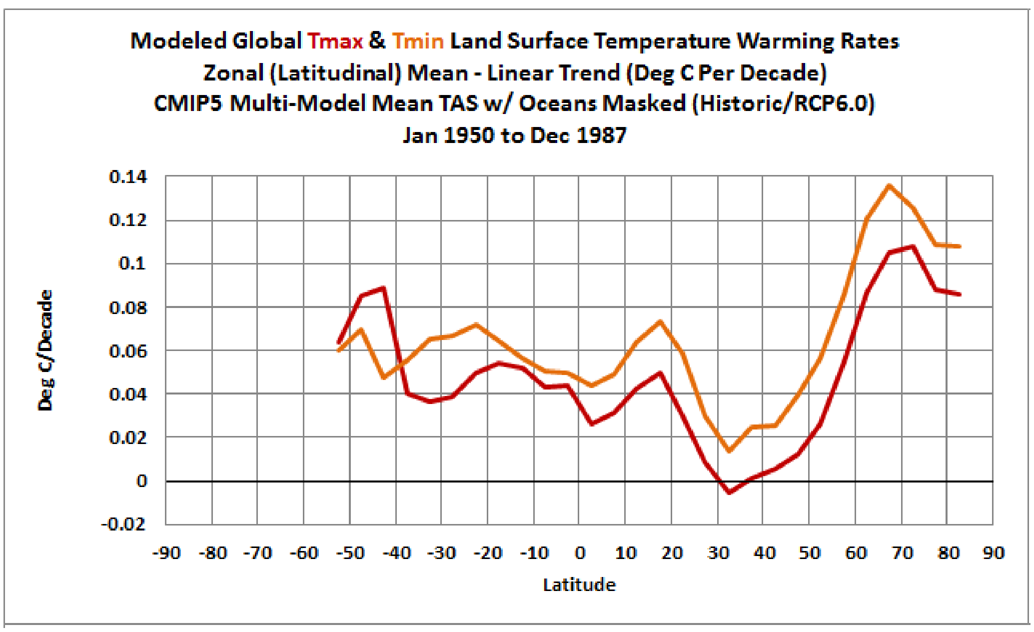


Figure 5-32

Figure 5-33 reveals the wide gap between the modeled and observed trends in global diurnal temperature range for the period of 1950 to 1987. In only one small region, at the mid-latitudes of the Northern Hemisphere, do the modeled trends in diurnal temperature range come even close to the observations.

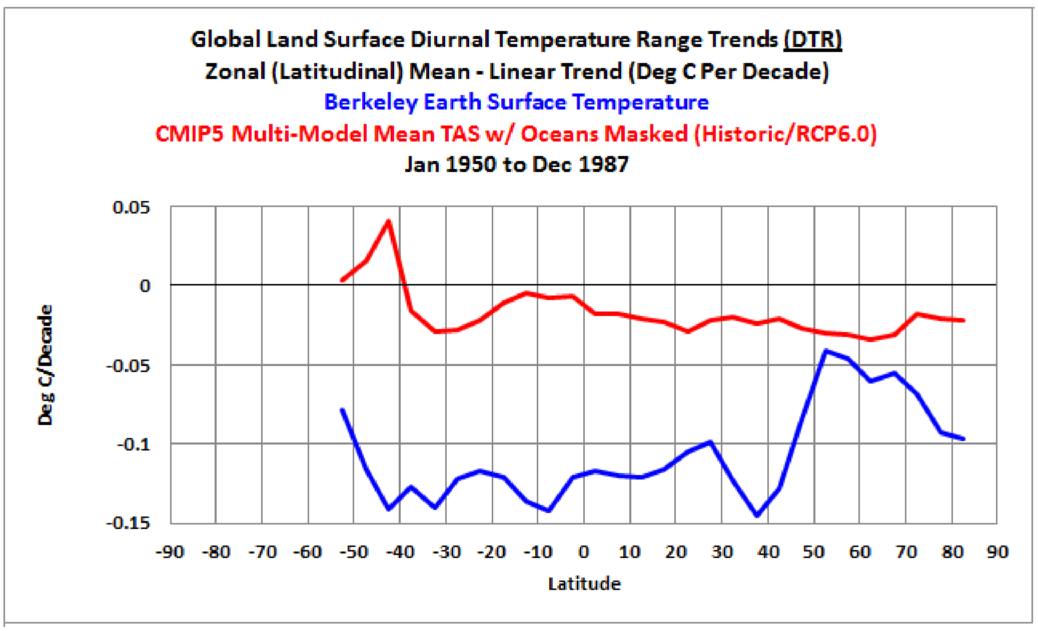


Figure 5-33

Finally, in Figure 5-34 I compare the modeled with the observed trends in global diurnal temperature ranges for the periods of 1950 to 1987 (dashed) and 1988 to 2011 (solid).

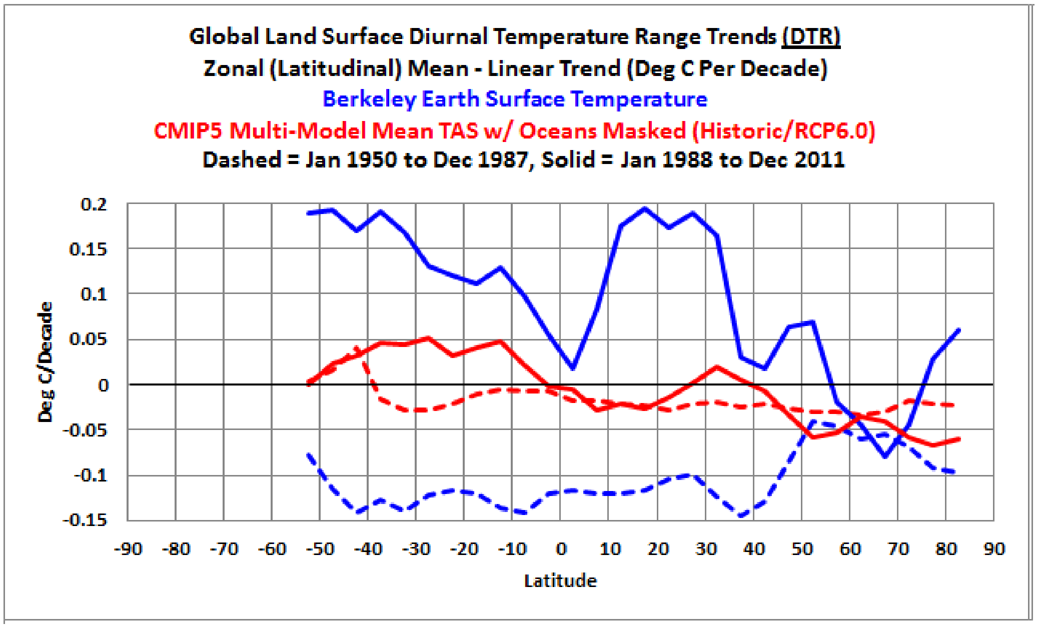


Figure 5-34

CHAPTER 5.5 SUMMARY

For the period of 1988 to the present, climate models estimated that global daily minimum (Tmin) land surface air temperatures warmed faster than daily maximum temperatures (Tmax). This modeled decrease in the DTR (Diurnal Temperature Range) was trumpeted as being a “fingerprint” of human-induced global warming. The recently released Berkeley Earth Surface Temperature dataset show that the exact opposite happened. BEST global land surface air temperature data show Tmax warming faster than Tmin — that is, that the global diurnal temperature range since 1988 is increasing, not decreasing.

I also showed that climate models cannot simulate the observed rates of warming and cooling of global Tmin, Tmax and the DTR on latitudinal bases, for the period of 1988 to present, and for the period of 1950 to 1987.

Climate models were thus shown to be incapable of simulating what has been heralded as a “fingerprint” of human-induced global warming.

Section 6 – Land Surface Temperatures: Which Regions Do Not Support the Models during the Current Warming Stoppage?

NCAR's Kevin Trenberth wrote the article Has Global Warming Stalled? for the Royal Meteorological Society in 2013. In it, he argued that decadal periods of no warming existed in the temperature record before the current warming stoppage and he argued that there were other signs that human-induced global warming continued. Dr. Trenberth used 2001 as the start year for the current warming halt, so we'll use 2001 as the start year for the model-data comparisons in this section. I show in this section where the land air surface temperatures are not cooperating with the modeler's computer simulations during the current halt in warming.

(Note: I commented on many of Kevin Trenberth's arguments in my blog post Open Letter to the Royal Meteorological Society Regarding Dr. Trenberth's Article "Has Global Warming Stalled?" Kevin Trenberth had compared the recent cessation period to a couple of decade-long periods — 1977 to 1986 and 1987 to 1996 — but the current warming stoppage has lasted longer than a decade. As I showed in my bog post, the additional years of this halt in warming make it unusual. Dr. Trenberth also mentioned "big jumps" in temperature between the decade-long flat temperature periods, but he failed to describe the causes of those "big jumps". In my blog post, I explained them as responses to the naturally occurring strong El Niño events and the 1976 Pacific climate shift.)

Due to the volatility of many of these small subsets of data and the short time period examined, the trends can change drastically within just a year or two. This analysis of regional data should, thus, has limited significance. Nevertheless, it does reveal that, yet again, the computer models failed to accurately simulate the global data.

Note: the models have already shown they cannot explain the stoppage period on a global basis and that they have no skill at modeling global surface temperatures on multidecadal timescales.

REGIONS PRESENTED

In April, 2012, I presented model-data comparisons of regional land surface air temperature data in my post "IPCC Models vs Observations – Land Surface Temperature Anomalies for the Last 30 Years on a Regional Basis."

In this section, I use the same regions. They were presented by the **IPCC in Figure 9.12 of AR4**, but I calculated the land surface temperature anomalies and linear trends based on the monthly data for the last 12+ years, January, 2001 to May, 2013. Again, the observations-based dataset I use is the new and improved CRUTEM4 land surface temperature anomalies. I selected “Land only” at the KNMI Climate Explorer for the CMIP5 multi-model ensemble mean simulations of surface air temperatures (“tas”). That selection masks the simulated sea surface temperature anomaly outputs.

The regions presented in the IPCC’s 5th Assessment Report may be different than these, but that report was not published as of this writing, so the regions used in their 2007 report will have to do.

The coordinates and labels are clarified on page 9 of the **Supplementary Materials for Chapter 9 of AR4**. The IPCC based their breakdown of the continental land masses on the Giorgi and Francisco (2000) papers “**Evaluating Uncertainties in the Prediction of Regional Climate**” and “**Uncertainties in Regional Climate Change Prediction: a Regional Analysis of Ensemble Simulations with the HadCM2 Coupled AOGCM**”. Both papers are paywalled, but Figure 6-1 below is the map of the regions which is available online. There are a few differences between the labels used by the IPCC and by Giorgi and Francisco. Example: The IPCC used SEU for Southern Europe, but Giorgi and Francisco (2000) called the region MED for Mediterranean. I’ve used the IPCC’s labels. The coordinates used are listed in the title blocks of the individual graphs.

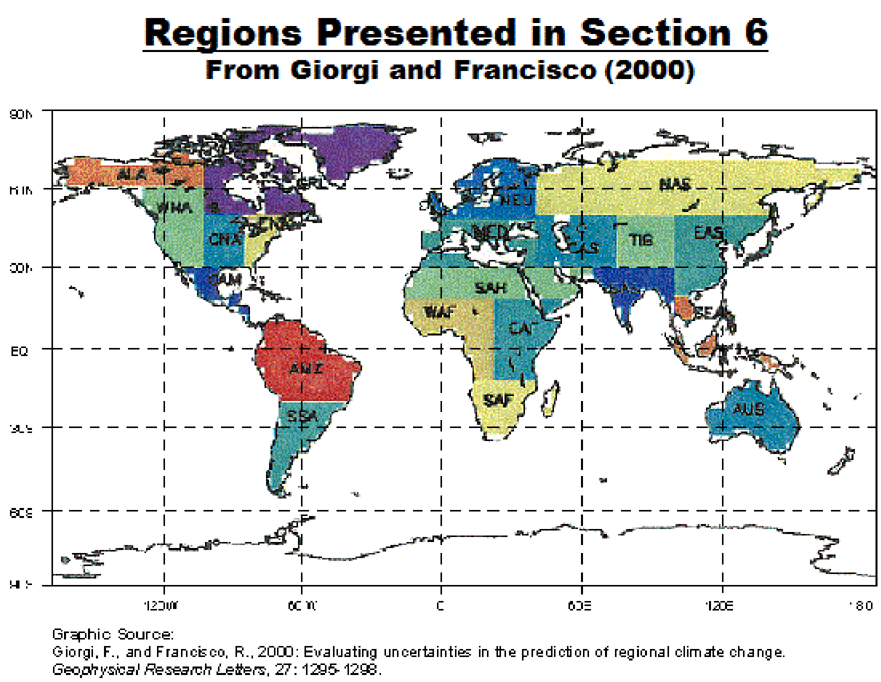


Figure 6-1

PRELIMINARY NOTES

Kevin Trenberth presented global land-plus-sea surface temperatures in his article. In this section, however, I'm presenting only land surface air temperatures. The cessation of warming since January, 2001 also appears in the land surface temperature data. (See Figure 6-2.) The observed global land surface air temperature anomalies warmed at a very slow rate of about 0.03 deg C/decade from January, 2001 to May, 2013, while during the period of January 1975 to December 2000, they warmed at a rate that was 9 times that trend or 0.27 deg C/decade.

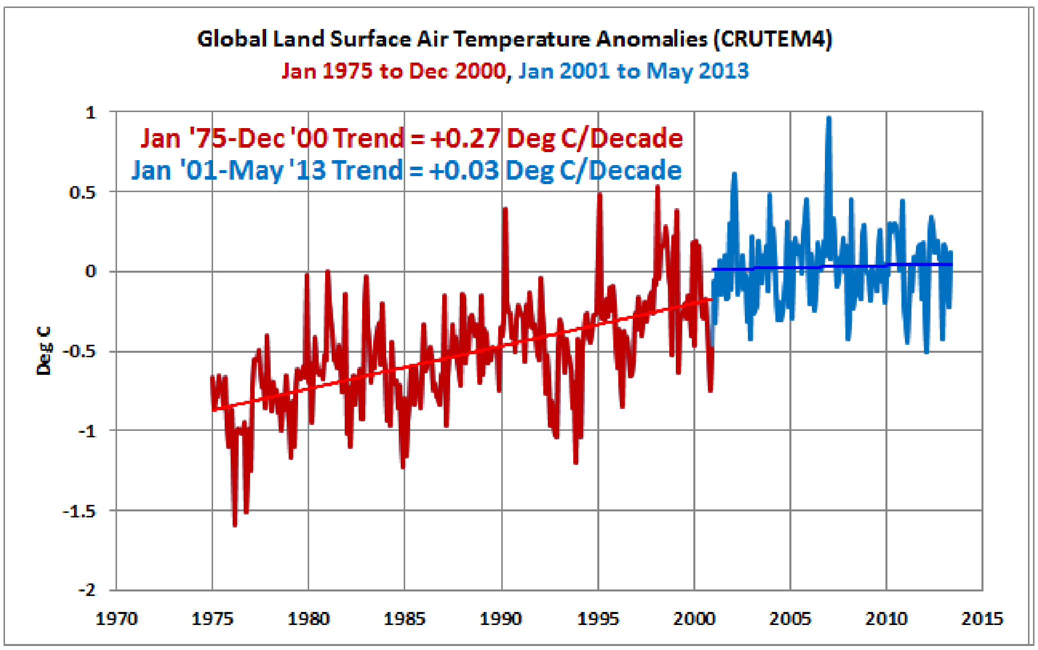


Figure 6-2

(Note: Based on the HADSST3 data, global sea surface temperatures have cooled slightly since 2001. (Figure 6-3). This cooling has been more than enough to counteract the slight warming taking place in the land surface air temperatures. I will examine sea surface temperature data during the satellite era in detail in Section 7 and then discuss the halt in the warming of sea surface temperature anomalies in Section 8.)

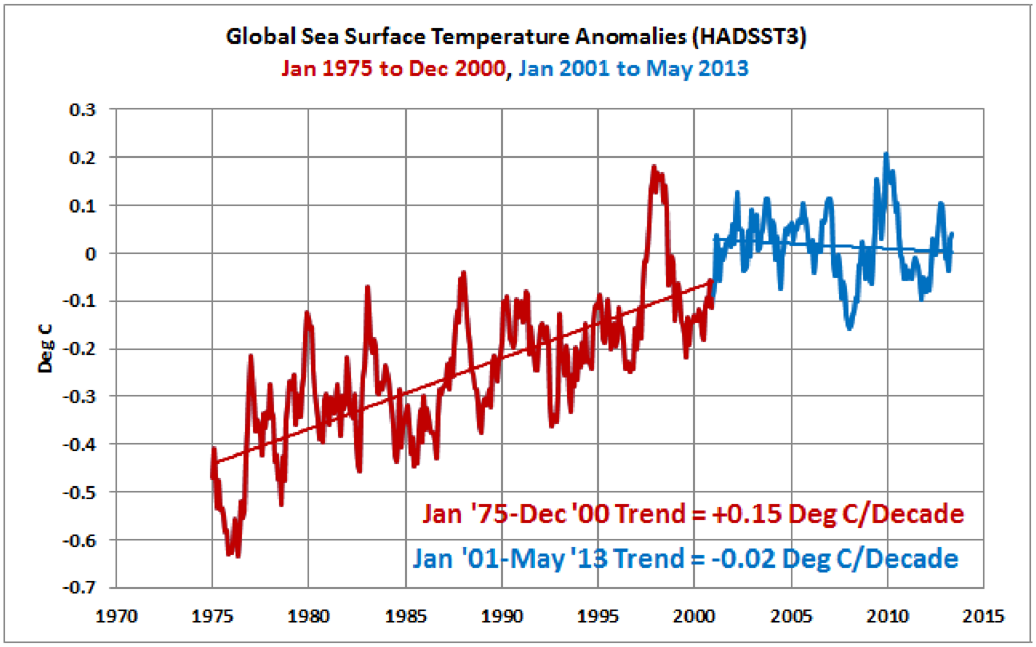


Figure 6-3

Another consideration is the volatility of the regional land surface temperature data. In the upcoming chapters, some of the regions I discuss are relatively small, especially the two European regions. I smooth the data with 13-month running-mean filters, but, even so, the data are still highly volatile. The volatility in some regions is related to El Niño and La Niña events, while in other regions, it is caused by something else entirely.

When looking at the volatility of the regional data, consider the task the IPCC has established for the modelers: short-term (decadal and multidecadal) regional forecasts/projections. The climate models used by the IPCC cannot model El Niño and La Niña processes. Even the specialized models that are used for forecasting whether the upcoming season will be an El Niño or La Niña have difficulty with predictions more than a year in advance. Some of you might believe short-term regional forecasts/projections are an impossible mission.

Some of the regional land surface temperature subsets clearly show downward cooling shifts in recent years.

I start with a quick look at the model-data comparison for the global data in Chapter 6.1, presenting a table of all of the regional modeled and observed trends for the period of January, 2001 to May, 2013. In the other chapters of this section, I discuss the regional data for each of the continents.

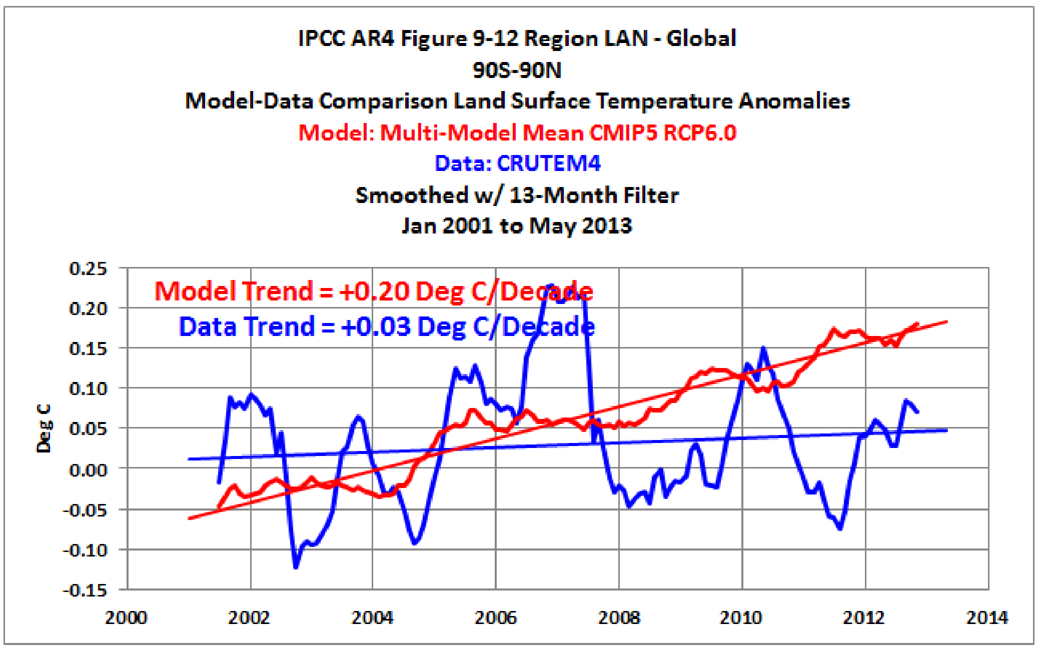
SPECIAL NOTE: As noted earlier, some readers might believe it better to use the climate models that were prepared specifically for short-term regional analyses in this section. I disagree. The relevant models are those which make **long-term** hindcasts and projections, not models that were fine-tuned to simulate a specific region over a specific time period. That is, the relevant models are those upon which the predictions of gloom and doom are based. Because my goal in this section is to show where global temperatures are not cooperating with the model programmers' assumptions about catastrophic anthropogenic global climate change, those are the models I will use.

NOTE ABOUT A LONGER-TERM REGIONAL COMPARISON

For a similar model-data comparison for regional land surface air temperature subsets (for a 3-decade term), see my post here. The data runs from January, 1982 to October, 2011, so it obscures the fact that warming stopped in 2001.

Chapter 6.1 – Stoppage Period Model-Data Comparisons: A Quick Look at Global Data

In Figure 6-4, I compare global land surface air temperature anomalies using the UKMO CRUTEM4 data and the land surface air temperature simulations of the multi-model ensemble mean of the climate models stored in the CMIP5 archive. The time period is January, 2001 to May, 2013. The data and model outputs have been smoothed with 13-month running-average filters. The modeled warming rate is about 0.20 deg C/decade, while observed land surface air temperatures only warmed at a rate of 0.03 deg C during the global warming stoppage. The modeled warming rate was about 6.6 times higher than the observed land surface air temperature anomaly warming rate over the past 12+ years. There remains a very slightly warming trend in land surface temperatures since 2001, but they are more than counteracted by the cooling that took place in the sea surface temperatures (Figure 6.3) during this time.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-4

It certainly does appear as though global land surface air temperature anomalies peaked in 2007 and have been cooling since then. It will be interesting to see what happens in the upcoming years — especially when the Atlantic Multidecadal Oscillation comes into play.

REGIONAL COMPARISON IN TABULAR FORM

In Table 6.1, I list the names, labels, and coordinates of the regions I discuss in the following chapters of Section 6. They are the same regions presented on page 9 of the **Supplementary Materials for Chapter 9 of the IPCC's AR4**. Table 6.1 also lists the modeled and observed land surface air temperature trends for the period of January, 2001 to May, 2013. I calculated the difference as the modeled trend minus the data trend. Therefore, the negative differences indicate the regions where the land surface temperatures warmed at a higher rate than the models' estimates.

Table 6.1- Regional Land Surface Air Temperature Model-Data Comparison

Time Period = January 2001 to May 2013 Dataset = CRUTEM4
Models = Multi-Model Ensemble Mean CMIP5 w/RCP6.0
Difference = Model Trend - Data Trend

CONTINENT	DESIGNATOR	REGION	COORDINATES	TREND (Deg C/Decade) DATA (CRUTEM4)	MODELS	DIFFERENCE (Deg C/Decade)
	LAN	Global	90S-90N	0.03	0.20	0.17
North America	ALA	Alaska	60N-72N, 170W-103W	-0.72	0.03	0.75
	CGI	Canada-Greenland-Iceland	50N-85N, 103W-10W	0.72	0.30	-0.42
	WNA	Western N. America	30N-60N, 130W-103W	-0.23	0.23	0.46
	CNA	Central N. America	30N-50N, 103W-85W	0.15	0.55	0.40
	ENA	Eastern N. America	25N-50N, 85W-50W	0.50	0.41	-0.09
	CAM	Central America	10N-30N, 116W-83W	0.20	0.31	0.11
South America	AMZ	Amazon	20S-12N, 82W-34W	-0.02	0.17	0.19
	SSA	Southern S. America	56S-20S, 76W-40W	0.01	0.12	0.11
Europe	NEU	Northern Europe	48N-75N, 10W-40E	-0.20	0.28	0.48
	SEU	Southern Europe	30N-48N, 10W-40E	0.18	0.21	0.03
Africa	SAR	Sahara	18N-30N, 20W-65E	0.35	0.08	-0.27
	WAF	Western Africa	12S-18N, 20W-22E	0.25	0.15	-0.10
	EAF	Eastern Africa	12S-18N, 22E-52E	0.32	0.15	-0.17
	SAF	Southern Africa	35S-12S, 10E-52E	0.10	0.14	0.04
Asia	NAS	Northern Asia	50N-70N, 40E-180E	-0.01	0.32	0.33
	CAS	Central Asia	30N-50N, 40E-75E	-0.11	0.14	0.25
	TIB	Tibet	30N-50N, 75E-100E	-0.27	0.23	0.51
	EAS	Eastern Asia	20N-50N, 100E-145E	-0.47	0.19	0.66
	SAS	Southern Asia	5N-30N, 65E-100E	0.15	0.13	-0.02
	SEA	Southeast Asia	11S-20N, 95E-155E	0.07	0.12	0.05
Australia	NAU	Northern Australia	30S-11S, 100E-155E	-0.16	0.17	0.33
	SAU	Southern Australia	45S-30S, 100E-155E	0.20	0.15	-0.05

CHAPTER 6.1 SUMMARY

During the recent halt in global warming, starting in 2001, the models estimated that global land surface temperatures should have warmed at a rate that was 6.6 times faster than the observed warming rate of approximately 0.03 deg C/decade.

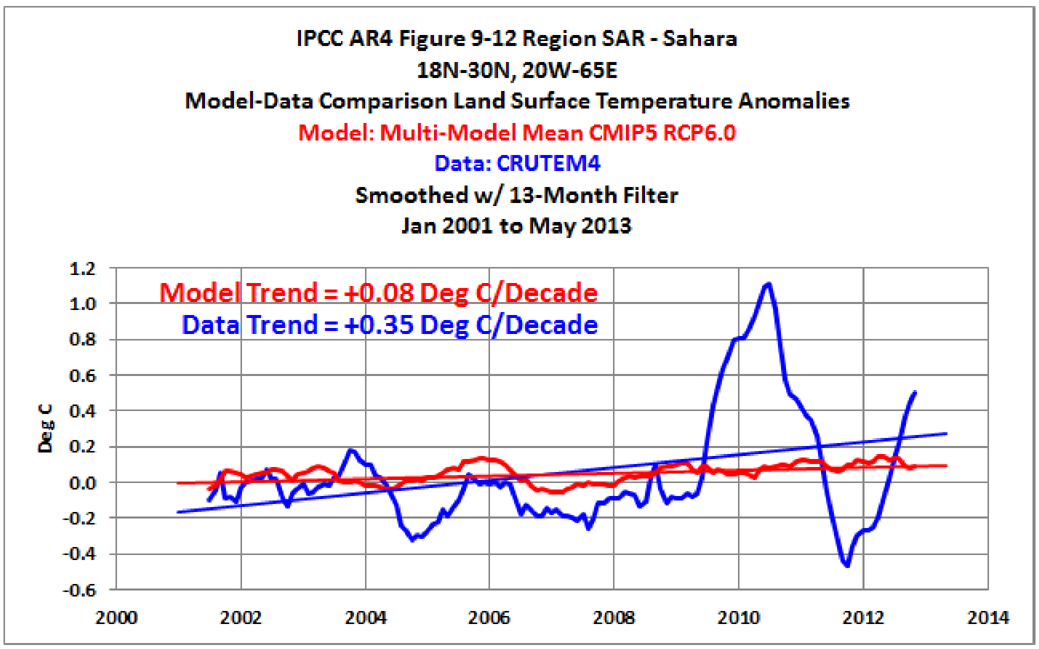
It appears as though global land surface temperature anomalies may have peaked in 2007 and that global surface temperatures have been cooling since then — but that time period since 2007 is much too short for the cooling to be very meaningful.

The models overestimated regional warming rates far more often than they underestimated them. While there were some regions where the models performed reasonably well, they were far outnumbered by regions where the models performed poorly.

Chapter 6.2 – Regional Stoppage Period Model-Data Comparisons: African Land Surface Temperature Anomalies

The IPCC divides Africa into 4 sub-regions: “Sahara,” “Western Africa,” “Eastern Africa,” and “Southern Africa.” The Sahara subset coordinates (18N-30N, 20W-65E**)** extend into Asia, but it’s difficult to avoid overlap with coordinates-based subsets.

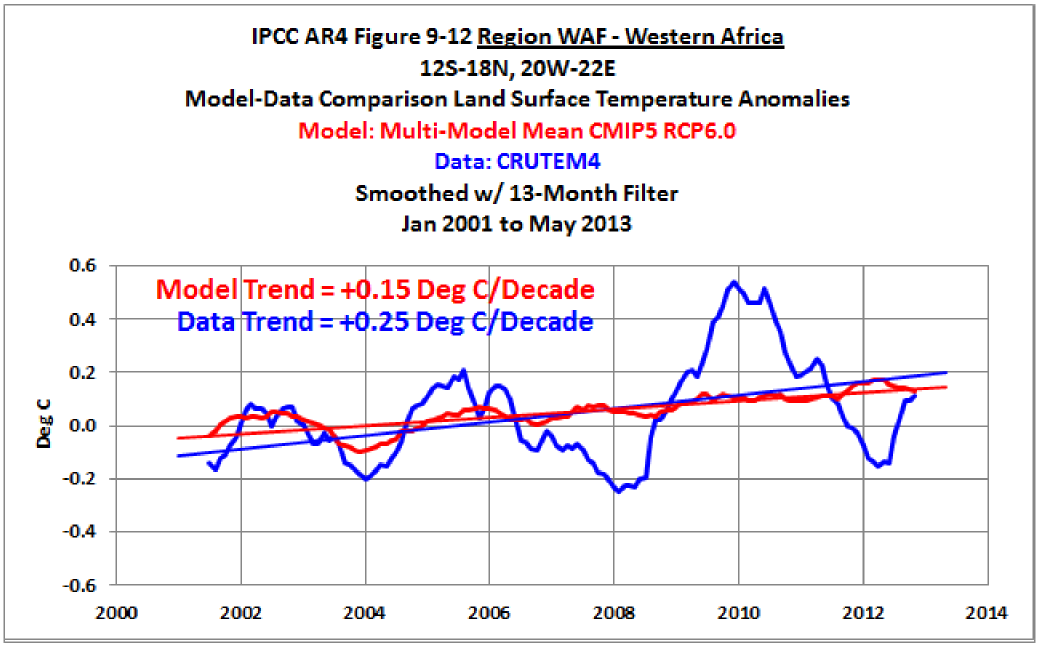
All four African regions (Figures 6-5 through 6-8) continued to show warming land surface air temperatures from January, 2001 to May, 2013, based on their linear trends. In the Sahara, the warming appears to have been caused by an unusual 2-year warming event that lasted from 2009 to 2011. Western, Eastern, and Southern Africa show more gradual increases in land surface air temperatures. In Eastern Africa, the observed warming rate was twice the modeled rate — not a very good showing on the part of the models.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-5

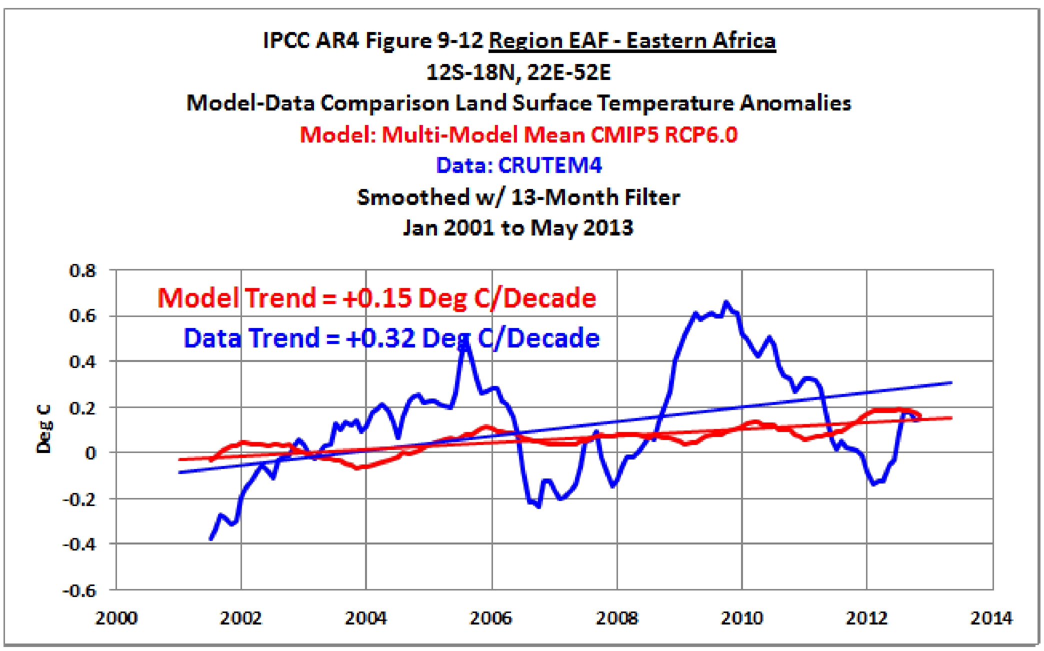
# # #



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-6

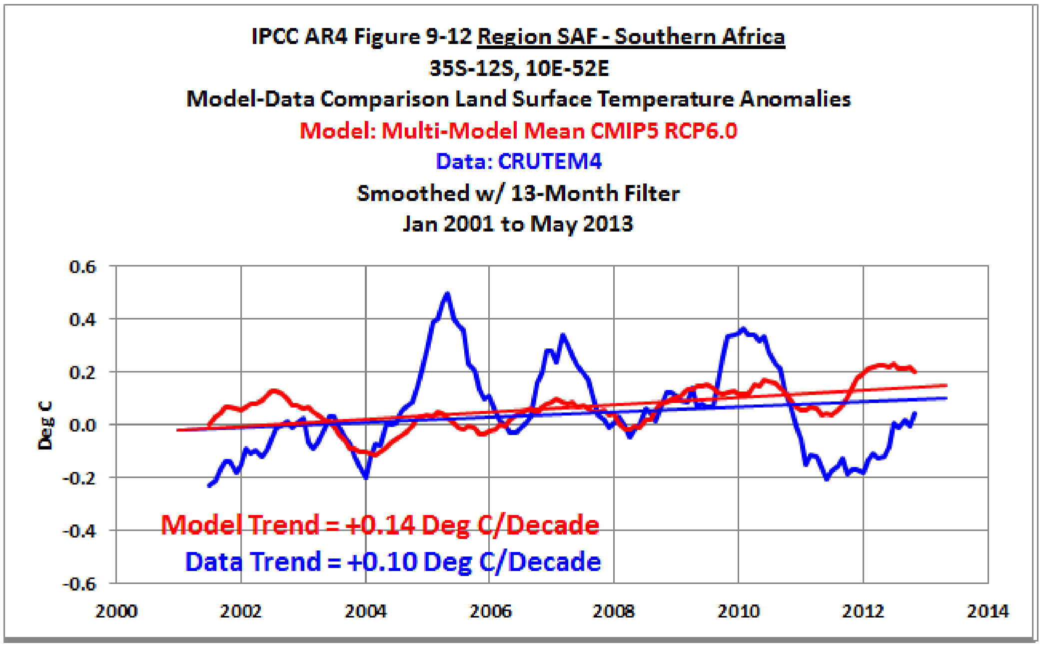
# # #



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-7

# # #



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-8

CHAPTER 6.2 SUMMARY

The models performed reasonably well at simulating land surface air temperatures in two of four Africa regions during this short-term comparison. The models underestimated the warming in the other two regions by large amounts.

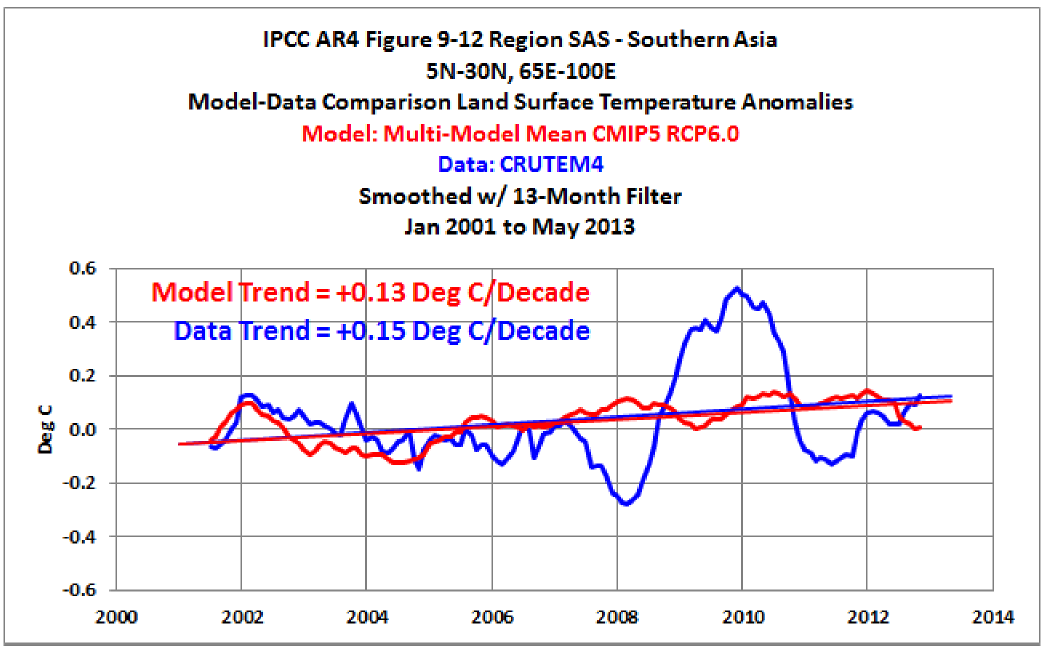
Chapter 6.3 – Regional Stoppage Period Model-Data Comparisons: Asian Land Surface Temperature Anomalies

The IPCC divides Asia into 6 sub-regions in their 4th Assessment Report: “Northern,” “Central,” “Eastern,” “Southern,” “Southeast,” Asia, and a region identified as “Tibet.” The coordinates used are shown in the title blocks of the graphs that follow.

Climate model performance in Asia was a mixed bag.

THE GOOD

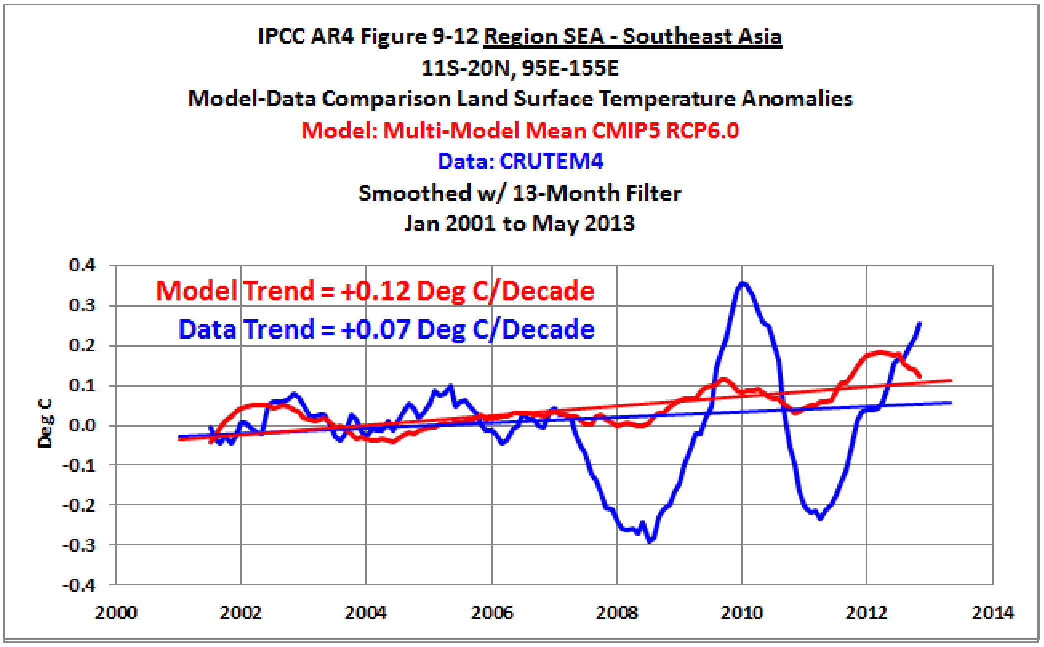
The models performed well in the Southern Asia and Southeast Asia regions for the period of January, 2001 to May, 2013. (See Figures 6-9 and 6-10.)



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-9

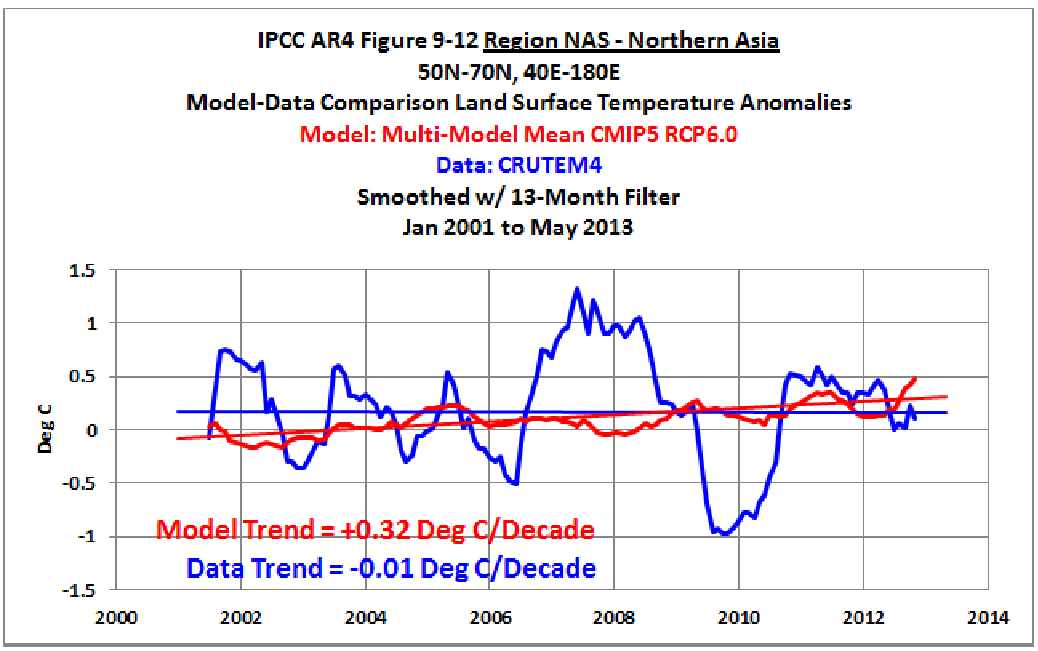
# # #



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-10

THE BAD



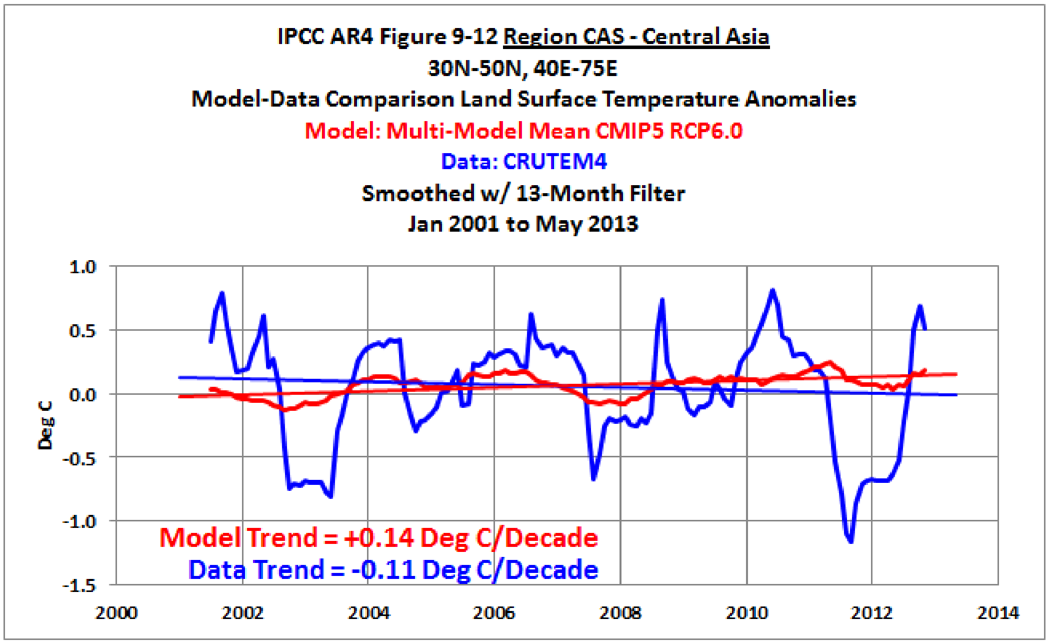
Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-11

Based on the linear trend, land surface temperature anomalies in Northern Asia have been relatively flat, showing little warming or cooling, since January, 2001. Figure 6-11 shows, however, that the models simulated persistent warming in that region.

Figure 6-11 is a great example of the absurdity of attempting to make short-term regional predictions. Note that the modeled warming trend is 0.32 deg C/decade, which is a high rate of warming compared to the modeled **global** trend of 0.2 deg C/decade, yet the yearly variations in the smoothed data dwarf the trend.

Central Asia is another example. (See Figure 6-12) There is a 0.25 deg C/decade difference between the modeled and observed trends. But, the annual variations in the data, which have been smoothed, make that difference appear to be insignificant.

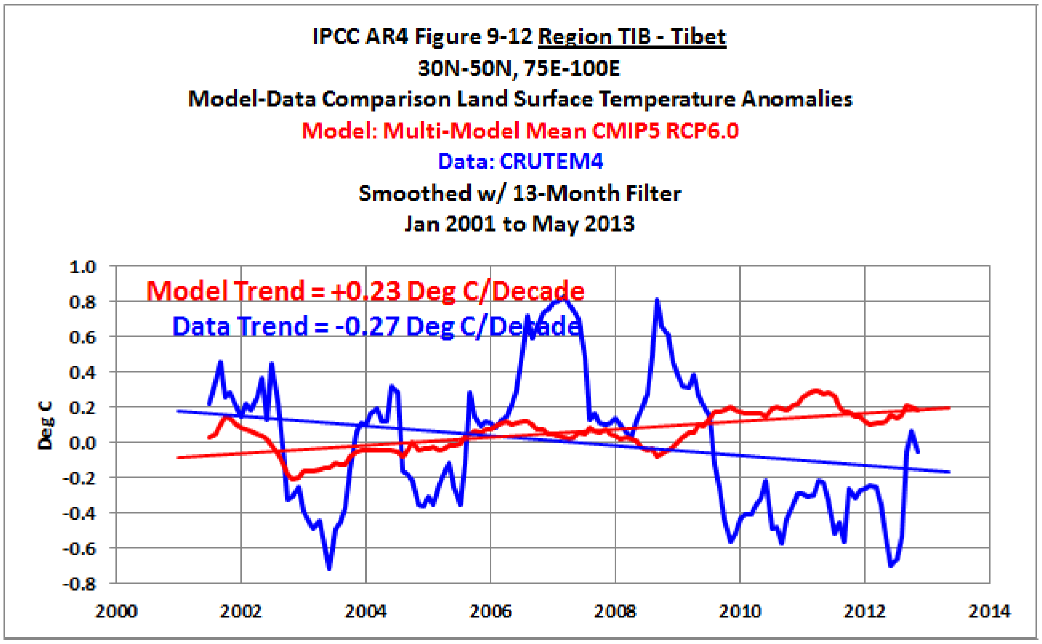


Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-12

THE REALLY BAD

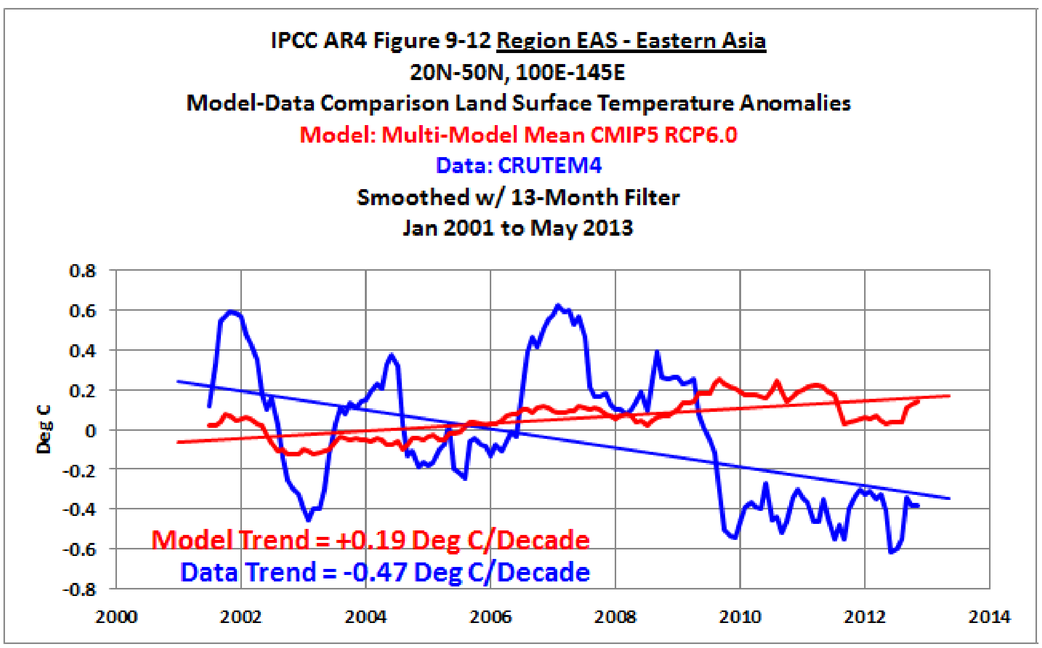
The land surface air temperature anomalies made significant downward shifts in 2009 in the last two Asian regions: Tibet and Eastern Asia (Figures 6-13 and 6-14). Thus, the linear trends show cooling in these regions since January, 2001. In addition, the models estimated warming.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-13

# # #



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-14

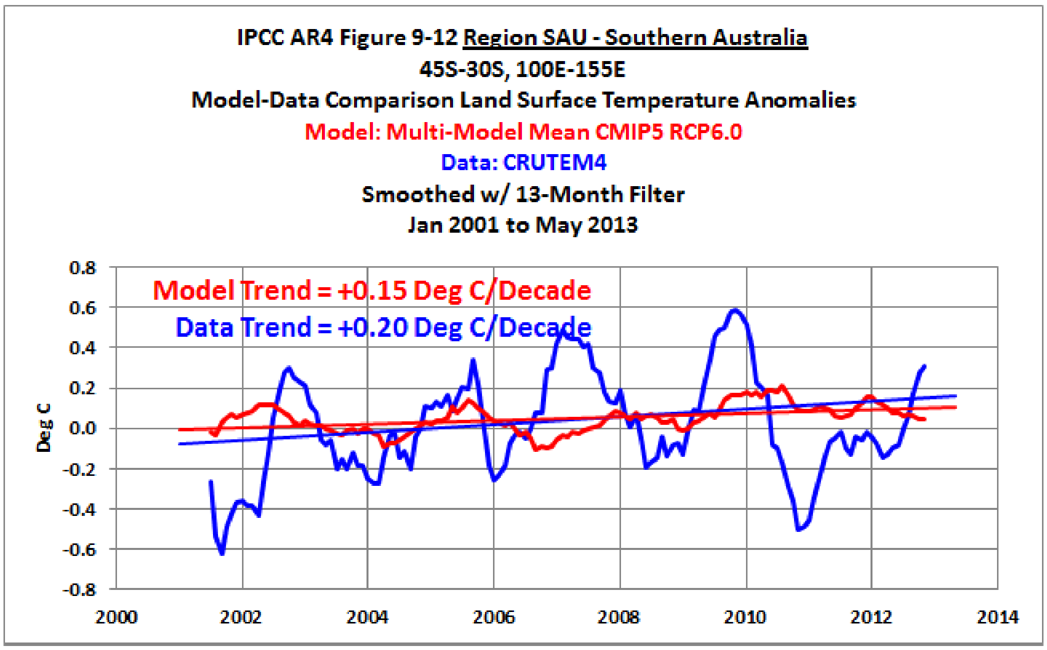
CHAPTER 6.3 SUMMARY

Only 2 of the 6 Asian regions showed warming land surface air temperatures during the recent cessation of global warming — Southern Asia and Southeast Asia. Those two regions are adjacent to one another. The other 4 Asian regions haven't been cooperating with the climate models since 2001. Two showed little to no warming and two cooled.

Chapter 6.4 – Regional Stoppage Period Model-Data Comparisons: Australian Land Surface Temperature Anomalies

I discussed Australian land surface temperature anomalies for the period of 1979 to present in Chapter 5.1. During that period, the modeled warming rate was 4 times higher than the observed warming rate.

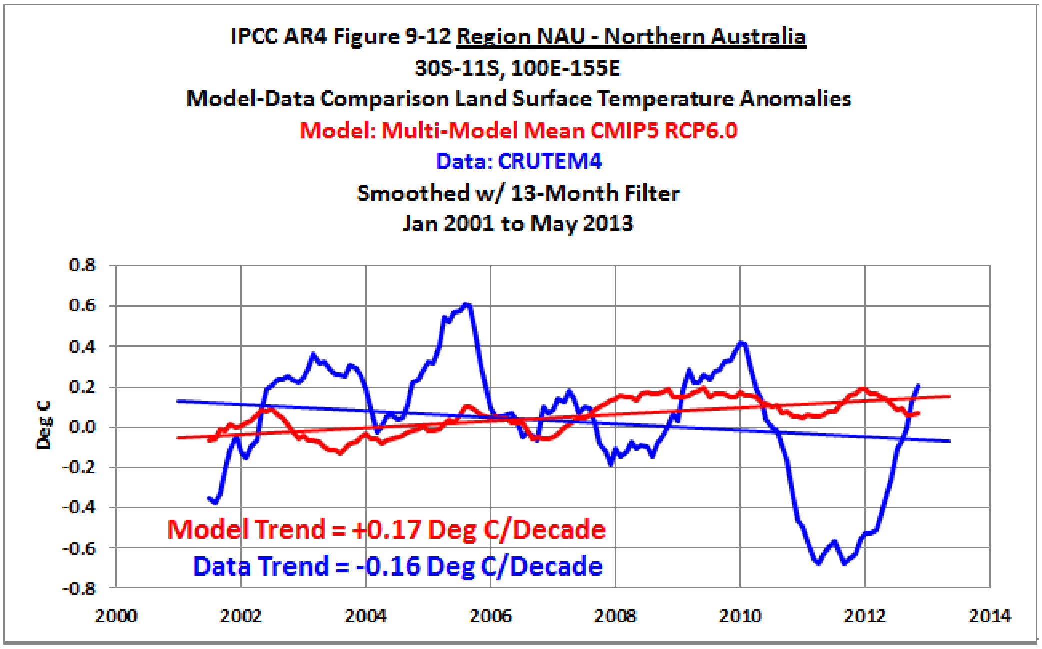
The IPCC divides Australia into 2 sub-regions: "Northern" and "Southern." In Southern Australia, the warming was in line with the model simulations during the cessation period. (See Figure 6-15.) The models performed well there, underestimating the warming by about 0.05 deg C/decade.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-15

In Northern Australia, on the other hand, land surface temperature anomalies cooled during the recent halt in global warming. (See Figure 6-16.) The models said they should have warmed.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-16

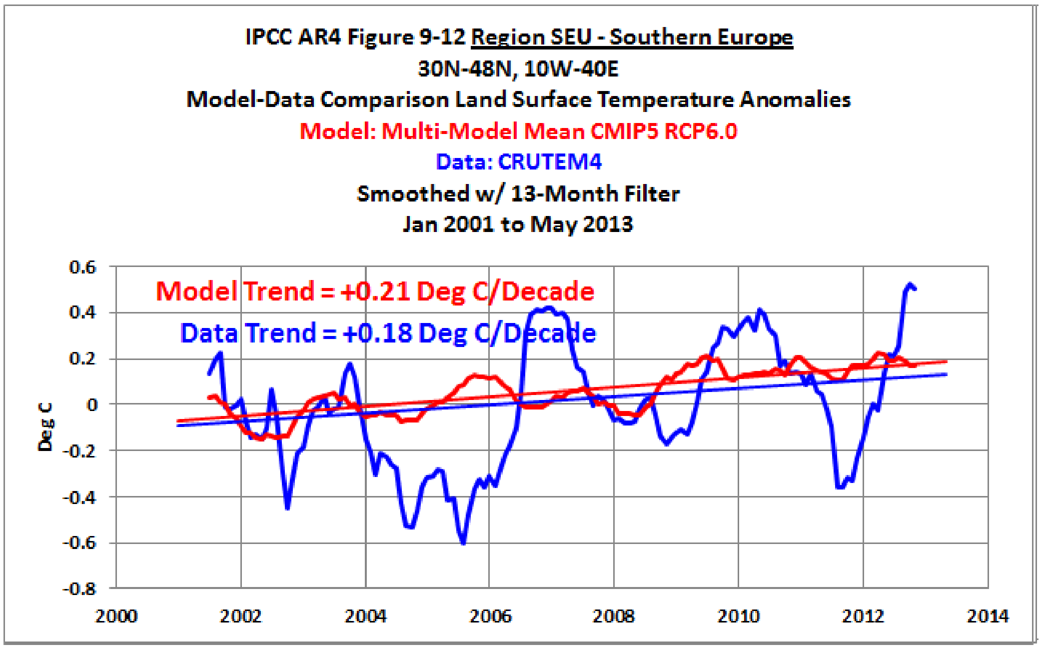
CHAPTER 6.4 SUMMARY

Unsurprisingly, while the models performed well in one Australian region, they did poorly in the other. Such inconsistent results make it impossible for climate modelers to rationally explain what climate model outputs mean.

Chapter 6.5 – Regional Stoppage Period Model-Data Comparisons: European Land Surface Temperature Anomalies

When Giorgi and Francisco (2000) divided Europe into two sub-regions, they called the southern region "Mediterranean," because it included extreme Northern Africa, north of 30N. The IPCC renames it "Southern Europe" in their Figure 9-12 in their 4th Assessment Report.

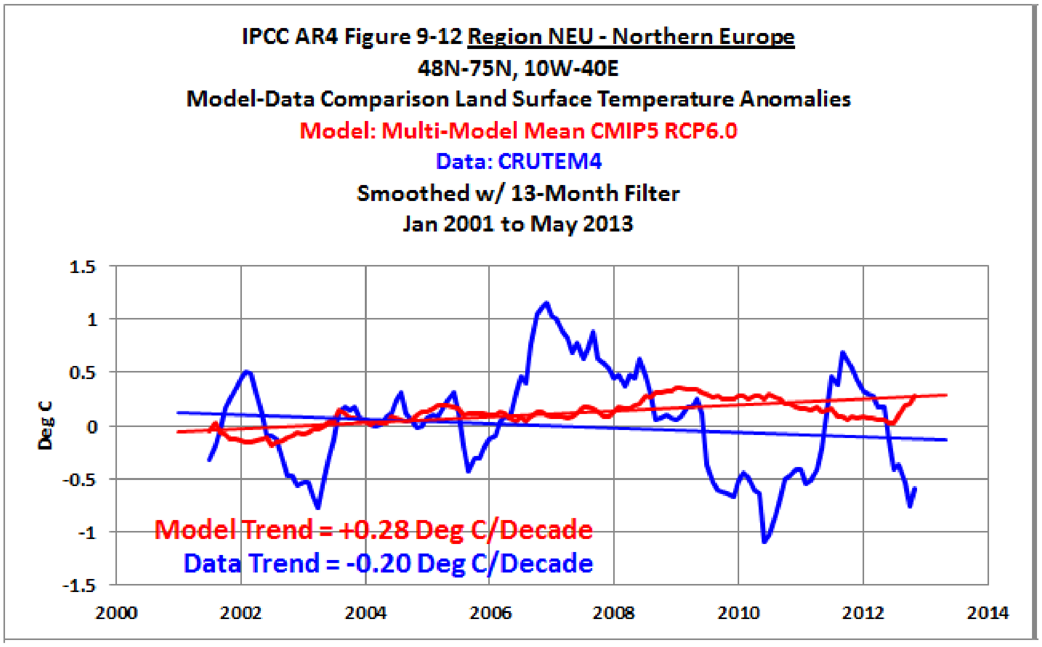
The Southern Europe (Mediterranean) model-data comparison is my Figure 6-17 below. The land surface air temperatures in this region warmed from January, 2001 to May, 2013. The models performed well here.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-17

The land surface temperature anomalies for Northern Europe have cooled in past 12+ years (Figure 6-18). The computer models with their warming rate of 0.28 deg C/decade say that Northern European land surface air temperatures should have warmed — but they've cooled. And the difference between the modeled and observed warming rates is a whopping 0.48 deg C/decade.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-18

CHAPTER 6.5 SUMMARY

Like Australia, there mixed results in only two European regions. The models performed well in Southern Europe but totally missed the mark in Northern Europe. And once again, the volatility of the actual changes in temperatures would severely limit the models' chances of regional short-term forecasting.

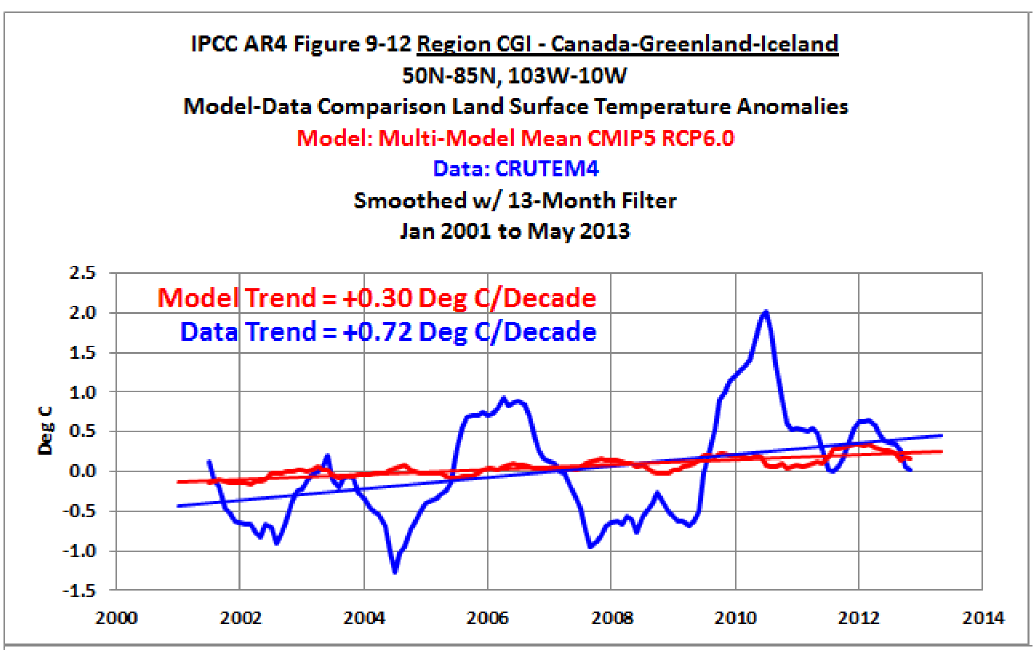
Chapter 6.6 – Regional Stoppage Period Model-Data Comparisons: North American Land Surface Temperature Anomalies

I discussed in Chapters 5.2 and 5.3 the failure of the climate models fail to accurately simulate the rates of warming of land surface air temperatures in Alaska and Greenland over the long term. Now, using the IPCC's sub-regions, I examine how the models fared in North America during the warming halt period.

Based on Giorgi and Francisco (2000), the IPCC divides land surface temperature data for North America into 5 regions. Their "Alaska" includes much of the northern high-latitudes of Canada. They include much of eastern Canada with Greenland and Iceland for their "Canada-Greenland-Iceland" region. There are three Canada-United States regions: "Western," "Central," and "Eastern" North America. The IPCC groups Mexico with Central America as a sub-region, but they include it with South America. I include Central America in this chapter.

OBSERVED HIGH RATES OF WARMING

Since January 2001, the two regions with the highest rates of warming in land surface air temperatures were in of North America. They were Canada-Greenland-Iceland and Eastern North America. (See Figure 6-19 and 6-20) The model-estimated rate of warming in Canada-Greenland-Iceland was far less than observed, while the models performed better in Eastern North America.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-19

# # #

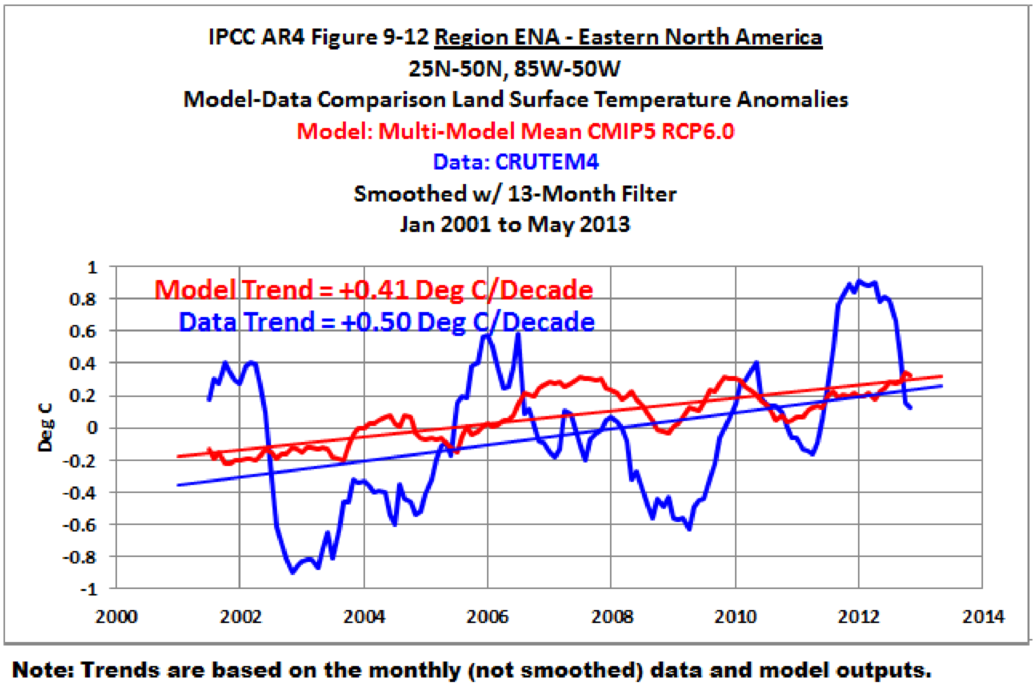
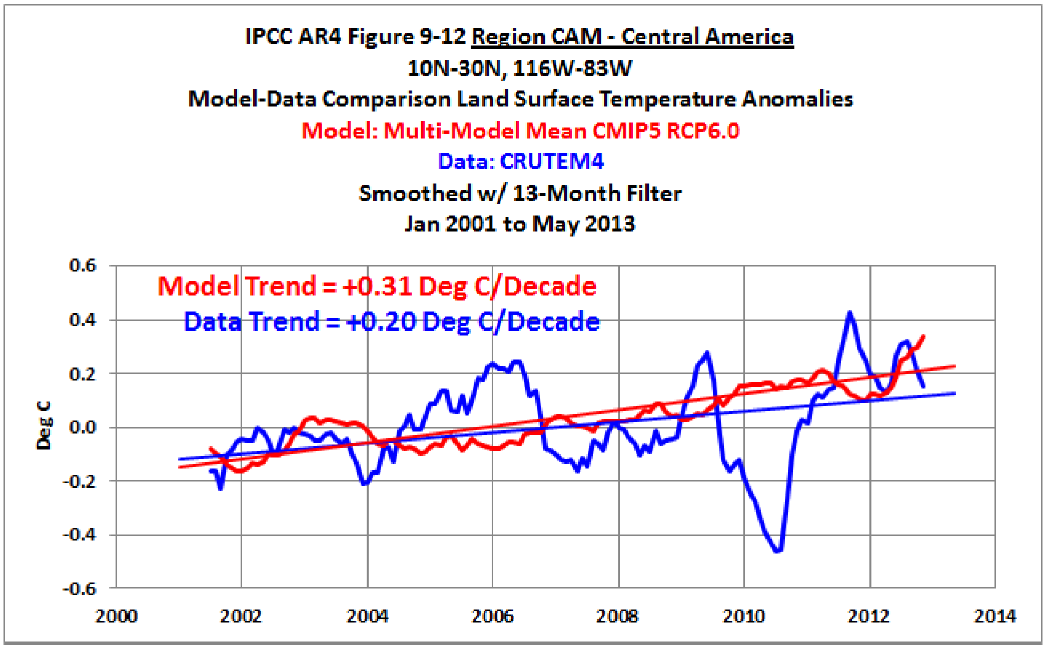


Figure 6-20

MORE MODERATE RATES OF WARMING

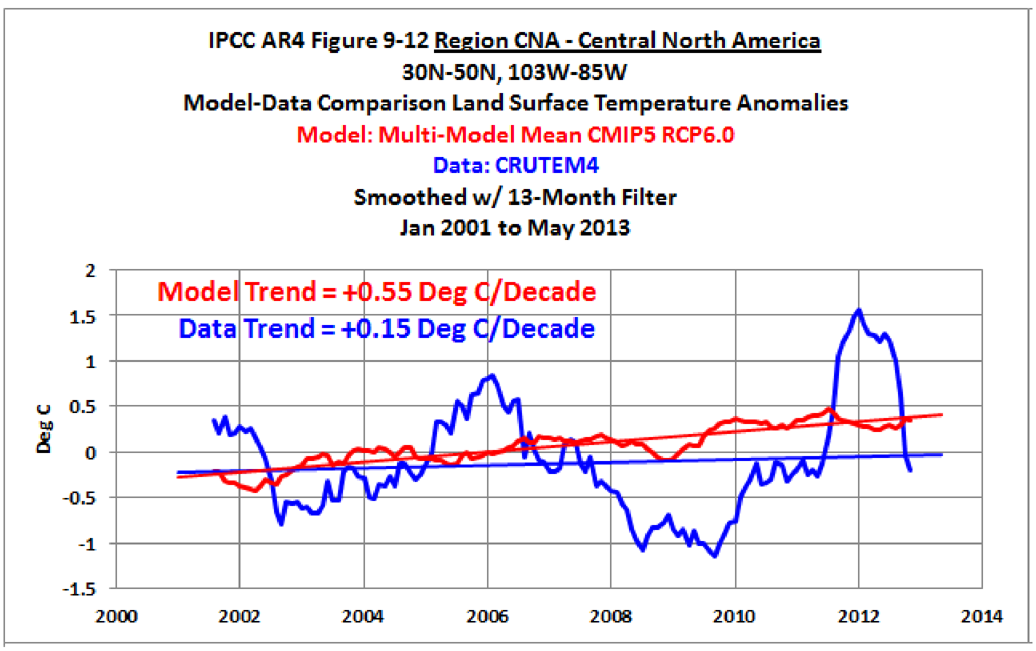
The warming rates of Central America and Central North America land surface air temperatures were more moderate but they definitely showed warming. But, in these regions, the models overestimated the warming, and in Central North America, they overestimated the warming by about 0.4 deg C/decade.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-21

# # #

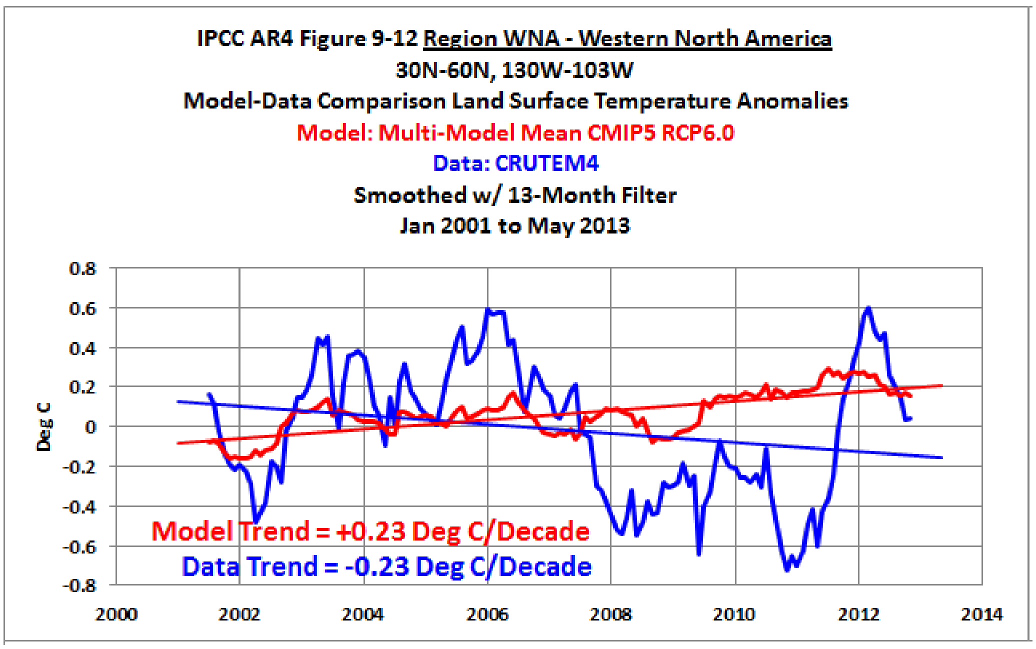


Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-22

OBSERVED HIGH RATES OF COOLING

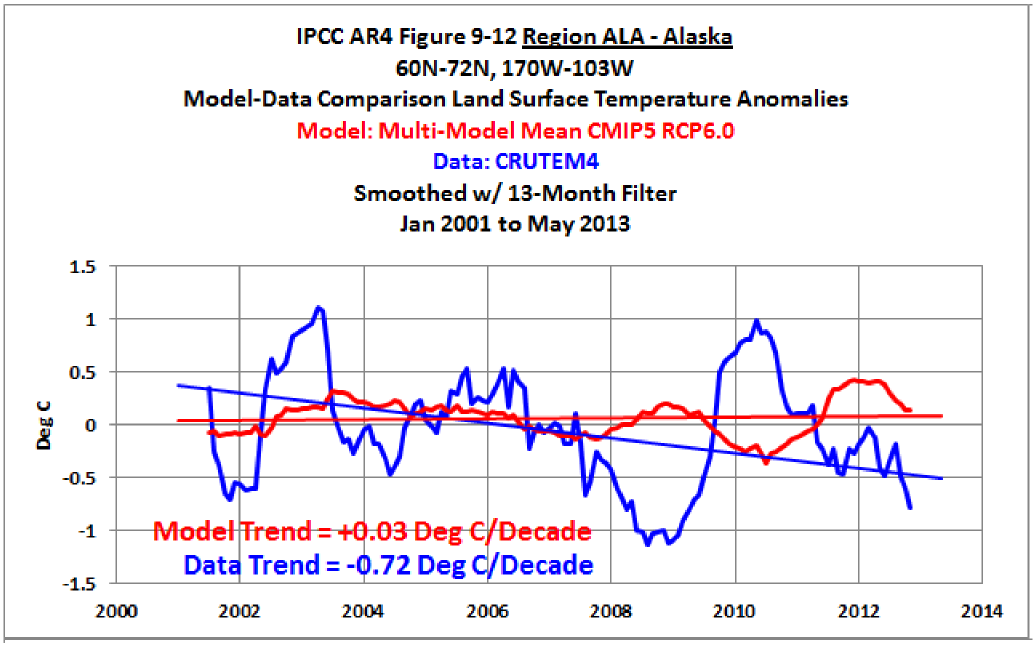
Since 2001, the Western North America region cooled at a rate of -0.23 deg C/decade, while the models estimated a warming trend of +0.23 deg C/decade. (See Figure 6-23.)



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-23

By far the highest rate of cooling for any global region occurred in the Alaska region. It cooled at a rate of -0.72 deg C/decade. The models, on the other hand, showed a slight warming.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-24

Note: You may have missed this very recent scientific study about the North American heat wave of March, 2012. Mainstream media overlooked it, for the most part, because normal weather doesn't sell newspapers or commercial TV. A dozen scientists studied the heat wave. They concluded that the heat wave in March, 2012 was the result of natural processes. The paper is Dole, et al. (2013) "The Making of An Extreme Event: Putting the Pieces Together." (Preprint edition available through that link.) The abstract reads (my boldface):

> *We examine how physical factors spanning climate and weather contributed to record warmth over the central and eastern U.S. In March 2012, when daily temperature anomalies at many locations exceeded 20°C. O**ver this region, approximately 1° C warming in March temperatures has occurred since 1901. This long-term regional warming is an order-of-magnitude smaller than temperature anomalies observed during the event, indicating the most of the extreme warmth must be explained by other factors**. Several lines of evidence strongly implicate natural variations as the primary cause for the extreme event. T**he 2012 temperature anomalies had a close analogue in an exceptionally warm U.S. March occurring over 100 years earlier**, **providing observational evidence that an extreme event similar to March 2012 could be produced through natural variability alone**. Coupled model forecasts and simulations forced by observed sea surface temperatures (SSTs) show that*

> *forcing from anomalous SSTs increased the probability of extreme warm temperatures in March 2012 above that anticipated from the long-term warming trend. In addition, forcing associated with a strong Madden-Julian Oscillation further increased the probability for extreme U.S. Warmth and provided important additional predictive information on the timing and spatial pattern of temperature anomalies. The results indicate that the superposition of a strong natural variation similar to March 1910 on long-term warming of the magnitude observed would be sufficient to account for the record warm March 2012 U.S. Temperatures. W**e conclude that the extreme warmth over the central and eastern U.S. In March 2012 resulted primarily from natural climate and weather variability, a substantial fraction of which was predictable**.*

The "anomalous SSTs" (sea surface temperatures) referred to were responses to the La Niña conditions in the tropical Pacific. As Dole, et al. (2013) explained:

> *…with below normal sea surface temperatures (SSTs) over the central and eastern tropical Pacific and above normal SSTs over Indonesia, the western tropical Pacific and the central North Pacific.*

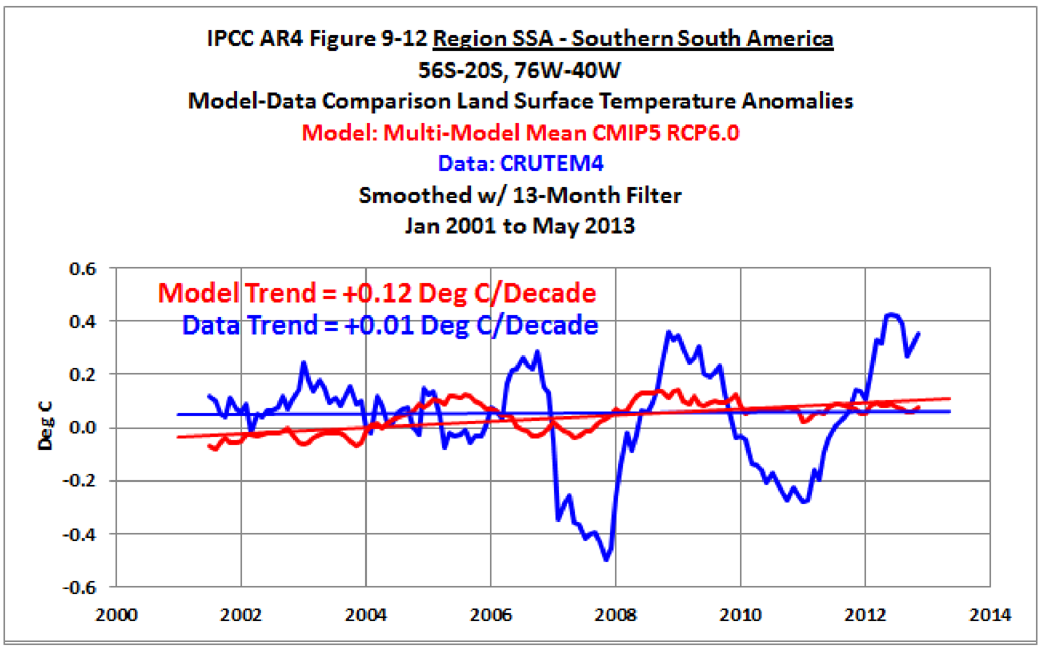
The Madden-Julian Oscillation referred to in the first quote from Dole, et al. (2013) is a short-term (30 to 60 day), coupled ocean-atmosphere mode of natural variability in the tropics. Because the Madden-Julian Oscillation typically occurs within one season, it is called an intra-seasonal oscillation. NOAA has a fairly easy-to-understand introduction to the Madden-Julian Oscillation here.

CHAPTER 6.6 SUMMARY

Of the 22 global land surface air temperature regions, North America contained the two regions with the highest rates of warming and cooling since 2001. Canada-Greenland-Iceland warmed at a rate of +0.72 deg C/decade and the Alaska region cooled at a rate of -0.72 deg C/decade. The models missed the mark by a rate of +0.75 deg C/decade in the Alaska region and by a rate of -0.42 in Canada-Greenland-Iceland.

Chapter 6.7 – Regional Stoppage Period Model-Data Comparisons: South American Land Surface Temperature Anomalies

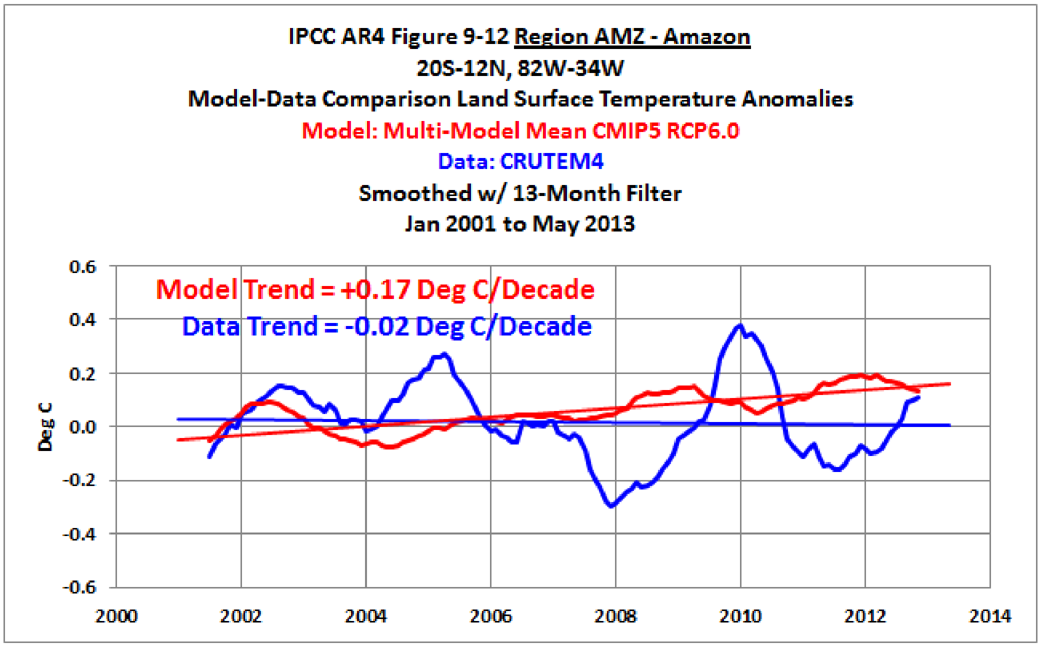
The IPCC divides South America into two regions: “Amazon” and “Southern South America.” Since 2001, the warming rate of Southern South America land surface temperature anomalies (Figure 6-25) was reasonably close to the modeled rate.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-25

“Amazon” land surface air temperature anomalies, on the other hand, haven’t warmed in 12+ years, as shown in Figure 6-26. Note the very strong El Niño- and La Niña-caused variations in the Amazon region’s observed land surface temperature anomalies.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

Figure 6-26

CHAPTER 6.7 SUMMARY

Like the other continents, the climate models simulated the warming rate of one region of South America well, but totally missed the mark on the other. (See also chapter 5.1 where I discuss South American land surface temperature anomalies for the period of 1979 to present.)

Chapter 6.8 – Closing Comments about the Short-Term (Since 2001) Model-Data Comparisons for Land Surface Temperature Anomalies

This section served a number of purposes. First, it illustrated which regions around the globe have not warmed or have cooled during the warming cessation period.

The second purpose of this section was to illustrate the magnitude of the annual variations in surface temperatures. In the graphs of the regional land surface air temperature anomalies, it is difficult to overlook the magnitude of the annual variability. That variability is easily seen even though the data in those graphs have been smoothed with 13-month running-average filters (filtering greatly reduces the variability). Some of the greatest variations are caused by El Niño and La Niña events. Some are caused by weather events, such as the North American heat waves.

Until climate modelers are able to simulate El Niño and La Niña processes and to predict weather events years into the future, model outputs will still be off the mark, wildly in many cases. Researchers have been trying to simulate El Niño and La Niña for decades, but, there are still major flaws as discussed in Guilyardi, et al. (2009) and Bellenger, et al. (2013).

Third, while some think that because the models performed well in a few of the regions, (so they must not be all that bad), the reality is, the models performed poorly in most regions. Their general poor performance leads to only one reasonable conclusion: the few times that model output resembled reality were mere happenstance. According to the observations-based data, some regions warmed, some showed no warming, and the others cooled. Excluding the “Alaska” region, the models said that 21 of the regions warmed, so they were bound to get it right a few times. Pure chance. Happenstance. Coincidence.

Section 7 – Satellite-Era Sea Surface Temperatures

The oceans and seas cover about 70% of the surface of the Earth. Most of us live on land, so some readers might be thinking, *Who cares about the surface temperatures of the oceans?* But, what those readers fail to recognize is that it's the surface temperatures of the oceans that dictate the weather and climate on land. The surface temperatures of the oceans, and the variations they exhibit due to coupled ocean-atmosphere processes, cause the big variations in land surface temperatures and precipitation. It is therefore of paramount importance for climate models to be able to accurately simulate the variations in sea surface temperatures caused by those natural ocean processes.

Unfortunately for the climate science community, climate models show **no skill** at being able to simulate sea surface temperatures. None. The primary cause of these shortcomings is their inability to simulate the coupled ocean-atmosphere processes that express themselves as El Niños and La Niñas and as modes of decadal and multidecadal variability such as the Atlantic Multidecadal Oscillation.

Once again, I'll present papers that discuss the many climate model failings: 1) associated with their attempts to simulate El Niño and La Niña processes, Guilyardi, et al. (2009) and Bellenger, et al. (2013); and 2) a paper discussing the models' failure to properly simulate the Atlantic Multidecadal Oscillation, Ruiz-Barradas, et al. (2013).

I will compare the climate model outputs of sea surface temperatures (which are identified as "tos" at the KNMI Climate Explorer webpage for the CMIP5 models) to satellite-era sea surface temperature data. I primarily use the Reynolds Optimum Interpolation sea surface temperature dataset. I discussed that dataset earlier in Chapter 2.4. The Reynolds OI.v2 dataset starts in November, 1981 and provides more than 30 years of sea surface temperature data based on satellite measurements and *in situ* observations from ship inlets and from moored and drifting buoys. To discuss multidecadal variability, I use the UKMO's long-term sea surface temperature reconstruction, HADISST.

NOAA uses the base years of 1971-2000 for the Reynolds OI.v2 data at their NOMADS website. The same base years were used for the model outputs.

RESULTS IN TABULAR FORM

In Table 7.1 are the modeled and observed warming and cooling trends of the sea surface temperatures of the global oceans and of the subsets included in this section. The trends are for the period of November, 1981 to July, 2013. Also shown, in the last column, are the differences between the trends of the models and data. (The differences contain a few errors due to rounding.) There are only two ocean basins where the observed warming rates were greater than the estimates of the models: the North Atlantic and the Arctic Ocean. And note that the difference between the Arctic data and what the models estimated there is only 0.02 deg C/decade (for the North Atlantic, it's only 0.03 deg C/decade).

Table 7.1 - Basin Sea Surface Temperature Model-Data Comparison

Time Period = Nov 1981 to Jul 2013 Dataset = Reynolds OI.v2
Models = Multi-Model Ensemble Mean CMIP5 w/RCP6.0
Difference = Model Trend - Data Trend

TABLE 7-1 - MODEL-DATA LINEAR TREND COMPARISON

		TREND		DIFFERENCE
		Modeled	Observed	Modeled Minus Observed
DATASET	COORDINATES	Deg C/Decade	Deg C/Decade	Deg C/Decade
Global	90S-90N	0.17	0.08	0.08
NINO3.4	5S-5N, 170W-120W	0.20	-0.14	0.34
East Pacific	90S-90N, 180-80W	0.15	0.01	0.14
Northern Hemisphere	0-90N	0.19	0.13	0.07
Southern Hemisphere	90S-0	0.14	0.05	0.09
North Atlantic	0-70N, 80W-0	0.19	0.23	-0.03
South Atlantic	60S-0, 70W-20E	0.17	0.06	0.10
Pacific	60S-65N, 120E-80W	0.17	0.06	0.11
North Pacific	0-65N, 100E-90W	0.20	0.07	0.13
South Pacific	60S-0, 120E-70W	0.14	0.04	0.10
Indian	60S-30N, 20E-120E	0.17	0.10	0.08
Arctic	65N-90N	0.11	0.12	-0.02
Southern	90S-60S	0.05	-0.05	0.10

There are well-known reasons for the additional warming of the Arctic and North Atlantic sea surface temperatures. Because the two basins are wide open to one another, Arctic sea surface temperatures are strongly influenced by those of the North Atlantic. The sea surface temperature anomalies of the North Atlantic have a mode of natural variability known as the Atlantic Multidecadal Oscillation. As a result of the Atlantic Multidecadal Oscillation, the North Atlantic warmed at a rate that was 2.7 times higher than the global trend during this period. This, in turn, warmed the sea surface temperatures of the Arctic Ocean.

The sea surface temperatures of the North Atlantic will eventually level off and then cool in the not-too-distant future — if they haven't leveled off already — and about 3 decades later, the surface temperatures of the North Atlantic will once again warm at a rate that's faster than the rest of the global oceans. In this way, the sea surface temperatures of the North Atlantic can add to the global warming during some time periods or suppress the global warming during others. (Land surface air temperatures in the Northern Hemisphere then exaggerate the effects of the multidecadal variations in sea surface temperatures.)

I first look at the global data, then examine the polar oceans. Then, I compare model outputs and data for the satellite-era sea surface temperature anomalies of the Indian Ocean and also for the Atlantic Ocean, with its well-known Atlantic Multidecadal Oscillation. Finally, the mighty Pacific.

Chapter 7.1 – Model-Data Comparison of Satellite-Era Sea Surface Temperature Anomalies: Global

I compare the models' estimates with the observed global sea surface temperature anomalies for the satellite era in Figure 7-1. The satellite era of sea surface temperature data extends for more than 31 years. During that time period, sea surface temperatures warmed at about half the rate estimated by the models used in the IPCC's 5th Assessment Report. Half the rate.

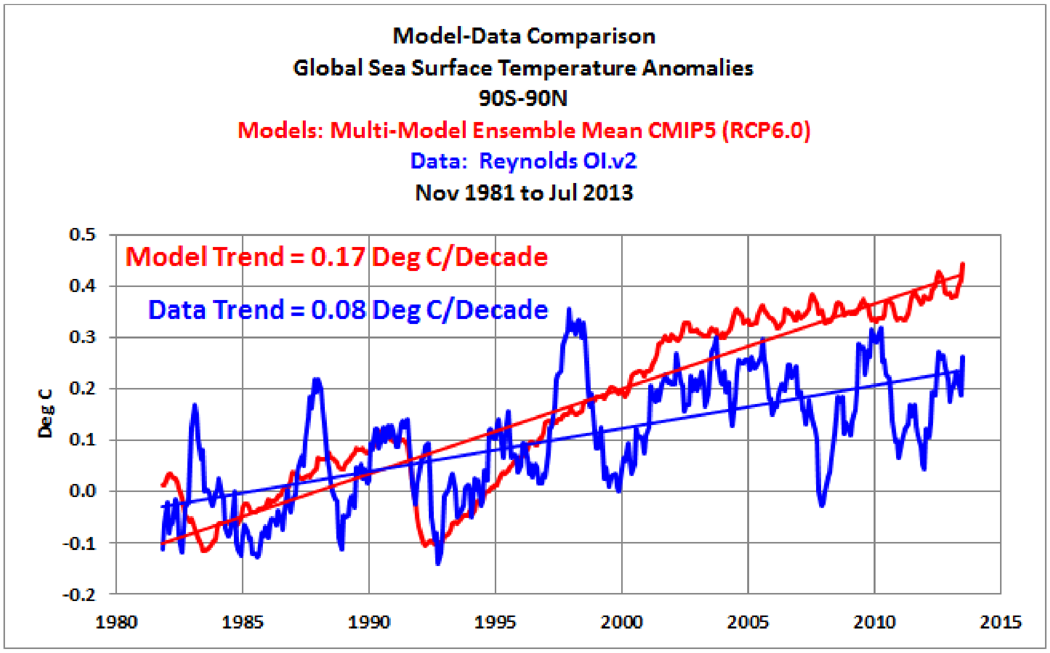


Figure 7-1

In other words, the models indicate that if manmade greenhouse gases were responsible for the warming of the sea surface temperatures of the global oceans, they should have warmed twice as fast as they actually did. If you think the models performed poorly based on the global performance, wait for the Pacific Ocean.

Global sea surface temperature trends for the period of November, 1981 to July, 2013 are compared in Figure 7-2 on a zonal-mean basis, along with the model-simulated warming rates. The models overestimated the sea surface temperature warming rates in the tropics and in the mid-latitudes of the Southern Hemisphere. The models also underestimated the warming rates at the high latitudes of the Northern Hemisphere, but did okay in areas where Arctic sea ice dominates.

(Note: Polar amplification is a phenomenon that is captured by land surface air temperature data, not sea surface temperature data. See Chapter 2.8.)

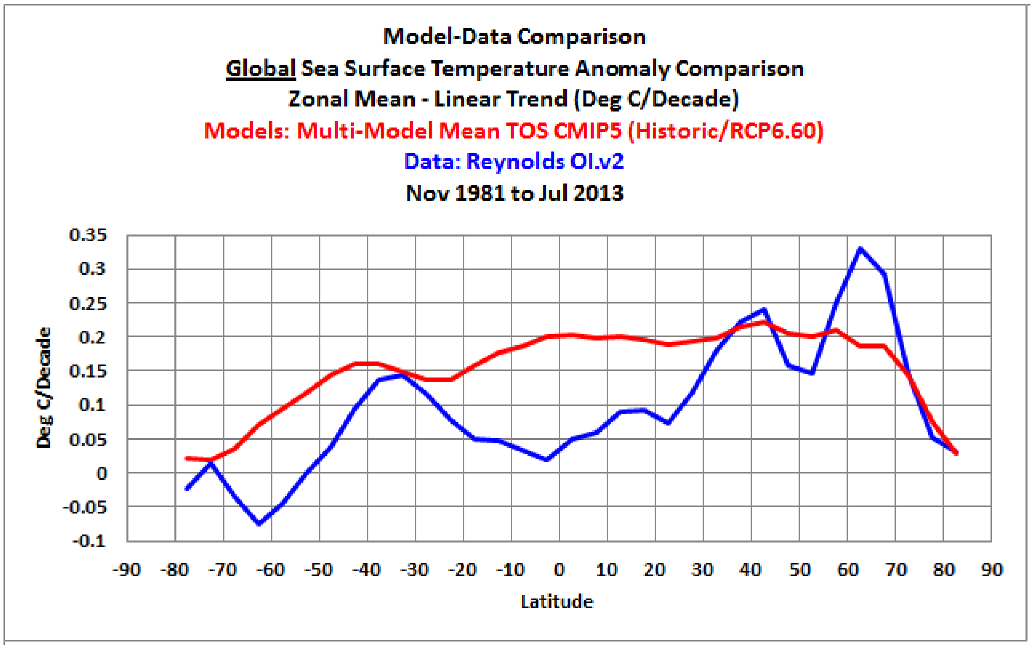


Figure 7-2

NORTHERN AND SOUTHERN HEMISPHERES

The models estimated that the Northern Hemisphere would warm 50% faster than it actually did over the past 30 years. (See Figure 7-3.)

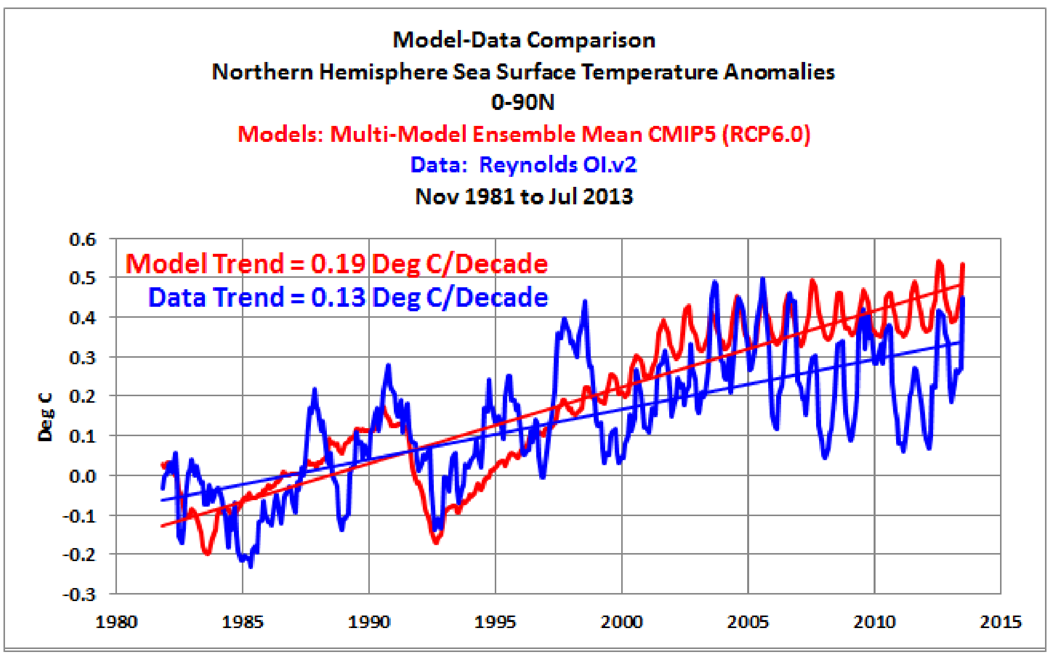


Figure 7-3

For the Southern Hemisphere, Figure 7-4, the models estimated sea surface temperatures would warm nearly 3 (2.8) times faster than they actually did. Bear this in mind: the oceans cover about 80% of the surface area of the Southern Hemisphere. That is a colossal modeling failure.

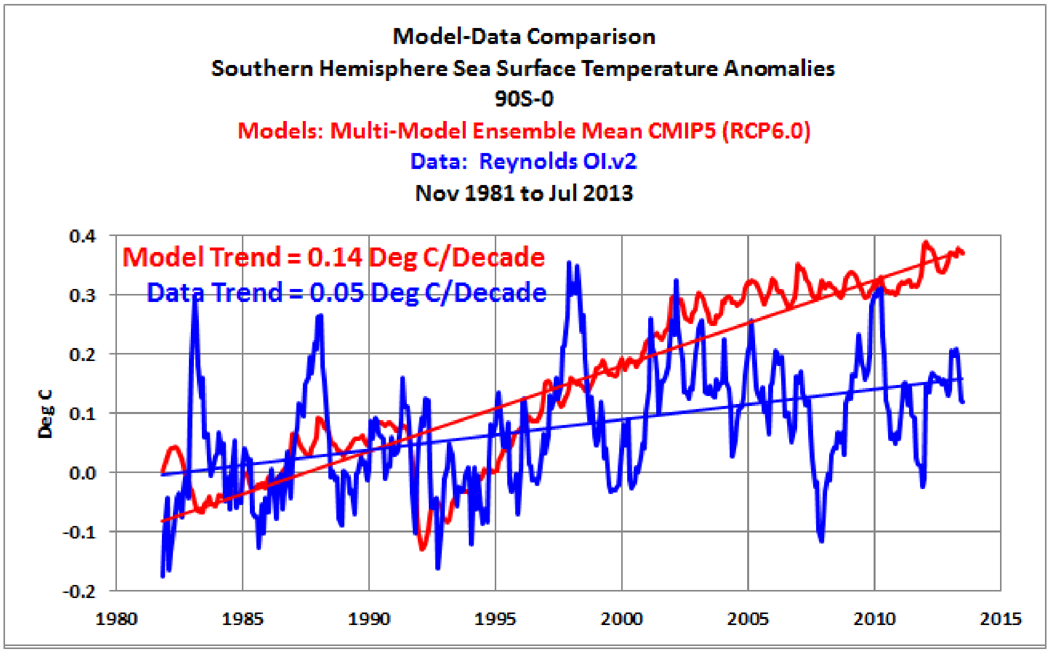


Figure 7-4

CHAPTER 7.1 SUMMARY

For over 30 years, global sea surface temperatures warmed at half the rate simulated by the climate models. A modeled warming rate **twice** the observed rate in global sea surface temperatures is a horrendously poor modeling effort. Such a failure is fatal to any potential for success at modeling global surface temperatures on a global scale, given the fundamental nature of a climate metric like sea surface temperatures: the oceans cover about 70% of the surface of the planet, and land surface air temperatures vary in response to sea surface temperatures.

The models, laboring under the assumption that manmade greenhouse gases cause sea surface temperatures to warm, estimated that the surface of Earth's oceans should have warmed twice as fast as they actually did. As I will discuss in Section 9, data indicate that sea surface temperatures are not impacted by manmade greenhouse gases.

Chapter 7.2 – Model-Data Comparison of Satellite-Era Sea Surface Temperature Anomalies: Polar Oceans

The Arctic Ocean and the Southern Ocean — the polar oceans — are unique. Sea ice coverage there varies seasonally, increasing and decreasing the area of open ocean available for satellite-based sea surface temperature measurements. To add to the complexity, while seasonal sea ice area has been decreasing in the Arctic Ocean, it has been increasing in the Southern Ocean. To accommodate temperature anomalies, researchers use the freezing temperature of sea water in any locations where there is sea ice. For example, for their Reynolds OI.v2 sea surface temperature anomalies, NOAA uses -1.8 deg C (absolute) as the base year temperatures for each month at the North Pole.

Sea surface temperature anomalies in the Arctic, Figure 7-5, have been increasing, and that warming is in line with the rate estimated by the multi-model ensemble mean of the CMIP5 models. The observed warming exceeds the model estimate by just a small amount. Keep in mind that the latitudes I've used for the Arctic Ocean (65N-90N) also include a small portion of the North Atlantic.

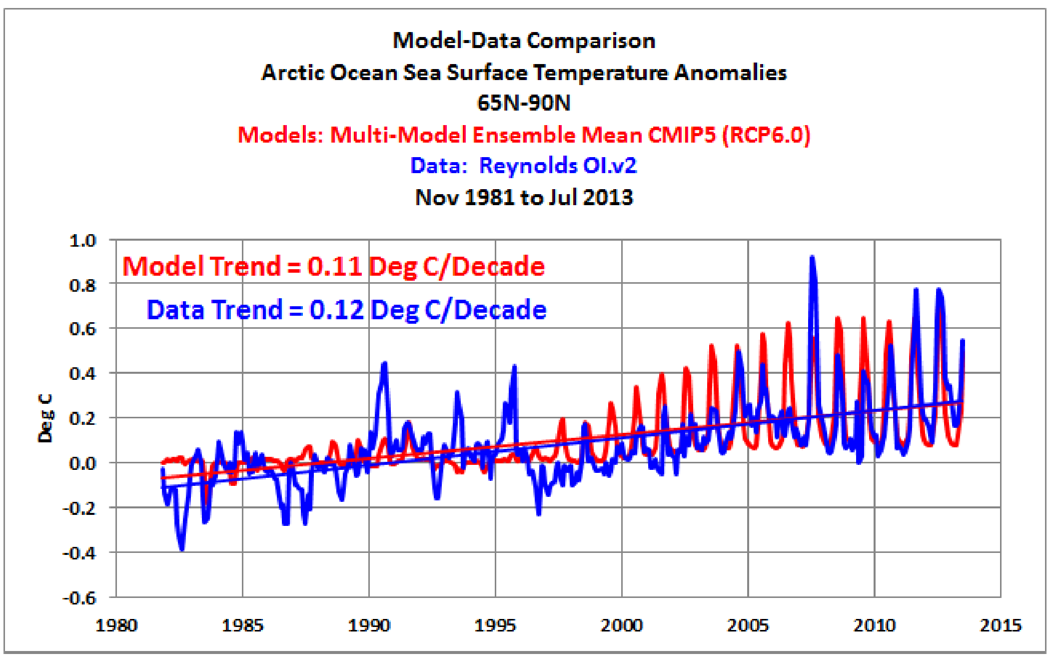


Figure 7-5

At the other end of the planet, the models failed to estimate the strong cooling that happened in the sea surface temperatures of the Southern Ocean. (See Figure 7-6.) The models simulated a warming rate of 0.05 deg C/decade over the past 31 years for the sea surface temperatures of the Southern Ocean, but the observed sea surface temperatures cooled at a rate of -0.05 deg C/decade.

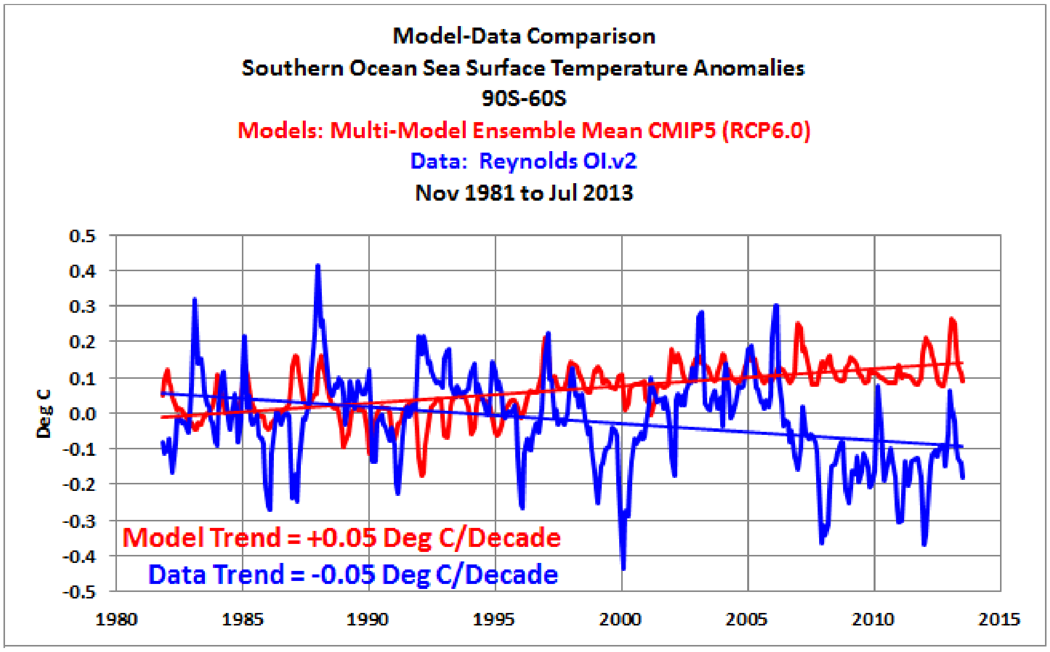


Figure 7-6

As you'll recall from Chapter 3.1, the climate models also simulated a decrease in sea ice area surrounding Antarctica but sea ice area has increased there.

CHAPTER 7.2 SUMMARY

If the Earth had only one polar ocean, the Arctic Ocean, the climate models could be said to have performed well at simulating polar sea surface temperatures. Unfortunately for climate model programmers, there are two polar oceans. If manmade greenhouse gases had caused the variations in polar sea surface temperatures over the past 30 years, the sea surface temperatures of the Southern Ocean would have warmed per the models. The modelers' assumptions were obviously wrong. The sea surface temperatures of the Southern Ocean have cooled.

Chapter 7.3 – Model-Data Comparison of Satellite-Era Sea Surface Temperature Anomalies: Indian Ocean

Asia limits the northward reach of the North Indian Ocean just north of the tropics. Therefore, the Indian Ocean is primarily a Southern Hemisphere ocean. For this reason, I didn't separate the data for the North and South Indian Ocean in this chapter.

The sea surface temperature data anomalies of the Indian Ocean warmed at a rate of 0.1 deg C/decade since November, 1981, Figure 7-7, but, the CMIP5-archived models estimated it would warm by 0.17 deg C/decade — 70% higher than observed.

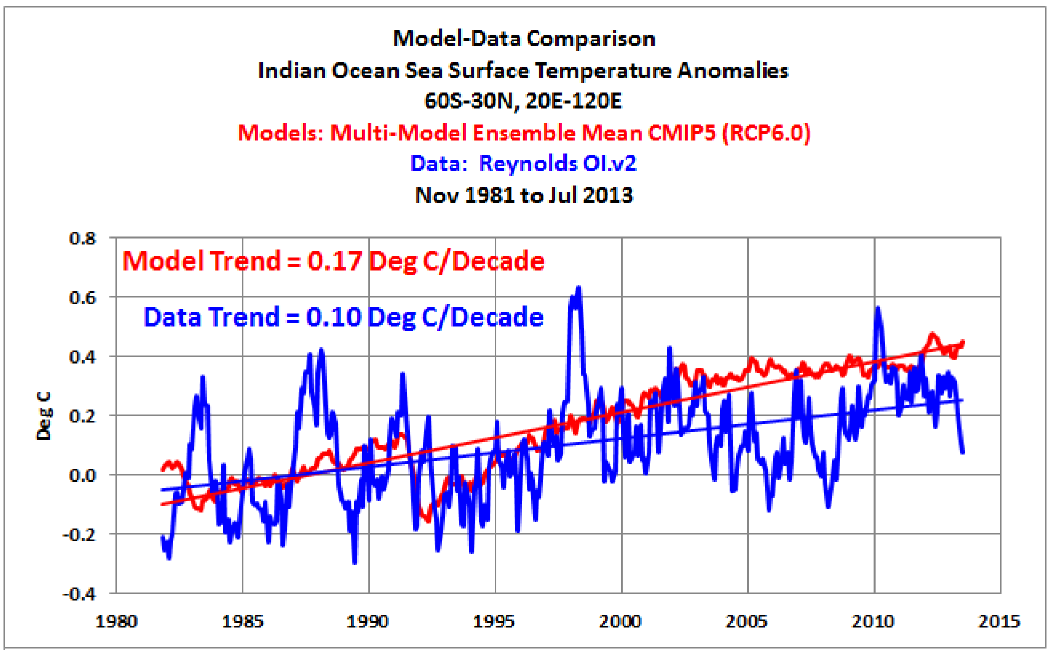


Figure 7-7

Looking at the warming and cooling rates of the modeled and observed sea surface temperatures in the Indian Ocean on a latitudinal basis in Figure 7-8, the models significantly overestimated the warming in the tropics and in the mid-latitudes of the Southern Hemisphere. The models also failed to capture the cooling that has taken place over the past 31 years in the portion of the Southern Ocean south of the Indian Ocean.

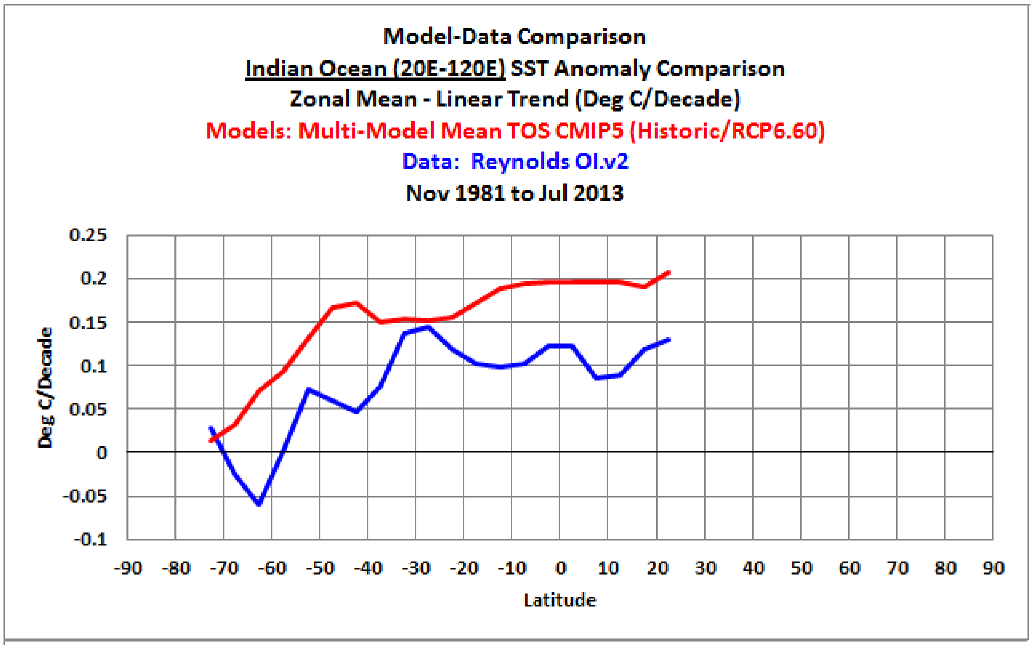


Figure 7-8

CHAPTER 7.3 SUMMARY

Short and simple: The climate models have estimated a warming rate for the Indian Ocean that is much too high over the past 31+ years.

Chapter 7.4 – Model-Data Comparison of Satellite-Era Sea Surface Temperature Anomalies: Atlantic Ocean

Unlike the Indian Ocean, the Atlantic Ocean stretches northward from the Southern Ocean surrounding Antarctica all the way up to the Arctic Ocean. The North Atlantic is also wide open to the Arctic Ocean, unlike the North Pacific which is restricted by the Bering Strait.

Of the three major ocean basins (Atlantic, Indian, and Pacific), the models performed best at estimating the warming of the Atlantic during the satellite era. The difference between the modeled and observed warming rates for the Atlantic Ocean is about 0.04 deg C/decade during the last 31+years.

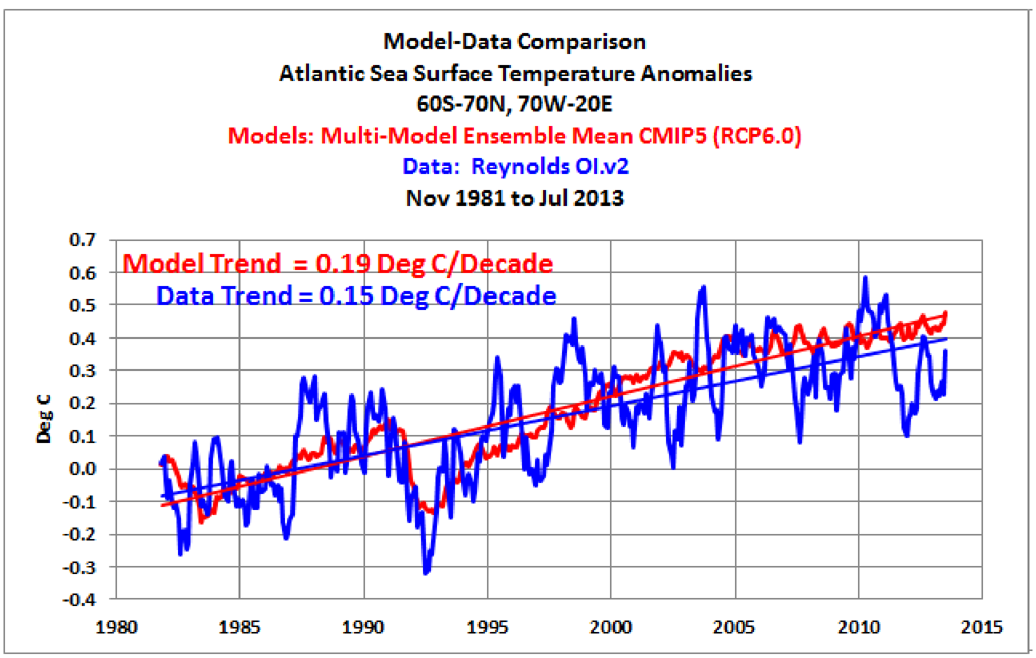


Figure 7-9

In the South Atlantic, the difference in the warming rates between the models and sea surface temperature data is about 0.11 deg C/decade. (See Figure 7-10.)

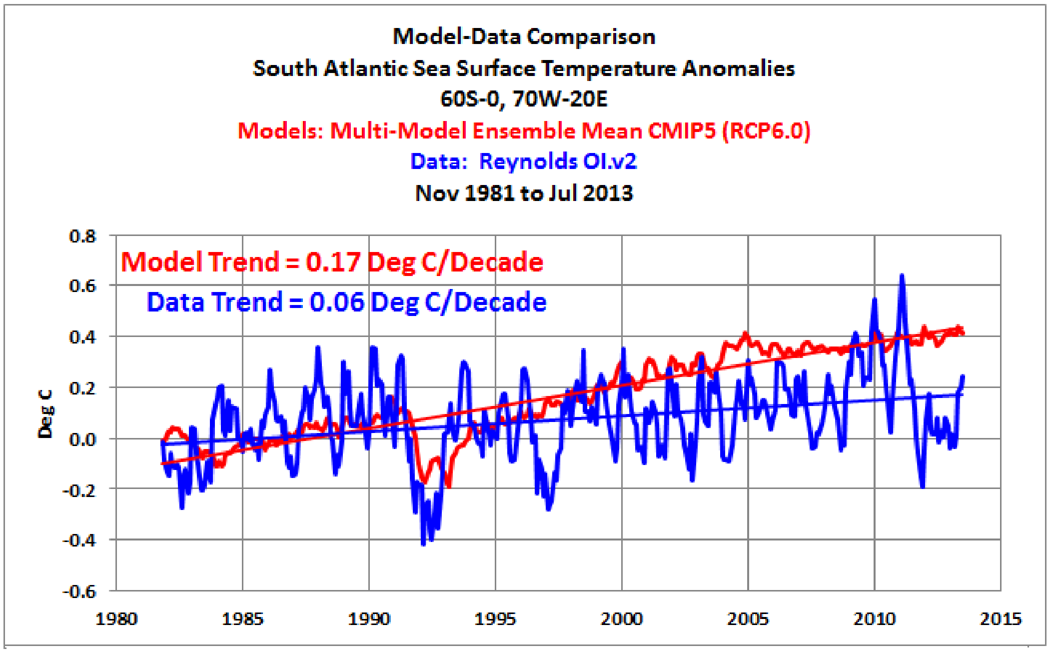


Figure 7-10

The sea surface temperatures of the South Atlantic also exhibit a curious behavior. The sea surface temperature anomalies were relatively flat from the late 1980s to the early 1990's when there was a major dip and rebound that appears to be a response to the eruption of Mount Pinatubo. There's another smaller dip and rebound a few years later. Other than those two dips and rebounds, the sea surface temperature anomalies were basically the same in 2008 (likely a little cooler) as they were in the late 1980s. Then, mysteriously, from 2009 to 2011, sea surface temperature anomalies shifted upwards, after which, they returned to previous levels. I have looked for an explanation for that temporary upward shift in the South Atlantic sea surface temperature data but haven't found one. As far as I know, there are no scientific papers that attempt to explain it. The reason I mention it: if it wasn't for that unexplained temporary upward shift in the sea surface temperatures of the South Atlantic from 2009 to 2011, the models would have performed even worse than they did.

In Figure 7-11 is the model-data comparison of North Atlantic sea surface temperature anomalies. The models underestimated the observed warming by 0.03 deg C/decade since November, 1981.

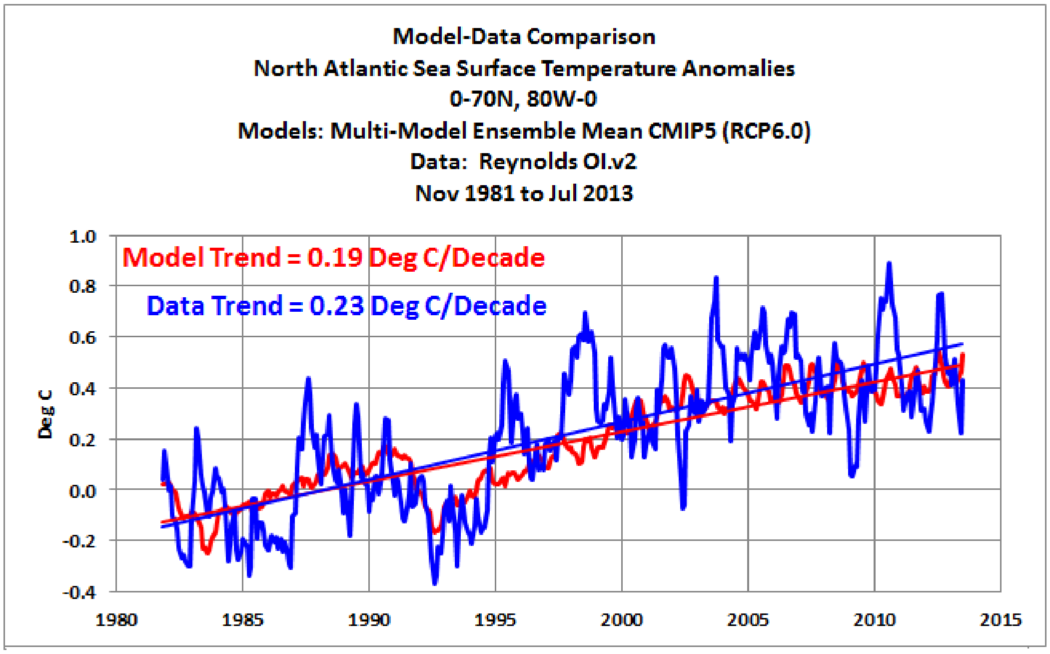


Figure 7-11

The above model simulations of sea surface temperatures might give the impression that the models performed well in the North Atlantic. But, a model-data comparison of Atlantic sea surface temperature trends from November 1981, to July, 2013 on a zonal mean basis (Figure 7-12) expose the models' failures.

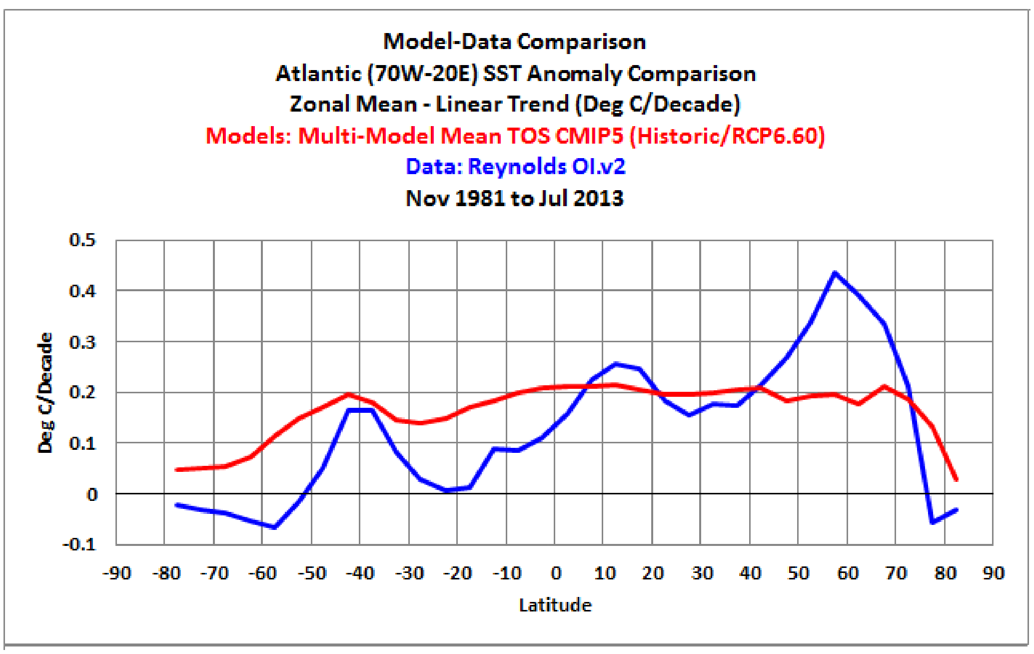


Figure 7-12

The models grossly underestimated the warming of the mid-to-high latitudes of the North Atlantic. Then, south of about 5 deg N, the models overestimate the warming… all the way to the Southern Ocean. There, in the ocean surrounding Antarctica, the models completely missed the cooling of sea surface temperatures that has taken place over the past 31 years.

THE NATURAL FACTOR THAT IS THE SOURCE OF THE ADDITIONAL WARMING OF THE NORTH ATLANTIC SURFACE TEMPERATURES

The North Atlantic has an additional mode of natural variability called the AMO (Atlantic Multidecadal Oscillation). I've mentioned it a few times already. As a result of the Atlantic Multidecadal Oscillation, for the period of November, 1981 to July, 2013 (the satellite era of sea surface temperature data), North Atlantic sea surface temperatures warmed almost 3 times faster than the global oceans. (See Figure 7-13.)

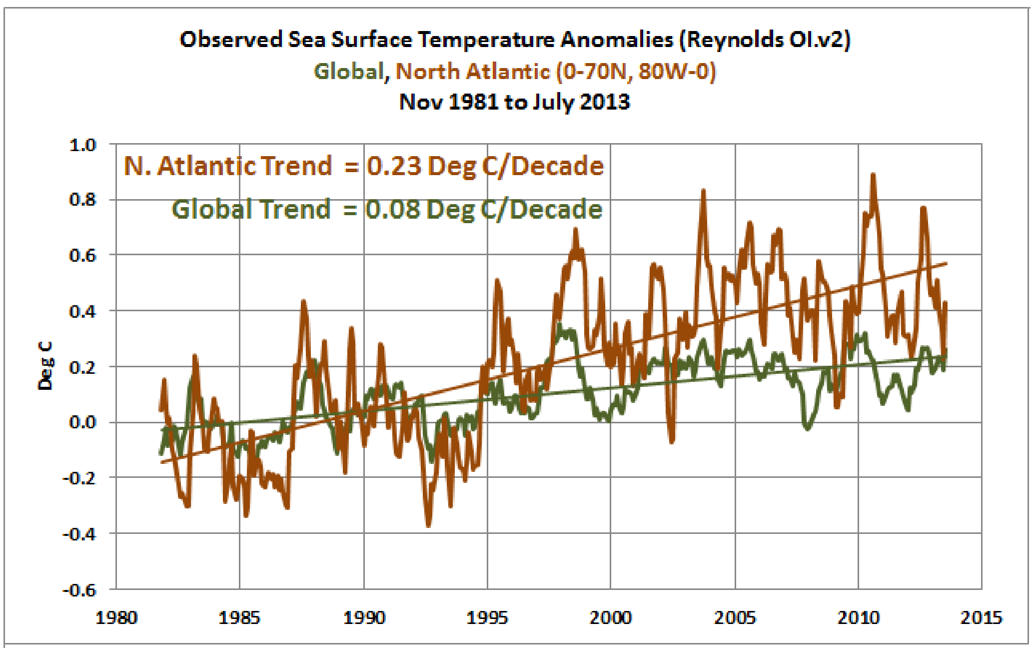


Figure 7-13

But, as Figure 7-14 reveals, the models estimated that the warming of the North Atlantic would be only slightly higher than the sea surface temperatures of the global oceans.

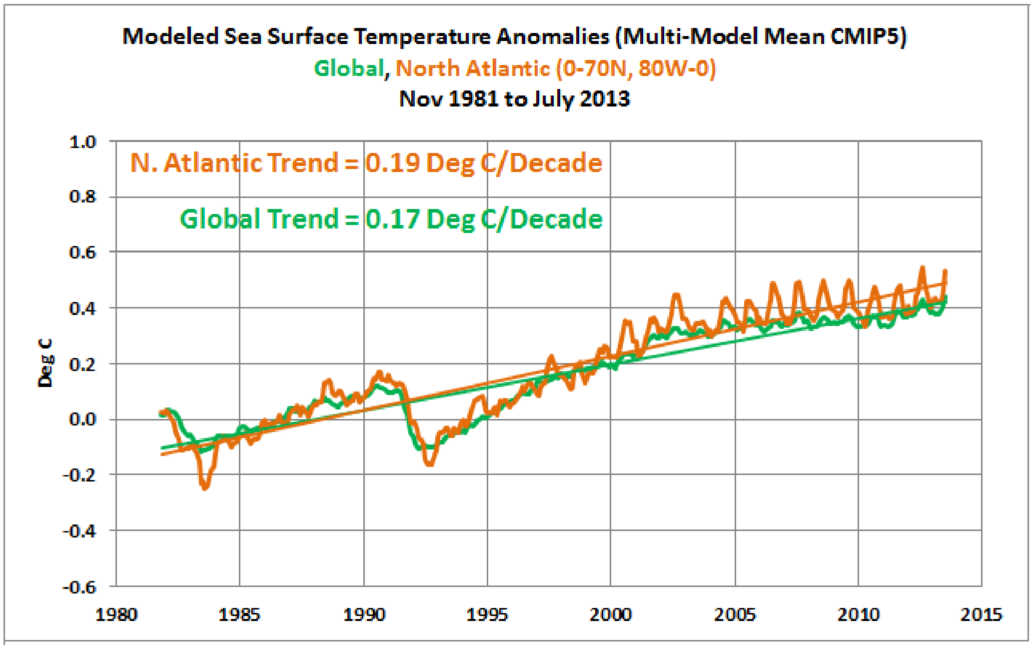


Figure 7-14

Think about that. In the real world, the sea surface temperatures of the North Atlantic warmed, over the last 31 years, almost 3 times faster than the global oceans. But, in the modeled world, where the warming of sea surface temperatures is forced by manmade greenhouse gases, the warming rate of the North Atlantic is very similar to that of the rest of the global oceans. That strongly suggests that the additional observed warming in the sea surface temperatures of the North Atlantic is not a forced response to manmade greenhouse gases — that the additional observed warming of the North Atlantic is a response to a natural coupled ocean-atmosphere process.

CHAPTER 7.4 SUMMARY

The climate models prepared for the IPCC's 5th Assessment Report grossly overestimated the sea surface temperature warming of the South Atlantic Ocean. In the North Atlantic, a powerful natural factor (the AMO) caused the sea surface temperature anomalies there to warm at a rate that was significantly higher than the rest of the global oceans. Because the models do not simulate the AMO, that the models happened to do okay for the North Atlantic was pure luck.

Or maybe the modelers tuned the models to the North Atlantic in an effort to have the models perform better in the Arctic. In doing so, they caused the models to perform very badly in all of the other ocean basins. That sounds very similar to the findings of Swanson (2013) "Emerging Selection Bias in Large-scale Climate Change Simulations." The preprint version of the paper is here. In the Introduction, Swanson writes (my boldface):

Here we suggest the possibility that a selection bias based upon warming rate is emerging in the enterprise of large-scale climate change simulation. Instead of involving a choice of whether to keep or discard an observation based upon a prior expectation, we hypothesize that this selection bias involves the 'survival' of climate models from generation to generation, based upon their warming rate. ***One plausible explanation suggests this bias originates in the desirable goal to more accurately capture the most spectacular observed manifestation of recent warming, namely the ongoing Arctic amplification of warming and accompanying collapse in Arctic sea ice. However, fidelity to the observed Arctic warming is not equivalent to fidelity in capturing the overall pattern of climate warming.***

Chapter 7.5 – The Models and the Atlantic Multidecadal Oscillation

I have discussed the Atlantic Multidecadal Oscillation a few times already in this book. Instead of sending you back to previous chapters, I'll repeat my earlier overview and expand on it by comparing modeled with observed sea surface temperature anomalies of the North Atlantic over the long-term (since 1870).

The earlier discussion (in Chapter 2.10 and repeated here) was from my book ***Who Turned on the Heat?***

> The Atlantic Multidecadal Oscillation, or AMO, is a natural mode of climate variability that occurs in the North Atlantic Ocean. The Atlantic Multidecadal Oscillation was first identified in the mid-1990s. As **Wikipedia** notes on its **Atlantic Multidecadal Oscillation webpage**:
>
> > *The AMO signal is usually defined from the patterns of SST [Sea Surface Temperature] variability in the North Atlantic once any linear trend has been removed.*

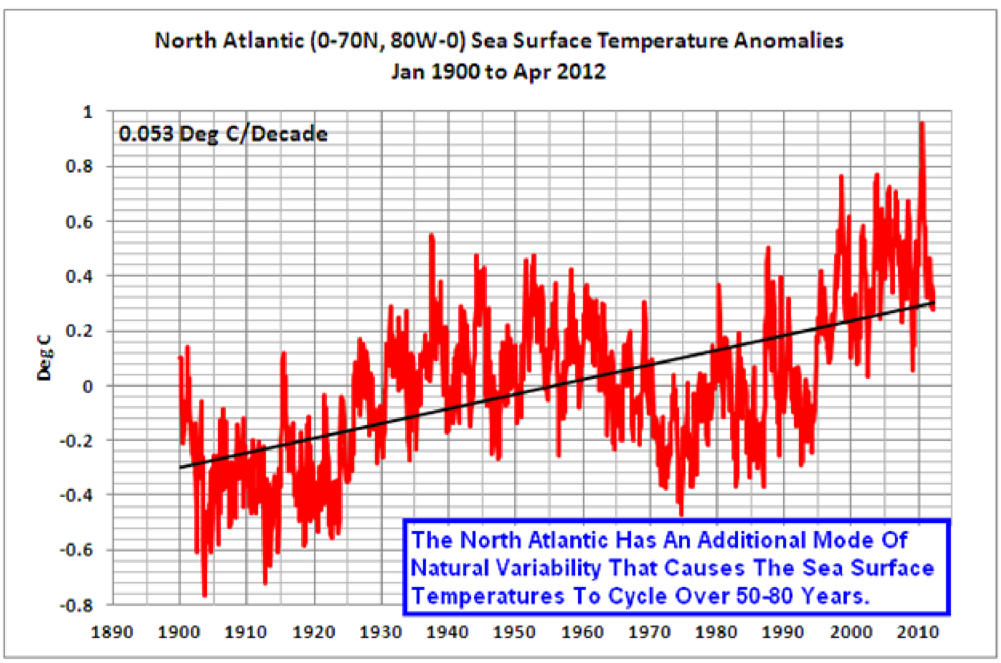


Figure 7-15

> Figure 7-15 is a graph of the observed sea surface temperature anomalies of the North Atlantic since 1900, along with their linear trend. North Atlantic sea surface temperature anomalies warmed at a rate of 0.053 deg C per decade since 1900

based on the linear trend. In addition to that overall warming, an additional long-term variation caused North Atlantic sea surface temperatures from 1900 to the late 1930's to warm relatively rapidly and then, to level off until the early 1960s when sea surface temperatures cooled quite rapidly until the mid-1970s. They then warmed once again. The length of the cycle since 1900 appears to be about 60 years. Paleoclimatological studies have shown that the AMO cycle varies in length, its time span ranging between 50 and 80 years.

To remove the linear trend from the data, also known as detrending, I determined the monthly values of the linear trend line, then subtracted those values from the North Atlantic sea surface temperature anomalies. (See Figure 7-16.) The black line at zero deg C is the actual linear trend of the detrended data. The trend is flat, i.e., the detrended North Atlantic sea surface temperature anomalies no longer have a trend.

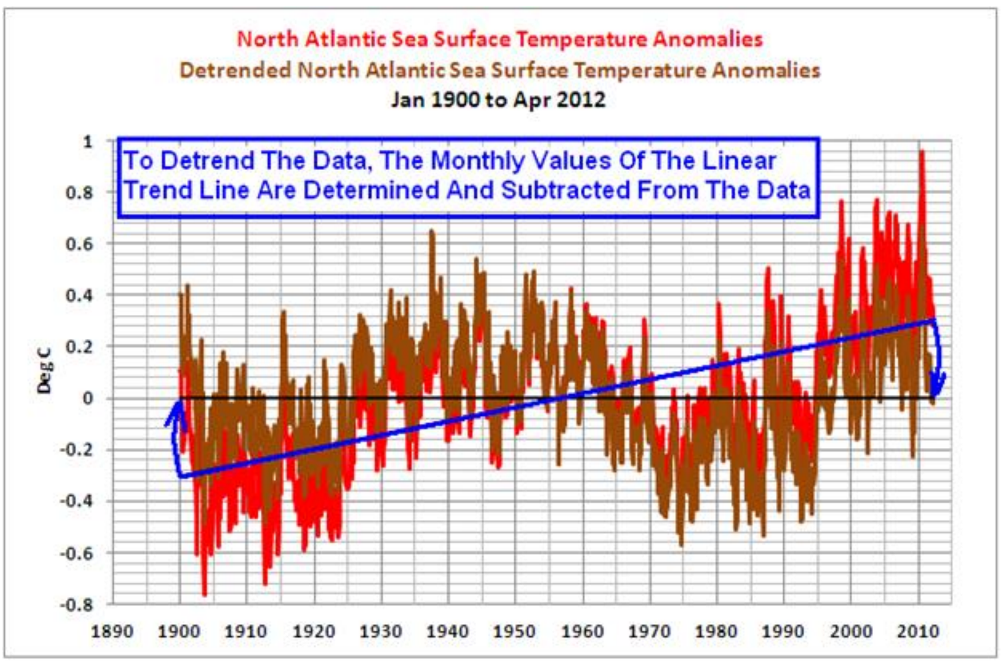


Figure 7-16

NOAA calls the detrended North Atlantic sea surface temperature anomaly data the "[Atlantic Multidecadal Oscillation (AMO) Index](#)." The monthly variations in the data in Figure 7-16 are quite strong. NOAA uses a 121-month running-average filter to show underlying multidecadal variations, so, I smoothed the data with a 121-month filter in Figure 7-17. The first warming period in the detrended data peaks in the early 1940s, then, cools slowly until the late 1950s. From the late

1950s until the mid-1970s, the detrended North Atlantic sea surface temperature anomalies cool rapidly. Then they warm, slowly, until the late 1980s and then, much more quickly through the end of the data. If history repeats itself, the multidecadal cycle in the detrended North Atlantic sea surface temperature anomalies will peak in the not-too-distant future.

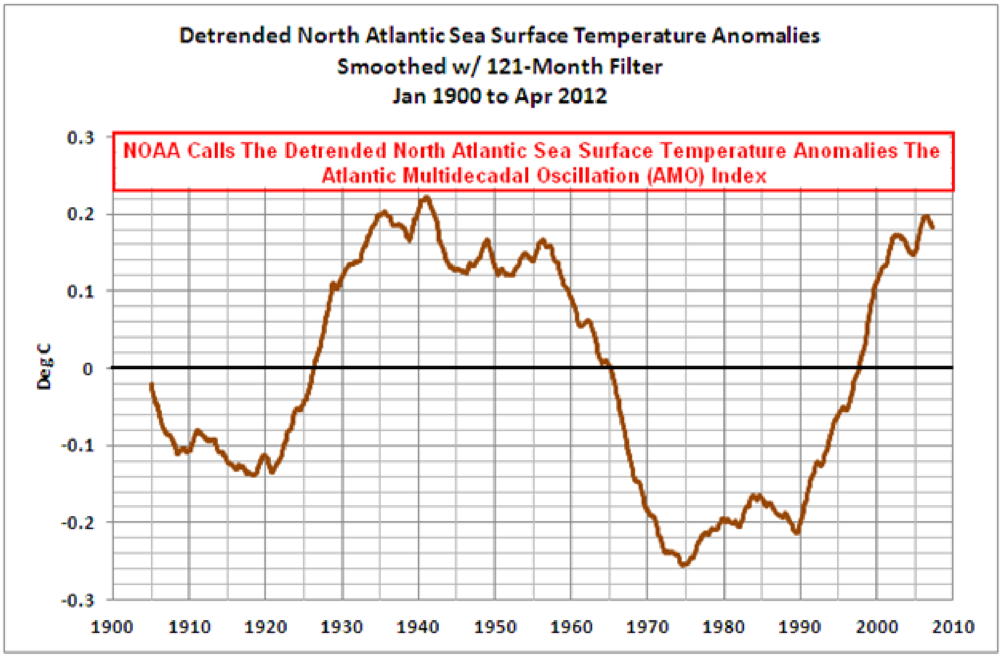


Figure 7-17

[End of reprint from ***Who Turned on the Heat?*** by Bob Tisdale]

In Figure 7-17, once the data have been detrended and smoothed, it is obvious that there are strong multidecadal variations in the sea surface temperature anomalies of the North Atlantic.

For further information about the Atlantic Multidecadal Oscillation, see the NOAA AOML (Atlantic Oceanographic and Meteorological Laboratory) Frequently Asked Questions webpage here, and my blog post here, and my introduction to the Atlantic Multidecadal Oscillation here.

Also see Tung and Zhou (2012) "Using Data to Attribute Episodes of Warming and Cooling in Instrumental Records." As I mentioned in Chapter 1.2, Tung and Zhou (2012) found the Atlantic Multidecadal Oscillation contributed about 40% to global warming since 1950.

Figure 7-18 is my updated presentation of the detrended North Atlantic sea surface temperature anomalies since the 1870's, using the UKMO HADISST dataset smoothed with a 121-month running-average filter.

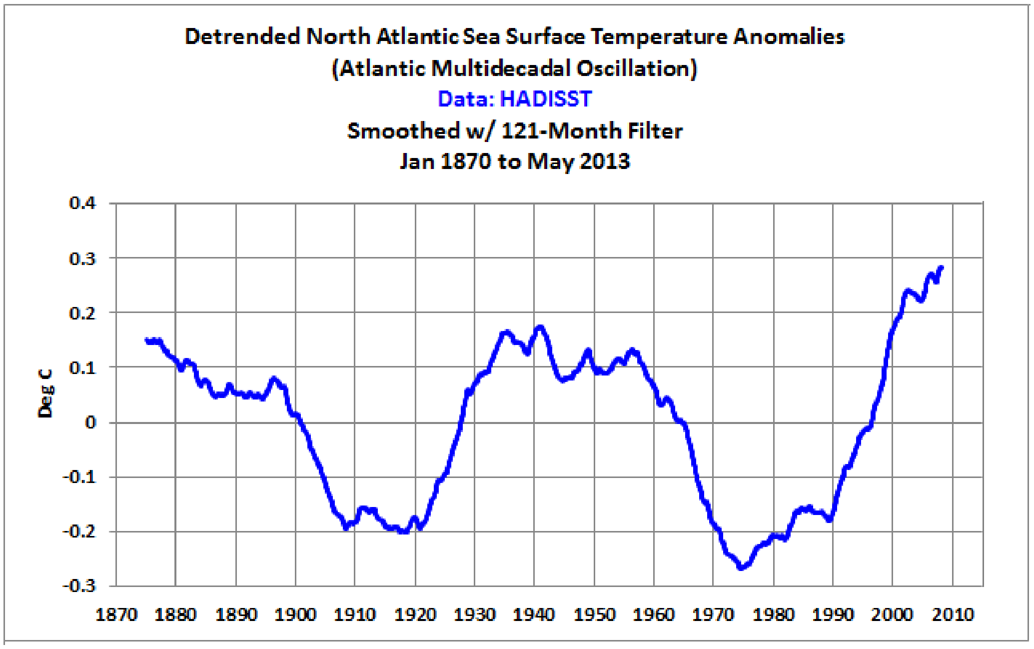


Figure 7-18

In Figure 7-19, I detrended and smoothed the computer model attempts to simulate North Atlantic sea surface temperature anomalies. While the models appear to have captured portions of the two downward, cooling, cycles, they failed to accurately simulate any of the warming that took place during the early warming period.

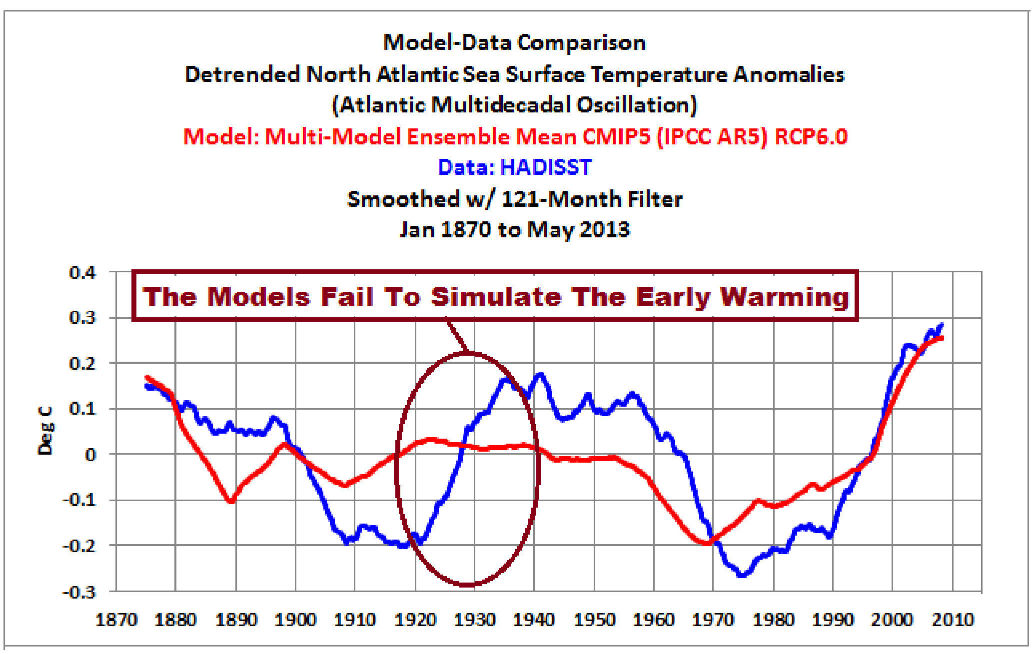


Figure 7-19

By failing to capture the observed warming during the early warming period, the strong implication of the models' output is that surface temperatures are capable of warming without being forced by manmade greenhouse gases. That, of course, then calls into question the cause of the warming during the recent warming period. If North Atlantic sea surface temperatures could warm without being forced during the early warming period (about 1920 to the mid-1930s), there is no reason to believe that anthropogenic factors were the only causes of the later warming — while the sole reason the models performed better during the later warming period is because they were tuned to that period.

AN ALTERNATE PRESENTATION OF THE ATLANTIC MULTIDECADAL OSCILLATION

In the 2006 peer-reviewed paper "Atlantic Hurricanes and Natural Variability in 2005", Trenberth and Shea suggest that, when presenting Atlantic Multidecadal Oscillation data, global sea surface temperature anomalies should be subtracted from the sea surface temperature anomalies of the North Atlantic. They write:

> *To deal with purely Atlantic variability, it is highly desirable to remove the larger-scale global signal that is associated with global processes, and is thus related to global warming in recent decades [Meehl, et al.., 2004; Barnett, et al.., 2005; Hansen, et al.., 2005]. Accordingly the global mean SST has been subtracted to derive a revised AMO index.*

Ideally, to isolate the additional variability of the North Atlantic, Trenberth and Shea should not have subtracted global sea surface temperature data from the North Atlantic data. The global data contains the North Atlantic. Thus, they subtracted a portion of the North Atlantic data from the North Atlantic data. They should have first removed the North Atlantic data from the global data and then subtracted that residual "Rest of the World" sea surface temperature data from the North Atlantic data.

Regardless, to keep the following comparison meaningful, I use the method presented by Trenberth and Shea (2006). They used the coordinates of 0-60N, 80W-0 for the North Atlantic, and the latitudes of 60S-60N for the global data, excluding the polar oceans. They used the UKMO HADISST dataset, so we're in agreement there.

Note: I used the base years of 1870-2012 for anomalies so that the base years would not skew the results of the subtraction.

In Figure 7-20, I present the revised Atlantic Multidecadal Oscillation index, as recommended by Trenberth and Shea. I subtracted the global sea surface temperature anomalies from the North Atlantic data. The multidecadal variations in the North Atlantic sea surface temperatures are plainly evident.

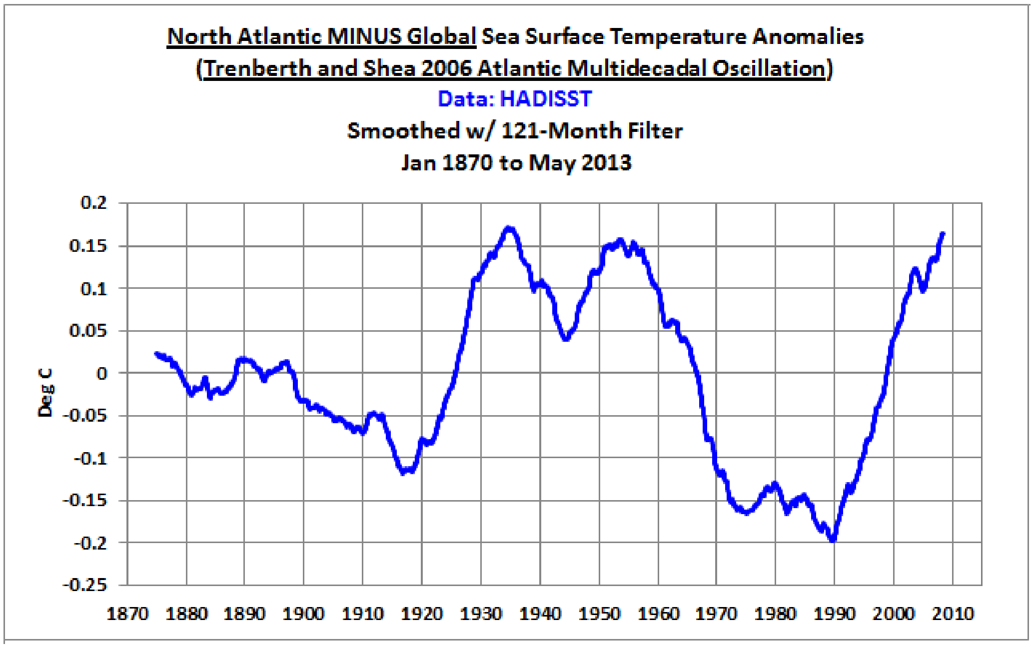


Figure 7-20

I compare the two versions of the Atlantic Multidecadal Oscillation index in Figure 7-21. Most notably, the Trenberth and Shea (2006) version has less variability than the detrended version.

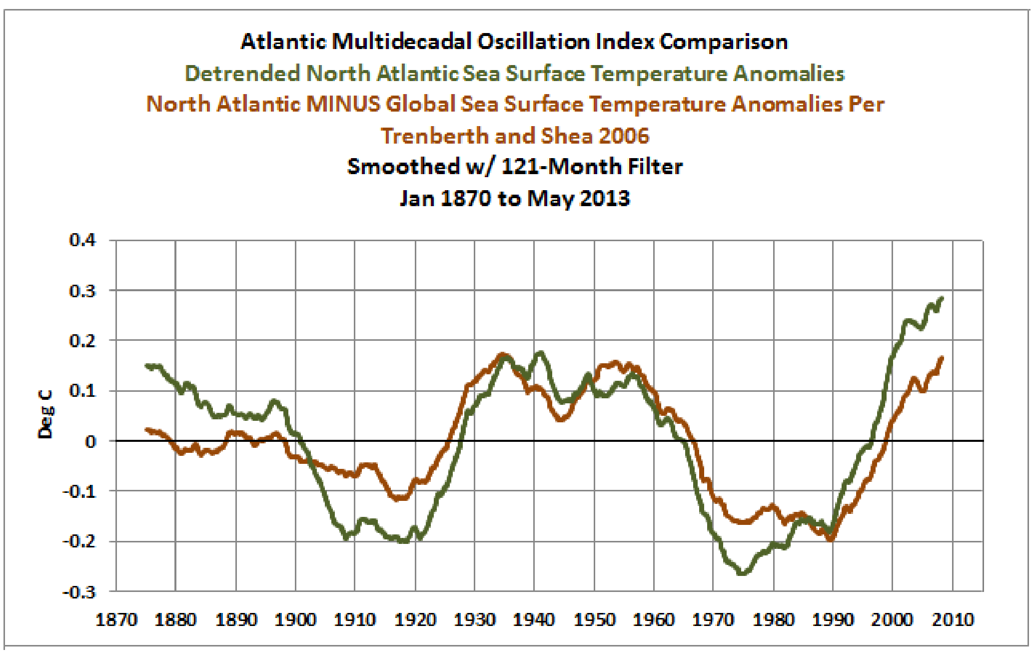


Figure 7-21

In Figure 7-22, I added the model results to the graph for comparison to the Trenberth and Shea depiction of the Atlantic Multidecadal Oscillation. As with the data, I subtracted the model output for global sea surface temperature anomalies from the model output for the North Atlantic. The models clearly cannot accurately simulate the additional multidecadal variations that exist in the North Atlantic sea surface temperature data.

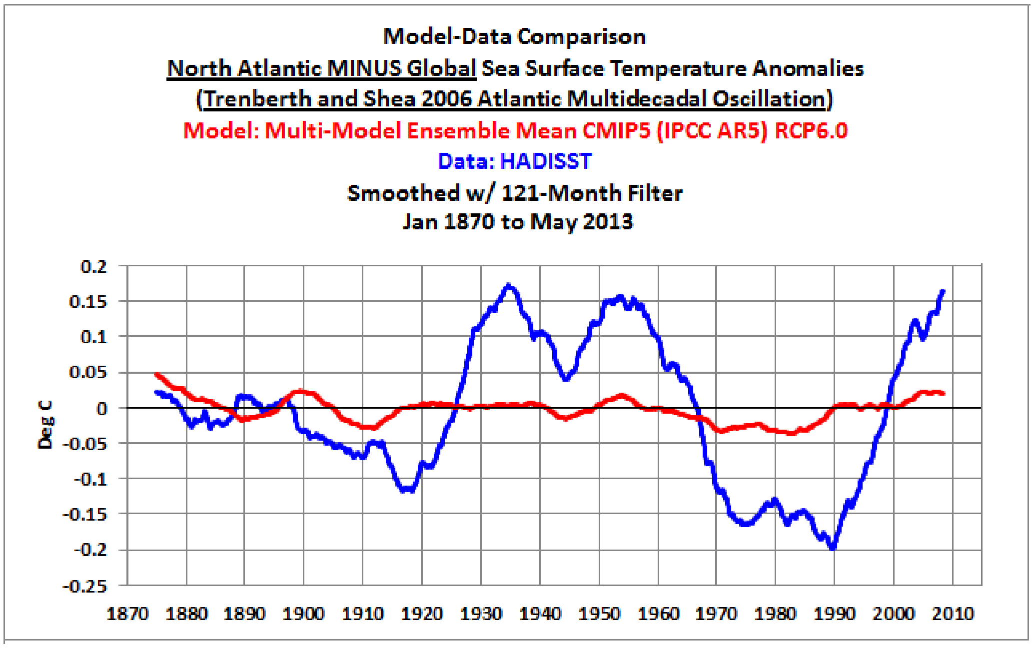


Figure 7-22

The clear implication of the above is that the additional observed variability of the North Atlantic sea surface temperature anomalies is **not** a response to the manmade greenhouse gas forcings that are programmed into the climate models.

CHAPTER 7.5 SUMMARY

Throughout this book, I use the multi-model ensemble mean of the climate models prepared for the IPCC's 5th Assessment Report because it best represents how the climate modelers/scientists believe surface temperatures (and other variables) should respond to manmade climate forcings.

In examining the Atlantic Multidecadal Oscillation, no matter how the variations are presented, the model mean does not accurately identify the multidecadal variations in the sea surface temperatures of the North Atlantic. This strongly suggests that the powerful ocean processes alone cause sea surface temperatures to warm and cool over multidecadal timescales without any noticeable help from manmade greenhouse gases.

Now consider the findings of Ruiz-Barradas, et al. "The Atlantic Multidecadal Oscillation in Twentieth Century Climate Simulations: Uneven Progress from CMIP3 to CMIP5." The full paper is here. At the beginning of their "Concluding Remarks" they explain why it's important for climate models to be able to accurately simulate the Atlantic Multidecadal Oscillation (my boldface):

> *Decadal variability in the climate system from the AMO is one of the major sources of variability at this temporal scale that climate models must aim to properly incorporate because its surface climate impact on the neighboring continents. This issue has particular relevance for the current effort on decadal climate prediction experiments been analyzed for the IPCC in preparation for the fifth assessment report. The current analysis does not pretend to investigate into the mechanisms behind the generation of the AMO in model simulations, but to provide evidence of improvements, or lack of them, in the portrayal of spatiotemporal features of the AMO from the previous to the current models participating in the IPCC.* ***If climate models do not incorporate the mechanisms associated to the generation of the AMO (or any other source of decadal variability like the PDO) and in turn incorporate or enhance variability at other frequencies, then the models ability to simulate and predict at decadal time scales will be compromised and so the way they transmit this variability to the surface climate affecting human societies.***

Chapter 7.6 – Model-Data Comparison of Satellite-Era Sea Surface Temperature Anomalies: Pacific Ocean

The Pacific Ocean is monstrously huge. It is massive, humongous, ENORMOUS. No superlative can fully do justice to its size. The Pacific Ocean covers more of the surface of the globe than all of the continental land masses combined. Even that analogy fails to portray its enormity.

Because there is no physical border between the Pacific and Southern Oceans, the Pacific effectively stretches from Antarctica in the south to the Bering Strait in the north. At the equator, the Pacific stretches east and west almost halfway around the globe. To put that into perspective, in my blog post here, I use an image of a protractor to portray the equatorial Pacific. I modified that image here for Figure 7-23. The Pacific does stretch almost halfway around the Earth.

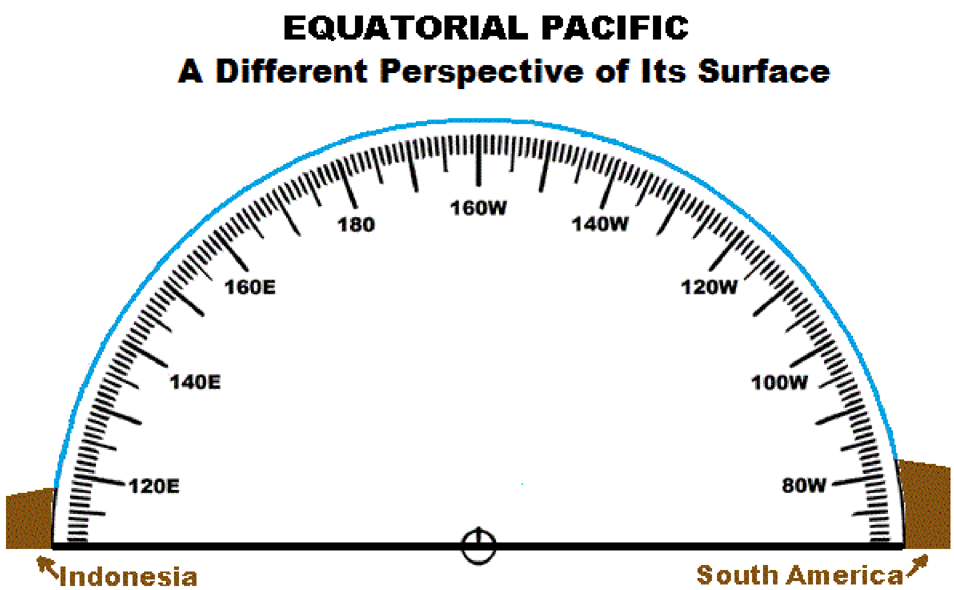


Figure 7-23

The following is a discussion and an illustration of the Pacific from my book: **Who Turned on the Heat?**

> As they say, seeing is believing. Try this. Open Google Earth on your computer and enter 0, -160, for the coordinates of 0 and 160W. After you hit Enter, Google Earth will zoom in on a barren part of the Pacific Ocean floor. Back out (i.e.,

minimize the image) until you get a complete image of the Globe. It should look similar to Figure 7-24.

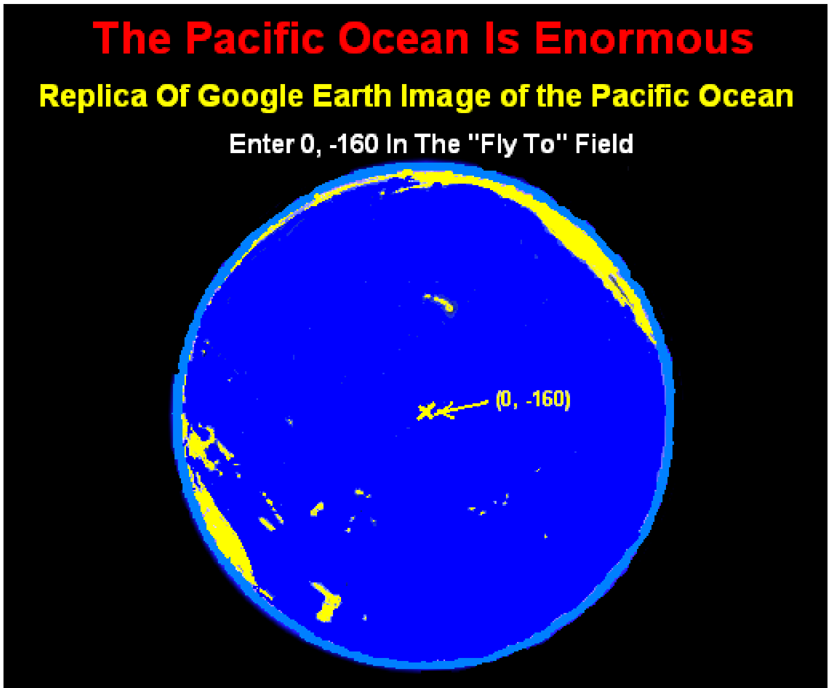


Figure 7-24

You see very little land. The North American coast is off to the north and northeast. New Zealand and part of Australia can be seen to the southwest. To the west of them is Indonesia. The coast of Asia makes a slight appearance in the northwest. Other than some islands, the rest is ocean, Pacific Ocean. To see even less land, try the coordinates of -23, -135, (23S, 135W), which will take you just northwest of the island of Mangareva. Now, back out again until you can see the whole globe. Even **less** land is visible. It makes one wonder why this planet is called "Earth."

[End of reprint from ***Who Turned on the Heat?***]

For the period of November, 1981 to July, 2013 (Figure 7-25), the sea surface temperatures of the Pacific Ocean (60S-65N, 120E-80W) warmed at a rate of only 0.06 deg C/decade. The models estimated it would warm almost 3 times that fast. The Pacific is the largest ocean on our planet, and over the past 3+ decades, the models overestimated the warming there by a factor of 2.8. That's atrocious!

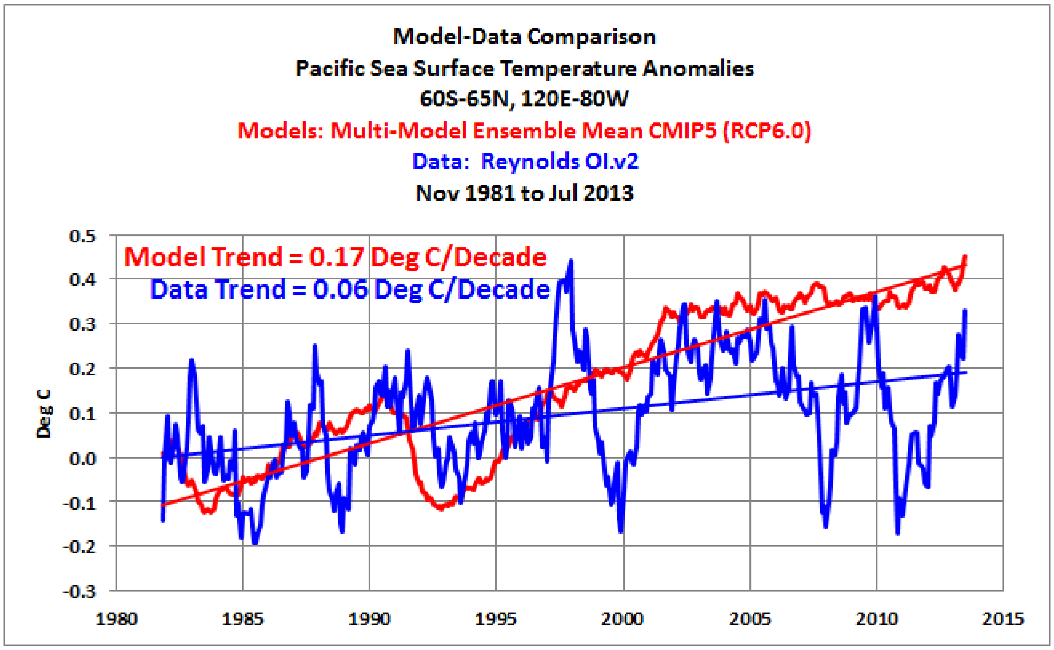


Figure 7-25

The Pacific sea surface temperatures show a dip and rebound response to the 1991 eruption of Mount Pinatubo. In the period after that, from about 1994 to the present, however, the sea surface temperature anomalies of the Pacific Ocean don't appear to have warmed at all. Let's check.

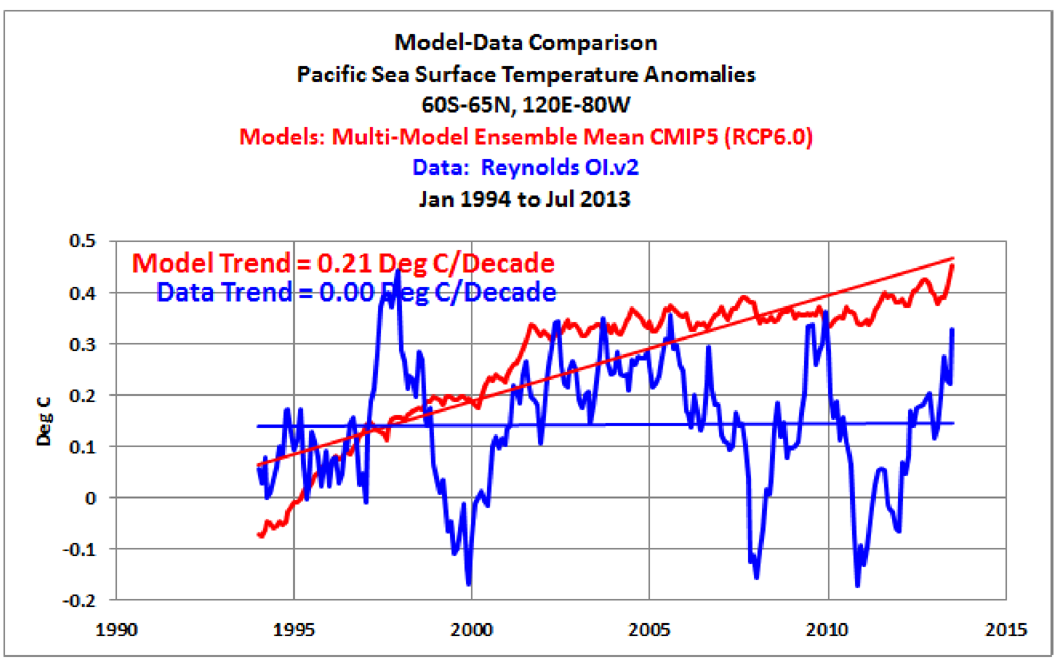


Figure 7-26

I compare the modeled and observed sea surface temperature anomalies of the Pacific Ocean for the period of January, 1994 to July, 2013 in Figure 7-26. Based on the linear trend of the data, the sea surface temperatures of the Pacific Ocean have not warmed in almost 20 years. The models, on the other hand, following their programmers' belief that manmade greenhouse gases warm the Pacific Ocean, estimated that Pacific Ocean sea surface temperatures should have warmed about 0.4 deg C over the past 2 decades.

The largest body of water on this planet hasn't warmed in 2 decades, and climate models cannot explain why.

Note: Some readers may have noticed that one could extend the period of no warming back another couple of years if one adjusted the Pacific sea surface temperature data for the dip and rebound caused by Mount Pinatubo aerosols. But, that would complicate the discussion unnecessarily, exceeding the scope of this book.

Regarding the North and South Pacific:

The observed sea surface temperature anomalies for the North and South Pacific are in Figures 7-27 and 7-28, along with the modeled sea surface temperature anomalies. The models overestimated the warming in both the North and the South Pacific by significant amounts.

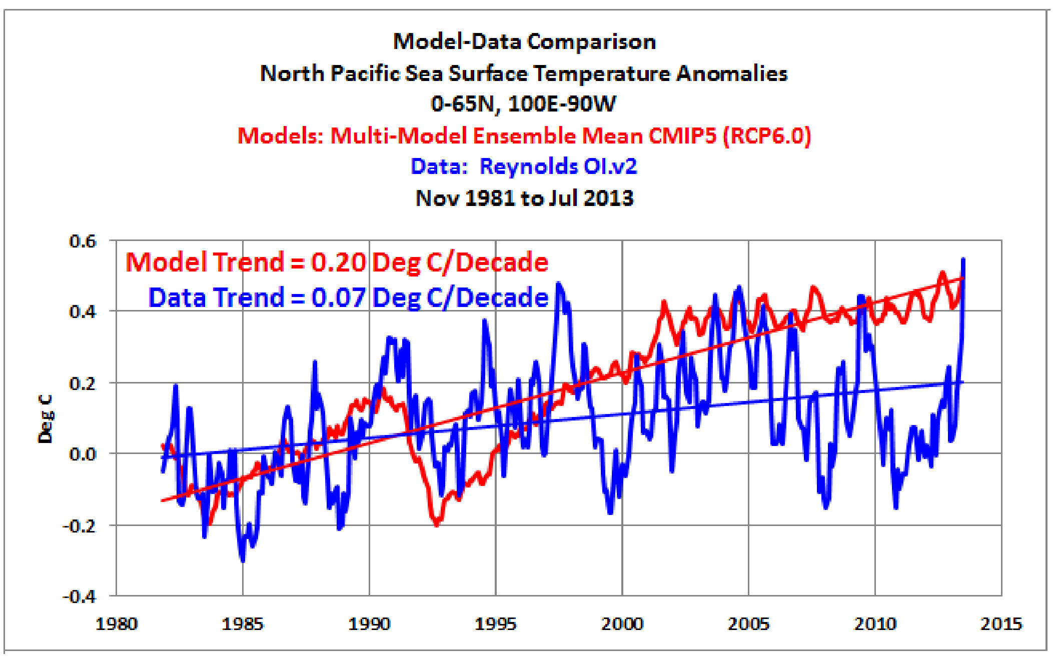


Figure 7-27

# # #

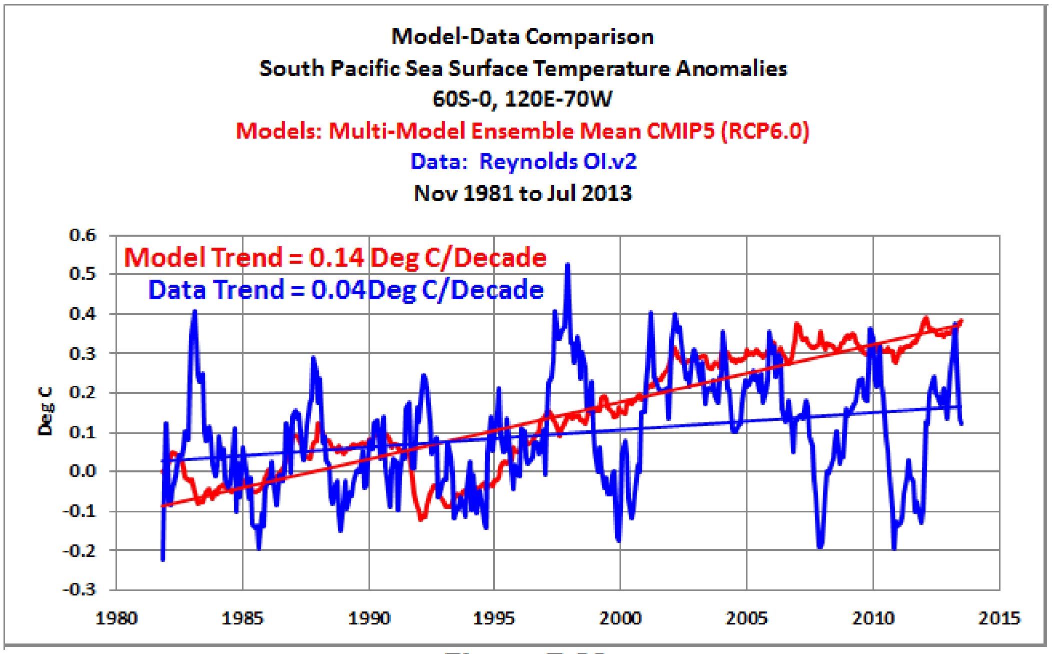


Figure 7-28

In the North Pacific, the models overestimated the warming by a factor of about 2.8. In the South Pacific, they overestimated the warming by more than 3.5 times.

(Note: Due to the shape of the Pacific Ocean, the coordinates used in Figures 7-27 and 7-28 do not match the coordinates used for the entire Pacific Ocean in Figure 7-25. That is the reason the trends for the North and South Pacific do not seem to agree with the trend for the Pacific as a whole.)

CHAPTER 7.6 SUMMARY

After trying for decades, climate modelers still cannot accurately simulate the warming, or lack thereof (Figure 7-26), of the largest ocean basin on the planet, the Pacific Ocean. Over the past 31+ years, a period which includes the last warming period, the sea surface temperatures of the Pacific warmed at a rate of only 0.06 deg C/decade.

Additionally, for the past 20 years, the sea surface temperatures of the Pacific Ocean have not warmed at all. But, the models, based on the assumption that anthropogenic greenhouse gasses have a measurable warming effect, insist they should have warmed by 0.4 deg C.

In the next chapter, I present a zonal-mean graph for the Pacific Ocean.

Chapter 7.7 – A Few More Reasons Why Climate Models Need to Be Able to Simulate El Niño and La Niña Processes

How the processes of El Niño and La Niña events in the tropical Pacific impact surface temperatures and precipitation around the globe is well known. Trenberth, et al. (2002) "The Evolution of El Niño-Southern Oscillation and Global Atmospheric Surface Temperatures" provides an excellent in-depth (though very technical) discussion.

In Chapter 3.2, I discussed how global precipitation, over the oceans and land, depends primarily on El Niño and La Niña events. Figure 3-7, using the GPCP v2.2 precipitation data, provided clear evidence of that fact. In Chapter 3.2, I showed that multidecadal variations in global precipitation over land appear to be strongly influenced by multidecadal variations in the dominance of El Niños and La Niñas. Throughout Section 6, short-term, regional, graphs clearly indicate that surface temperatures in many regions are strongly impacted by El Niños and La Niñas, i.e., most of the strong variations in many regions are simply responses to El Niño and La Niña events. In Chapter 6.8, I discussed how the IPCC's recent attempt to simulate short-term regional climate was futile because the models can't simulate El Niño and La Niña processes or their aftereffects. Also see Guilyardi, et al. (2009) "Understanding El Niño in Ocean-Atmosphere General Circulation Models: Progress and Challenges":

> *Because ENSO is the dominant mode of climate variability at interannual time scales, the lack of consistency in the model predictions of the response of ENSO to global warming currently limits our confidence in using these predictions to address adaptive societal concerns, such as regional impacts or extremes (Joseph and Nigam 2006; Power, et al.. 2006).*

Basically, Guilyardi et al. are saying that El Niño and La Niña events are known to be the main cause of variations (including extreme highs and lows) in temperature and precipitation throughout the globe on annual, multiyear, decadal, and multidecadal, timescales. Because climate models cannot accurately simulate El Niño and La Niña events or their aftereffects, their estimates about future regional temperatures and precipitation have no value — none, zip, zero, nada.

Now, I discuss a few more reasons for why it is of paramount importance that climate models be able to simulate El Niño and La Niña — a capability that climate models presently do not have.

In Figure 7-29, I compare observed and modeled rates of warming and cooling in Pacific sea surface temperature anomalies over the past 31+ years, using a zonal-mean (latitude average) graph. The models, basing their estimates on the assumption that manmade greenhouse gases can significantly affect the Pacific Ocean, estimated that the sea surface temperatures would warm. They show a high rate of warming in the North Pacific — a trend of about 0.2 deg C/decade. In the Southern Hemisphere, the modeled warming rates gradually increase, though not uniformly, from no warming near Antarctica to the 0.2 deg C/decade at the equator.

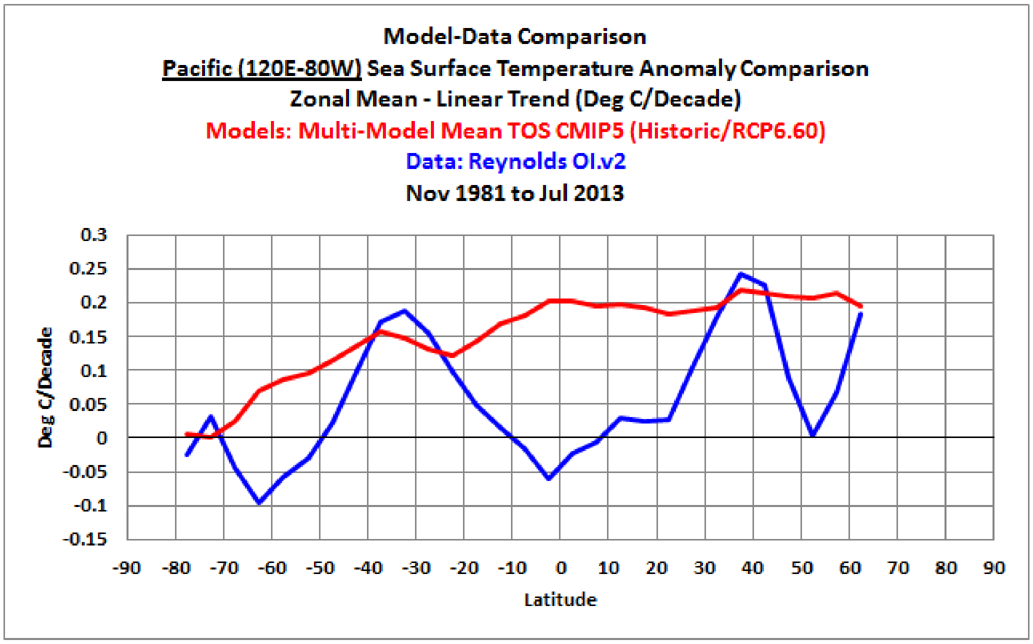


Figure 7-29

The sea surface temperature anomaly data in Figure 7-29 show the surface of the Pacific Ocean actually warmed in a completely different fashion than the models supposed it would. Sea surface temperatures cooled near the equator, and there was very little warming in the tropical Pacific as a whole — where the models said it should have warmed significantly. The mid-latitudes in both hemispheres of the Pacific warmed slightly more than the models estimated they would. The Southern Ocean surrounding Antarctica cooled, and in the high-latitudes of the North Pacific, the data show little warming at about 52 deg N, then a sharp rise in the warming rate from the 52N to 65N.

The spatial pattern of warming in the mid-latitudes with little warming in the tropics, is the effect of an El Niño-dominated period; i.e., a period when an enormous volume of naturally created warm water flowed from the tropics into the mid-latitudes. This warming is obvious in the right-hand cell of Figure 7-30, a trend map of the observations-based data. The greatest warming happened east of Japan, in the North Pacific in an area called the KOE (Kuroshio-Oyashio Extension), and in the South Pacific, east of Australia and New Zealand, along the SPCZ (South Pacific Convergence Zone).

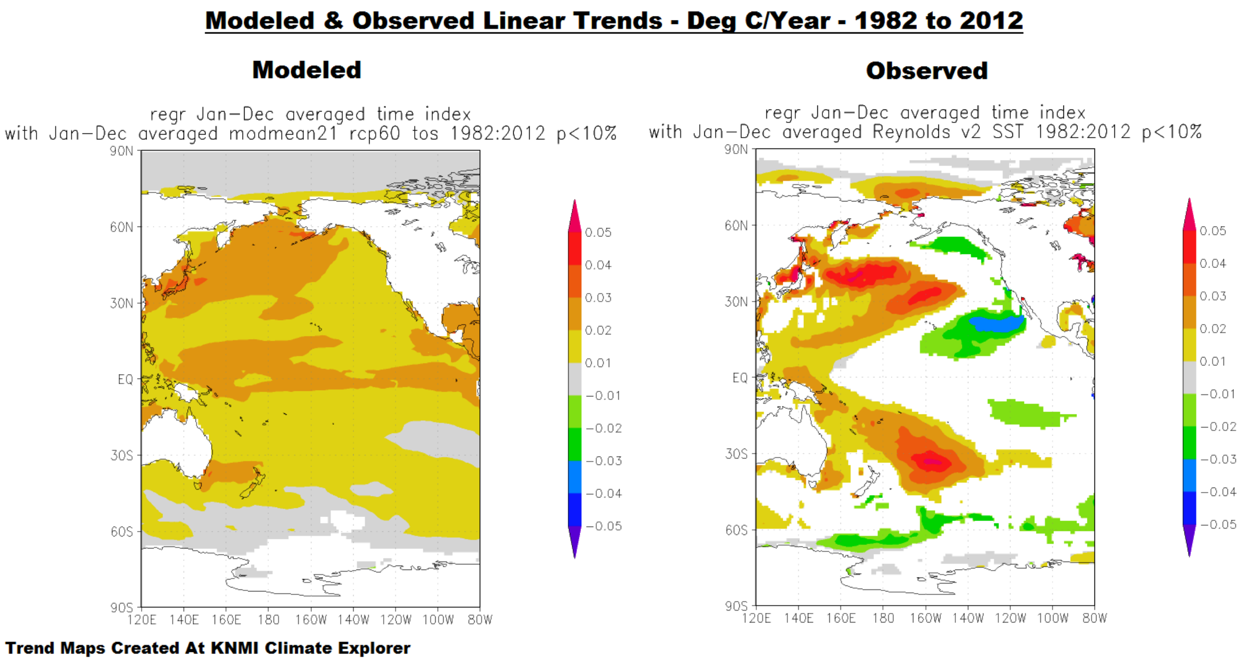


Figure 7-30

Two notes:

Note 1: One of the benefits of websites like the KNMI Climate Explorer and NOAA NOMADS is that they allow users to select a desired subset of the data like the Pacific Ocean by entering global coordinates. For example, the longitudes of 120E to 80W capture most of the tropical Pacific. Unfortunately, ocean shorelines don't follow straight lines. So those same longitudes also capture Hudson Bay, which is not part of the Pacific. The warming in Hudson Bay likely (slightly) biases the zonal mean graph of the Pacific in Figure 7-29 at high latitudes.

Note 2: Something else is clearly seen in the right-hand trend map, (the observations-based data) in Figure 7-30. There has been little to no warming in most of the East Pacific in over 3 decades. In fact, some regions of the East Pacific even cooled over the past 31 years. By dividing the Pacific Ocean sea surface temperature data at the dateline (180 deg), then, extending eastward to 80W (near Panama) and also from pole to pole, Figure 7-31, it becomes obvious that the sea surface temperatures of the entire East Pacific Ocean have not warmed in 31 years. The climate models estimated that the East Pacific sea surface temperatures should have warmed at a rate of 0.15 deg C/decade. In other words, over the past 3+ decades, the models estimated that the East Pacific Ocean warmed more than 0.45 deg C — but it hasn't warmed at all. In view of the fact that the East Pacific Ocean covers about 33% of the surface of the global oceans, such an error is monumental.

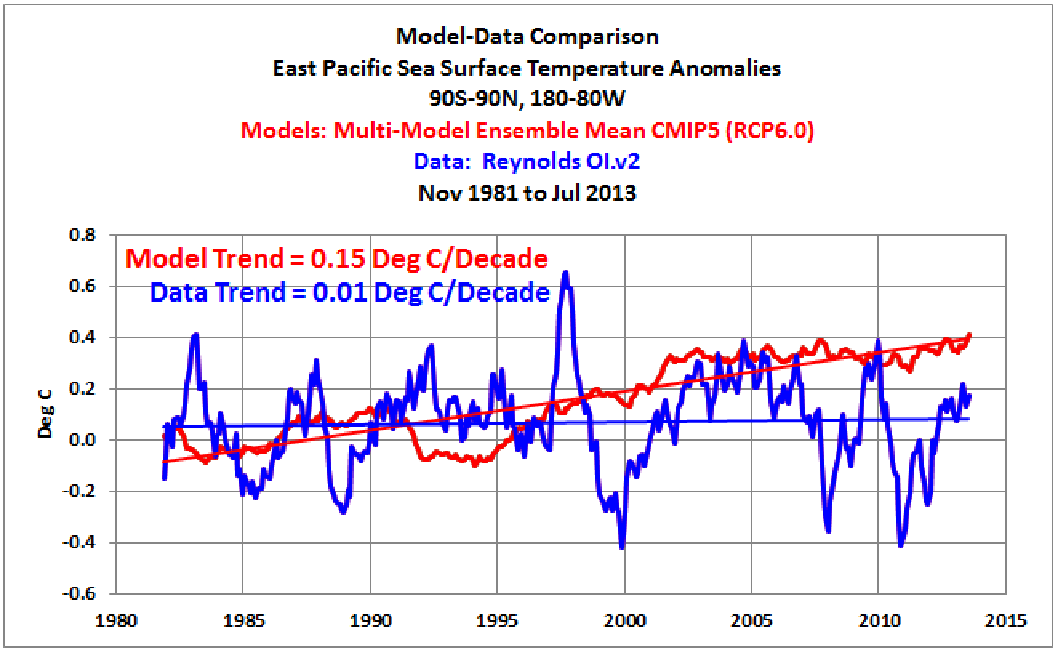


Figure 7-31

THE EL NIÑO-LA NIÑA PROCESSES THAT CREATE THOSE WARMING PATTERNS IN THE PACIFIC

1. How the Warm Water Is Created for El Niño Events

A major La Niña event can create a huge volume of warm water in a relatively short period of time. Ocean heat content data represents the heat stored in the oceans at given depths. (The ocean heat content data presented in this chapter is from the NODC (National Oceanographic Data Center), for the depths of 0-700 meters. It is available through the KNMI Climate Explorer.) In the tropical Pacific, the El Niño- and La Niña-caused variations in the ocean heat content take place in the top 300 meters, thus, using the dataset for the depths of 0-700 meters covers those variations.

In Figure 7-32 is the ocean heat content data of the tropical Pacific, for depths of 0-700 meters, for the period of January, 1955 to March, 2013. There are 3 three-year La Niñas, each highlighted with a dark red, dashed, line. The 1995/96 La Niña is solid red. The 3-year La Niña of 1954-56 created the initial warm water that fueled the El Niño events that happened from 1957/58 to 1972/73. The lesser La Niña events that trailed each of those interim El Niños replenished only part of the warm water released by those El Niños, so the long-term trend is negative (that is, the tropical Pacific cooled from 1957 to 1973). The 1973-76 La Niña, another 3-year event created the initial warm water which fueled the El Niños from 1976/77 to 1994/95, once again, with the trailing La Niñas replacing only part of the warm water released by those El Niños. As a result, the ocean heat content cools from 1976 to 1995. Also evident during this second period is the sharp drop in tropical Pacific ocean heat from the heat-releasing, colossal, 1982/83 El Niño, followed by the partial replenishment of that heat during the trailing 1998/2001 La Niña. All the long-term warming of ocean heat content in the tropical Pacific to this point happened during the two main La Nina events, 1954-56 and 1973-76.

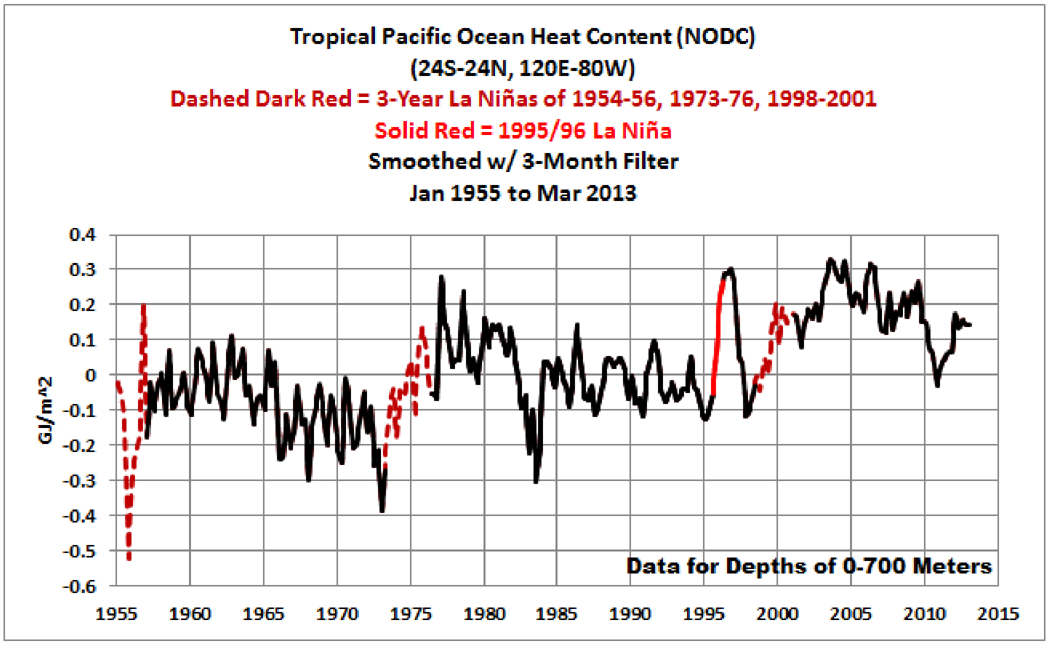


Figure 7-32

The 1995/96 La Niña appears (in red) in the ocean heat content data for the tropical Pacific as the leading edge of the large upward spike in the late 1990s. That 1-year La Niña created the warm water for the strongest El Niño of the 20th century, the 1997/98 El Niño, seen in Figures 7-32 and 7-33 in the big downward slope of that spike. The 1995/96 La Niña, along with the heat replenishment provided by the weaker, 3-year, 1998-01 La Niña, shifted up the ocean heat content of the tropical Pacific.

To highlight that upward step, in Figure 7-33 I zoom in on the period that starts in 1995. I also include the period-average values before and after the combined impact of the 1995/96 La Niña surge plus the lesser recharge of the 1998-01 La Niña. Because the 1998-01 La Niña merely replenished heat released by the 1997/98 El Niño, the primary cause of the upward shift was the 1995/96 La Niña.

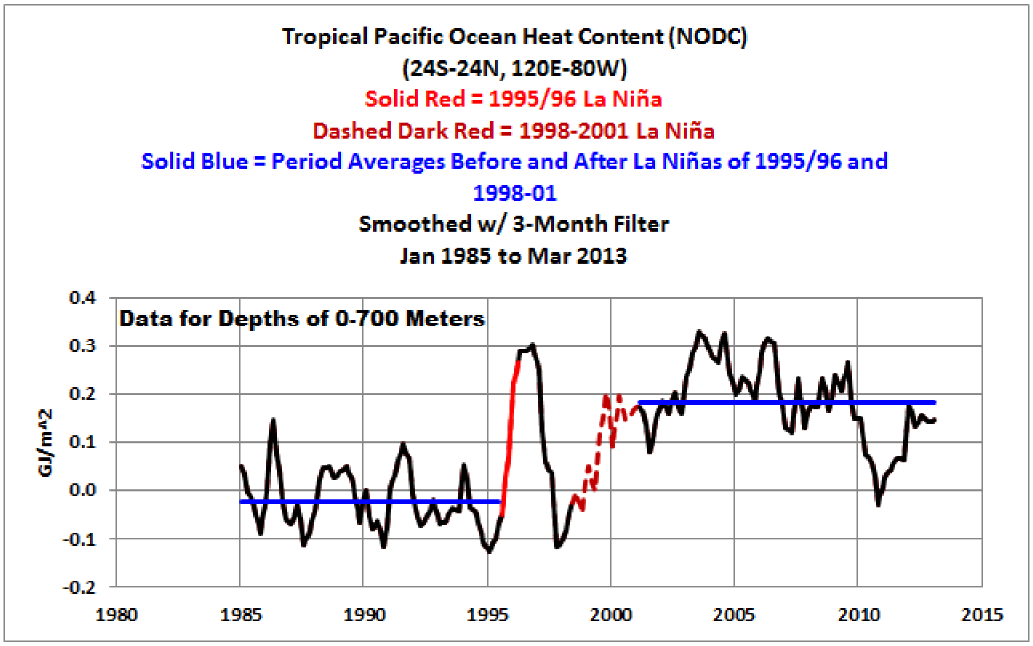


Figure 7-33

How do La Niñas create heat (in the form of warm water) to fuel El Niños?

Stronger-than-normal trade winds during La Niñas reduce cloud cover over the tropical Pacific, allowing more sunlight to enter and warm the tropical Pacific to depths of about 100 meters. The resulting warm water collects in an area of the western tropical Pacific called the West Pacific Warm Pool. It's also known as the Indo-Pacific Warm Pool because it extends into the Indian Ocean.

The following two peer-reviewed scientific papers confirm that the warm water for El Niños is created during La Niñas. The first is McPhaden (1999) "Genesis and Evolution of the 1997-98 El Niño". There, McPhaden writes:

> *For at least a year before the onset of the 1997–98 El Niño, there was a buildup of heat content in the western equatorial Pacific due to stronger than normal trade winds associated with a weak La Niña in 1995–96.*

The La Nina-associated, stronger-than-normal trade winds in the tropical Pacific indirectly cause the build-up of heat in two ways:

(1) Stronger trade winds cause more cool water than normal to be upwelled along the central and eastern equatorial Pacific. The cooler waters result in less convection and less cloud cover, allowing more sunlight to enter and warm the tropical Pacific to depth.

(2) The stronger trade winds also push the normal cloud cover farther to the west, again, allowing more sunlight to enter and warm the tropical Pacific waters to depths of about 100 meters.

This is confirmed in the second paper, Trenberth, et al. (2002) The Evolution of El Niño-Southern Oscillation and Global Atmospheric Surface Temperatures." There, Trenberth, et al. (2002) write (my boldface and brackets):

> *The negative feedback between SST [sea surface temperature] and surface fluxes can be interpreted as showing the importance of the discharge of heat during El Niño events and of the recharge of heat during La Niña events.* ***Relatively clear skies in the central and eastern tropical Pacific allow solar radiation to enter the ocean****, apparently offsetting the below normal SSTs, but the heat is carried away by Ekman drift, ocean currents, and adjustments through ocean Rossby and Kelvin waves, and the heat is stored in the western Pacific tropics.* ***This is not simply a rearrangement of the ocean heat, but also a restoration of heat in the ocean****.*

In short, the warm waters for El Niño events are created naturally, fueled by the sun, during La Niñas.

2. El Niño Processes Which Warm Western Pacific Sea Surface Temperatures, (primarily in the KOE (Kuroshio-Oyashio Extension) and the SPCZ (South Pacific Convergence Zone) (See Figures 7-29 and 7-30.)

An El Niño event releases a huge volume of warm water from both the surface and from below the surface of the western tropical Pacific. That sunlight-created warm water is carried rapidly eastward along the equator (by the temporarily engorged Equatorial Counter Current) and then spreads out across the central and eastern tropical Pacific, sometimes reaching as far east as the coastline of the Americas during strong El Niños. As shown in the graph of the sea surface temperature anomalies of the East Pacific (Figure 7-31), however, the East Pacific is only the temporary home of the warm water released by El Niños. That's why the sea surface temperatures of the East Pacific display the major variations, but, show no overall, long-term warming for the past 31 years.

The El Niño heat discharge does not "consume" all of that warm water. The remaining warm waters (the leftovers) are returned to the western Pacific via phenomena called Rossby waves, and via the return of the trade winds, which push the leftover warm water on the surface back to the west. Some of that leftover warm water helps to recharge the West Pacific Warm Pool for the next El Niño. The remainder of it either flows into the tropical Indian Ocean, or is carried by ocean currents to the north and south, toward the poles, along the western Pacific. That leftover warm water then collects in the KOE (Kuroshio-Oyashio Extension) and the SPCZ (South Pacific Convergence Zone). All of the above redistribution of leftover warm water occurs during the transition from El Niño to La Niña and during the La Niña that trails the El Niño.

A LOOK AT THE KUROSHIO-OYASHIO EXTENSION SEA SURFACE TEMPERATURE DATA

The sea surface temperature anomaly data of the Kuroshio-Oyashio Extension (30N-45N, 150E-150W) confirm the above El Niño – La Niña analysis. (See Figure 7-34.) I also include in Figure 7-34 the sea surface temperature anomalies of the NINO3.4 region of the equatorial Pacific. (As I mentioned in Chapter 3.2, the NINO3.4 region data are a commonly used index for the timing, strength, and duration of El Niño and La Niña events.) The NINO3.4 data have also been inverted (multiplied by -1.0) so that the El Niño events are the downward spikes and the La Niñas are the upward ones. The data start in 1995 because the 1991 eruption of Mount Pinatubo skews the relationship between the NINO3.4 and Kuroshio-Oyashio Extension data. I also smoothed both datasets with 13-month running-average filters due to the volatility of the Kuroshio-Oyashio Extension data. One last note about Figure 7-34: I shifted the Kuroshio-Oyashio Extension data upward by 0.45 deg C to zero that dataset in 1997 for easier comparison with the La Niña of 1998-01.

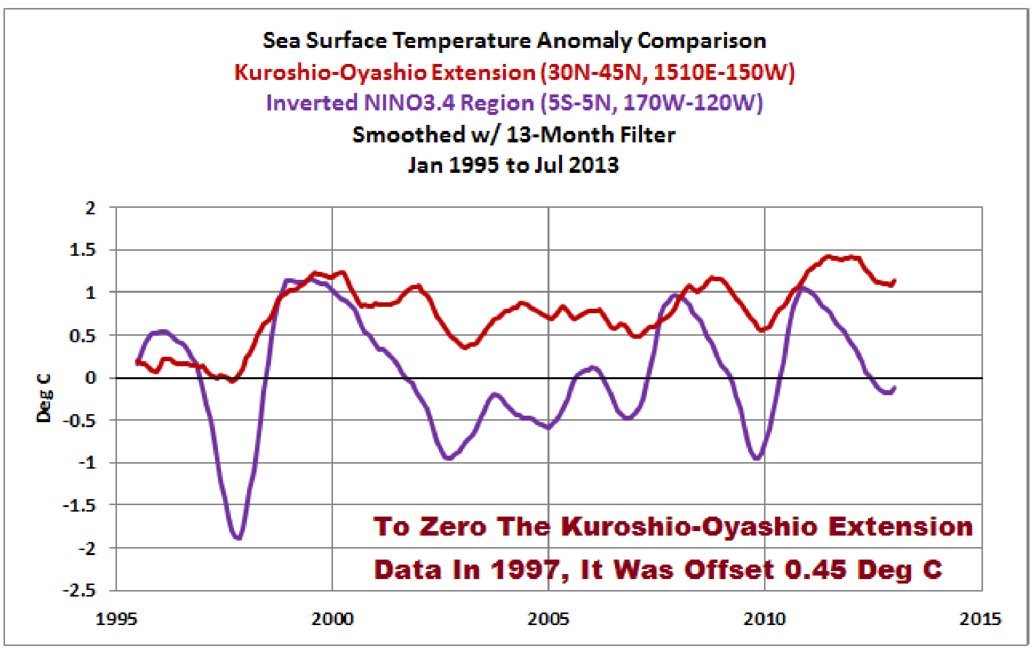


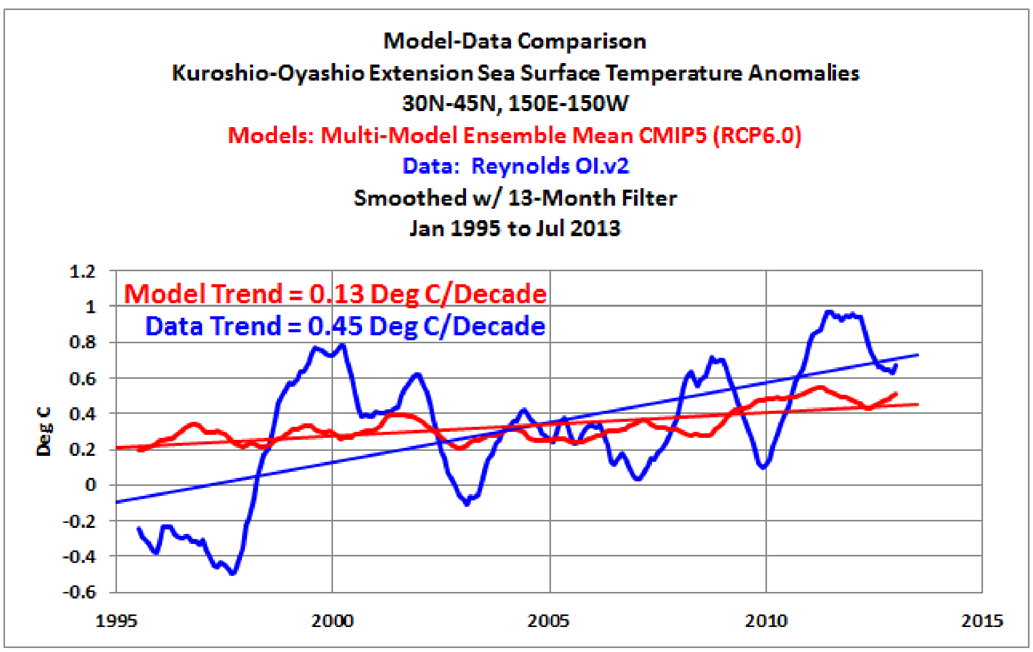
Figure 7-34

The large downward spike in the inverted NINO3.4 data (purple curve) in the late 1990s was the colossal El Niño of 1997/98. The trailing upward hump in the inverted NINO3.4 sea surface temperature anomalies is the 1998-2001 La Niña. During the transition from the 1997/98 El Niño to the 1998-01 La Niña, the warm water that was left over from the 1997/98 El Niño caused the sea surface temperature anomalies of the Kuroshio-Oyashio Extension to warm about 1.2 deg C (based on the smoothed data). That warming in the North Pacific took place east of Japan and extended eastward to the central North Pacific. The warming there was comparable in strength to the La Niña which was taking place along the equator. Essentially, a secondary El Niño event was taking place in the mid-latitudes of the North Pacific while the La Niña was occurring in the tropics. The warming of the Kuroshio-Oyashio Extension counteracted the effects of the 1998-01 La Niña. This prevented some regions throughout the Northern Hemisphere from cooling in response to the 1998-01 La Niña.

Notice also that the Kuroshio-Oyashio Extension data did not cool proportionally during the 1997/98 El Niño.

The added warmth of the sea surface temperatures of the Kuroshio-Oyashio Extension took around 7 years to cool by about 0.7 deg C before the combined effects of the 2006/07 El Niño and 2007/08 La Niña caused another large but temporary warming in KOE sea surface temperatures. After that set of events, the Kuroshio-Oyashio Extension data shift upward again in response to the 2009/10 El Niño and 2010/11 La Niña.

All things considered, the two most noteworthy features of the Kuroshio-Oyashio Extension sea surface temperature data since 1995 are: the upward shift in response to the 1997/98 El Niña and 1998-01 La Niña; and the apparent upward shift in response to the 2009/10 El Niño and 2010/11 La Niña.



Note: Trends are based on the monthly (not smoothed) data and model outputs.

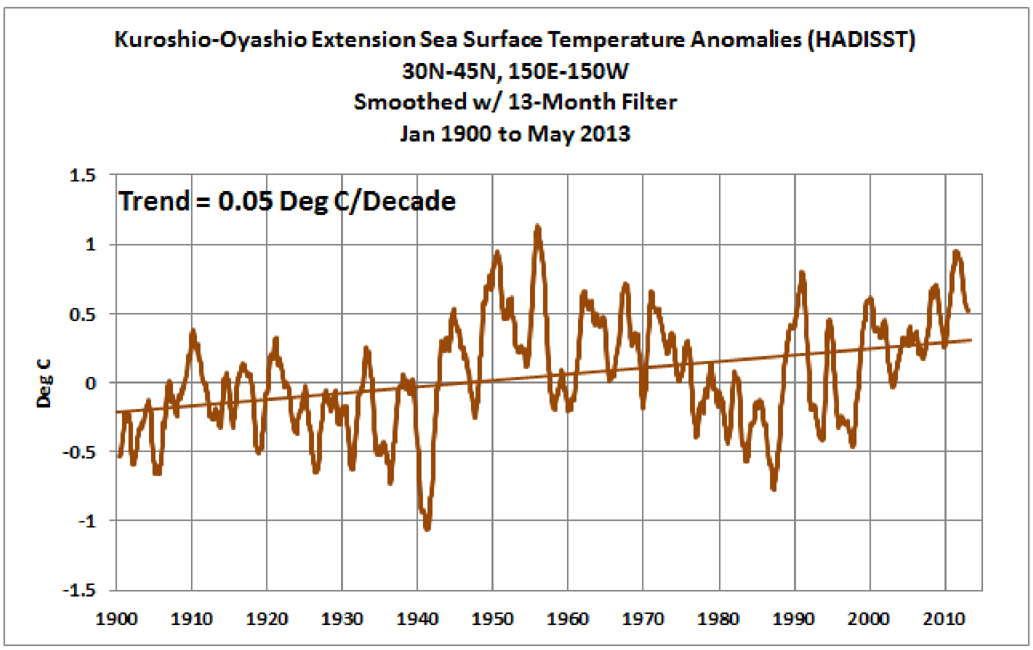
Figure 7-35

Because the models cannot simulate El Niño and La Niña processes and their aftereffects, the multi-model mean underestimates the warming in the Kuroshio-Oyashio Extension by a factor of 3.4, as shown in Figure 7-35.

ON THE IMPORTANCE OF THE KUROSHIO-OYASHIO EXTENSION

The variations in the **sea** surface temperature anomalies of the Kuroshio-Oyashio Extension strongly impact North American **surface** temperatures and precipitation.

In Figure 7-36, I present the sea surface temperature anomalies of the Kuroshio-Oyashio Extension (30N-45N, 150E-150W) from January, 1900 to May, 2013, using the UKMO HADISST sea surface temperature reconstruction. Since 1900, the warming rate is only 0.05 deg C/decade, but the data exhibit large multidecadal variations. For instance, the trend was higher since 1995 (Figure 7-35) because it includes the warming caused by the strong El Niños of 1997/98 and 2009/10. Also note the large surge around 1988. That was initiated by the 1988/89 La Niña, which was redistributing warm water left over from the prolonged 1986/87/88 El Nino.



Note: Trends are based on the monthly (not smoothed) data.

Figure 7-36

PDO (Pacific Decadal Oscillation)

To present why the variations in the surface temperatures of the Kuroshio-Oyashio Extension are important, we first need to discuss the Pacific Decadal Oscillation.

When discussing the multiyear and decadal variability of the North Pacific sea surface temperatures, the climate science community presents the North Pacific data in a very abstract form called the PDO (Pacific Decadal Oscillation) . The PDO was first calculated as part of Zhang, et al. (1997) "ENSO-like Interdecadal Variability: 1900–93". In Zhang, et al. (1997), the PDO was identified as "NP".

The impacts of the Pacific Decadal Oscillation on weather in North America have been presented in a number of papers: See Mantua "The Pacific Decadal Oscillation and Climate Forecasting for North America". Also see the Texas A&M University webpage titled "The Ocean's Influence on North American Drought" for additional references and the combined impacts of the PDO and AMO. That TAMU webpage is a portion of the online book *Our Ocean Planet - Oceanography in the 21st Century* by Robert Stewart.

As discussed in Chapter 2.10, the PDO index is a statistically created dataset. The PDO basically represents how closely the spatial pattern of the sea surface temperatures of the North Pacific (north of 20N) matches the spatial pattern created by El Niño and La Niña events. However, the spatial pattern in the sea surface temperature anomalies of the North Pacific is also impacted by wind patterns (and the interrelated sea level pressures), and, as a result, the multidecadal variations in the PDO index are different than those of El Niño and La Niña events. For further information about the PDO (what it represents and what it does not represent), refer to my posts here, here, and here.

In Figure 7-37, I present the Pacific Decadal Oscillation Index data with 13-month smoothing. The multidecadal variations are visible.

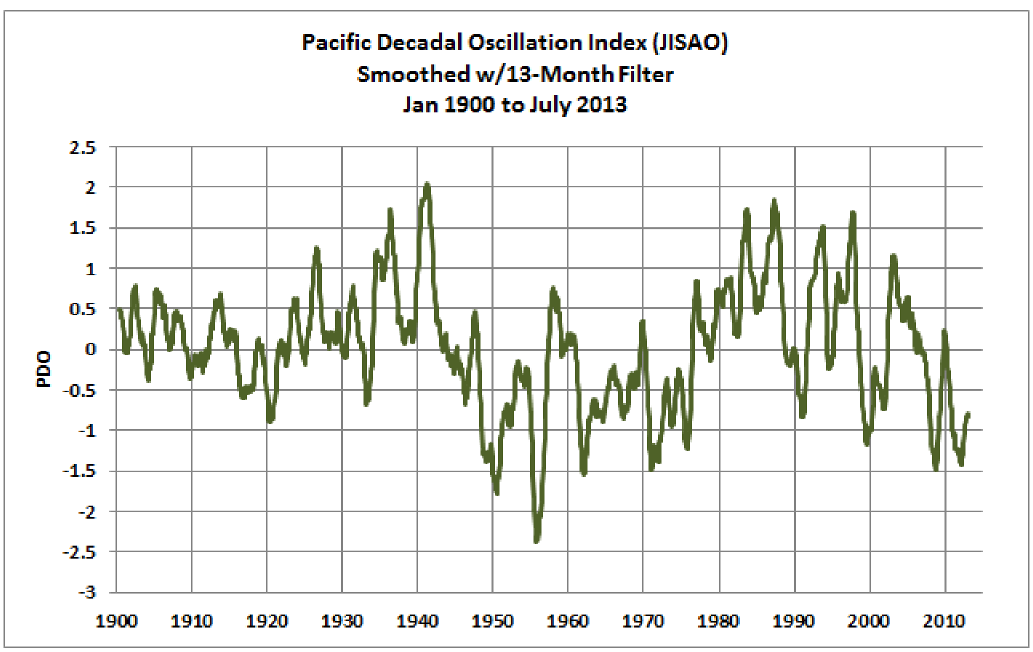


Figure 7-37

JISAO (Joint [NOAA and University of Washington] Institute for the Study of the Atmosphere and Ocean) describes how the PDO index is calculated (my boldface and brackets):

> *Updated standardized values for the PDO index,* ***derived as the leading PC [Principal Component] of monthly SST anomalies in the North Pacific Ocean, poleward of 20N. The monthly mean global average SST anomalies are removed to separate this pattern of variability from any "global warming" signal that may be present in the data****.*

A more detailed description: The sea surface temperature anomaly data for the North Pacific north of 20N are divided into 5 deg latitude by 5 deg longitude grid cells. Global sea surface temperature anomalies are subtracted from the sea surface temperature anomalies of each of the North Pacific grid cells. Then, a principal component analysis is performed. The PDO index is the leading principal component, and it is presented standardized (divided by its standard deviation).

(Note: The standardization multiplies the variations of the data by a factor of about 5.7 and makes the PDO seem as strong as the variations in NINO3.4 region sea surface temperature anomalies.)

As I said, the PDO index is a statistically created dataset. It's also based on a combination of three different datasets. JISAO notes:

> *Data sources for this index are:*
> *UKMO Historical SST data set for 1900-81;*
> *Reynold's Optimally Interpolated SST (V1) for January 1982-Dec 2001)*
> **** OI SST Version 2 (V2) beginning January 2002*

The old "UKMO historical SST" dataset and the Reynolds OI.v1 datasets are both obsolete. The "UKMO historical SST" has been replaced with HADSST3 and Reynolds OI.v1 has been replaced by Reynolds OI.v2.

In view of the above, the PDO Index data in Figure 7-37 should look familiar (compare with Figure 7-36). In Figure 7-38, I compared the PDO Index data with the sea surface temperature anomalies of the Kuroshio-Oyashio Extension (30N-45N, 150E-150W), after I detrended, standardized, and inverted the KOE data. I smoothed both datasets with 121-month running-average filters. The two datasets are remarkably similar — especially when one considers that the PDO is derived from two obsolete sea surface temperature datasets and only one current dataset.

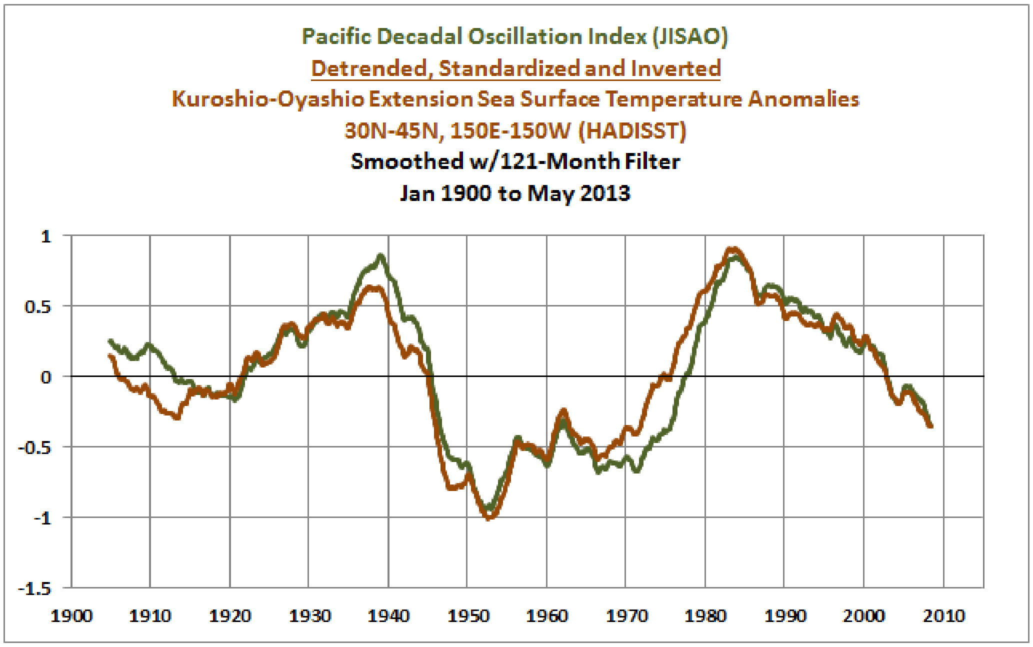


Figure 7-38

In Figure 7-39, I present the same two datasets, except the Kuroshio-Oyashio Extension data have not been inverted in it. That is, the KOE data have only been detrended and standardized. The two datasets are basically mirror images.

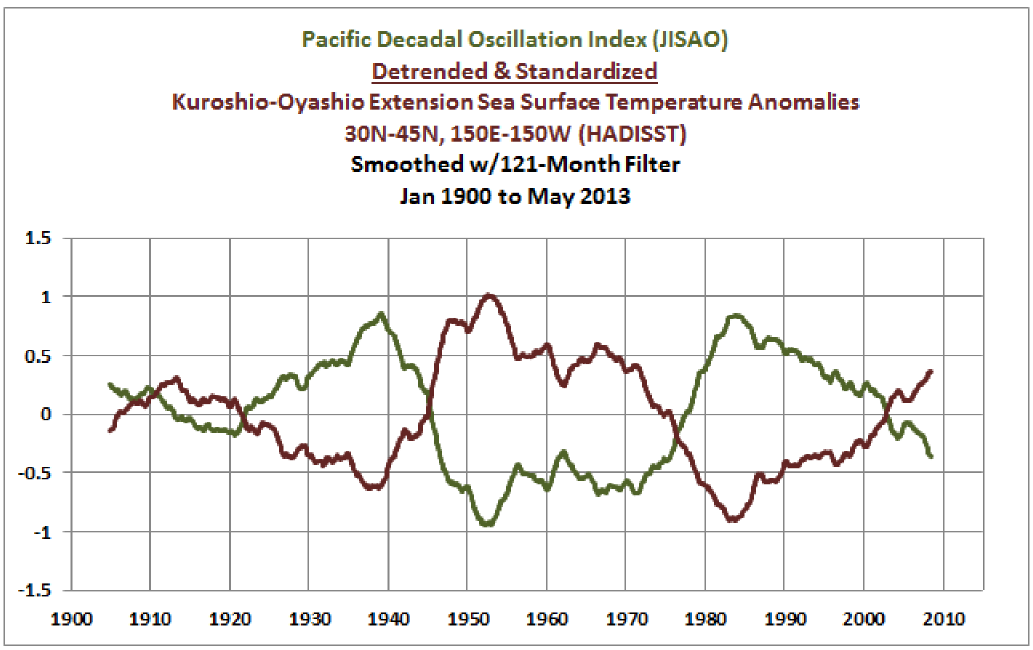


Figure 7-39

On decadal timescales, the PDO index is basically the inverse of the variations in the sea surface temperatures of the Kuroshio-Oyashio Extension.

The two datasets (with the KOE data inverted) also agree remarkably well with 13-month smoothing. (See Figure 7-40.)

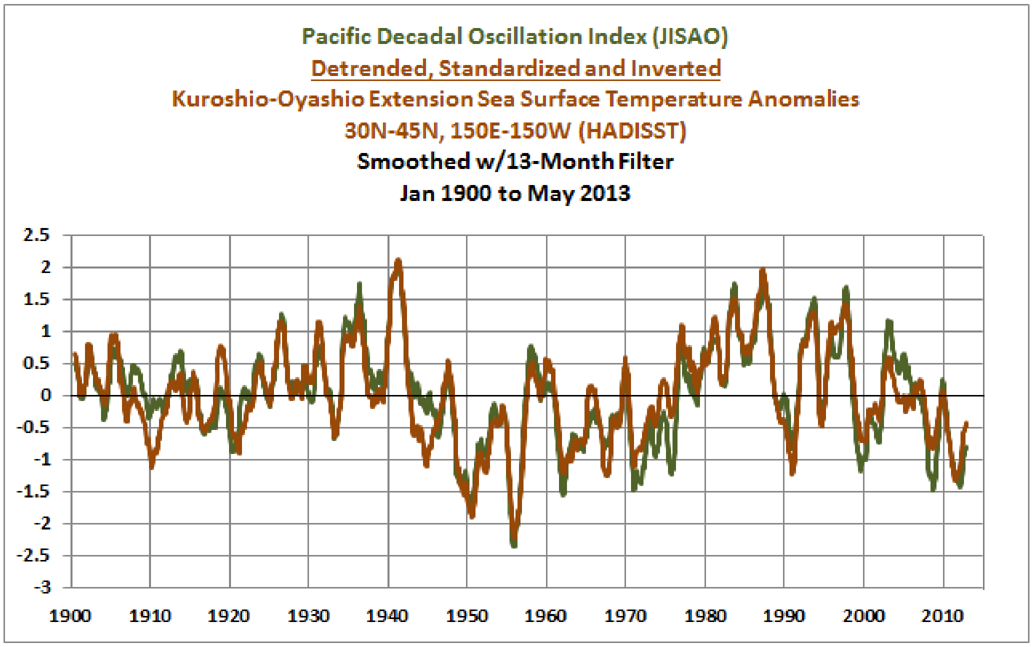


Figure 7-40

To better illustrate the actual relationship between the two datasets, the Kuroshio-Oyashio Extension, in Figure 7-41, the data have not been inverted. Again, they're basically mirror images, which means the PDO index is inversely related to the variations in the sea surface temperatures of the Kuroshio-Oyashio Extension.

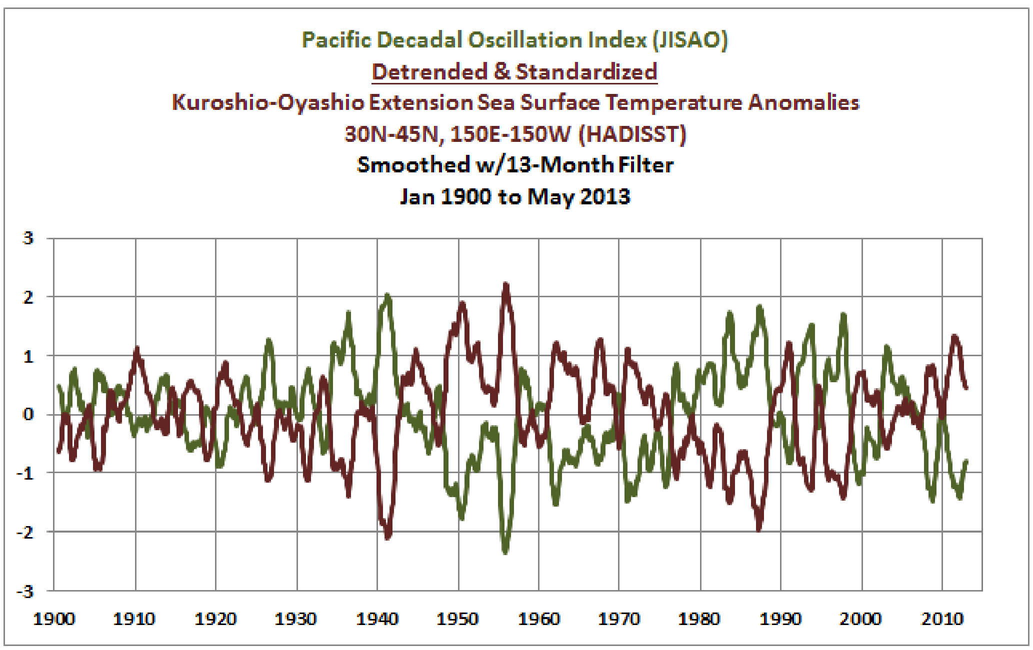


Figure 7-41

Based on the unsmoothed monthly data, the PDO is anti-correlated with the detrended Kuroshio-Oyashio Extension sea surface temperature data. The correlation coefficient of the monthly data is -0.81, which is relatively high for two climate-related indices, one of which is in a very abstract form.

THE SIGNIFICANCE OF THE COMPARISON OF THE PDO AND KUROSIO-OYASHIO EXTENSION SEA SURFACE TEMPERATURE DATA

The variations in both the PDO and Kuroshio-Oyashio Extension sea surface temperature anomalies are byproducts of El Niño and La Niña events. The PDO has known impacts on surface temperatures and precipitation. Thus, because the variations in the sea surface temperature anomalies of the Kuroshio-Oyashio Extension are so similar to those of the very abstract PDO (except inverted), the variations in KOE sea surface temperatures should have effects on surface temperature and precipitation that are similar but opposite to the PDO. Additionally, because the climate models cannot simulate the warming of the sea surface temperatures of the Kuroshio-Oyashio Extension (Figure 7-35), it's safe to say the models cannot simulate the variability of the Pacific Decadal Oscillation.

The sea surface temperatures of the KOE dominate the sea surface temperatures of the North Pacific. I showed above that the variations in the sea surface temperatures of the KOE are dependent on El Niño and La Niña and that the models cannot even come close to simulating the warming and cooling of the Kuroshio-Oyashio Extension data since 1995.

CHAPTER 7.7 SUMMARY

El Niño and La Niña events cause planet-wide natural changes — sometimes extreme changes — in regional weather patterns on annual, multiyear, and decadal timescales. Climate models cannot simulate the processes associated with El Niño and La Niña events or their aftereffects. Therefore, climate models cannot simulate the natural causes of changes in regional weather patterns.

El Niño and La Niña events are also one of the primary causes of multidecadal variations in the sea surface temperatures of the North Pacific. The multidecadal variability of the sea surface temperatures of the North Pacific is known to cause changes in weather patterns around the Northern Hemisphere. Climate models cannot simulate the sea surface temperatures of the North Pacific. Nor can the models simulate the sea surface temperatures of a crucial area of the North Pacific, the Kuroshio-Oyashio Extension, where the variations in sea surface temperatures dominate those of the North Pacific. It is, therefore, impossible to imagine how climate model projections of global temperature and precipitation on multidecadal timescales could possibly have any value.

That was the fundamental message of Ruiz-Barradas, et al. "The Atlantic Multidecadal Oscillation in Twentieth Century Climate Simulations: Uneven Progress from CMIP3 to CMIP5", who mention the Pacific Decadal Oscillation in passing. The full paper is here. Again, they wrote (my highlights):

> *Decadal variability in the climate system from the AMO is one of the major sources of variability at this temporal scale that climate models must aim to properly incorporate because its surface climate impact on the neighboring continents. This issue has particular relevance for the current effort on decadal climate prediction experiments been analyzed for the IPCC in preparation for the fifth assessment report. The current analysis does not pretend to investigate into the mechanisms behind the generation of the AMO in model simulations, but to provide evidence of improvements, or lack of them, in the portrayal of spatiotemporal features of the AMO from the previous to the current models participating in the IPCC.* ***If climate models do not incorporate the mechanisms associated to the generation of the AMO (or any other source of decadal variability like the PDO) and in turn incorporate or enhance variability at other frequencies, then the models ability to simulate and predict at decadal time scales will be compromised and so the way they transmit this variability to the surface climate affecting human societies.***

Section 8 – Sea Surface Temperatures: Which Ocean Basins Do Not Support the Models during the Current Warming Stoppage?

This section is similar to Section 6, but in this section I examine the model outputs and the sea surface temperature data for the individual ocean basins to determine which ocean basins are not supporting the models estimates about sea surface temperatures during the latest cessation of warming.

Keep in mind, in Section 7, I showed that climate models have no skill at simulating surface sea temperatures, neither on a global basis nor in most ocean basins around the globe. I also showed in Chapter 7.5 that the models cannot simulate the multidecadal variations in the sea surface temperatures of the North Atlantic. They also cannot simulate the El Niño-and-La Niña-related variations in the North Pacific. (See Chapter 7.7.)

In this section, to show where sea surface temperatures are not cooperating with model simulations, I once again use 2001 for the start year of the cessation of warming because that was the year selected by Kevin Trenberth in his article Has Global Warming Stalled? for the Royal Meteorological Society in 2013. (See my blog post Open Letter to the Royal Meteorological Society Regarding Dr. Trenberth's Article "Has Global Warming Stalled?")

There are wide swings in the sea surface temperatures of the ocean basin data, and because the time periods studied are so short, trends may be different a few years from now. This section is being presented for those curious about how the individual ocean basins are responding during the halt period. That is, which ocean basins are driving the enduring cessation in warming.

Once again, I'll be use the Reynolds OI.v2 sea surface temperature data. The base years for model output and data anomalies are 1971 to 2000, NOAA's standard base years for this dataset.

BASIN COMPARISON IN TABULAR FORM

In Table 8.1, I present the modeled and observed warming and cooling rates for the sea surface temperatures of the global oceans and of the subsets included in this section — for the period of January, 2001 to July, 2013. The last column includes the differences between the trends for the models and data. (The differences contain a few errors due to rounding.)

Table 8.1 - Basin Sea Surface Temperature Model-Data Comparison

Time Period = Jan 2001 to Jul 2013 Dataset = Reynolds OI.v2
Models = Multi-Model Ensemble Mean CMIP5 w/RCP6.0
Difference = Model Trend - Data Trend

TABLE 8.1 - MODEL-DATA SEA SURFACE TEMPERATURE LINEAR TREND COMPARISON				
		TREND		DIFFERENCE
		Modeled	Observed	Modeled Minus Observed
DATASET	COORDINATES	Deg C/Decade	Deg C/Decade	Deg C/Decade
Global	90S-90N	0.08	-0.03	0.11
NINO3.4	5S-5N, 170W-120W	-0.10	-0.63	0.53
East Pacific	90S-90N, 180-80W	0.04	-0.19	0.23
Northern Hemisphere	0-90N	0.08	-0.02	0.10
Southern Hemisphere	90S-0	0.08	-0.04	0.12
Atlantic	60S-70N, 70W-20E	0.11	0.06	0.04
North Atlantic	0-70N, 80W-0	0.10	0.07	0.02
South Atlantic	60S-0, 70W-20E	0.10	0.08	0.02
Pacific	60S-65N, 120E-80W	0.07	-0.14	0.21
North Pacific	0-65N, 100E-90W	0.06	-0.12	0.18
South Pacific	60S-0, 120E-70W	0.08	-0.16	0.24
Indian	60S-30N, 20E-120E	0.09	0.11	-0.02
Arctic	65N-90N	0.09	0.20	-0.11
Southern	90S-60S	0.03	-0.23	0.26

Globally, sea surface temperatures have cooled slightly at a rate of -0.03 deg C/decade since January, 2001, but, the models estimated they would warm at a rate of 0.08 deg C/decade. Based on these short-term linear trends, the models performed reasonably well in the Atlantic and Indian Ocean basins. The models underestimated the warming in the Arctic Ocean by 0.11 deg C/decade. The relatively high rates of cooling in the Pacific and Southern Oceans indicate they are the primary drivers of the stop in warming since 2001.

One last preliminary note: Because the models are so inept at simulating sea surface temperatures over the past 31 years, there's no reason to go into long descriptions of how badly the models did in each basin in the short term. Therefore, the individual chapters do not include summaries. I'll summarize the entire section in the last chapter.

Chapter 8.1 – Stoppage Period Model-Data Comparisons: Global and Hemispheric Sea Surface Temperature Anomalies

TIME-SERIES GRAPHS

Global sea surface temperatures cooled at a rate of -0.03 deg C/decade since January, 2001 (Figure 8-1). But, the models estimated the sea surface temperatures of the global oceans would warm — at a rate of 0.08 deg C/decade.

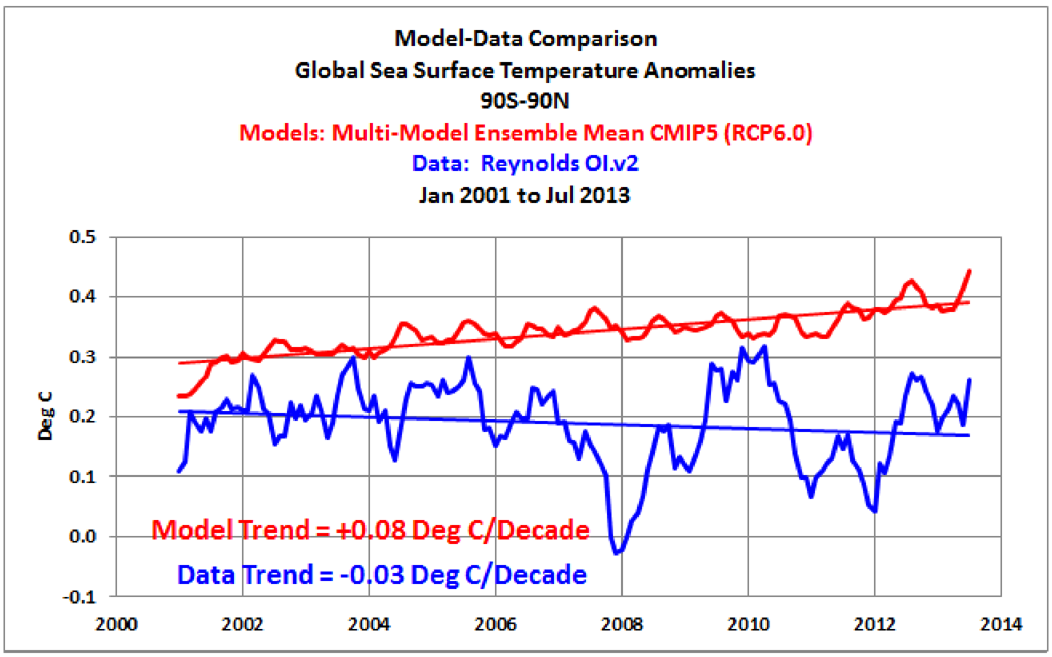


Figure 8-1

Northern Hemisphere sea surface temperatures (Figure 8-2) show a cooling rate of -0.02 deg C/decade during the recent stoppage period. Sea surface temperatures in the Southern Hemisphere (Figure 8-3) have a higher rate of cooling, -0.04 deg C/decade. In both hemispheres, the models estimated it would warm – about 0.10 to 0.12 deg C/decade.

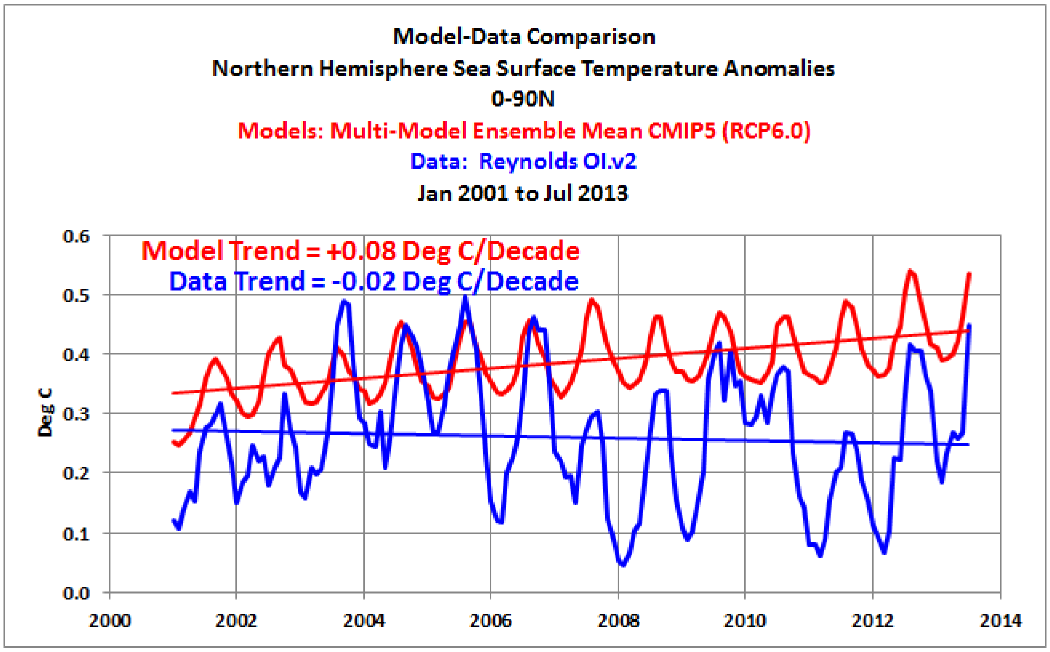


Figure 8-2

# # #

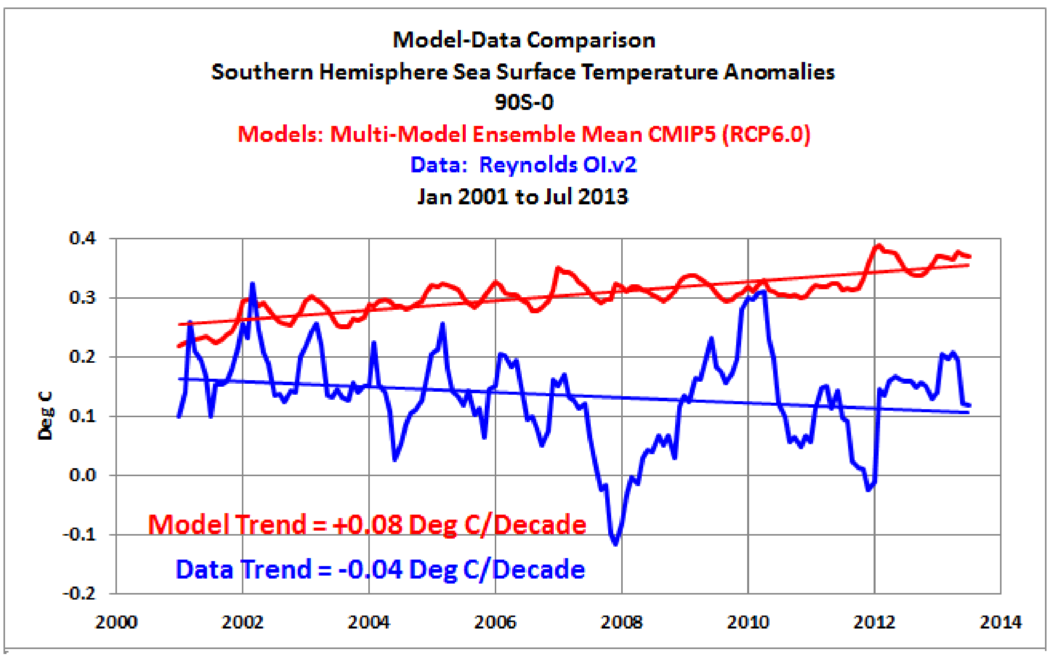


Figure 8-3

ZONAL-MEAN GRAPH

The models estimated that the global oceans would warm fairly uniformly from the mid-latitudes of the Southern Hemisphere to the high-latitudes of the Northern Hemisphere — with less warming in the tropics and polar oceans. (See Figure 8-4.) The sea surface temperature **data** once again indicates something totally different. Observed data show the highest rates of warming in the mid-latitudes of the Northern Hemisphere and in the Arctic Ocean. Counterpoised to that warming, the Southern Ocean, the tropics, and a portion of the higher latitudes of the Northern Hemisphere (south of the Arctic, 50N-65N) show cooling.

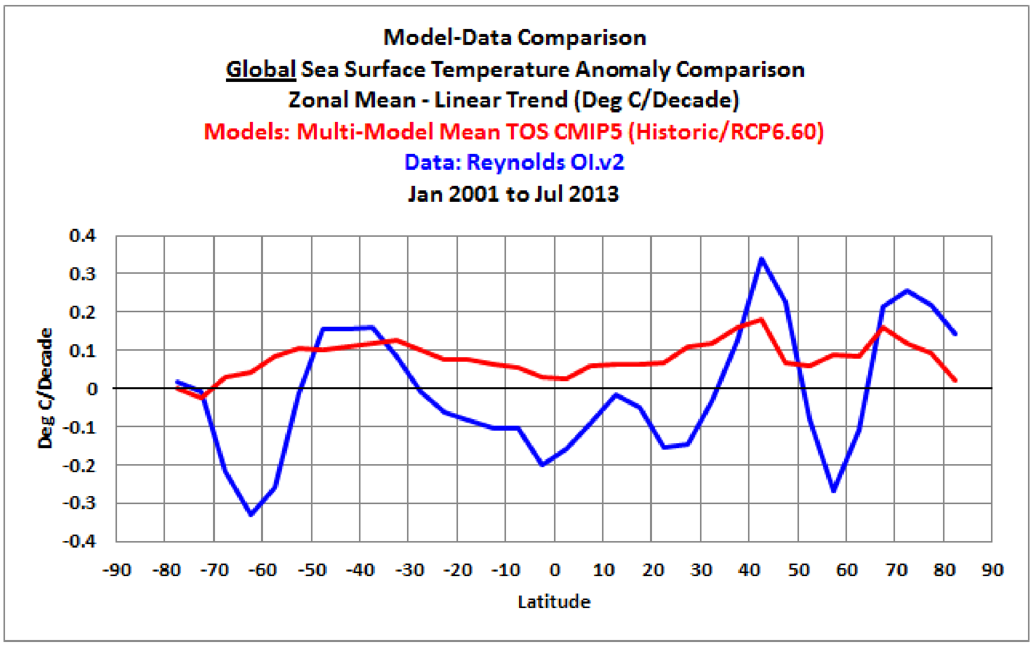


Figure 8-4

Chapter 8.2 – Stoppage Period Model-Data Comparisons: Sea Surface Temperature Anomalies of the Polar Oceans

The models underestimated the warming of Arctic sea surface temperatures since 2001 (Figure 8-5) by about 0.11 deg C/decade. At the other end of the globe, in the Southern Ocean (Figure 8-6), the models said it would warm at a relatively slow rate of 0.03 deg C/decade. But, the sea surface temperatures of the Southern Ocean actually cooled — at a rate of -0.23 deg C/decade. That's a whopping difference of more than 0.25 deg C/decade.

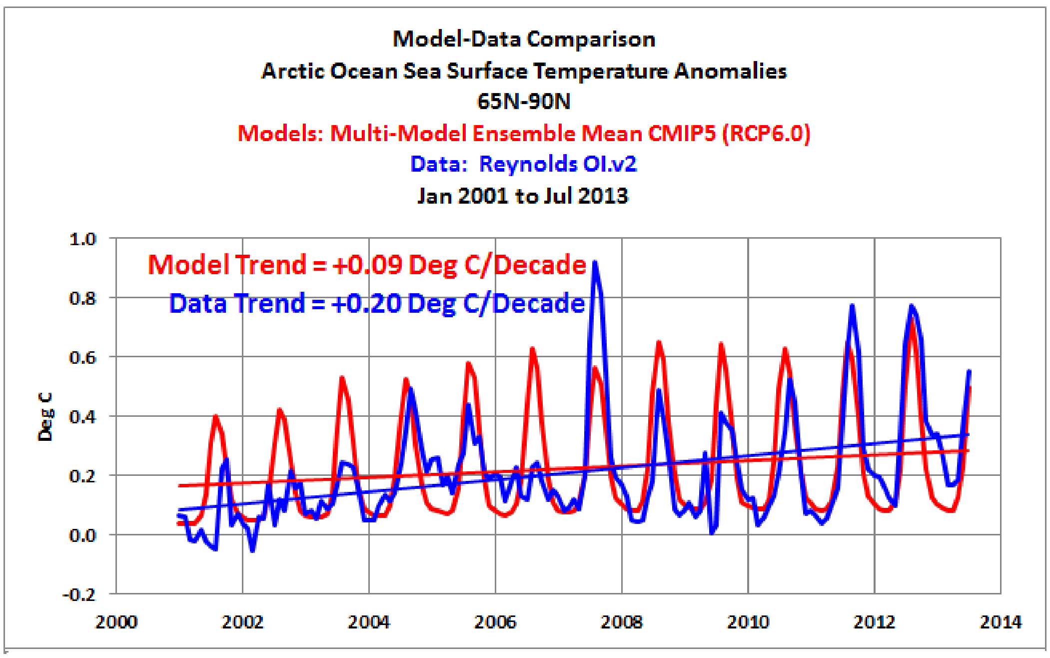


Figure 8-5

# # #

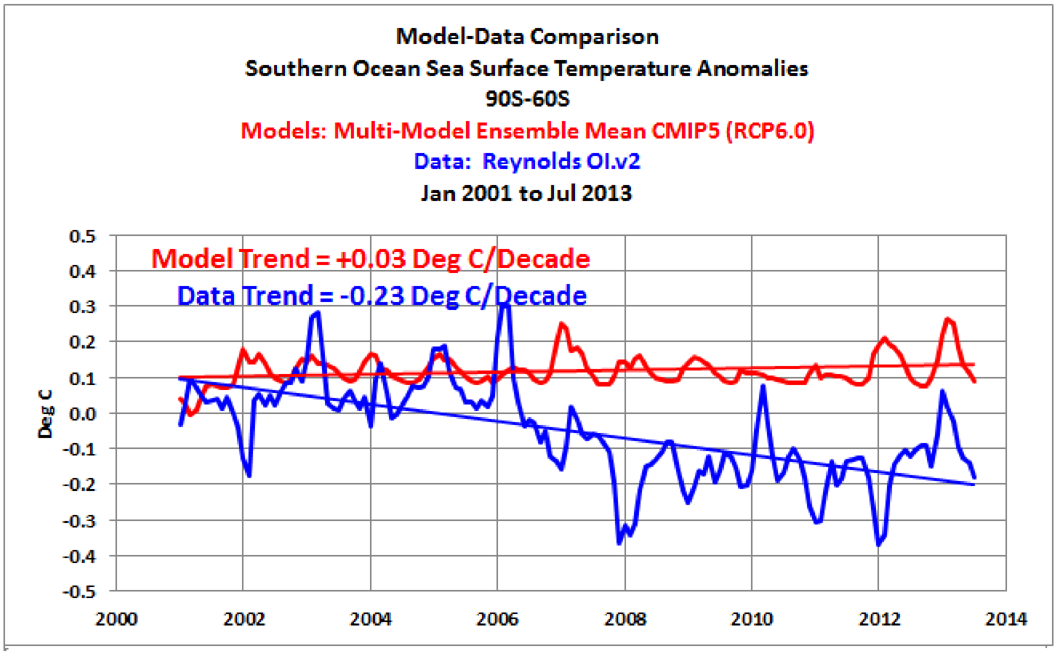

Model-Data Comparison
Southern Ocean Sea Surface Temperature Anomalies
90S-60S
Models: Multi-Model Ensemble Mean CMIP5 (RCP6.0)
Data: Reynolds OI.v2
Jan 2001 to Jul 2013
Model Trend = +0.03 Deg C/Decade
Data Trend = -0.23 Deg C/Decade
Deg C
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
2000
2002
2004
2006
2008
2010
2012
2014

Figure 8-6

Chapter 8.3 – Stoppage Period Model-Data Comparisons: Sea Surface Temperature Anomalies of the Atlantic Ocean

TIME-SERIES GRAPHS

The Atlantic Ocean, from 60S-70N, warmed at a rate of only 0.06 deg C/decade from January, 2001 to July, 2013 (Figure 8-7) but, the models simulated that the Atlantic should have warmed at a rate of 0.11 deg C/decade. The difference is relatively small.

(Note: this difference does not correspond to the average of the North and South Atlantic. This is likely due to the differences in the coordinates used for the North Atlantic.)

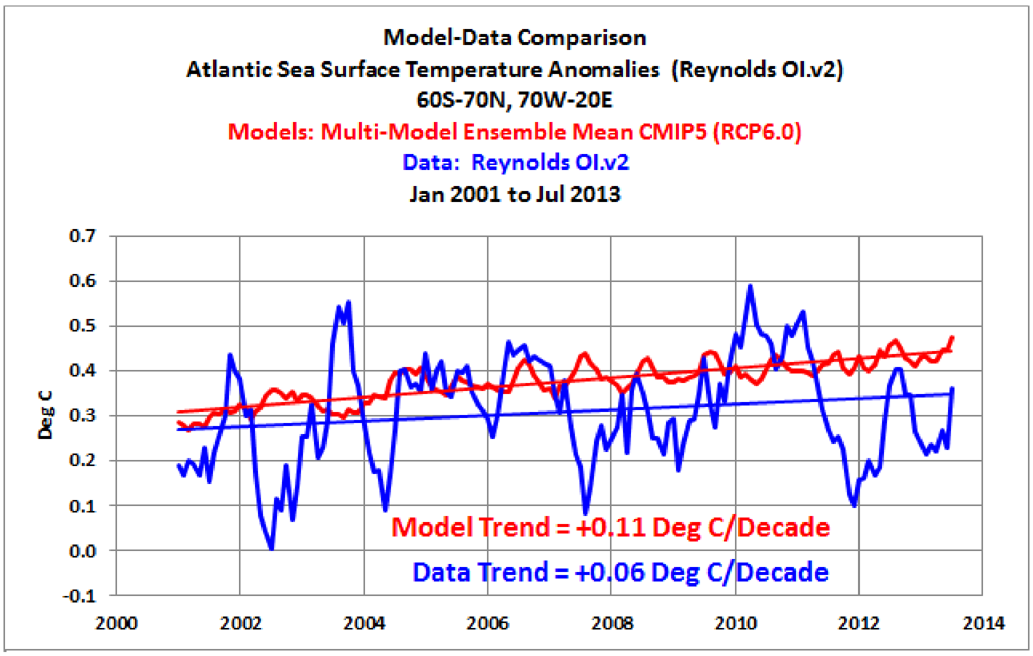


Figure 8-7

The models' estimated warming rates in the North and South Atlantic were the same, at 0.10 deg C/decade. (See Figures 8-8 and 8-9.) The actual warming of the South Atlantic, as discussed in Chapter 7.4, was caused by the unusual (and, to date, completely unexplained) warming event of 2009 to 2011. The differences between the modeled and observed warming rates in the North and South Atlantic were about the same in both basins: 0.02 to 0.03 deg C/decade.

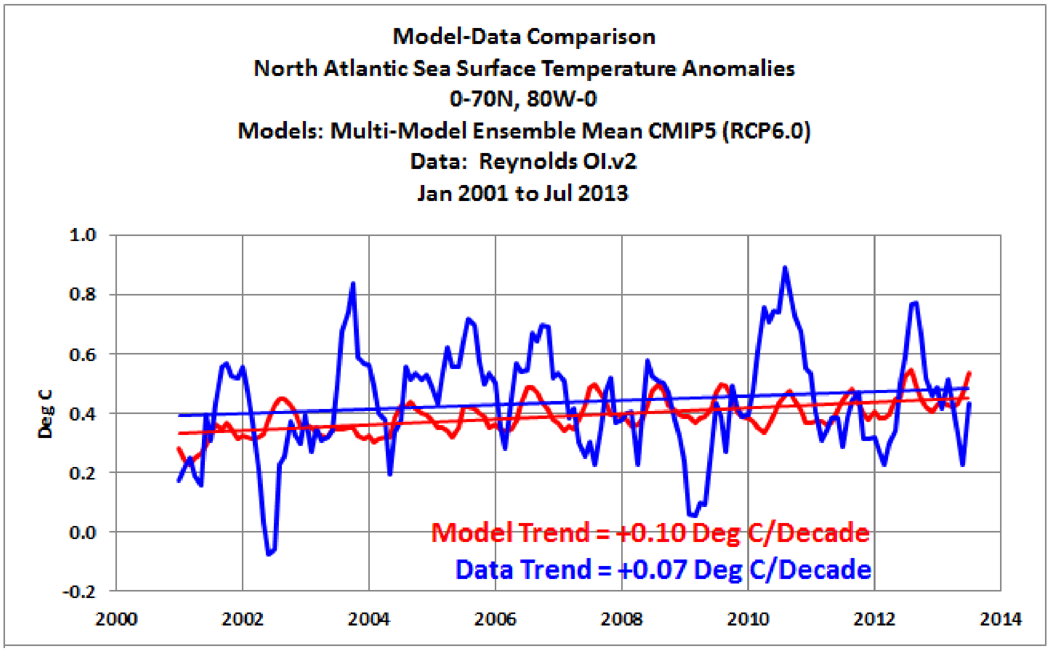


Figure 8-8

# # #

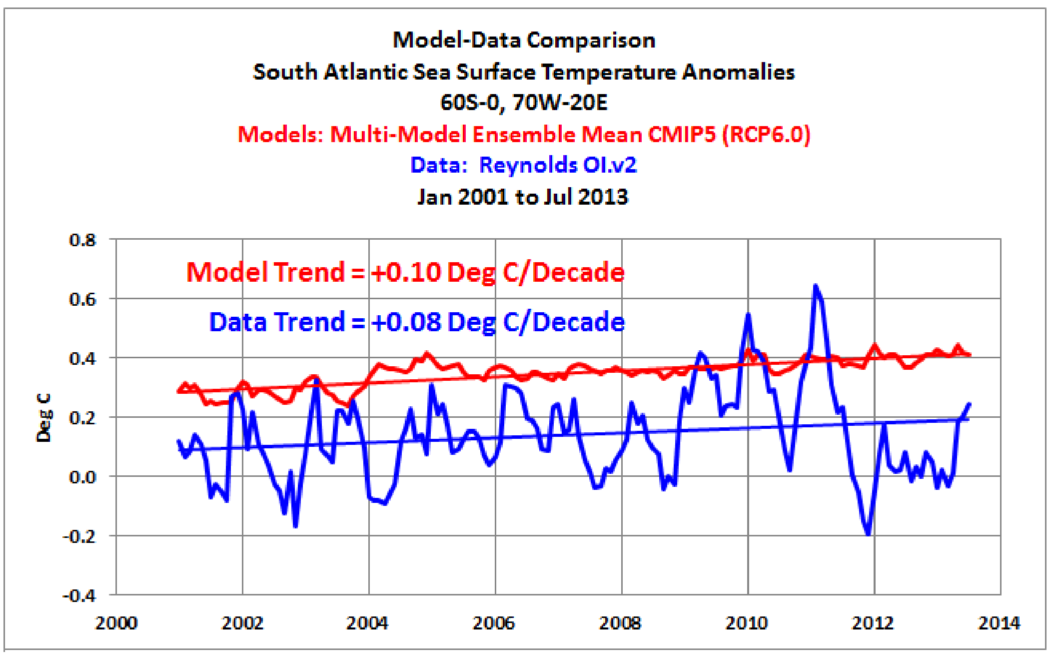


Figure 8-9

Note: The North Atlantic sea surface temperature data (Figure 8-8) has been even flatter for the past decade (since 2003). It is possible that the Atlantic Multidecadal Oscillation has reached its peak. Thus, it’s also probable the sea surface temperatures of the North Atlantic will cool in the near future, during the upcoming multidecadal cooling portion of the Atlantic Multidecadal Oscillation.

ZONAL-MEAN GRAPH

On a latitudinal basis, the mid-latitudes, 55S to 35S, of the South Atlantic showed the most warming since 2001. (See Figure 8-10.) Those are the latitudes at which the mysterious warming event occurred. The tropical North Atlantic showed the second highest rate of warming. All other latitudes in the Atlantic showed cooling, even the high latitudes of the North Atlantic. The models, on the other hand, estimated a much more uniform (though still variable) warming rate during the stoppage period, from the mid-latitudes of the South Atlantic to the high-latitudes of the North Atlantic.

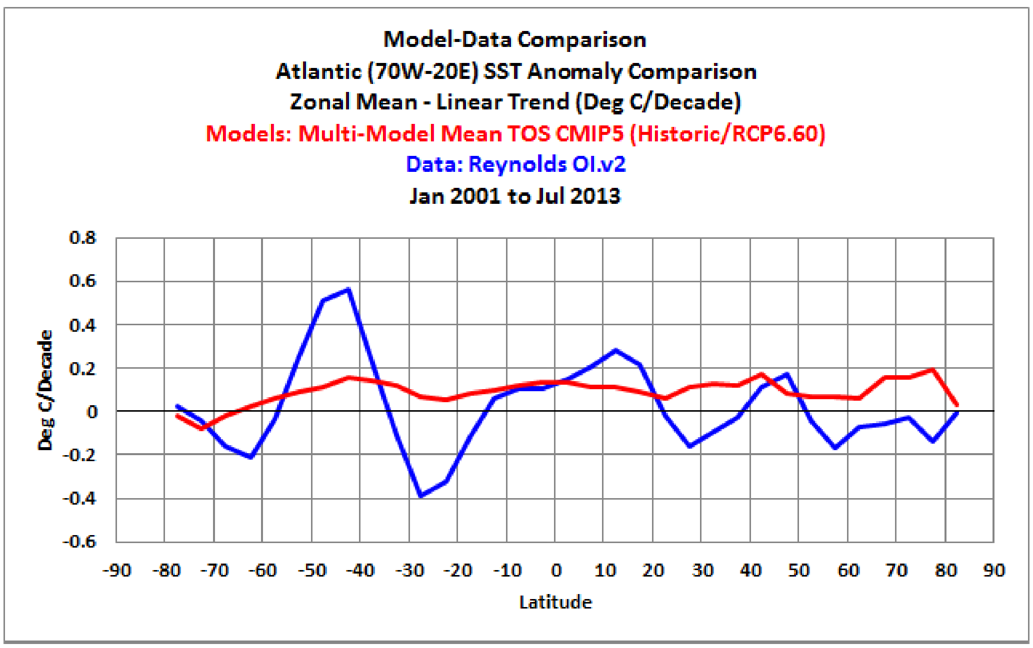


Figure 8-10

Chapter 8.4 – Stoppage Period Model-Data Comparisons: Sea Surface Temperature Anomalies of the Indian Ocean

Since January, 2001, the Indian Ocean warmed at the relatively high rate of 0.11 deg C/decade (Figure 8-11). The models estimated warming that was slightly less than that.

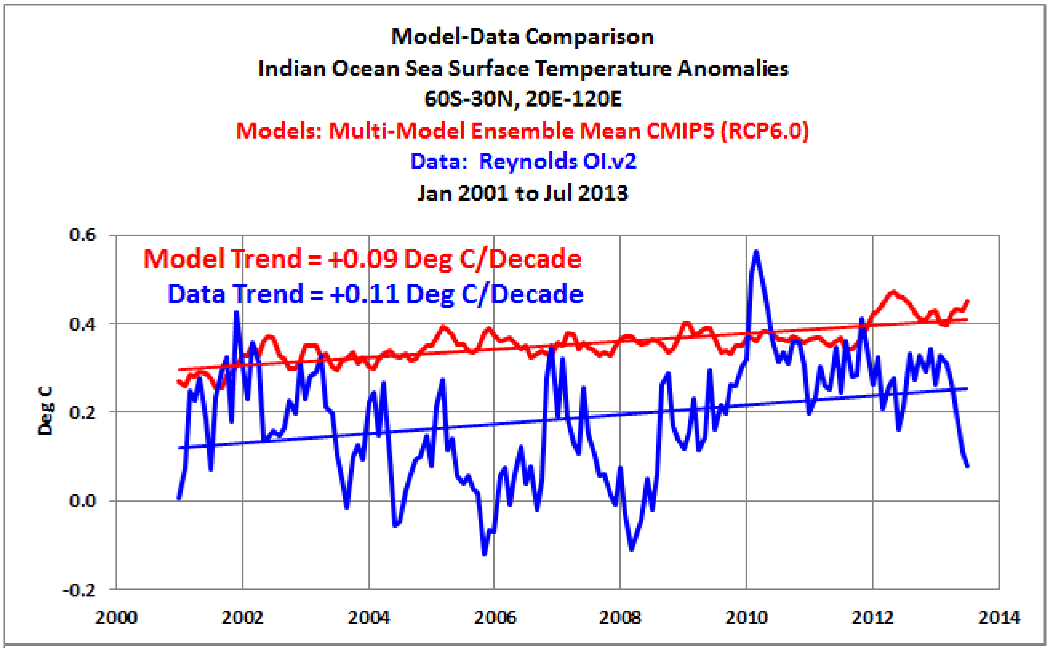


Figure 8-11

On a zonal-mean basis, in Figure 8-12, I show the modeled and observed warming rates of the Indian Ocean for the period of January, 2001 to July, 2013. The South Indian Ocean showed the greatest warming in that basin from 55S to 10S. The sea surface temperatures of the North Indian Ocean, including the Arabian Sea and the Bay of Bengal, cooled slightly. The greatest cooling occurred in the related portion of the Southern Ocean. The model output here (Figure 8-12) bears almost no resemblance to reality. Big fail.

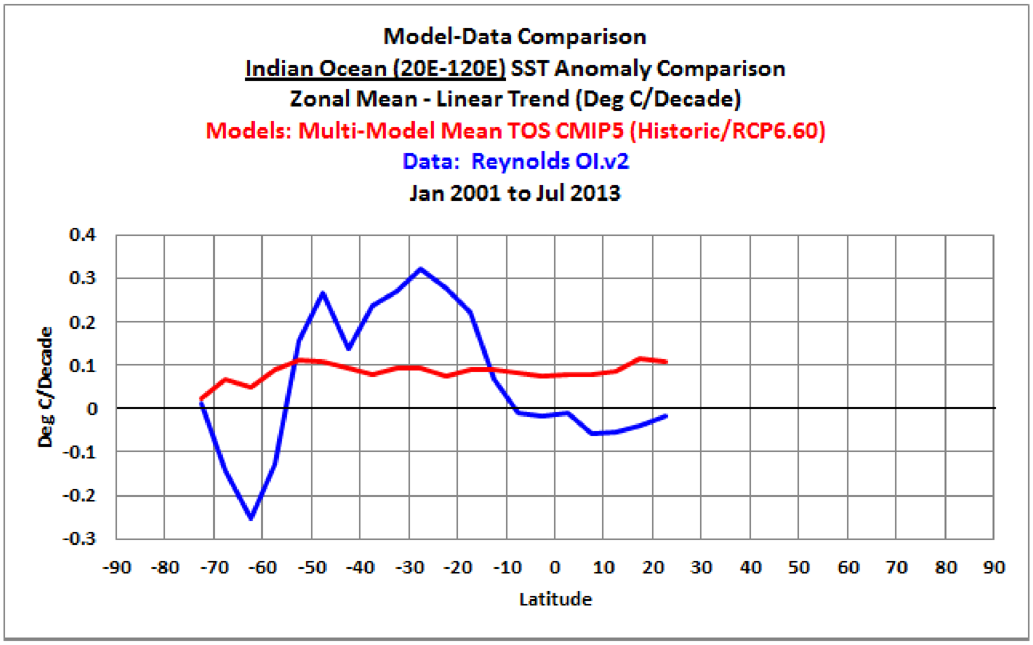

Model-Data Comparison
Indian Ocean (20E-120E) SST Anomaly Comparison
Zonal Mean - Linear Trend (Deg C/Decade)
Models: Multi-Model Mean TOS CMIP5 (Historic/RCP6.60)
Data: Reynolds OI.v2
Jan 2001 to Jul 2013
Deg C/Decade
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
Latitude

Figure 8-12

Chapter 8.5 – Stoppage Period Model-Data Comparisons: Sea Surface Temperature Anomalies of the Pacific Ocean

TIME-SERIES GRAPHS

The sea surface temperatures of the Pacific Ocean, the largest ocean on the planet, have cooled considerably since 2001. (See Figure 8-13.) The observed rate of cooling was -0.14 deg C/decade. The models, however, operating under the assumption that anthropogenic greenhouse gases warm the surface of the Pacific Ocean, estimated that temperatures there should have warmed at a rate of about 0.07 deg C/decade. The models missed the mark by about 0.21 deg C/decade.

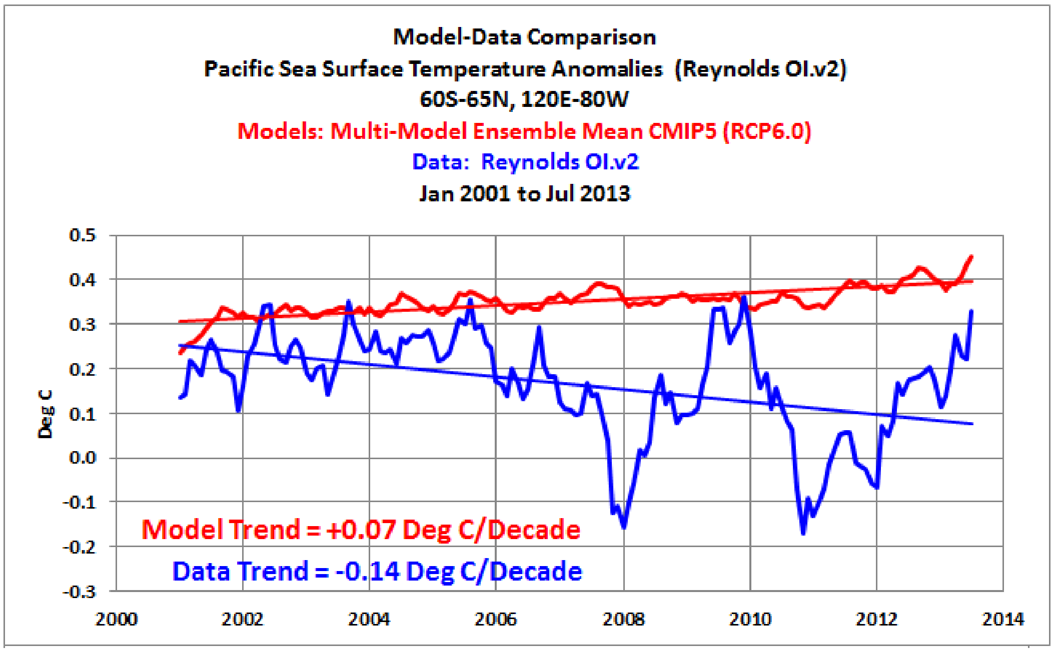


Figure 8-13

The sea surface temperatures of both the North Pacific (Figure 8-14) and the South Pacific (Figure 8-15) cooled since global warming halted over a decade ago, with the South Pacific cooling the fastest. Wrong once again, the model-estimated warming rate is slightly higher in the South Pacific than in the North Pacific, so the difference between the modeled and observed trends is greater in the South Pacific.

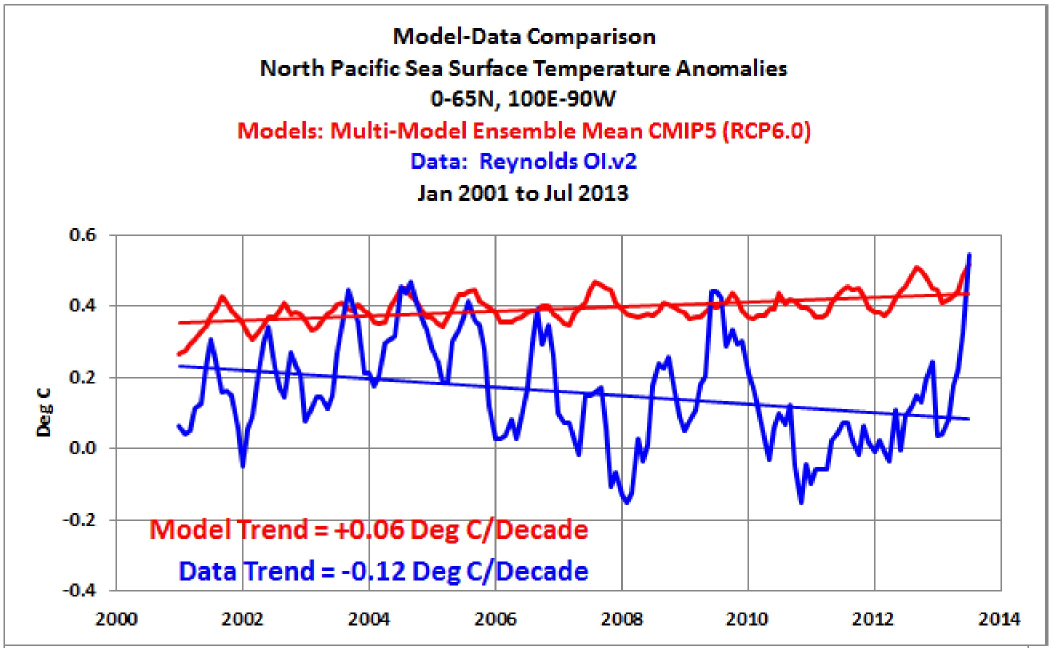


Figure 8-14

# # #

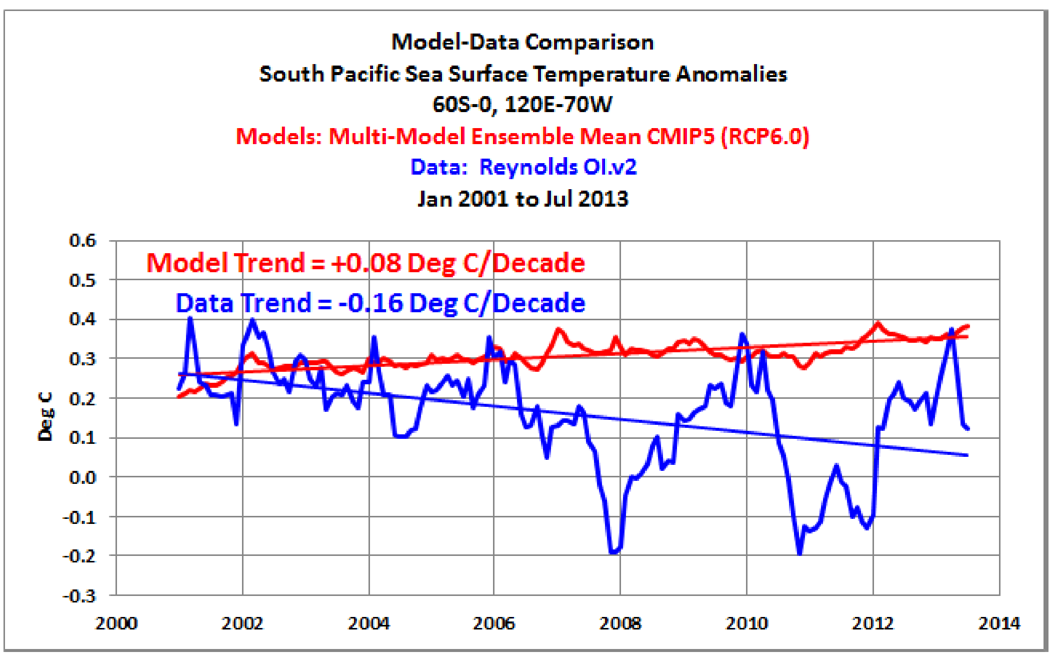


Figure 8-15

ZONAL-MEAN GRAPH

Looking at the sea surface temperature trends on a latitudinal basis since January, 2001 (Figure 8-16), the mid-latitudes of the North Pacific (the latitudes of the Kuroshio-Oyashio Extension) show the highest rate of warming. A very low rate of warming is still taking place in the mid-latitudes of the South Pacific, within the latitudes of the SPCZ (South Pacific Convergence Zone). More than offsetting those two areas where sea surface temperatures are warming, most of the Pacific has been cooling since 2001. That includes the Southern Ocean, the tropical Pacific, and the high latitudes of the North Pacific. The models appear to be simulating a completely different ocean in a totally different world.

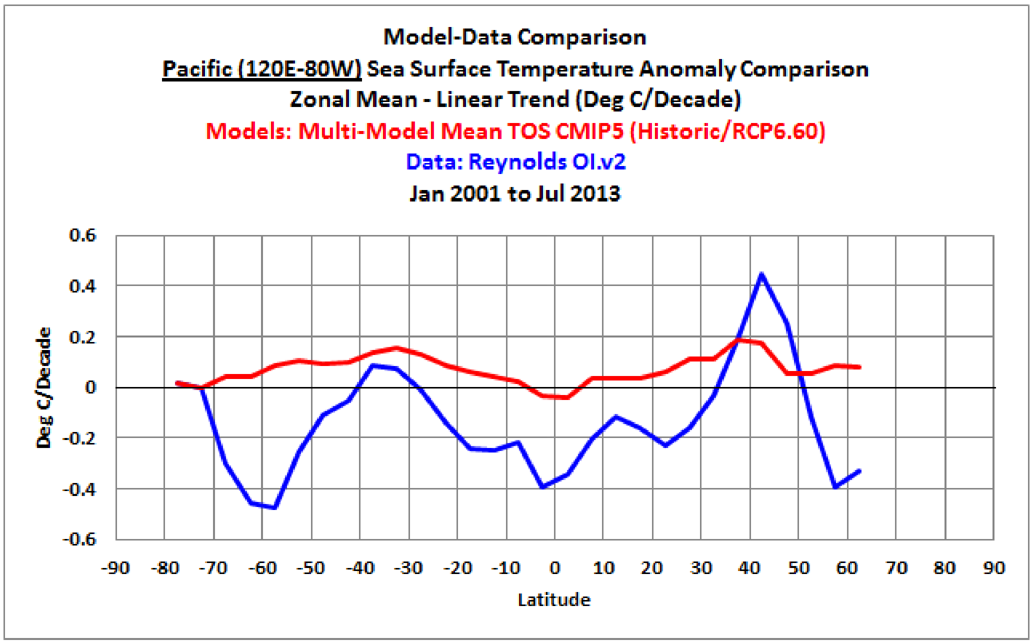


Figure 8-16

EAST PACIFIC SUBSET

In Chapter 7.7, I discuss the fact that East Pacific sea surface temperatures haven't warmed in 31 years. As I illustrate in Figure 8-17, the sea surface temperature anomalies of the East Pacific Ocean (90S-90N, 180-80W) have cooled at the high rate of -0.19 deg C/decade.

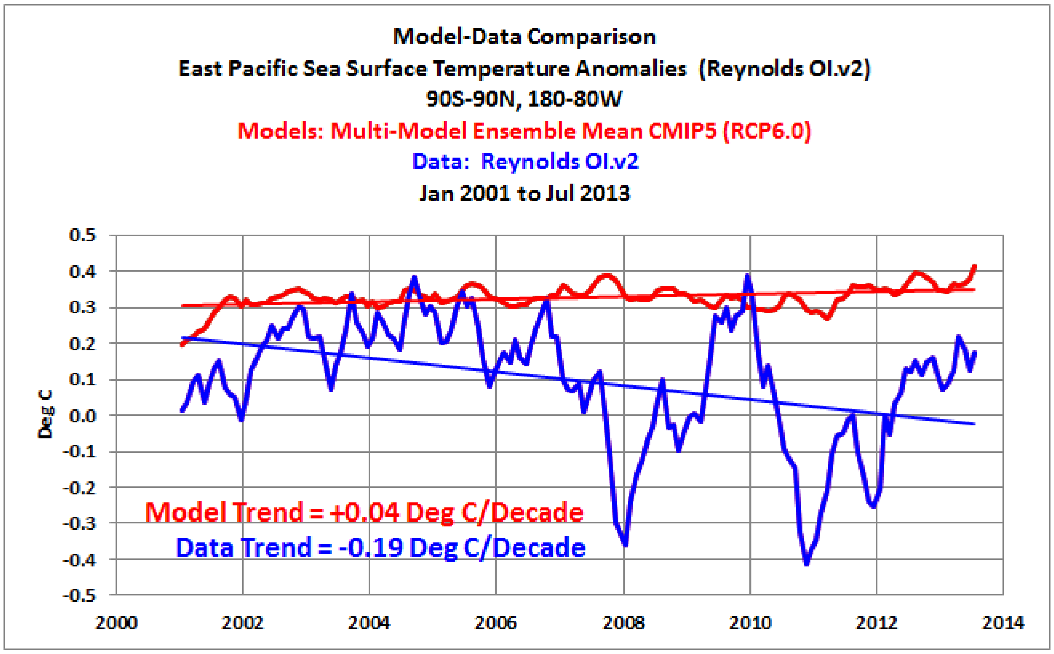

Model-Data Comparison
East Pacific Sea Surface Temperature Anomalies (Reynolds OI.v2)
90S-90N, 180-80W
Models: Multi-Model Ensemble Mean CMIP5 (RCP6.0)
Data: Reynolds OI.v2
Jan 2001 to Jul 2013
Deg C
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
2000
2002
2004
2006
2008
2010
2012
2014
Model Trend = +0.04 Deg C/Decade
Data Trend = -0.19 Deg C/Decade

Figure 8-17

Chapter 8.6 – Closing Comments on the Stoppage Period Model-Data Comparisons of Sea Surface Temperature Anomalies

In Figure 8-18, I present the sea surface temperature anomalies for the NINO3.4 region of the central equatorial Pacific (The surface temperatures of the NINO3.4 region are a commonly used index of the frequency, strength, and duration of El Niño and La Niña events). NOAA considers a NINO3.4 sea surface temperature anomaly of +0.5 deg C or warmer to be El Niño conditions, and a NINO3.4 sea surface temperature anomaly of -0.5 deg C or cooler to be La Niña conditions — thus, the color coding of red for El Niño conditions and blue for La Niña conditions. It's very obvious that the first half of the last 12+ years were dominated by El Niño events, with one brief dip into La Niña conditions. During the second half of the 12 years, La Niña conditions not only returned, they dominated. The transition from El Niño to La Niña domination is clearly seen in the high cooling rate (- 0.63 deg C/decade) of the NINO3.3 sea surface temperature anomalies.

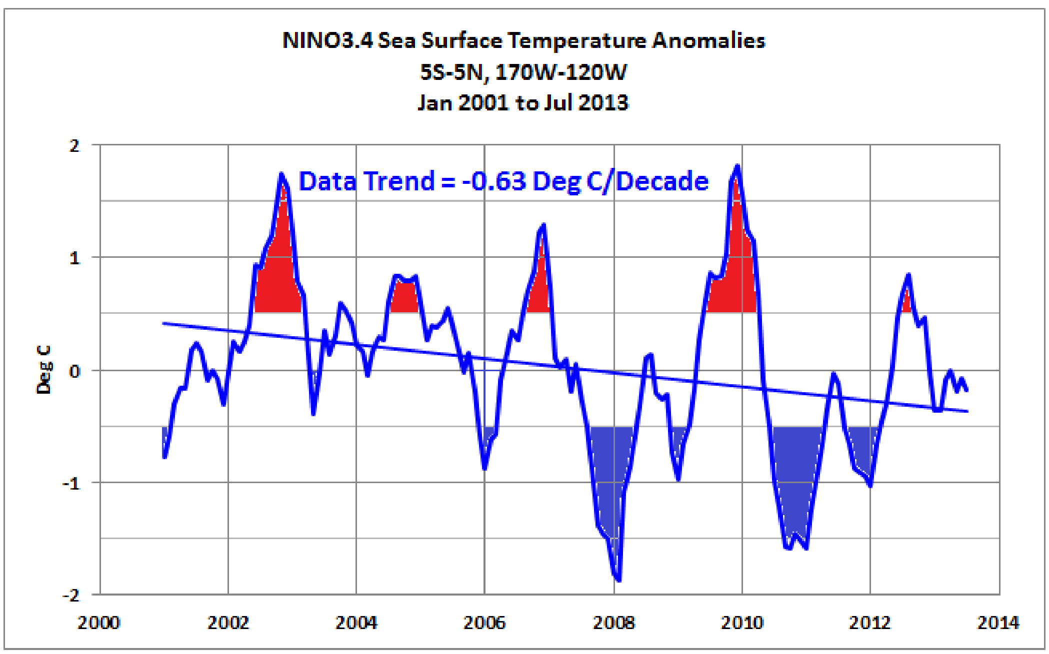


Figure 8-18

In Figure 8-19, I present a trend map of the sea surface temperatures of the global oceans from 2001 to 2012. Areas that warmed are shown in oranges and reds and those that cooled are shown in greens, blues, and purple. The warming in the South Atlantic is associated with the mysterious warming event there in 2009 to 2011. The warming in the northwest Pacific is likely a response to the recent domination of La Niñas — during La Niñas, more sunlight-fueled warm water than normal is distributed by ocean currents from the tropical Pacific into the North Pacific.

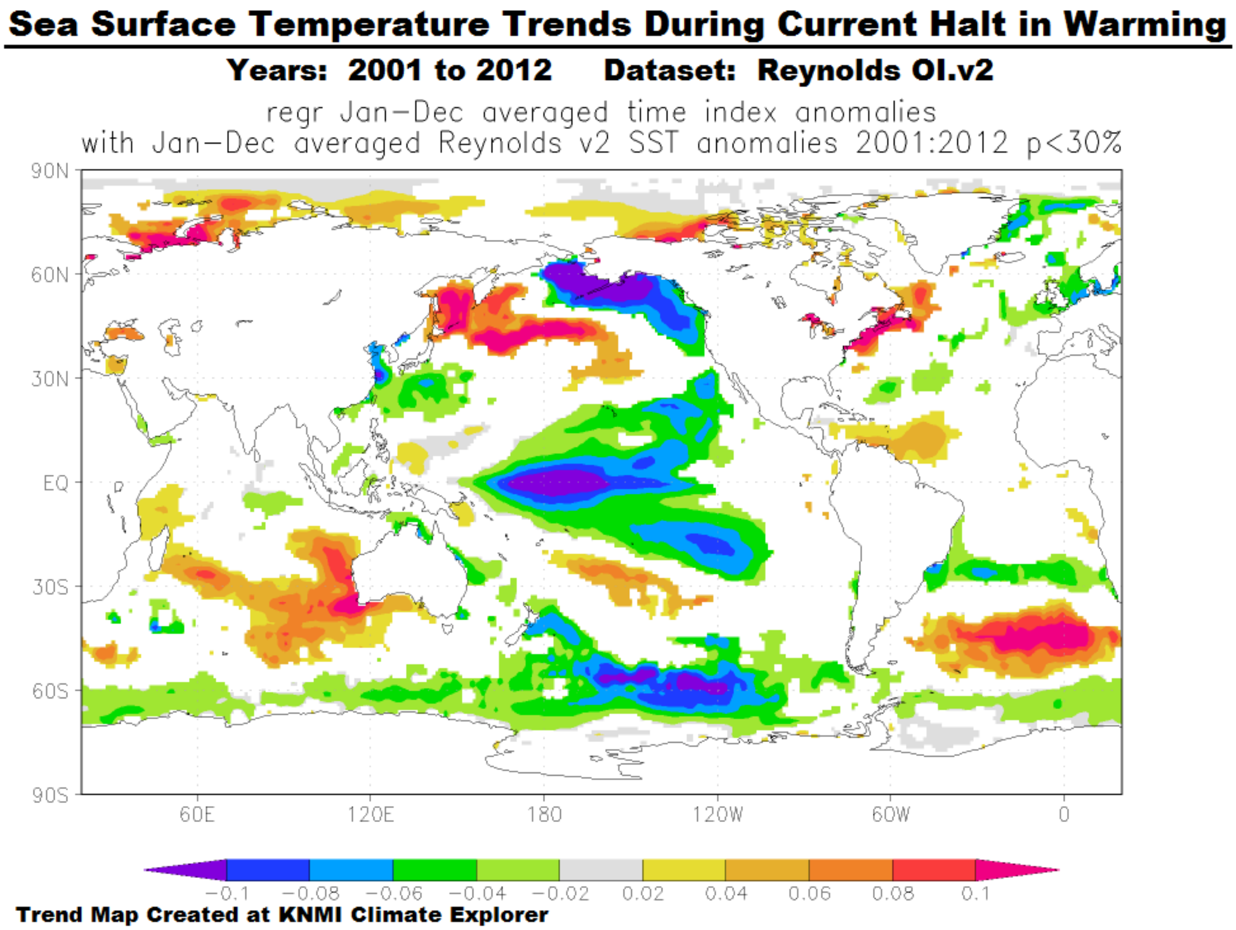


Figure 8-19

As a whole, the Southern Ocean surrounding Antarctica has cooled since 2001. Moreover, as shown in Chapter 7.2, it has been cooling since the start of the Reynolds OI.v2 data in November, 1981. (See Figure 7-6.)

The cooling pattern in the tropical Pacific reflects the transition from a Central Pacific El Niño event phase to a La Niña phase (Central Pacific El Niños as opposed to the stronger East Pacific El Niños). The high latitudes of the North Pacific and a portion of the Southern Ocean also showed high rates of cooling. The cooling in those two regions is likely, in part, a response to the transition from El Niño to La Niña in the tropical Pacific.

Thus, as all the above makes abundantly clear, the models completely failed to predict the current cessation of global warming because they cannot simulate the alternating decadal and multidecadal phases of El Niño and La Niña dominance. (See Guilyardi, et al. (2009) "Understanding El Niño in Ocean-Atmosphere General Circulation Models: Progress and Challenges" and Bellenger, et al. (2013) "ENSO Representation in Climate Models: from CMIP3 to CMIP5"). And that brings to mind the portion of Guilyardi, et al. (2009) I quoted earlier:

> *Because ENSO is the dominant mode of climate variability at interannual time scales, the lack of consistency in the model predictions of the response of ENSO to global warming currently limits our confidence in using these predictions to address adaptive societal concerns, such as regional impacts or extremes (Joseph and Nigam 2006; Power, et al. 2006).*

All in all, it makes no difference whether one looks at the short-term sea surface temperature data during the current halt period or the full term of the satellite-era sea surface temperature data which starts in November, 1981. The climate models used by the IPCC for their 5th Assessment Report show no skill at all at being able to simulate how, when, or why sea surface temperatures have warmed and cooled. The warming of the sea surface temperatures over the past 3+ decades was a response to coupled ocean-atmosphere processes and the climate modelers cannot simulate those processes. And the cessation of warming was caused by those same coupled ocean-atmosphere processes, which the climate modelers cannot simulate. Conclusion: climate models have no value for historical attribution studies and even less for projections of future climate.

Section 9 – Do Ocean Data Confirm or Contradict the Hypothesis of Human-Induced Global Warming?

The subject of how poorly climate models simulate El Niño and La Niña events has been discussed numerous times throughout this book. And I've discussed why they must be able to simulate those processes if the models are to have any value. This section reinforces and expands on those discussions.

In 2012, I published an ebook about the long-term effects of strong El Niño events: ***Who Turned on the Heat?*** The subtitle is: *The Unsuspected Global Warming Culprit: El Niño-Southern Oscillation*. At present, it is only available in .pdf format through my website. (There are links at the end of this section.)

As I discuss in the Introduction to ***Who Turned on the Heat?*** (See the preview here.)

> *The strength of ENSO phases, along with how often they happen and how long they persist, determine how much heat is released by the tropical Pacific into the atmosphere and how much warm water is transported by ocean currents from the tropics toward the poles. During a multidecadal period when El Niño events dominate (a period when El Niño events are stronger, when they occur more often and when they last longer than La Niña events), more heat than normal is released from the tropical Pacific and more warm water than normal is transported by ocean currents toward the poles — with that warm water releasing heat to the atmosphere along the way. As a result, global sea surface and land surface temperatures warm during multidecadal periods when El Niño events dominate. They have to. There's no way they cannot warm. Conversely, global temperatures cool during multidecadal periods when La Niña events are stronger, last longer and occur more often than El Niño events. That makes sense too because the tropical Pacific is releasing less heat and redistributing less warm water than normal then.*

The models show **no skill** at being able to simulate the warming of sea surface temperatures of the global oceans over the past 3 decades — how they've warmed, when they've warmed, why they've warmed — yet the IPCC continues to insist that ocean warming can be attributed to manmade CO_2. Suppose the IPCC, because of the many failings of climate models, has mistaken a series of sunlight-fueled (not manmade CO_2-fueled) warming events for human-induced global warming.

It's really not a supposition.

Ocean heat content data and satellite-era sea surface temperature data do not support the hypothesis of human-induced global warming. That is, the data strongly suggest that the oceans did not warm due to manmade greenhouse gases.

To understand how the ocean actually warms and cools, one must understand how El Niño and La Niña events work. Collectively known as ENSO (El Niño-Southern Oscillation – "El Niño" (and "La Niña") indicates the ocean part of the phenomenon and "Southern Oscillation" indicates the atmospheric part), it is an extremely fascinating process.

SOME BACKGROUND:

I first presented this discussion of the natural (not human-induced) warming of the global oceans back in January, 2009 at my blog. Then, thanks to Anthony Watts, those posts reached a much wider audience through his blog WattsUpWithThat, the world's most-viewed website about global warming and climate change and voted "Best Science Blog" three years running in the Weblog Awards, making it a "Hall of Fame" honoree. Those first posts on this topic at my blog are here and here, and the cross posts at WattsUpWithThat are here and here. Not long after that, KNMI added the NODC (National Oceanographic Data Center) Ocean Heat Content data (0-700 meters) to their Climate Explorer so that the ocean heat content data could be examined more thoroughly. Immediately, it was obvious that La Niña events were responsible for the long-term warming of the ocean heat content in the tropical Pacific and in the tropics as a whole.

People who comment frequently at WattsUpWithThat come from a wide variety of backgrounds. They include physicists, oceanographers, mathematicians, statisticians, engineers, persons well versed in fluid dynamics, etc… They are more than happy to offer their insights on the topics at hand. In the 4+ years since those first posts, we have presented and discussed additional findings in dozens of blog posts, about the El Niño and La Niña processes and their long-term effects on the warming of surface temperatures and ocean heat content. From bloggers' questions and comments, I learned where more-detailed and easier-to-read explanations were needed and which datasets were needed to confirm the ENSO processes.

AN EXPLANATORY NOTE:

In this section, I primarily discuss ocean heat content and sea surface temperature, but there are numerous other variables, the data for which confirm our understanding of El Niño and La Niña processes. Those variables include: sea level, lower troposphere temperatures, land surface air temperatures, trade winds strength and direction, cloud amount, precipitation, downward shortwave radiation (sunlight), downward longwave radiation (infrared radiation), warm water volume, depth-averaged (ocean) temperature, and ocean currents. I've created animations of maps for many of those variables to demonstrate how the many variables respond to El Niños and La Niñas.

Each time I present the following, I revise the sequence of the presentation and change the wording of many of the descriptions — trying to make it easier to understand. Hopefully, my readers will find that I have succeeded with what follows.

Chapter 9.1 – A Brief Introduction to El Niño Events

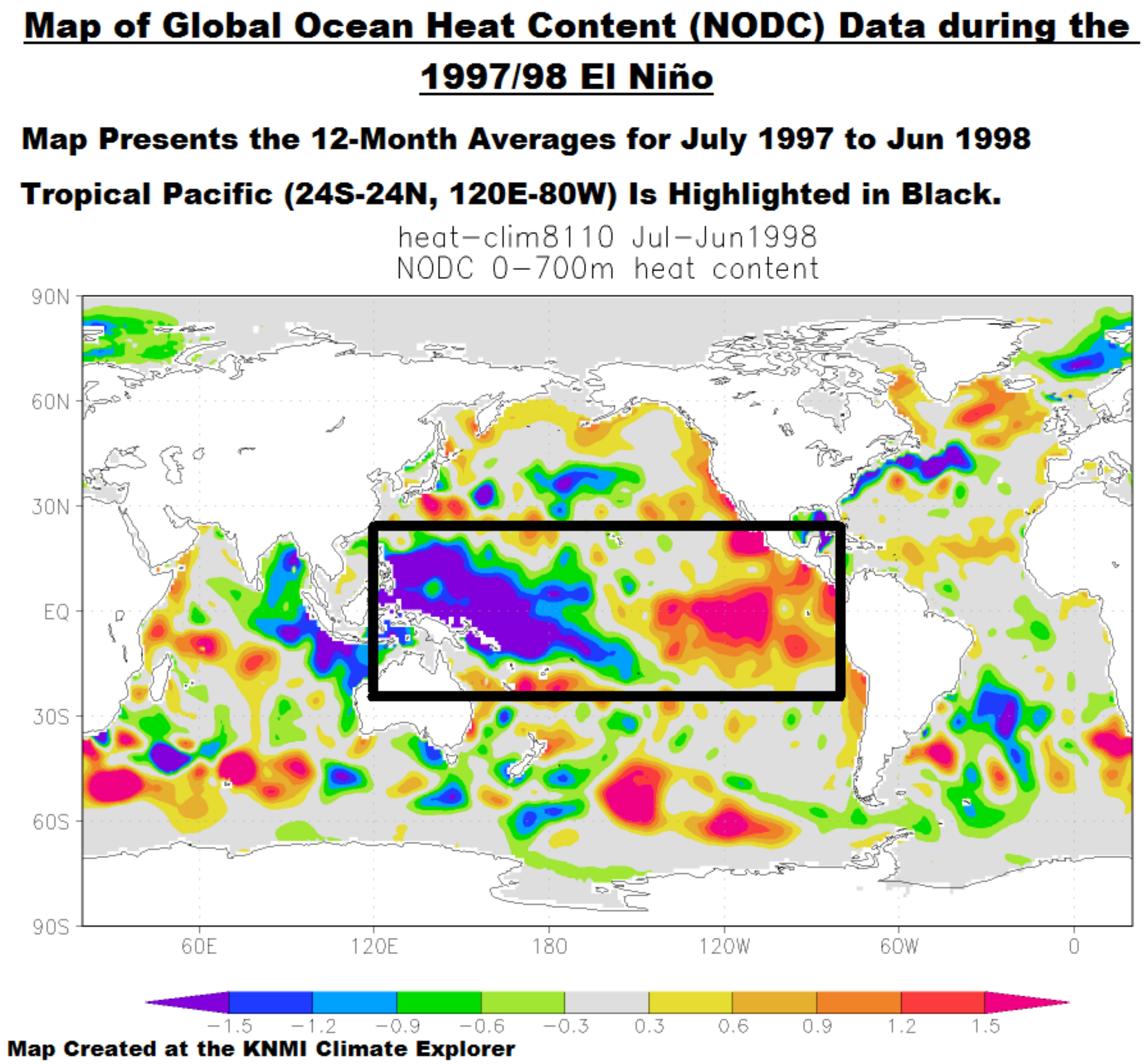


Figure 9-1

The tropical Pacific is highlighted in the map of the NODC (National Oceanographic Data Center) Ocean Heat Content Data, Figure 9-1. Like other datasets, the NODC ocean heat content data for depths of 0-700 meters (about 0-2300 feet) are available on a gridded basis through the KNMI Climate Explorer. The map is for the 12-month period from July, 1997 to June, 1998, and it captures the colossal 1997/98 El Niño. During the El Niño, the ocean heat content decreased in the western tropical Pacific and increased in the eastern tropical Pacific. That is, there are negative ocean heat content anomalies in the western tropical Pacific (the West Pacific Warm Pool) and positive anomalies in the eastern tropical Pacific.

How That Occurs: During an El Niño, warm surface <u>and subsurface</u> waters (to depths of about 300 meters) from the West Pacific Warm Pool are carried eastward and much of that warm water is spread across the surface of the eastern tropical Pacific. This is seen below in the map of sea surface temperature anomalies (Reynolds OI.v2) for the global oceans, Figure 9-2.

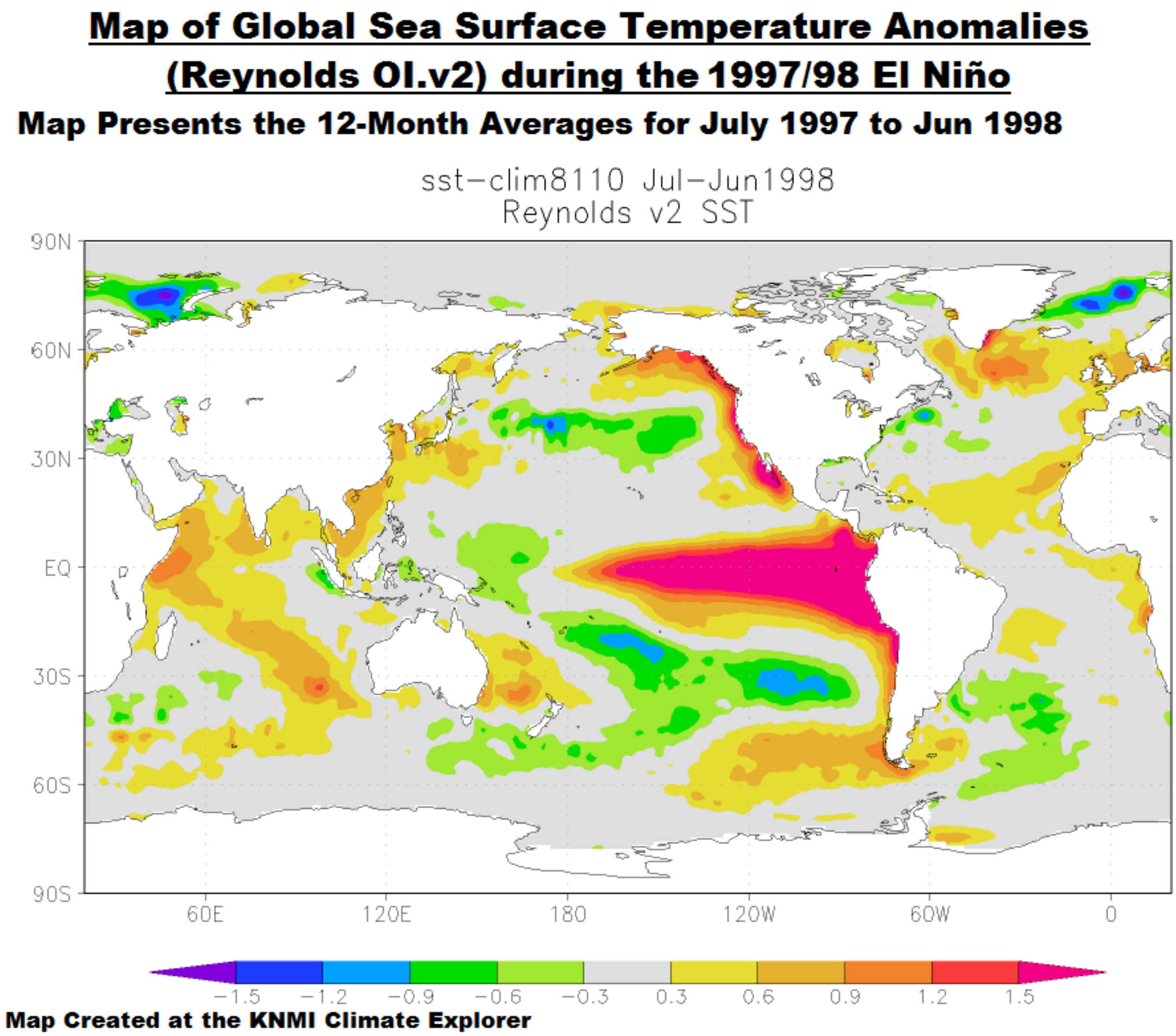


Figure 9-2

Note, however, in Figure 9-2, how small the decrease in the sea **surface** temperatures in the western tropical Pacific is compared to the huge drop in the **ocean heat content** data there (Figure 9-1). This indicates that much of the warm water that had been released from the West Pacific Warm Pool to travel east, where it spread across the surface of the eastern tropical Pacific, came from **below the surface** of the West Pacific Warm Pool.

To cause the sea surface temperatures in the eastern tropical Pacific to warm, an El Niño does not **create** heat in the eastern tropical Pacific. It simply sends warm water eastward. During "normal" (ENSO-neutral) times, sea surface temperatures (absolute, not anomalies) in the eastern equatorial Pacific are considerably cooler than they are in the west — as much as 8 deg C cooler. The El Niño sends the warmer water from the western tropical Pacific eastward into the cooler eastern portion. This raises the surface temperatures in the eastern tropical Pacific.

During times of "normal" (ENSO-neutral) conditions, the warm pool in the western tropical Pacific pumps a tremendous amount of moisture into the atmosphere, and, as a result, it is one of the principal drivers of climate around the globe. During an El Niño, all of that changes. Because the tropical Pacific stretches almost halfway around the world, when all of that warm water floods into the eastern tropical Pacific, the evaporation, convection, and cloud cover (that's normally in western Pacific) also travel east along with it. Those major ocean-atmospheric shifts, in turn, relocate the jet streams and disrupt global weather patterns, causing floods in some regions and droughts in others; cooler surface temperatures in some locations and warmer surface temperatures in others. Overall, more regions warm than cool.

And outside of the tropical Pacific, much of that initial warming and cooling occurs without the transfer of heat from the tropical Pacific. In fact, much of Trenberth, et al. (2002) explains how surface temperatures remote to the tropical Pacific warm and cool in response to El Niños — without requiring the direct transfer of heat from the tropical Pacific into those other regions.

El Niños don't create heat; they simply relocate warm water. But, because during an El Niño more of the surface of the tropical Pacific is covered by warm water, the added warm water causes more heat than normal to be released into the atmosphere through evaporation. As a result, during an El Niño (i.e., the discharge phase of ENSO), the tropical Pacific releases ocean heat to the atmosphere.

Note: The Pacific Warm Pool is known by a number of names: West Pacific Warm Pool, Indo-Pacific Warm Pool, or simply Pacific Warm Pool. I'll use West Pacific Warm Pool simply to remind readers of its location.

CHAPTER 9.1 SUMMARY

An El Niño releases warm water stored in the western tropical Pacific and spreads it across the surface of the eastern tropical Pacific. Because more of the surface of the tropical Pacific is, thereby, covered by warmer water, more heat than normal is released into the atmosphere through evaporation. That is how an El Niño “discharges” heat from the tropical Pacific. The other portion of the discharge phase, which I will discuss later, is a result of what happens to the leftover warm water from the El Niño which is redistributed out of the tropical Pacific at the end of the El Niño.

Chapter 9.2 – ENSO Is a Chaotic Sunlight-Fueled Recharge-Discharge Oscillator

Please don't let the title of this chapter concern you. It's a relatively easy concept to understand. We've already discussed how El Niño events act as the "discharge" phase. "**Chaotic**" means that ENSO does not act like a sine wave, smoothly cycling from El Niño to La Niña and back to El Niño, in a uniform oscillation. There can be back-to-back El Niños and back-to-back La Niñas. Sometimes a 1-year El Niño is followed by a La Niña that lasts for 3 years. Not only the durations, but the strengths of the El Niño and La Niña events vary. Why is ENSO chaotic? Researchers have been studying El Niños and La Niñas for decades and they still don't know.

The **"recharge"** takes place during La Niña events, and it is caused by a temporary reduction in cloud amount (caused by the La Niña) which allows more sunlight to enter and warm the tropical Pacific — thus, **"sunlight-fueled"**.

Trenberth, et al. (2002) is a widely cited scientific paper about the impacts of El Niño events on surface temperatures and precipitation around the globe. It's a brilliant paper, and it's very complex — with lots of scientific terms. Thankfully, it provides a brief, reasonably easy-to-understand, description of El Niño and La Niña events. From Trenberth, et al. (2002) (my boldface):

> *The negative feedback between SST [sea surface temperature] and surface fluxes can be interpreted as showing the importance of the discharge of heat during El Niño events and of the recharge of heat during La Niña events.* ***Relatively clear skies in the central and eastern tropical Pacific allow solar radiation to enter the ocean****, apparently offsetting the below normal SSTs, but the heat is carried away by Ekman drift, ocean currents, and adjustments through ocean Rossby and Kelvin waves, and the heat is stored in the western Pacific tropics.* ***This is not simply a rearrangement of the ocean heat, but also a restoration of heat in the ocean****.*

Basically, according to Trenberth, et al. (2002), El Niño events release heat. That is, El Niño events are the "**discharge"** phase (discussed in Chapter 9.1). Trenberth, et al. (2002) also note that El Niño events are fueled by warm water created by La Niñas and that the warm water is a product of a temporary increase in sunlight, resulting from a La Niña-induced reduction in cloud cover. I discussed in Chapter 7.7 the ocean heat content and solar radiation aspects of ENSO, but it bears repeating.

The recharge/restoration aspect of ENSO, described by Trenberth, et al. (2002), is evident in the NODC ocean heat content data for the tropical Pacific. See Figure 9-3 which depicts the variations in the ocean heat content for the tropical Pacific, the highlighted region in the map in Figure 9-1. Its coordinates are 24S-24N, 120E-80W.

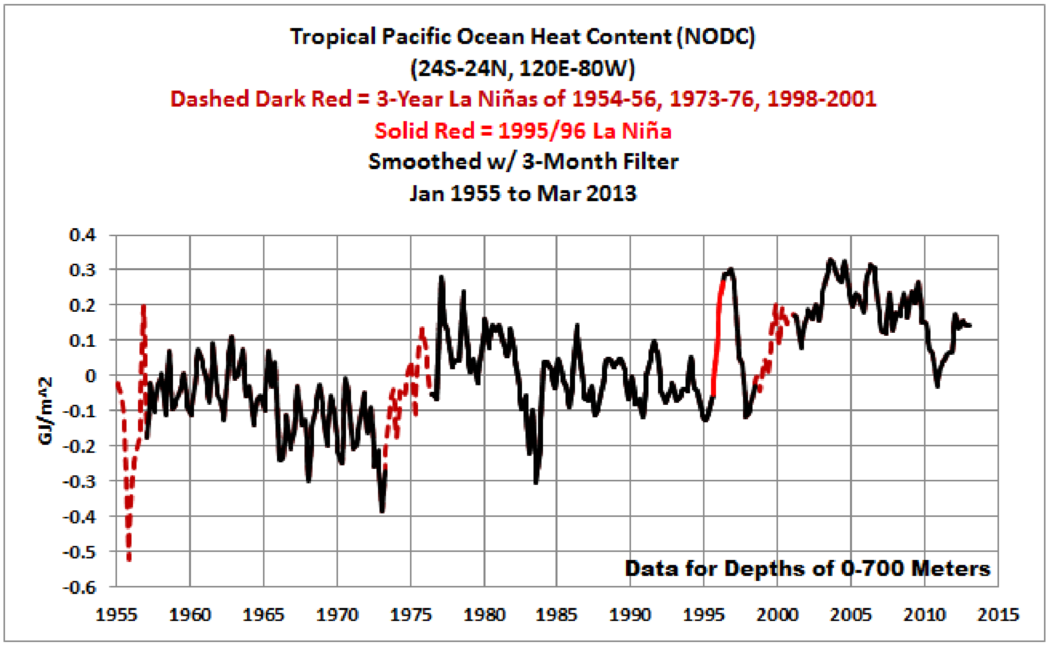


Figure 9-3

The 3 three-year La Niña events of 1954-56, 1973-76, and 1998-01 (the long La Niñas) are highlighted in dark red, dashed lines in Figure 9-3, and the 1995/96 La Niña (the strong La Niña) is highlighted in red. According to the data, the 1973-76 La Niña not only recharged the heat discharged by El Niños from 1957 to 1973, it added to the heat content. Likewise, the 1995/96 La Niña (one might call it a “super La Niña”) replenished the heat discharged by the El Niños during the period of 1976 to 1995, and it added to the heat content. The sharp drop between the 1995/96 and 1998/01 La Niña events was caused by the heat discharged during the gigantic 1997/98 El Niño. Then, the 1998-01 La Niña recharged most of the heat discharged by the 1997/98 El Niño. There were other discharges and lesser recharges between the major La Niñas, but the highlighted, long and strong, La Niña events were the primary charging events — that is, they are the primary causes of the warming of the ocean heat content in the tropical Pacific since 1955. In other words, without those four long and strong La Niñas, the ocean heat content of the tropical Pacific would have cooled since 1955.

All datasets have strengths and weaknesses depending on which part of the globe one is looking at. For instance, ocean heat content data in the tropical Pacific can be broken down into two periods, pre- and post-early 1990s. That’s when NOAA completed the installation of a group of buoys across the tropical Pacific — like weather stations out in the open ocean. (See the [NOAA Tropical Ocean-Atmosphere (TAO) project] website for further information.) Because those buoys were installed for studying El Niño and La

Niña events and processes, they also include measurements of numerous subsurface ocean variables including temperature measurements at different depths. As a result, the ocean heat content data for the tropical Pacific after the early 1990s is reasonably accurate. Before then, the data sampling is random, dependent on the needs of each particular research project. Thus, the ocean heat content data before 1990 must be taken with a generous pinch of salt. Example: the 1982/83 El Niño created a large dip in the data as expected, but the 1986/87/88 El Niño hardly registered in the pre-1990 data, even though those two El Niño events were comparable in magnitude (when the differences in duration are taken into account). Given the relative sparseness of the source data before the early 1990s, I've always been amazed to see how well the 3-year La Niña events make their presence known.

The 1995/96 La Niña is seen in the NODC ocean heat content data for the tropical Pacific as the leading edge of the large upward spike in the late 1990s. The 1995/96 La Niña created the warm water for the strongest El Niño of the 20th century, the 1997/98 super-El Niño. That 1997/98 El Niño is the trailing edge of the La Niña spike. The 1995/96 La Niña, along with replenishment during the 3-year 1998-01 La Niña, effectively shifted up the ocean heat content of the tropical Pacific.

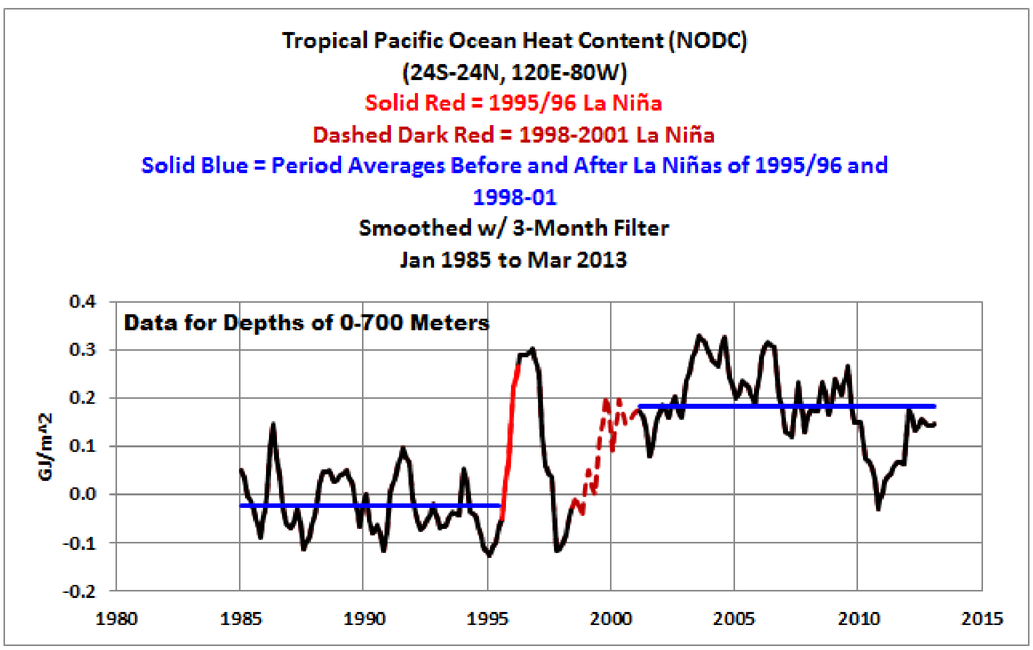


Figure 9-4

To help highlight the upward step, Figure 9-4 zooms in on the period starting in 1995. That graph also includes the period-average values before and after the combined impacts of the 1995/96 and 1998-01 La Niña events. Because the 1998-01 La Niña merely replenished part of the heat released by the 1997/98 El Niño, the primary cause of the upward shift was the 1995/96 La Niña.

McPhaden (1999) "Genesis and Evolution of the 1997-98 El Niño" explained what fueled the monstrous 1997/98 El Niño.

> *For at least a year before the onset of the 1997–98 El Niño, there was a buildup of heat content in the western equatorial Pacific due to stronger than normal trade winds associated with a weak La Niña in 1995–96.*

How would stronger trade winds during a La Niña create heat (in the form of warm water) for an El Niño? During La Niña events, the east-to-west trade winds are stronger than normal. This causes more cool subsurface waters to be upwelled along the equatorial Pacific. Figure 9-5 shows the sea surface temperature anomalies for the period of July, 1998 to June, 1999, the first year of the 1998-01 La Niña. Note the cool sea surface temperature anomalies along the equatorial Pacific.

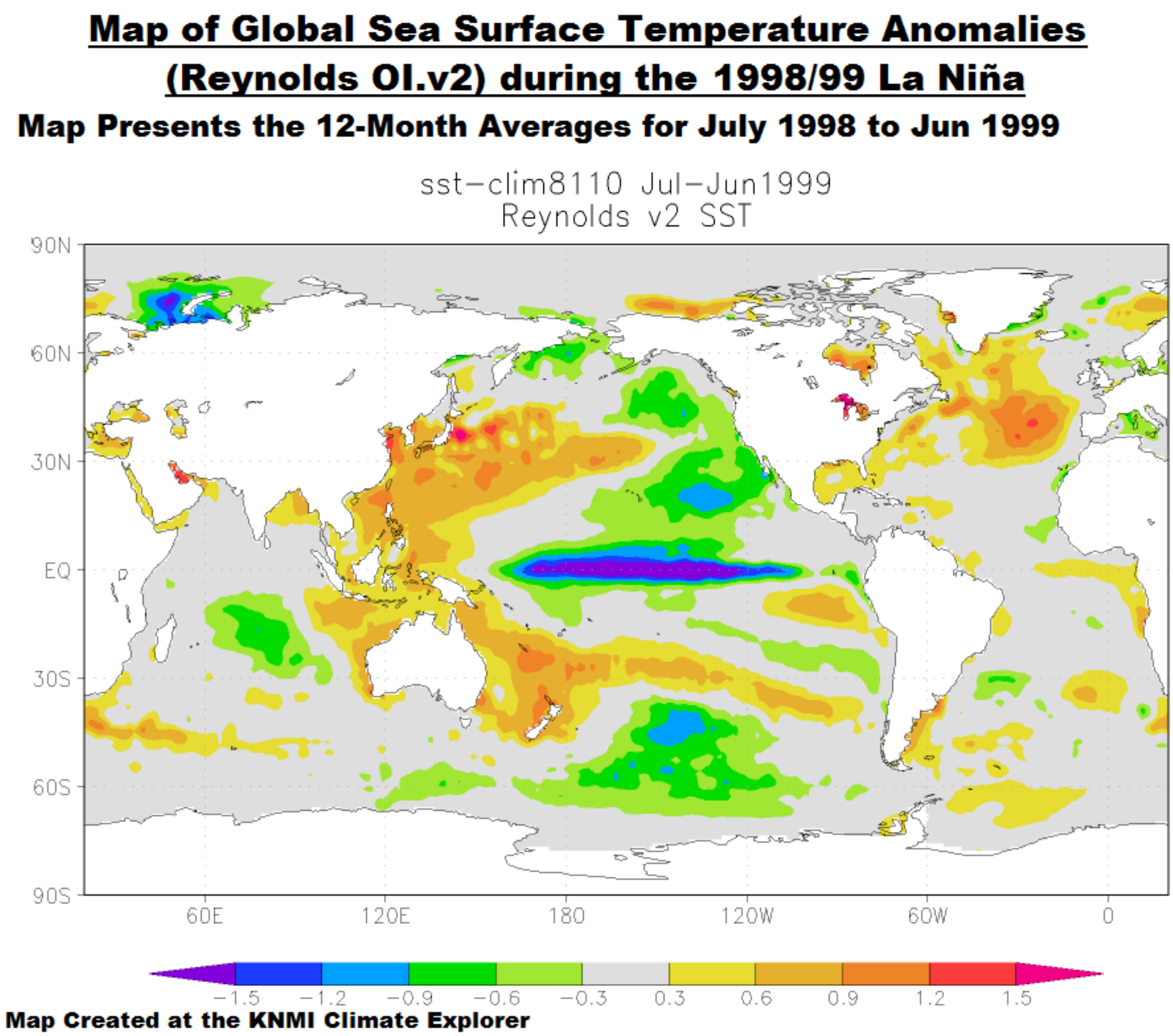


Figure 9-5

Because the sea surface temperatures are cooler than normal along the equator, there is less evaporation, less convection, and less cloud cover there.

Less cloud cover, as noted by Trenberth, et al. (2002), means more sunlight can enter and warm the tropical Pacific to depths of about 100 meters. The resulting warm water collects in an area of the western tropical Pacific called the West Pacific Warm Pool. It's also called the Indo-Pacific Warm Pool because it extends into the Indian Ocean.

A REANALYSIS CONFIRMS THE ROLE OF SUNLIGHT

The NCEP/DOE Reanalysis-2 includes surface downward shortwave radiation and downward longwave radiation data, starting in January, 1979. Bear in mind that a reanalysis is the output of a climate model that includes data as one of the inputs. A reanalysis is data that has been modified and infilled by a special climate model. A reanalysis is not the same as the climate models used by the IPCC for hindcasts and projections.

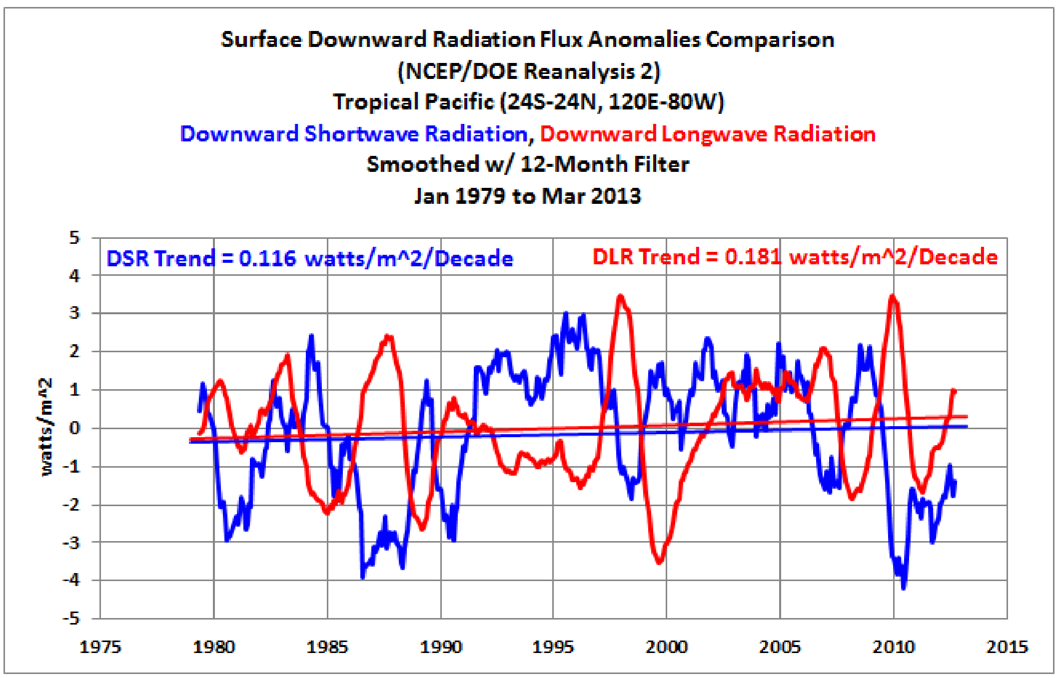


Figure 9-6

Figure 9-6 presents the downward shortwave radiation (sunlight) and downward longwave radiation (infrared radiation) reanalysis "data" at the surface of the tropical Pacific, starting in January, 1979. The downward longwave radiation (red) curve serves as a reasonable proxy for the timing, strength, and duration of El Niño and La Niña events because the downward longwave (infrared) radiation at the surface of the tropical Pacific rises during El Niño events and decreases during La Niña events — (except for the 3 to 4 years following the eruption of Mount Pinatubo in 1991. There should be a couple of El Niños during the early 1990s.)

Pavlakis, et al. (2006) "ENSO Surface Longwave Radiation Forcing Over the Tropical Pacific" has a nice summary of why downward longwave (infrared) radiation increases during an El Niño:

> *The DLR depends mainly on the vertical distributions of temperature and water vapour in the lower troposphere, as well as on the cloud amounts and cloud radiative properties.*

In other words, during an El Niño, downward longwave (infrared) radiation increases in the eastern tropical Pacific because the sea surface temperatures are warmer, which results in warmer lower troposphere temperatures and more water vapor due to the increase in evaporation, which, in turn, results in increased cloud amounts. The opposite holds true for La Niñas, i.e., downward longwave (infrared) radiation decreases during La Niñas.

If downward longwave radiation decreases during La Niñas, then downward longwave radiation cannot be responsible for recharging the heat content of the tropical Pacific during La Niñas. But downward shortwave radiation, i.e. sunlight, fits the role. Figure 9-6 shows that downward shortwave radiation (sunlight) at the surface of the tropical Pacific decreases during El Niños (because cloud cover over the tropical Pacific increases during El Niños), and, conversely, downward shortwave radiation (sunlight) increases during La Niñas (because there is less cloud cover over the tropical Pacific). As a result, it is downward shortwave radiation (sunlight) that supplies the energy to warm (recharge or replenish) the ocean heat content of the tropical Pacific during La Niñas.

For those interested, Pavlakis, et al. (2008) "ENSO Surface Shortwave Radiation Forcing Over the Tropical Pacific" goes into more detail about the interrelationships between sea surface temperature, total cloud amount and downward shortwave radiation (sunlight), in the tropical Pacific.

THE TRENDS IN THE DOWNWARD LONGWAVE AND DOWNWARD SHORTWAVE RADIATION DATA

In looking at the long-term trends of the two datasets in Figure 9-6, some readers may be thinking that the downward longwave (infrared) radiation rose faster than the downward shortwave radiation (sunlight). While that's true, something else has to be considered.

Downward longwave (infrared) radiation can only penetrate the ocean surface a few millimeters, while sunlight can penetrate the oceans to depths of about 100 meters.

Most of the sunlight is absorbed in the top 10 meters or so, but even at a depth of 10 meters, the impact of sunlight on the oceans is many orders of magnitude greater than that of infrared radiation.

Additionally, downward longwave (infrared) radiation only penetrates the top few millimeters of the ocean surface, and that's where evaporation takes place. That's why many oceanographers and physicists believe that any additional infrared radiation from manmade greenhouse gases would only add to the huge amounts of evaporation already taking place from the ocean surface, i.e., they do not believe that humans can impact the heat content of the ocean.

The above confirms parts of the quote from Trenberth, et al. (2002):

1) La Niña events can and do recharge the ocean heat content of the tropical Pacific, but the data reveal they are also capable of "overcharging" it, i.e., adding more heat than preceding El Niños had discharged, thus, the step-up in ocean heat content;

2) sunlight, not infrared radiation, fuels the recharge or replenishment of ocean heat during La Niñas.

SUNLIGHT AND INFRARED RADIATION ALONG THE EQUATORIAL PACIFIC

I presented and discussed above the downward shortwave radiation and downward longwave radiation data for the tropical Pacific because El Niño and La Niña events can impact the entire tropical Pacific. But the main focus of El Niños and La Niñas is along the **equatorial** Pacific. That's why many of NOAA's ENSO-related metrics rely on equatorial Pacific data, using the latitudes of 5S to 5N. For a few examples, see the NOAA Monthly Atmospheric & SST Indices and Weekly ENSO Update webpages.

In Figure 9-7, I illustrate the NCEP/DOE Reanalysis-2 downward shortwave radiation and downward longwave radiation reanalysis data for the equatorial Pacific, starting in 1979. The coordinates are 5S-5N, 120E-80W, stretching almost halfway around the globe — this time along the equator. Downward shortwave radiation (sunlight) increased greatly there during that time; i.e., the positive "sunlight" trend of 1.7 watts/m^2 is considerable. On the other hand, the downward longwave (infrared) radiation decreased at a sizable rate based on the linear trend. If manmade greenhouse gases had a dominant impact on the ENSO-related downward longwave (infrared) radiation, the trend should have increased over this time period — but it decreased.

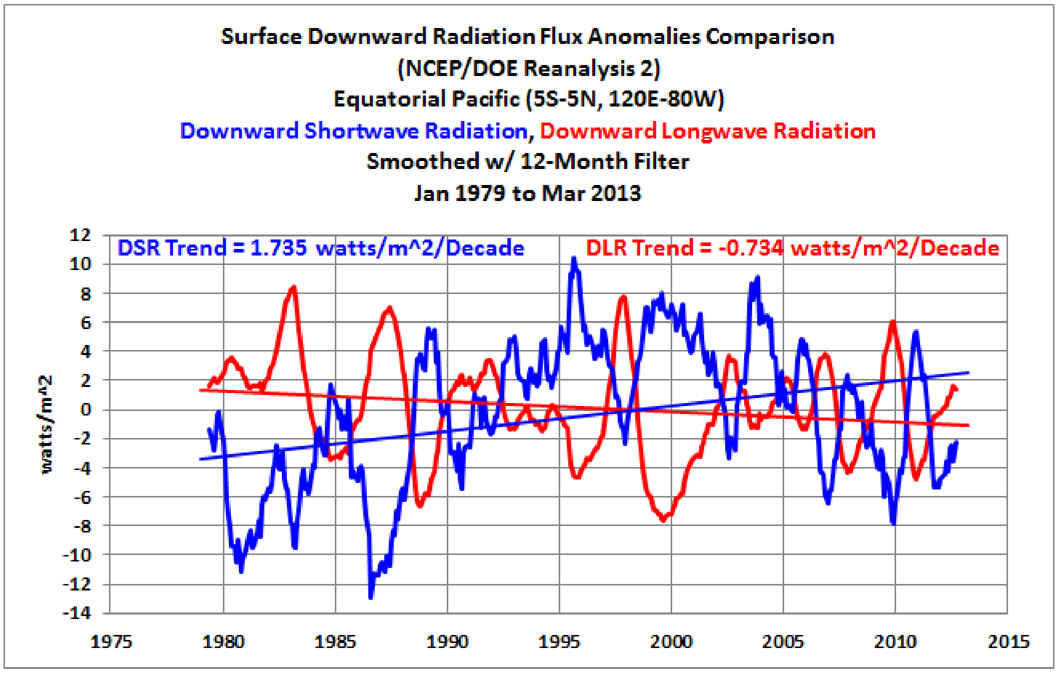


Figure 9-7

Again, the downward longwave and shortwave radiation data are based on a reanalysis, thus, like the other types of climate models, they need to be taken with a pinch of salt — maybe two or three pinches. Even so, not only does sunlight have an impact on the oceans that's many orders of magnitude greater than infrared radiation, the reanalysis shows a major increase in sunlight at the surface of the equatorial Pacific since 1979, along with a considerable decrease in infrared radiation there.

CHAPTER 9.2 SUMMARY

Ocean heat content data for the tropical Pacific confirms that long and strong La Niña events provide the warm water that fuels El Niño events. Downward shortwave radiation data (albeit a reanalysis) confirms that it is the temporary increases in sunlight during La Niñas (caused by well-known La Niña processes) which supply the energy to create the warm water that fuels El Niños.

Guilyardi, et al. (2009), a scientific paper that is quite pointed in its criticism of the climate models' failure to simulate El Niño and La Niña processes, contains one sentence in particular that is very pertinent this discussion (my boldface):

> ***These recurrent biases, already present in CMIP1 15 yrs ago**, arise from numerous factors including overly strong trade winds, leading to increased cooling via oceanic upwelling, mixing, and latent heat flux to the atmosphere; a diffuse thermocline structure, leading to improper sensitivity of SST to anomalous*

> *upwelling and vertical mixing;* ***insufficient surface and penetrating solar radiation****, and weak ocean vertical mixing in the subtropics, leading to subsurface temperature errors along the equator; and weak tropical instability waves, resulting in too little meridional spreading of SST anomalies during cold events (Meehl, et al.. 2001; Luo, et al.. 2005; Wittenberg, et al.. 2006; Lin 2007a).*

Since their first attempts at modeling more than 15 years ago, the modelers have failed to program into the models' code enough sunlight to drive ENSO. This means that climate modelers have been trying to force El Niño and La Niña processes with infrared radiation from day one and they have had no success with those efforts. Apparently ENSO is **not** a chaotic, manmade-greenhouse-gas-fueled, recharge-discharge oscillator, but the modelers keep writing the same code, over and over again, trying force an ENSO response from increases in human-induced infrared radiation.

This leads to a strong, logical, presumption that the modelers are intentionally avoiding adding a sufficiently strong sunlight parameter to their models (to make ENSO work) for a reason they consider of vital importance. That is, unless their persistence in the face of failure is due to gross incompetence, their deliberate repetition of what they know does not work leads to the highly plausible conclusion that the modelers do not want their models to show what the data has shown clearly: that periodic, La Niña-caused variations in sunlight at the surface of the tropical Pacific, and not manmade greenhouse gases, fuel ENSO, the most powerful mode of natural variability on the planet.

Chapter 9.3 – Dividing the Global Oceans into Subsets is Very Revealing

I created the following map, Figure 9-8, at the KNMI Climate Explorer. It shows where the sea surface temperatures of the global oceans warmed during the last 31 years and by how much. The temperature scale is: oranges and reds represent areas that have warmed to different levels based on their linear trends; and greens and blues indicate areas that have cooled over the past 31 years. The scaling of the trends is in deg C/year.

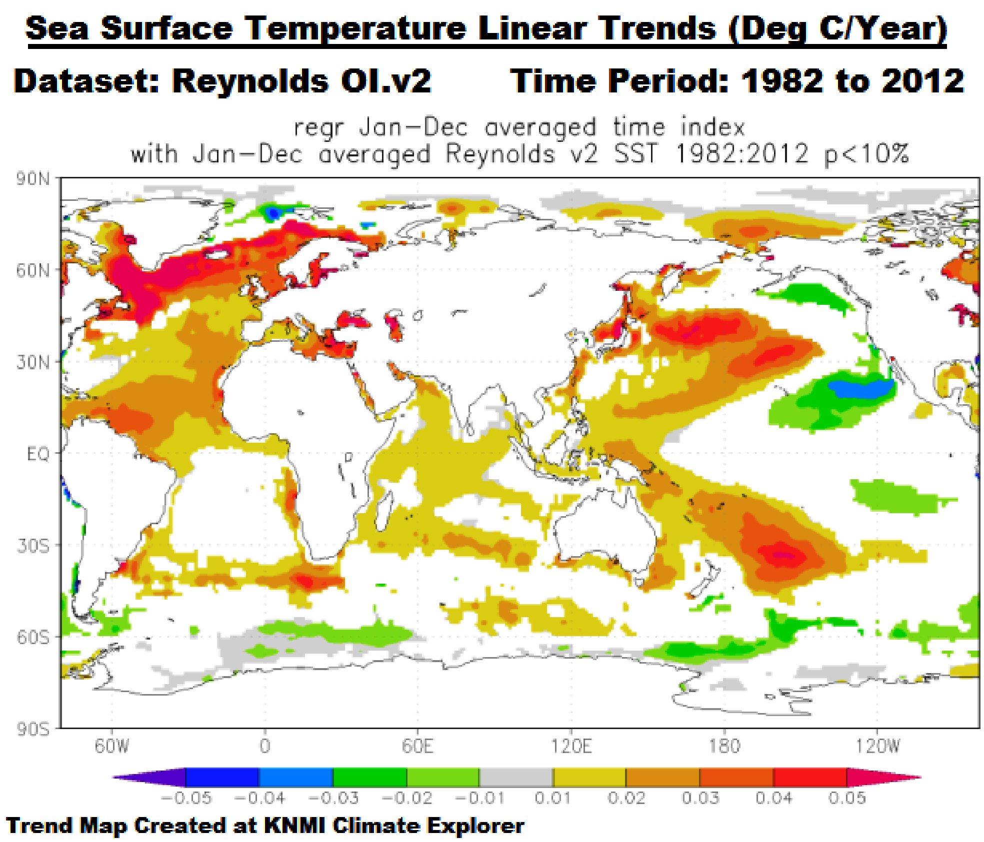


Figure 9-8

I begin with the North Atlantic, where most of the warming occurred.

THE NORTH ATLANTIC (WITH THE ATLANTIC MULTIDECADAL OSCILLATION)

Scientists are well aware that the sea surface temperatures of the North Atlantic are significantly impacted by a powerful natural mode of variability called the AMO (Atlantic Multidecadal Oscillation). The AMO causes the sea surface temperatures of the North

Atlantic to warm faster than the rest of the global oceans during some multidecadal periods and to warm more slowly and actually cool during others. (See NOAA's "Frequently Asked Questions About the *Atlantic Multidecadal Oscillation (AMO)* " webpage and the RealClimate glossary webpage for the "Atlantic Multidecadal Oscillation.") Since about 1974, the sea surface temperatures of the North Atlantic warmed much more than the other global oceans. The period of 1974 to 2012 is highlighted in red in the graph of the Atlantic Multidecadal Oscillation (AMO) Index data, Figure 9-9.

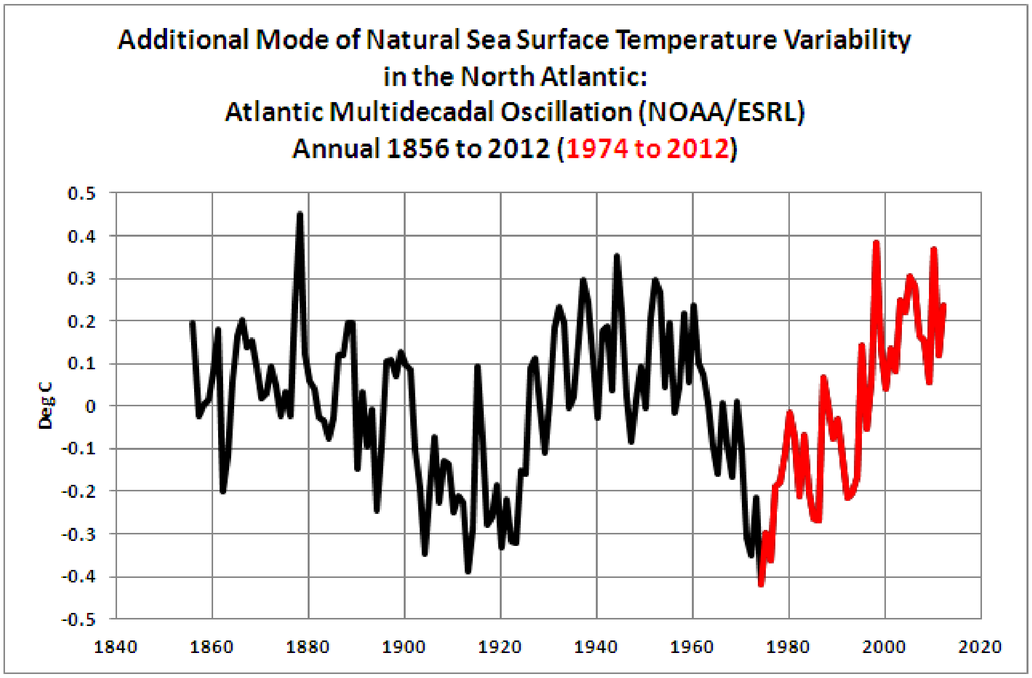


Figure 9-9

That AMO dataset is available from the NOAA Earth System Research Laboratory (ESRL) website here. Keep in mind, however, that AMO dataset has been detrended, which basically means that they took the North Atlantic sea surface temperature anomalies and laid them flat so that there is no trend in the data. (See Chapter 2.10.) That is done to make it easier to see the multidecadal variations in sea surface temperatures there. Since the mid-1970s, the Atlantic Multidecadal Oscillation added to the global warming we've experienced. There have also been multidecadal periods in the past, and, there should continue to be periods in the future, according to the NOAA webpage linked above, when the Atlantic Multidecadal Oscillation suppresses global warming — assuming global warming continues. Basically, the additional warming of the sea surface temperatures of the North Atlantic has ridden atop of the warming of the sea surface temperatures of the rest of the global oceans during the satellite era.

THE SUBSETS OF THE GLOBAL OCEANS

Because the global oceans did not warm uniformly, as Figure 9-8 shows, I divided the global oceans into three parts: (1) the North Atlantic (0-90N, 80W-40E), discussed above; (2) the East Pacific (90S-90N, 180-80W) because, as a region, it shows very little warming; and (3) the rest of the global oceans — made up of the South Atlantic, Indian and West Pacific [a weighted average of: a: 0-90N, 40E-180 at 28%; and b: 90S-0, 80W-180 at 72%]. (See Figure 9-10.) Parts of the Arctic Ocean and of the Southern Ocean surrounding Antarctica are included in the selected regions.

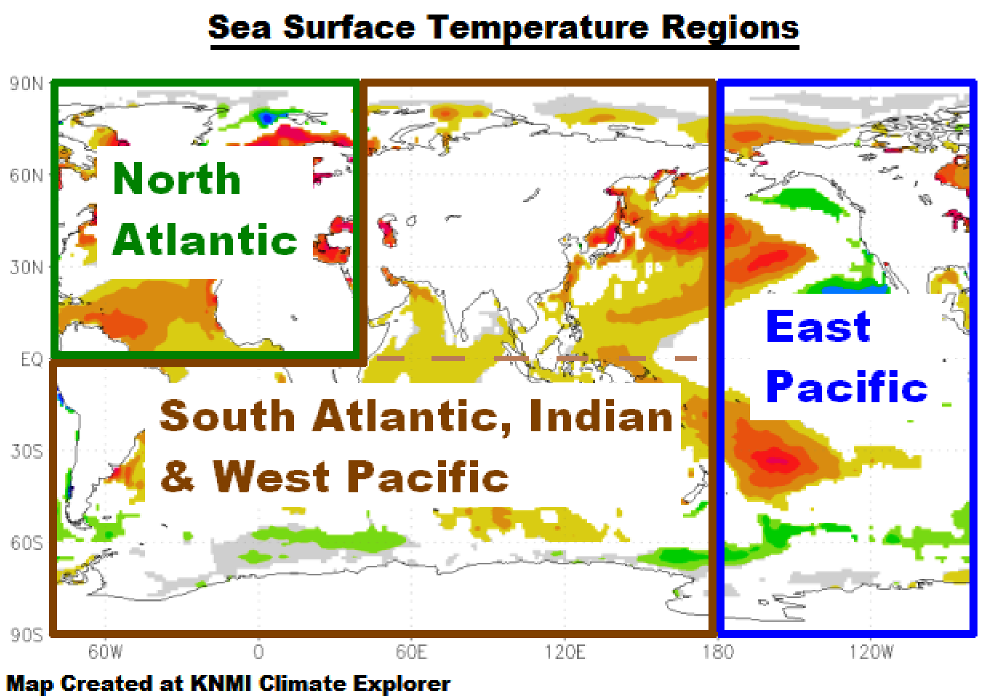


Figure 9-10

One more comment about the North Atlantic. The ESRL Atlantic Multidecadal Oscillation Index data are based on the coordinates 0-70N, 80W-0. On my map in Figure 9-10, I use 0-90N, 80W-40E. That is, I expand the North Atlantic so that it also includes the Mediterranean Sea and a portion of the Arctic Ocean. Do the expanded coordinates for the North Atlantic make a difference in the sea surface temperatures? No. The sea surface temperature anomalies for the two subsets of the North Atlantic are basically the same. (See Figure 9-11 where I compare the two subsets.)

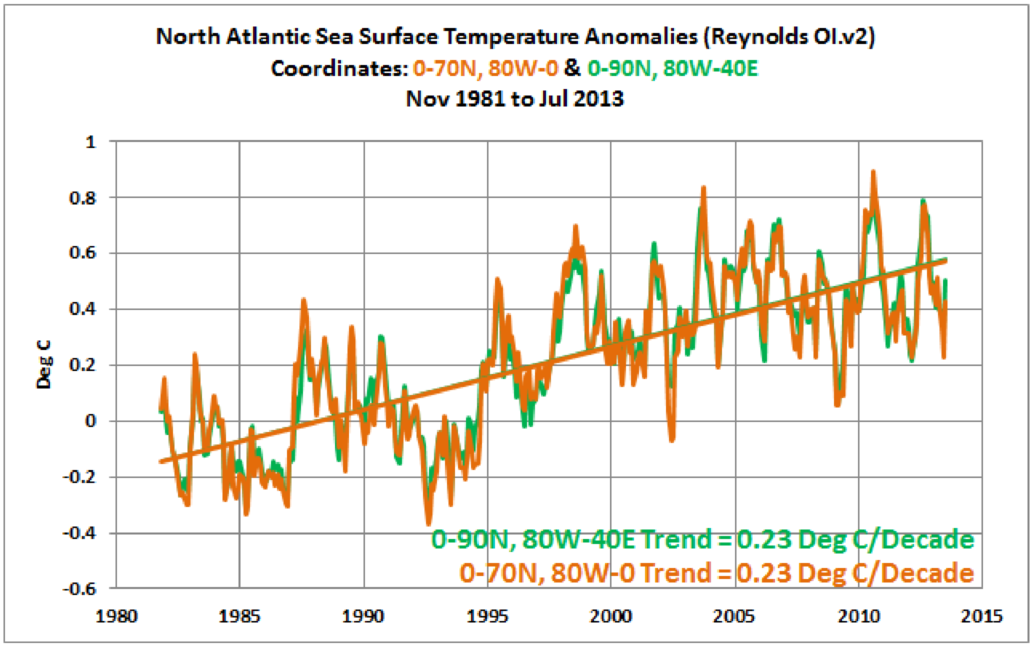


Figure 9-11

The East Pacific (90S-90N, 180-80W)

What also stands out quite plainly in the trend map of sea surface temperatures in Figure 9-8 is that much of the Pacific Ocean has not warmed since 1982. There's a "C"-shaped pattern of warming that begins in the west Pacific, which researchers would call an ENSO-related pattern. Much of the eastern Pacific, on the other hand, shows no warming. In fact, there are a few areas of the eastern Pacific that cooled over the past 31 years. Note the one blue and green (cooling) area on the Figure 9-8 map is in the eastern tropical North Pacific, west of Mexico.

The satellite-era sea surface temperature anomaly data for the East Pacific region shows lots of variability. (See Figure 9-12.) The large upward spikes are caused by El Niño events, and the downward troughs are caused by La Niñas. That an El Niño is capable of temporarily raising the sea surface temperatures of the entire East Pacific Ocean more than 0.5 deg C (0.9 deg F) is remarkable. ENSO is an exceptionally powerful force of nature. Keep in mind, the area selected for the East Pacific stretches from pole to pole, covering about 33% of the surface of the global oceans. It takes a monumental amount of warm water to cause the sea surface temperatures of the East Pacific to warm that much.

Where does all that warm water come from? The warm water for the El Niño comes from West Pacific Warm Pool to depths of about 300 meters. The West Pacific Warm Pool varies in size; at times it covers an area the about size of Russia or twice the size of the United States. As discussed in other sections of the book, the warm water for the 1997/98 El Niño was created during the 1995/96 La Niña, by the increase in sunlight reaching the tropical Pacific during that La Niña. Prior to the 1995/96 La Niña, there had been a multidecadal decrease in ocean heat content in the tropical Pacific, thus, the source for all of that warm water must have been the 1995/96 La Niña.

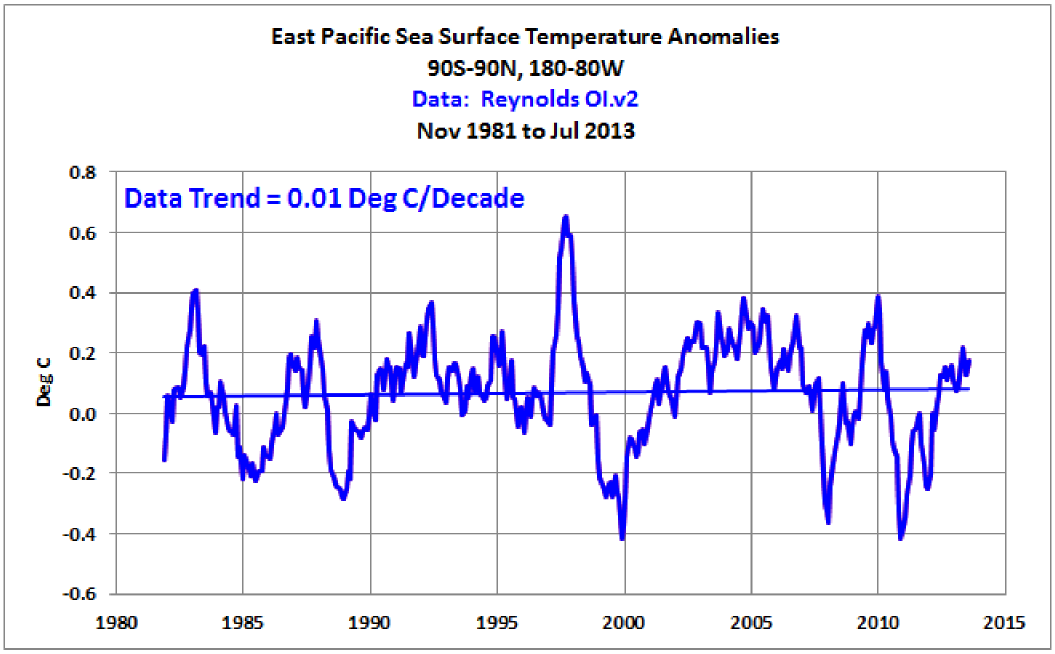


Figure 9-12

Note the linear trend line that EXCEL determined for the data. It shows a warming rate of 0.01 deg C/decade. In other words, the sea surface temperatures of the East Pacific show little to no warming in 31 years. That indicates the East Pacific is only the temporary home of the warm waters released by El Niño events. The warm water floods into the East Pacific during an El Niño and it flows back out again when the El Niño is over.

Using the current generation of climate models stored in the IPCC's CMIP5 archive, the average of all of the dozens of model outputs of sea surface temperatures for this time period reveal the models' gross failure. While the observed East Pacific surface temperatures remained unchanged (based on the linear trend), the models, hampered by their programmers' beliefs about human CO2, estimated it warmed — more than 0.45 deg C over the past 31 years. (See Figure 9-13.)

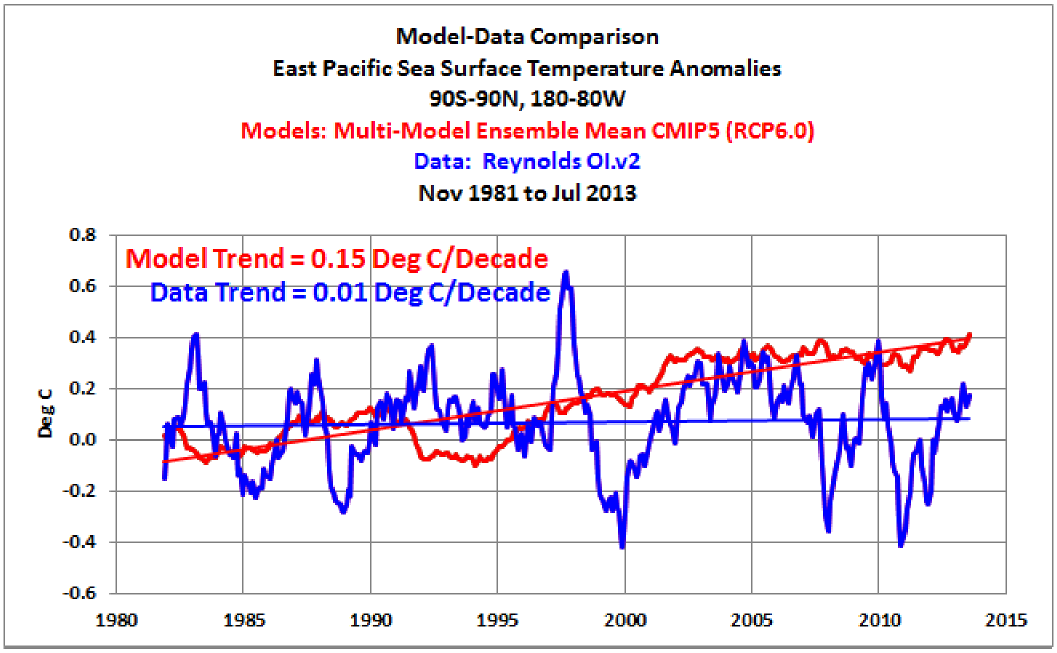


Figure 9-13

CHAPTER 9.3 SUMMARY

The global oceans have not warmed uniformly during the satellite-era of sea surface temperature data — the last 31 years. I divided the global oceans into three subsets for the data analysis. The North Atlantic warmed the most because it has a powerful additional (long-term) mode of natural variability called the Atlantic Multidecadal Oscillation. The sea surface temperatures of the East Pacific Ocean, which covers about 33% of the surface of the global oceans, have warmed very little over the past 3 plus decades; there are wide swings in sea surface temperatures there and those swings are responses to El Niño and La Niña events.

I discussed two of the three subsets in this chapter. The third comes next.

Chapter 9.4 – ENSO-Caused Upward Steps in Sea Surface Temperatures

THE SOUTH ATLANTIC, INDIAN AND WEST PACIFIC OCEANS

I examine the sea surface temperature data of the South Atlantic, the Indian and West Pacific Oceans as a whole in this chapter. This ocean sub-region was highlighted in the map in Figure 9-10. In the Southern Hemisphere, it stretches from 80W east to the dateline, and in the Northern Hemisphere, it covers the oceans from 40E to the dateline.

The sea surface temperature data for this region illustrate some remarkable effects. The sea surface temperature anomalies have clear upward steps, followed by decadal periods of cooling. (See Figure 9-14.) Even with the dip-and-rebound in the early 1990s caused by sun-blocking aerosols from the eruption of Mount Pinatubo, the upward steps are blatantly obvious.

The periods highlighted in red in Figure 9-14 are the official months of the 1986/87/88, the 1997/98, and the 2009/10 El Niño events according to NOAA's Oceanic NINO Index. I shifted the data 6 months to account for the time lag between the El Niños and the responses of the sea surface temperatures of the South Atlantic, Indian, and West Pacific Oceans. I applied the same 6-month time lag to the official months of the 1988/89, the 1998-01, and 2010/11 La Niñas, which are highlighted in blue.

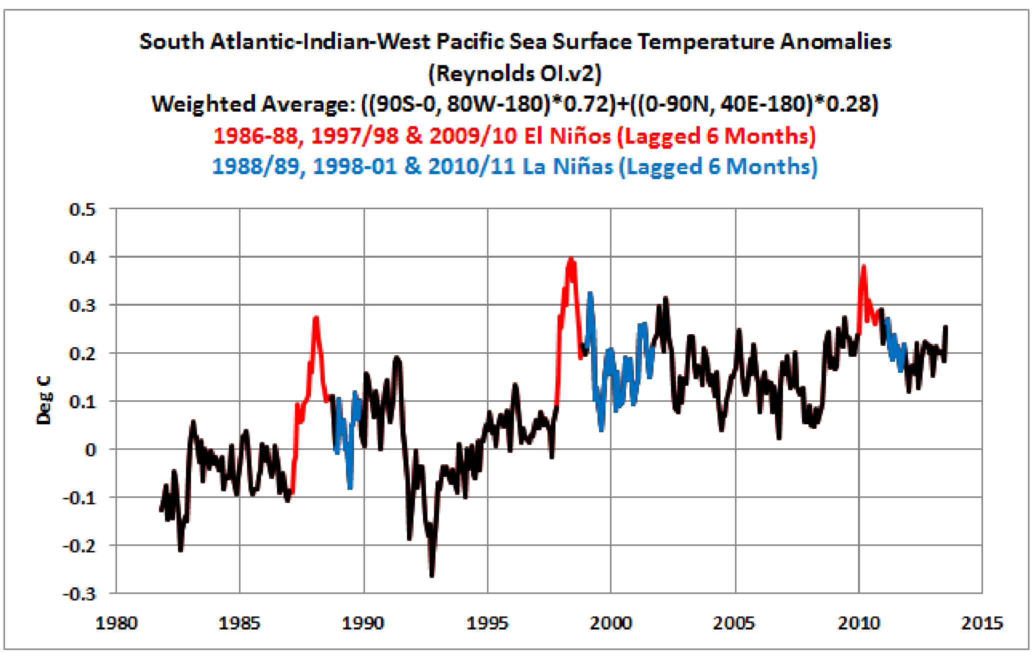


Figure 9-14

Until a recent article by Kevin Trenberth of NCAR, there had been no discussion of those upward steps in any document presented by the climate science community.

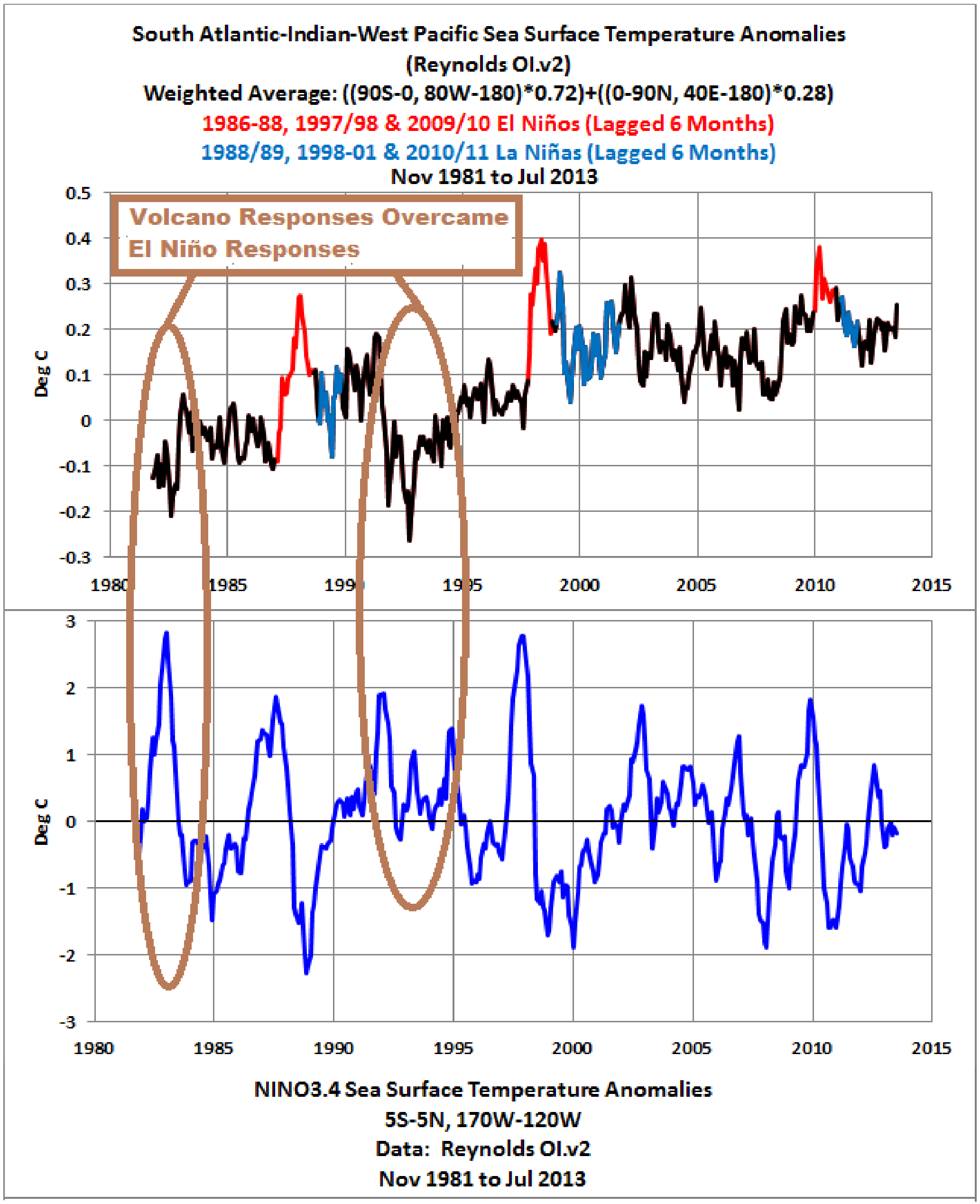


Figure 9-15

The sea surface temperature anomalies of the NINO3.4 region — the commonly used index for the timing, strength, and duration of El Niño and La Niña events — confirm that the big upward shifts are responses to strong El Niño events, especially the El Niño events of 1986/87/88 and 1997/98. (See the bottom cell of Figure 9-15.) The top cell is the same as Figure 9-14. It includes the color-coded sea surface temperature anomalies of the South Atlantic, Indian, and West Pacific Oceans — with the approximate timings of the eruptions of El Chichon in 1982 and Mount Pinatubo in 1991 highlighted. The sea surface temperature anomalies of the South Atlantic, Indian, and West Pacific Oceans would normally have warmed in response to the El Niños that occurred at those times, but the effects of the sun-blocking aerosols from the volcanos counteracted and overwhelmed the normal El Niño responses. The only strong El Niño events during the last 31 years that were NOT impacted by volcanos were those in 1986/87/88, 1997/98, and 2009/10. Those are also the years when the surface temperatures shifted upward.

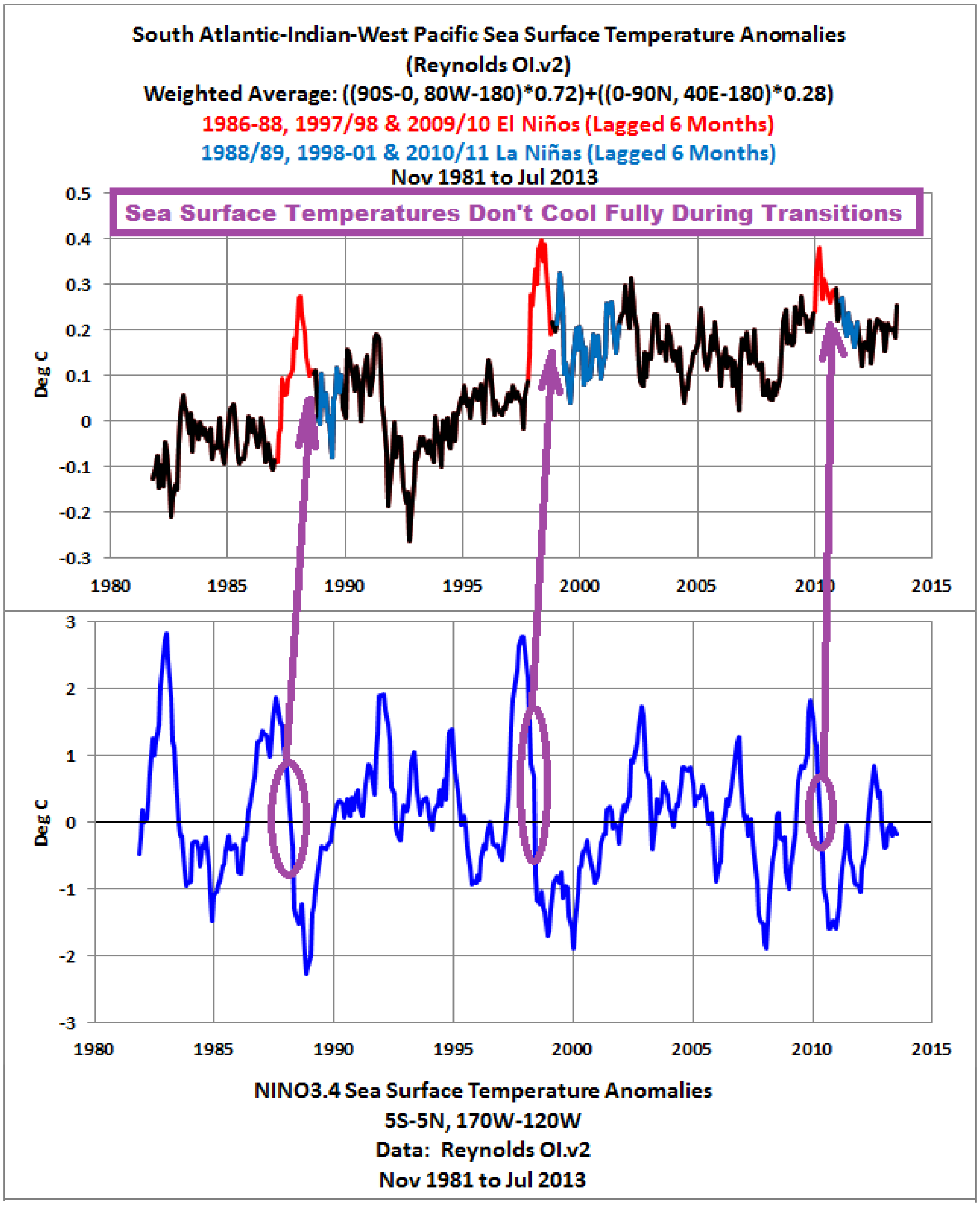


Figure 9-16

Figure 9-16 includes the same two graphs as Figure 9-15, but I've annotated them differently. This time we'll focus on the La Niñas highlighted in blue. It's plainly obvious that effects on the sea surface temperatures of the South Atlantic, Indian and West Pacific Oceans of the 1988/89 and the 1998-01 La Niña events are not proportional to the El Niños that preceded them. I've highlighted the decay of the El Niños and the transitions to La Niñas in the NINO3.4 data. Something is obviously preventing the sea surface temperatures of the South Atlantic, Indian and West Pacific Oceans from cooling fully during the transition from those strong El Niño events to the trailing La Niñas.

To illustrate this, I show the responses of the sea surface temperatures of the South Atlantic, Indian, and West Pacific Oceans to the 1997/98 El Niño and 1998-01 La Niña by directly comparing them with the NINO3.4 data. (See Figure 9-17.) To accomplish the direct comparison, I shifted the NINO3.4 data 6-months back to accommodate the time lag (the NINO3.4 ENSO data region is in the central, equatorial Pacific, thus, it takes about 6 months for the South Atlantic, Indian, and West Pacific Oceans to respond to the ENSO events. I also scaled (multiplied by a factor of 0.12) the NINO3.4 data to account for the differences in the responses of the two regions' datasets to the 1997/98 El Niño, and shifted the NINO3.4 data upward by 0.05 deg C simply to align (for a better visual presentation) the start and peak of the leading edges of the responses to the 1997/98 El Niño.

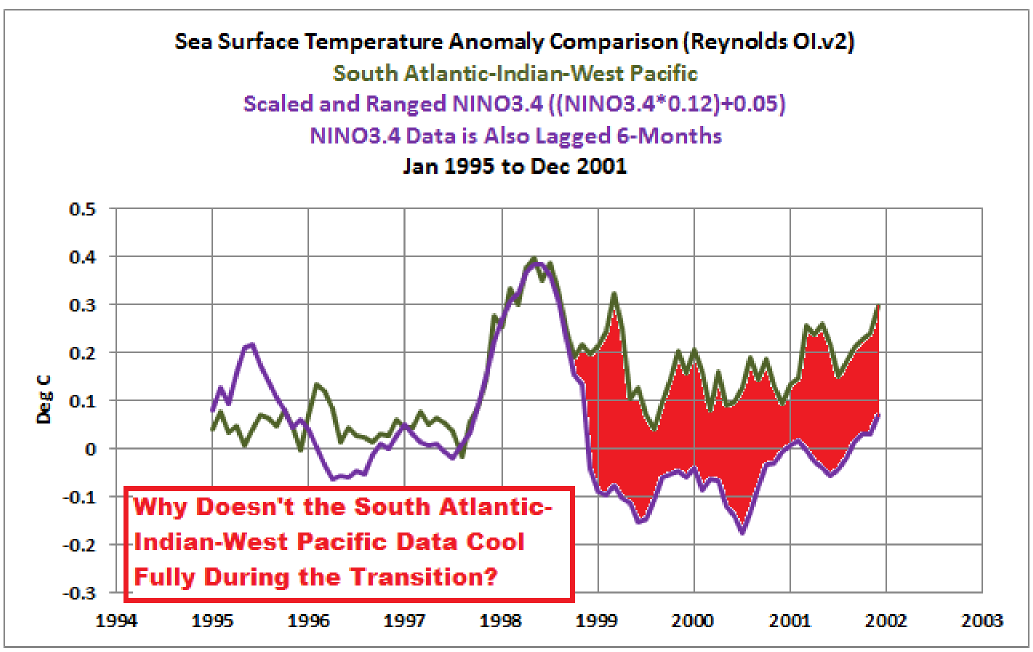


Figure 9-17

It is clear that the sea surface temperature anomalies of the South Atlantic, Indian, and West Pacific Oceans echoed the NINO3.4 data during the warming that took place in response to the 1997/98 El Niño. Thereafter, like the NINO3.4 region's temperatures, they began to cool. But, then, suddenly and inexplicably, the sea surface temperatures in the South Atlantic, Indian, and West Pacific Oceans stopped cooling during the transition to La Niña. Why?

Note 1: if the sea surface temperature anomalies for the South Atlantic, Indian and West Pacific Oceans did cool fully in response during those transitions to the trailing La Niñas, then the sea surface temperatures of that region would have a curve similar to the East Pacific (Figure 9-12), and the East Pacific hasn't warmed in 31 years.

Note 2: it is difficult, in Figure 9-16, to determine with a significantly high level of confidence that there was an upward shift in response to the 2009/10 El Niño, so it can be considered only a logical possibility.

Before I answer why, another curious (though not unexpected) thing happens when the sea surface temperature data for the North Atlantic is combined with the data for the South Atlantic, Indian, and West Pacific Oceans. The sea surface temperature anomalies for the Atlantic, Indian, and West Pacific Oceans region show the same very clear upward steps as those in the South Atlantic, Indian, and West Pacific Oceans. (See Figure 9-18.)

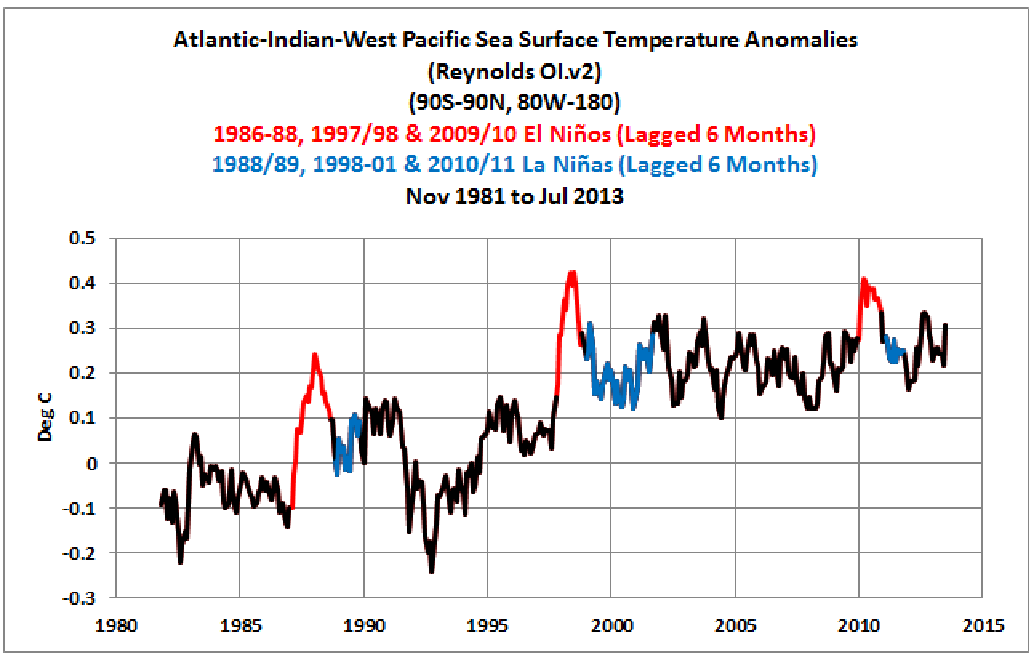


Figure 9-18

But there's a difference between this combined dataset which includes the North Atlantic and the basic South Atlantic, Indian, and West Pacific Oceans dataset (Figure 9-14) that excludes it. By including the North Atlantic, the sea surface temperatures do not show the long-term (decadal) cooling between the strong El Niños. They don't warm either. Other than the dip-and-rebound associated with the 1991 eruption of

Mount Pinatubo, the sea surface temperature anomalies for the Atlantic, Indian, and West Pacific Oceans are remarkably flat between the strong El Niños.

Excluding the effects of the volcanic eruptions, the three standout features of the sea surface temperatures of the Atlantic, Indian, and West Pacific Oceans are: (1) their long-term warming depends on the El Niño events of 1986/87/88 and 1997/98; (2) they do not cool proportionally during the trailing La Niñas of 1988/89 and 1998-01; and (3) they remain relatively flat over the decade-long periods between the El Niño events of 1986/87/88 and 1997/98 and between the 1997/98 and 2009/10 El Niños.

There are no peer-reviewed, climate model-based, scientific studies that explain these very clear upward steps.

All one need do is to look at a trend map like the one in Figure 9-8 to see that the sea surface temperatures of the East Pacific Ocean have not warmed. One would expect that, by now, someone from the climate science community, just out of basic curiosity, would have wanted to investigate to try to explain it. Maybe they haven't addressed it because it would force them to also explain the three outstanding features of the warming of sea surface temperatures for the Atlantic, Indian and West Pacific Oceans, which depend not on human CO2, but on the sunlight-fueled El Niño events of 1986/87/88 and 1997/98.

CHAPTER 9.4 SUMMARY

The warming of the North Atlantic (Figure 9-10) was an expected response to the additional, powerful, mode of natural variability called the Atlantic Multidecadal Oscillation. While the sea surface temperatures of the East Pacific Ocean (Figure 9-12) haven't warmed in 31 years, the models (following their programmers' assumption that human CO2 significantly affects the ocean) estimated that they should have warmed considerably (Figure 9-13). In the South Atlantic-Indian-West Pacific data (Figure 9-14), sea surface temperatures for that region warmed, but in a very curious way. The primary causes of the warming of the sea surface temperatures of the South Atlantic-Indian-West Pacific Oceans were the strong El Niño events of 1986/87/88 and 1997/98 and, possibly, of 2009/10. The sea surface temperatures there cooled slowly — they did not warm like the North Atlantic — over the decade between each strong El Niño event. And the sea surface temperatures of that region did not cool proportionally (to the variations in the central equatorial Pacific, the NINO3.4 data) during the La Niñas that trailed those strong El Niños. The end result: strong El Niño events caused the sea surface temperatures of the South Atlantic-Indian-West Pacific Oceans to warm in very clear upward steps. Why?

Chapter 9.5 – What Caused the Upward Shifts?

In Figure 9-19, I present two sea surface temperature anomaly maps that I showed above separately as Figures 9-2 and 9-5. The left-hand map shows the average global sea surface temperature anomalies for the period of July, 1997 to June, 1998 and it captures the 1997/98 El Niño taking place in the eastern tropical Pacific. To capture the first year of the 1998-01 La Niña, the right-hand cell presents a similar map for the period of July, 1998 to June, 1999.

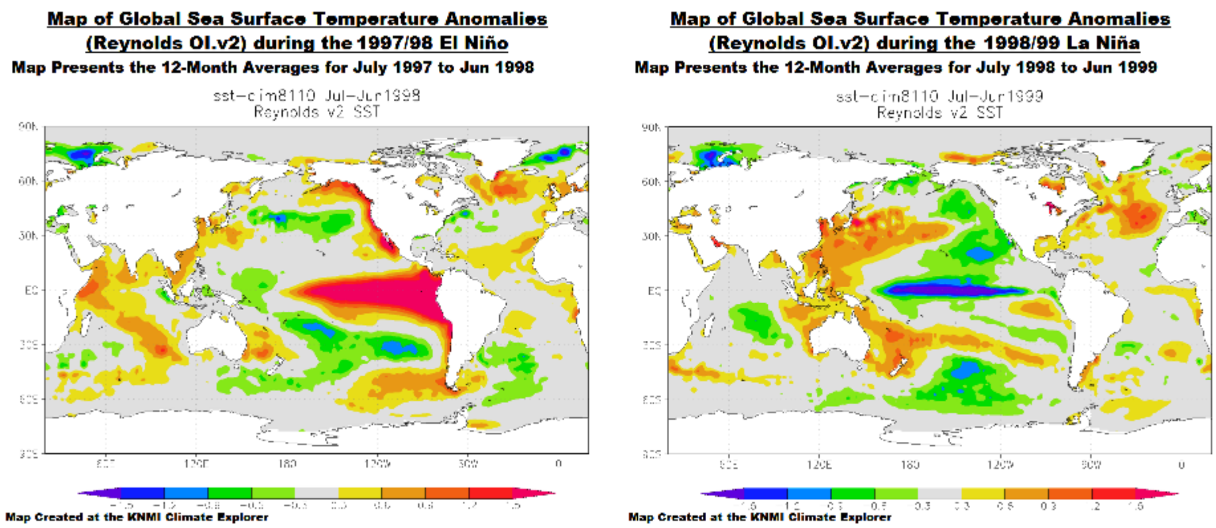


Figure 9-19

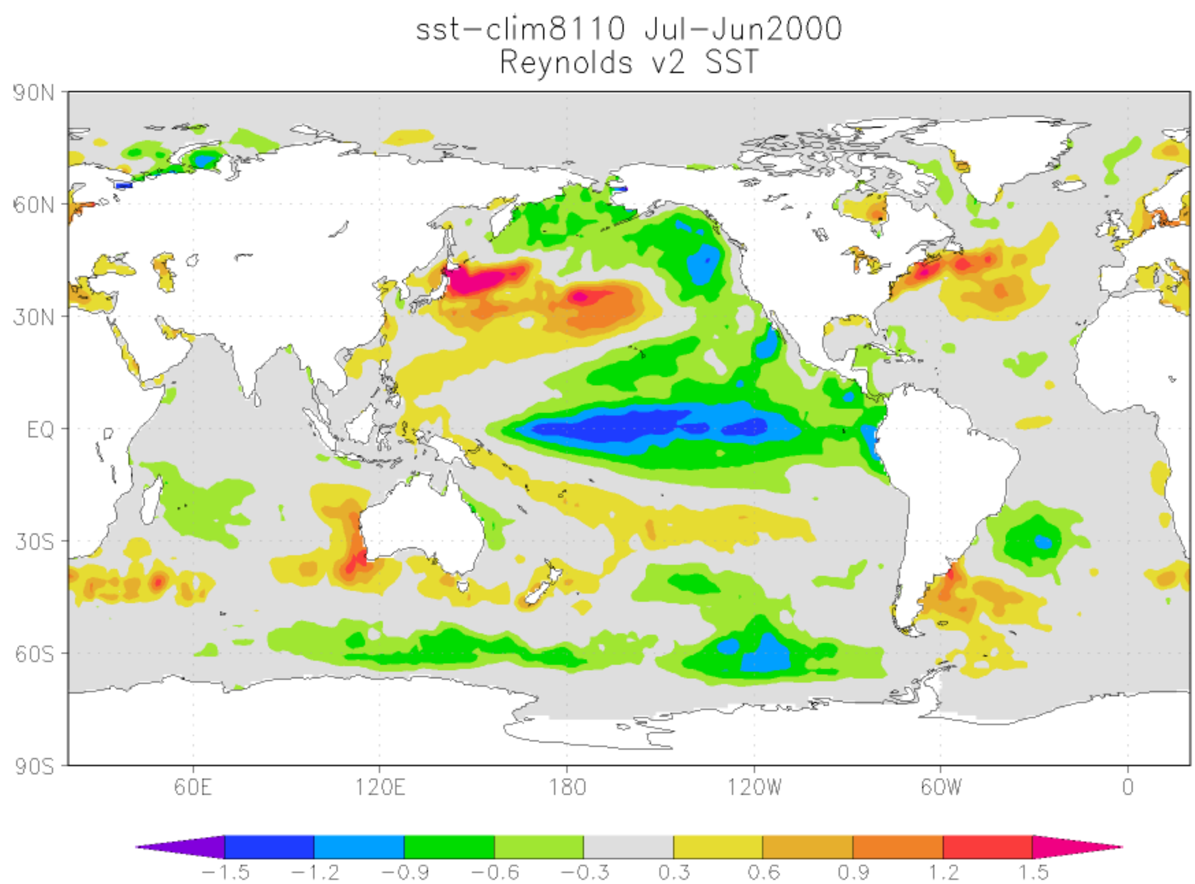
As presented by Trenberth, et al. (2002), and as I clarify in this section, an El Niño acts as the discharge mode of a chaotic, sunlight-fueled, recharge-discharge oscillator. Warm water from the surface and below the surface of the western tropical Pacific is spread across the surface of the central and eastern tropical Pacific, primarily along the equator. This response to the 1997/98 El Niño is seen in the left-hand map of Figure 9-19. I also mentioned above that the sea surface temperatures of the East Pacific (Figure 9-12) show a tremendous amount of variability (temporary warming and cooling) caused by El Niño and La Niña events but they haven't warmed in 31 years based on the linear trend. This shows that the East Pacific is only the temporary home of the warm water released by El Niño events. The warm water (from the surface and below the surface of the West Pacific Warm Pool) floods into the East Pacific during an El Niño, and it flows back out again when the El Niño is over.

The question yet to be answered is: where did the leftover warm water go after it flowed back out of the East Pacific? The answer lies in the right-hand cell of Figure 9-19. The leftover warm water was spread out across the western tropical Pacific and the East Indian Ocean, with much of that leftover warm water concentrated along the KOE (Kuroshio-Oyashio Extension) east of Japan and along the SPCZ (South Pacific Convergence Zone) east of Australia and New Zealand.

By the second year of the 1998-01 La Niña, Figure 9-20, the leftover warm water is primarily concentrated east of Japan, along the KOE (Kuroshio-Oyashio Extension).

Map of Global Sea Surface Temperature Anomalies (Reynolds OI.v2) during the 2nd Year of 1998-01 La Niña

Map Presents the 12-Month Averages for July 1999 to June 2000



Map Created at the KNMI Climate Explorer

Figure 9-20

A number of mechanisms send the leftover warm water back to the West Pacific and East Indian Oceans. The first is the return of the trade winds following an El Niño.

Trade Winds

The trade winds in the Pacific blow from east to west across the tropical Pacific during “normal” conditions. They cause the sea surface temperatures in the western tropical Pacific to be warmer than they are in the east by blowing the surface of the tropical Pacific from east to west under the tropical sun, warming the waters all along the way. The trade winds also cause the accumulation of warm water in the West Pacific Warm Pool. The warm water basically “stacks up” there so that the sea level in the West Pacific Warm Pool is temporarily higher (about 0.5 meters) than it is in the eastern equatorial Pacific. A weakening of the trade winds in the western tropical Pacific initiates an El Niño. The east-to-west-flowing trade winds are then no longer strong enough to hold back the “stacked up” warm water in place in the West Pacific Warm Pool, so gravity takes over and the warm water floods into the east.

The trade winds reverse during the El Niño, becoming westerlies. This provides positive feedback for the El Niño, helping to drive even more warm water from the West Pacific Warm Pool to the east, toward the Americas.

As the El Niño loses power, the trade winds return to their normal east-to-west direction. The renewed trade winds simply sweep what remains of the warm El Niño surface water (the leftovers) back to the West Pacific. Ocean currents carry the rest of the leftover warm water toward the poles and into the Indian Ocean.

The warm water left over from the 1997/98 El Niño is obvious in the right-hand cell of Figure 9-19 in the East Indian and West Pacific Oceans. In fact, when I first presented these ENSO-caused upward steps in sea surface temperatures more than 4 years ago (see my posts here and here, and the cross posts at WattsUpWithThat here and here), I used the sea surface temperature anomalies of the East Indian and West Pacific Oceans (60S-65N, 80E-180). (See Figure 9-21.) The sea surface temperature anomalies of the East Indian and West Pacific have a higher warming trend than the South Atlantic-Indian-West Pacific data (about 47% higher), because more of the leftover warm water ends up in the East Indian and West Pacific oceans. The two datasets have a correlation coefficient of 0.92 (1.0 being perfect), which is relatively high for surface temperature datasets. But, that is to be expected in this case, because one dataset (East Indian-West Pacific) is a subset of the other (South Atlantic, Indian, and West Pacific).

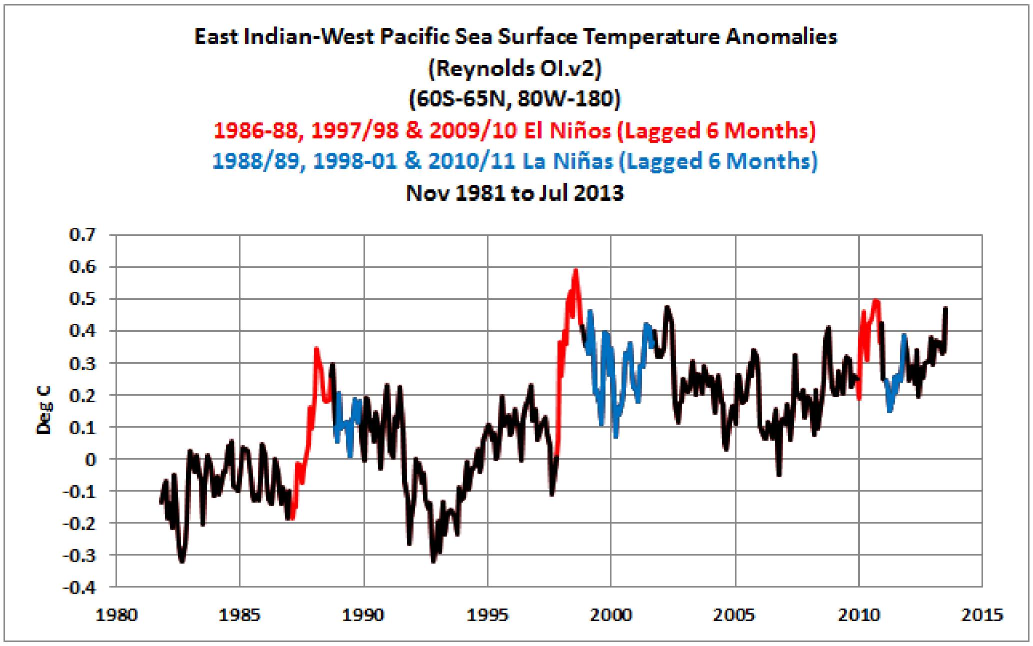


Figure 9-21

In the map of sea surface temperatures two years after the 1997/98 El Niño, Figure 9-20, it is clearly seen that the warm water obviously collected in the Kuroshio-Oyashio Extension, east of Japan. I discussed the importance of the El Niño residuals in that region in Chapter 7.7. I'll now repeat and expand on that discussion.

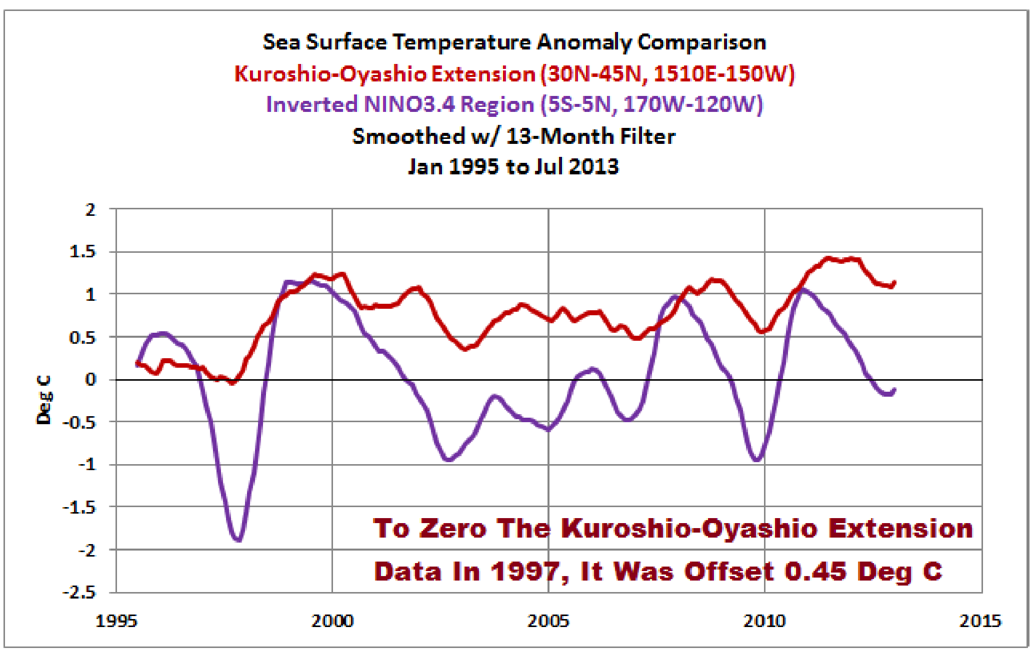


Figure 9-22

In Figure 9-22, to capture the impact of the 1997/98 El Niño on the sea surface temperatures of the Kuroshio-Oyashio Extension, I present the sea surface temperature anomaly data of the Kuroshio-Oyashio Extension (30N-45N, 150E-150W), starting in 1995. Also included in the graph are the sea surface temperature anomalies of the NINO3.4 region of the equatorial Pacific (the commonly used index for the timing, strength, and duration of El Niño and La Niña events). I inverted (multiplied by -1.0) the NINO3.4 data, so El Niño events are the downward spikes and La Niñas are the upward ones. The data start in 1995 because the eruption of Mount Pinatubo skews the relationship between the NINO3.4 data and the data from the Kuroshio-Oyashio Extension. I also smoothed both datasets with 13-month running-average filters due to the volatility of the Kuroshio-Oyashio Extension data. I also shifted the Kuroshio-Oyashio Extension data upward by 0.45 deg C to “zero” that dataset in 1997 — for easier comparison to the La Niña of 1998-01.

The large downward spike in the inverted NINO3.4 data (purple curve) in the late 1990s was the colossal El Niño of 1997/98. The trailing upward hump in the inverted NINO3.4 sea surface temperature anomalies is the 1998-2001 La Niña. The warm water left over from the 1997/98 El Niño caused the sea surface temperature anomalies of the Kuroshio-Oyashio Extension to warm about 1.2 deg C (based on the smoothed data) during the transition from the 1997/98 El Niño to the 1998-01 La Niña. That warming in the North Pacific took place east of Japan and extended eastward into the central North Pacific. The warming in the KOE was comparable in strength to the La Niña-caused cooling along the equator taking place at the same time. It’s as if a secondary El Niño event was happening in the mid-latitudes of the North Pacific while a La Niña was occurring in the tropics. The warming of the Kuroshio-Oyashio Extension counteracted the cooling effects of the 1998-01 La Niña and prevented some regions throughout the Northern Hemisphere from cooling in response to the 1998-01 La Niña.

The sea surface temperatures of the Kuroshio-Oyashio Extension have a rather unique signature. (See Figure 9-23.) The Kuroshio-Oyashio Extension is very volatile, but even with that volatility a number of things stand out plain as day. First, the KOE response to El Niños is similar to that of the South Atlantic, Indian, and West Pacific data. That is, the sea surface temperature anomalies of the Kuroshio-Oyashio Extension warm in response to El Niño events. But, notice the responses during what should be the cool-down time of the 1988/89 and 2010/11 La Niña events and the first year of the 1998-01 La Niña. Counter to what would be expected, the sea surface temperature anomalies continued to warm. Not only do they not cool proportionally during those La Niña events; they warm. Then, later, they cool during the decadal periods between the strong El Niños. In addition, they exhibit some intriguingly anomalous behavior, like the spike in temperature about 1991.

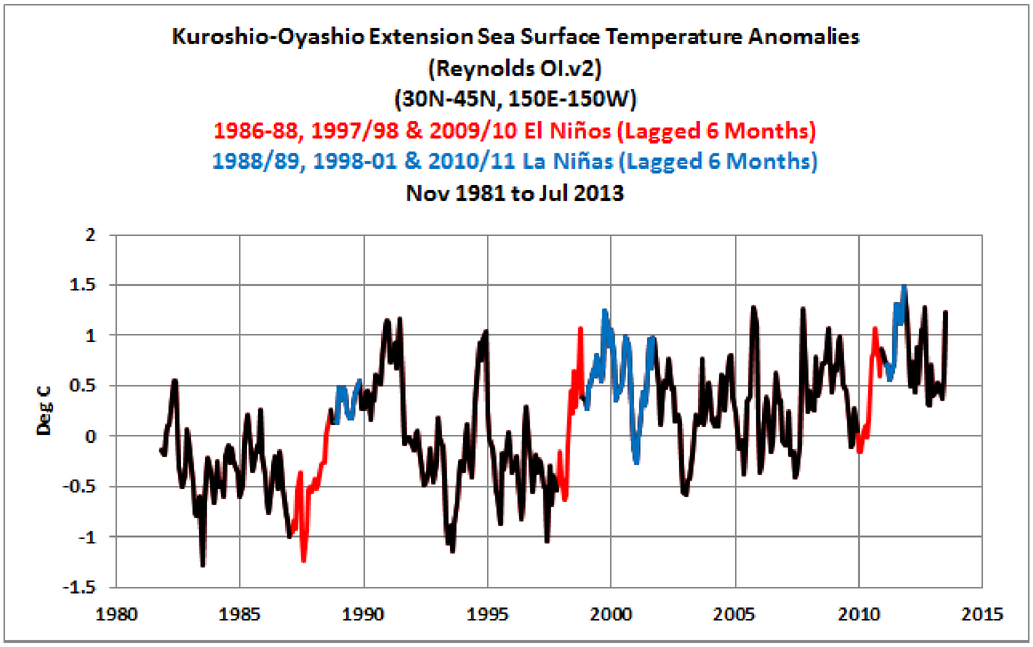


Figure 9-23

Research about the variability of the Kuroshio-Oyashio Extension has been going on for decades. It has been studied intensely. Yet, thus far, I have not found a single research paper that quantifies the impact of ENSO on the long-term warming trend there.

Back to the mechanisms that cause the upward steps: Above I discussed how the trade winds resume at the end of an El Niño and sweep the leftover warm **surface** waters back to the western Pacific. There is another mechanism called a "slow-moving, off-equatorial, Rossby wave" that carries all of the leftover warm water that's **below** the surface back to the western Pacific.

Rossby Waves

The next few paragraphs are from my book: ***Who Turned on the Heat?***

> The 1997/98 El Niño was an East Pacific event. Warm waters flooded east near the equator and slammed up against the coasts of the Americas. The trade winds reversed and became westerlies (now blowing west to east) and temporarily held the warm water against the American coasts. After the peak of the El Niño, a slow-moving, oceanic, Rossby wave formed in the northeast tropical Pacific, west of the Central American coast, at about 5N-10N. The Rossby wave is clearly visible in ocean heat content anomaly animations, and even more so in sea level residual animations from the Jet Propulsion Laboratory (JPL).

Rossby Wave Visible In JPL Sea Level Residual Video "tpglobal.mpg"

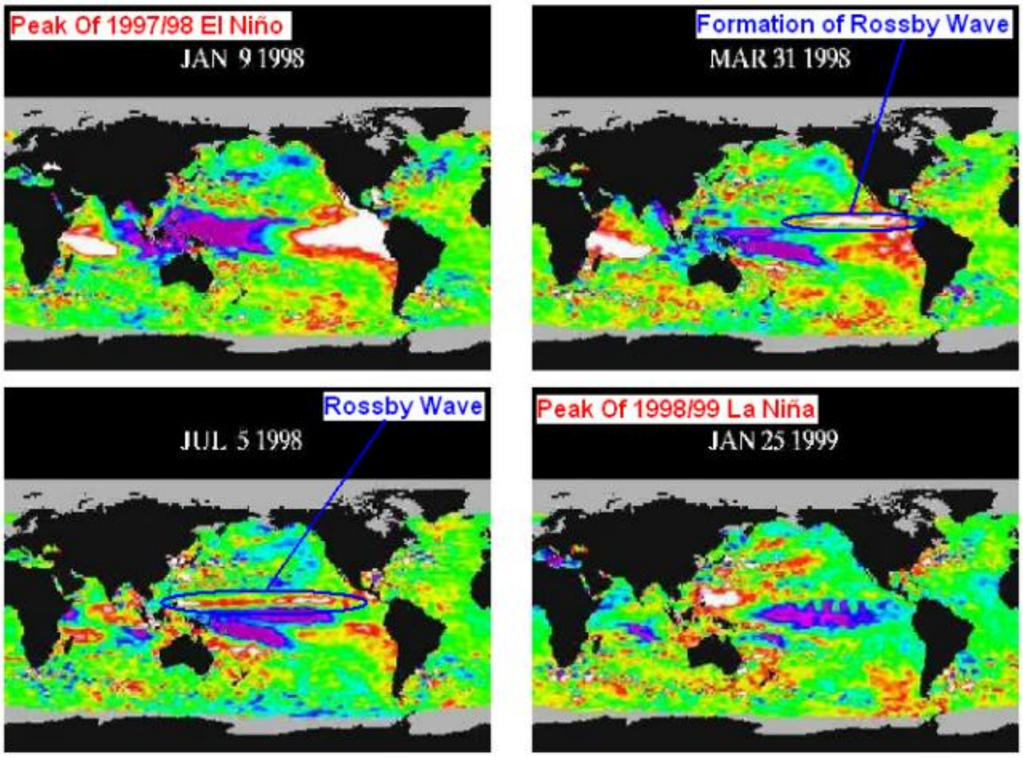


Figure 9-24

In Figure 9-24, I highlighted the Rossby wave in screen captures from a JPL video. The upper left-hand cell captures the peak of the 1997/98 El Niño. The upper right-hand cell shows the formation of the Rossby wave and the lower left-hand cell captures the Rossby wave travelling from east to west off the equator, at approximately 5N-10N. It is carrying leftover warm water back to the western Pacific during the transition from the 1997/98 El Niño to the La Niña that followed. It's important to note that Rossby wave is not visible in the sea surface temperature records. Last, in the lower right hand cell of Figure 9.24, notice what happens to the sea level residuals in the western Pacific after the Rossby wave reaches there. The sea level anomalies skyrocket. It's like another (a secondary) El Niño is taking place in the western tropical Pacific (off the equator) while the La Niña is taking place in the eastern tropical Pacific (along the equator).

There are no ENSO indices that capture those Rossby waves or their aftereffects. All of the sea surface temperature-based ENSO indices sample sea surface temperatures along the equator, but the Rossby waves occur off the equator and they have little to no impact on the surface temperatures even there.

The Rossby wave can be seen in the first 10 to 15 seconds of the YouTube video titled "Impact of the 1998 through 2001 La Niña on Sea Level Residuals". That video is a cropped version of the Jet Propulsion Laboratory animation "tpglobal.mpeg", which used to be available through the JPL Ocean Surface Topography from Space website. Unfortunately, JPL has since removed it from their Video Gallery. The slow-moving Rossby wave can also be seen in my Animation 3-1. It is a gif animation created from screen captures from the JPL animation discussed above. In the Animation 3-1, I limited the period to 1998.

If you allow the YouTube video to play through, you will note that there are no comparably sized Rossby waves carrying cool waters back to the western tropical Pacific at 5N-10N after the 1998/99/00/01 La Niña.

To confirm this basic difference between El Niño and La Niña events, refer to the video "Full YouTube version of the JPL animation 'tpglobal.mpeg'", which runs from 1992 to 2002. There are also no comparably-sized Rossby waves carrying cool waters back to the western tropical Pacific at 5N-10N or at 10S-5S after any La Niña event.

A number of sea level residual animations from JPL are still available on their site. One captures the Rossby wave after the 1997/98 El Niño. See their "SSH and SST – Global" video that compares sea surface height and sea surface temperature. It runs data from 1996 to 1999 and plays at a relatively slow speed. The sea level residuals are the top maps, and the sea surface temperature maps are on the bottom.

As discussed, surface and subsurface warm waters that are left over from the El Niño are carried back to the western tropical Pacific. Some of that leftover warm water helps to recharge the West Pacific Warm Pool for the next El Niño, some of the leftover warm water is carried into the eastern Indian Ocean by a current called the Indonesian Throughflow, and some of the warm water is carried toward the poles.

[End of an edited and expanded discussion from **Who Turned on the Heat?**]

The climate science community is very much aware of those off-equatorial Rossby waves and how they return leftover warm waters from the east Pacific to the west after El Niños. For example, they are discussed under the heading of "3.1 Ocean Processes" in the 2006 paper by Dykstra titled "The ENSO Phenomenon: Theory and Mechanisms." The mechanisms discussed are part of the delayed-oscillator theory.

The International Research Institute for Climate and Society (IRI) website has a relatively easy-to-understand, but a much-more-detailed, discussion of delayed-oscillator theory. See their "Advanced ENSO Theory: The Delayed Oscillator" webpage. Additionally, there are papers that explain the transport of the leftover warm water from the Pacific into the Indian Ocean. For example, Cai, et al. (2005) "Transmission of ENSO Signal to the Indian Ocean".

Yet, there are still no studies that quantify the impacts of those Rossby waves on the long-term warming of the sea surface temperatures of the:

- East Indian and West Pacific Oceans (Figure 9-21)
- South Atlantic, Indian, and West Pacific Oceans (Figure 9-14)
- Atlantic, Indian, and West Pacific Oceans (Figure 9-18)

CHAPTER 9.5 SUMMARY

The upward steps in the sea surface temperatures of the South Atlantic, Indian, and West Pacific Oceans (Figure 9-14) and other subsets of the global oceans are caused by the leftover warm water from El Niño events. At the conclusion of an El Niño, warm surface waters are swept back to the western Pacific by the return of the trade winds. Another phenomenon called a Rossby wave carries leftover subsurface waters back to the west Pacific. Some of the leftover warm water is used to recharge to West Pacific Warm Pool for the next El Niño. The rest of the leftover warm water is carried toward the poles in the Pacific and also into the eastern Indian Ocean by ocean currents and additional mechanisms associated with ENSO.

Chapter 9.6 – A Note About ENSO Indices

Because El Niño and La Niña events have impacts on weather around the globe, e.g., surface temperature and precipitation, and because ENSO events come in various combinations of frequency, duration, strength, and "flavors", which have different global impacts, researchers have sought out ENSO indices to try to characterize each El Niño and La Niña. "Flavors" refers to the fact that some El Niños occur in the central equatorial Pacific and some El Niños extend all the way to the coasts of the Americas.

The Southern Oscillation Index portrays one of the atmospheric components of El Niño and La Niña events. It was created by Sir Gilbert Walker in the 1920s and it represents the difference in the sea surface pressures between Tahiti and Darwin, Australia. That is, the Southern Oscillation Index only represents is a difference in pressure between two points on the globe. It wasn't until the 1960s that the Southern Oscillation Index was linked to El Niño and La Niña events.

In the 2001 letter Indices of El Niño Evolution, Trenberth and Stepaniak argued that two ENSO indices are needed to capture the differences in development and characteristics of El Niño events as those ENSO events as they portray themselves in the sea surface temperatures of the tropical Pacific: (1) NINO3.4 sea surface temperature anomalies of the central equatorial Pacific; and (2) the "Trans NINO Index," or TNI, to capture the "contrast in SSTs across the equatorial Pacific." The Trans NINO Index is rarely used, but, NINO3.4 sea surface temperature anomalies continue to be widely used as an ENSO index. Yet, the NINO3.4 data only indicate the effects of El Niño and La Niña events on the sea surface temperature anomalies of the NINO3.4 region of the central equatorial Pacific.

Instead of using a single variable like sea surface temperature anomalies, Wolter and Timlin (1993) created the MEI (Multivariate ENSO Index), which, as its name implies, is composed of multiple variables in the tropical Pacific. The primary variable is the sea surface temperature anomalies of the NINO3 region (the NINO3 region is bordered by the coordinates of 5S-5N, 150W-90W and is just east of the NINO3.4 region). The other 5 MEI variables slightly alter the shape of the curve of the NINO3 data, but, even with all of their variables, they could never hope to capture all the impacts of the warm waters that are left over from strong El Niño events.

More recently, in the 2007 paper "El Niño Modoki and Its Possible Teleconnection", Ashok, et al. created the El Niño Modoki Index. Using the sea surface temperature anomalies of 3 regions in the tropical Pacific, it was prepared to determine whether an El Niño was an East Pacific El Niño or a Central Pacific El Niño, what the authors call an El Niño Modoki.

Have any ENSO indices been created to determine the impacts of El Niño and La Niña events on ocean heat content? No. Have any ENSO indices been created to quantify the leftover (residual) warm water from an El Niño or quantify its aftereffects? No.

In fact, in the closing notes of Trenberth, et al. (2002), they wrote (my boldface):

> *The main tool used in this study is correlation and regression analysis that, through least squares fitting, tends to emphasize the larger events. This seems appropriate as it is in those events that the signal is clearly larger than the noise. Moreover, the method properly weights each event (unlike many composite analyses).* ***Although it is possible to use regression to eliminate the linear portion of the global mean temperature signal associated with ENSO, the processes that contribute regionally to the global mean differ considerably, and the linear approach likely leaves an ENSO residual.***

Further to this, see Compo and Sardeshmukh (2010) "Removing ENSO-Related Variations from the Climate Record". They write (my boldface):

> *An important question in assessing twentieth-century climate is to what extent have ENSO-related variations contributed to the observed trends. Isolating such contributions is challenging for several reasons, including ambiguities arising from how ENSO is defined.* ***In particular, defining ENSO in terms of a single index and ENSO-related variations in terms of regressions on that index, as done in many previous studies, can lead to wrong conclusions. This paper argues that ENSO is best viewed not as a number but as an evolving dynamical process for this purpose.***

Note: While Compo and Sardeshmukh made a small step in the right direction, they missed a very important aspect of ENSO. They overlooked the significance of the huge volume of warm water left over from some El Niño events and they failed to account for its contribution to the rise in global sea surface temperature anomalies since about 1975/76.

In short, the upward shifts in the sea surface temperatures of the South Atlantic, Indian, and West Pacific cannot be accounted for with the statistical techniques used by Trenberth et al. (2002) and other papers that use similar methods.

CHAPTER 9.6 SUMMARY

ENSO indices only indicate the impacts of El Niño and La Niña events on the variables being measured, where they are being measured. They are used to indicate the frequency, magnitude, and duration of ENSO events. They cannot be used to account for all of the impacts of ENSO events throughout globe and they completely fail to take into account the warm waters left over from strong El Niño events.

Chapter 9.7 – Have ENSO Events Been Impacted By Manmade Greenhouse Gases?

Figure 9-25 shows the simulated sea surface temperature anomalies of the NINO3.4 region since 1900 (specifically, the multi-model mean of the IPCC's CMIP5 simulations — historic/RCP6.0 — of the NINO3.4 region sea surface temperature anomalies). The models' estimates of global sea surface temperature anomalies are also shown. Notice that the simulated warming rate of the **equatorial** Pacific (NINO3.4 region) is quite a bit higher than the simulated rate of the **global** sea surface temperatures — about 37% higher.

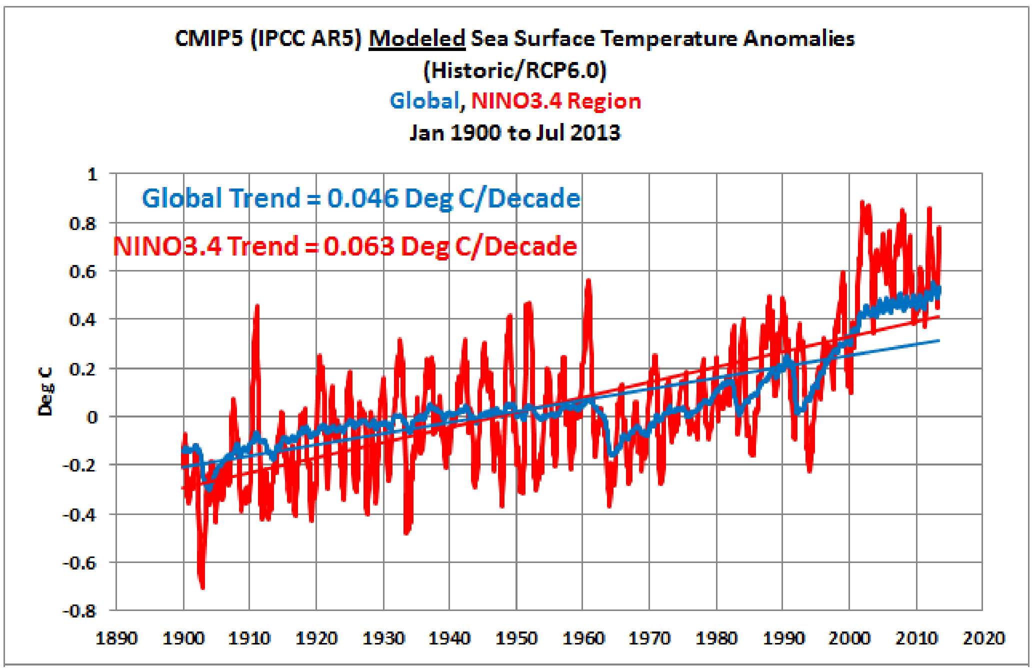


Figure 9-25

Contrary to the estimates of the models shown in Figure 9-25, while observed global sea surface temperature anomalies did warm since 1900, the sea surface temperatures of the equatorial Pacific did not.

The equatorial Pacific was not well traveled by ships before the opening of the Panama Canal in 1914. Even after that, for many years, the sea surface temperature source data is sparse. Data samples are especially sparse for the two multiyear periods during the two World Wars, the 1910s and the 1940s. Sampling gets better in the 1950s, 60s, and 70s, but, it has to be taken with a big pinch of salt before the satellite era (1981). As a result of the limited source data, there are differences in scientists' reconstructions of sea surface temperature anomalies along the equatorial Pacific, and those differences impact the long-term warming rates of the NINO3.4 data. (See Figure 9-26.) The ERSST.v3b dataset shows warming in the NINO3.4 region, but, the Kaplan dataset shows cooling, and the HADISST data shows a long-term trend of the sea surface temperatures along the equatorial Pacific that is relatively flat.

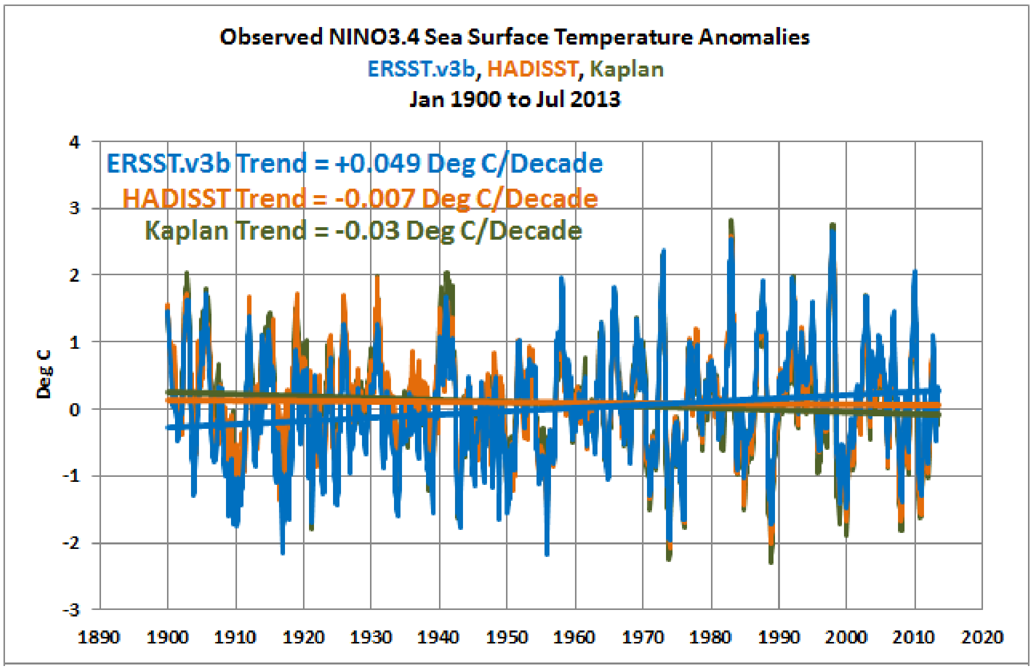


Figure 9-26

The differences result from the different methods used to infill missing data. In Figure 9-27, I present the average of the above three reconstructions of NINO3.4 data. As shown, the long-term trend of the average NINO3.4 sea surface temperature anomalies is basically flat — no long-term warming or cooling.

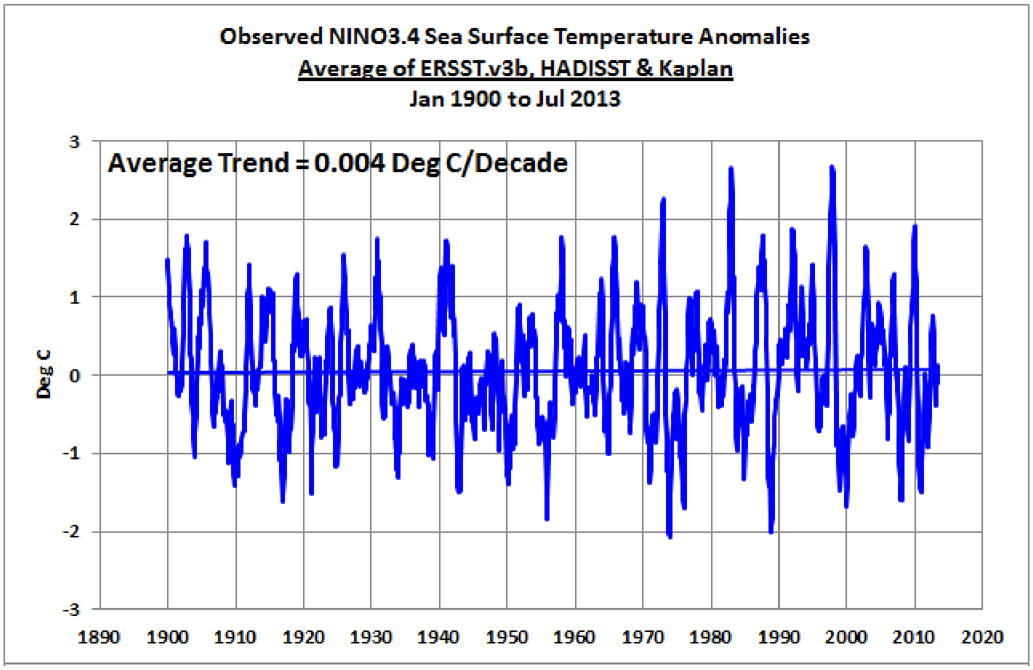


Figure 9-27

Bear in mind, the equatorial Pacific is one of the primary upwelling regions in the global oceans. That is, except during El Niño events, cool waters from below the surface of the central and eastern equatorial Pacific are being constantly pumped to the surface at tremendous volumes. Those cool, upwelled waters are then heated by the sun as they travel westward (pushed the trade winds). La Niña and El Niño events then enhance that warming in the tropical Pacific and periodically distribute the warm water (they create-and-release) around the global oceans. But, because ENSO is a **chaotic**, sunlight-fueled, recharge-discharge oscillator, the volume of warm water created and redistributed by La Niña and El Niño events varies in time.

In other words, ENSO heats and redistributes the cool waters being upwelled from below the surface of the equatorial Pacific, and ENSO does this at random times and intensities. As noted earlier, during multidecadal periods when El Niños dominate, global surface temperatures warm. Conversely, global surface temperatures cool during periods when La Niña events dominate, because the tropical Pacific is releasing less heat and redistributing less warm water than "normal".

Figure 9-27 shows that the El Niño events were strongest in the 1970s, 80s, and 90s. Some researchers have claimed that the increased El Niño strength was caused by manmade greenhouse gases. Opposing those claims, Giese et al. (2009) "The 1918/19 El Niño" argues that the 1918-19 El Niño was much stronger than portrayed by sea surface temperature reconstructions. The Texas A&M press release for that paper [here] includes:

> *Giese adds, "The most commonly used indicator of El Niño is the ocean temperature anomaly in the central Pacific Ocean. By that standard, the 1918-19 El Niño is as strong as the events in 1982-83 and 1997-98, considered to be two of the strongest events on record, causing some researchers to conclude that El Niño has been getting stronger because of global warming. Since the 1918-19 El Niño occurred before significant warming from greenhouse gasses, it makes it difficult to argue that El Niños have been getting stronger."*

In the paper, Giese et al. (2009) ended:

> *The methodology used in this paper could also be used to understand other strong, but poorly observed, El Niño events, such as the 1939–41 and 1912 El Niños.*

This suggests that those other two early El Niño events may also have been stronger.

This topic was also addressed by the Ray & Giese (2012) paper "Historical Changes in El Niño and La Niña Characteristics in an Ocean Reanalysis". The abstract ends:

> *Overall, there is no evidence that there are changes in the strength, frequency, duration, location or direction of propagation of El Niño and La Niña anomalies caused by global warming during the period from 1871 to 2008.*

The phrase "direction of propagation" typically refers to the fact that some El Niño events appear to form east to west at the surface, while others form from west to east.

CHAPTER 9.7 SUMMARY

There are scientific papers that strongly indicate that the magnitude, timing, and duration of ENSO events have NOT been impacted by manmade greenhouse gases.

Climate model outputs show that if manmade greenhouse gases were responsible for the warming of the global oceans since 1900, sea surface temperatures along the equatorial Pacific would have warmed faster than the rest of the global oceans.

Data from the real world contradict the virtual world of the models. In the real world, based on the average of 3 sea surface temperature data reconstructions, the sea surface temperature anomalies of the NINO3.4 region have not warmed since 1900. That indicates the rest of the global oceans had warmed around the equatorial Pacific for more than a century.

Climate models fail to properly simulate El Niño and La Niña processes — no ifs, ands, or buts.

Chapter 9.8 – A Few Notes About the Warming of Ocean Heat Content Data Outside of the Tropical Pacific

PRELIMINARY NOTES

The source of the ocean heat content data in this chapter is the KNMI Climate Explorer. The ocean heat dataset is from the NODC (National Oceanographic Data Center) and it includes observations to depths of 700 meters. The NODC presents their data in terms of Joules*10^22 on a quarterly basis. KNMI converts that to Gigajoules per square meter (GJ/m^2) so that the data can be examined on a gridded basis. This also allows for easy comparisons of subsets. KNMI also presents the NODC's quarterly data in a monthly format. That is, e.g., the data for 1st quarter of 1999 is the same for January through March of 1999. This allows the NODC data to be easily compared to other datasets that are presented on a monthly basis, but it does create tiny shifts (jumps) in the NODC data every 3 months. I've smoothed the data with a 3-month running-average filter to eliminate that distracting visual effect.

DISCUSSION

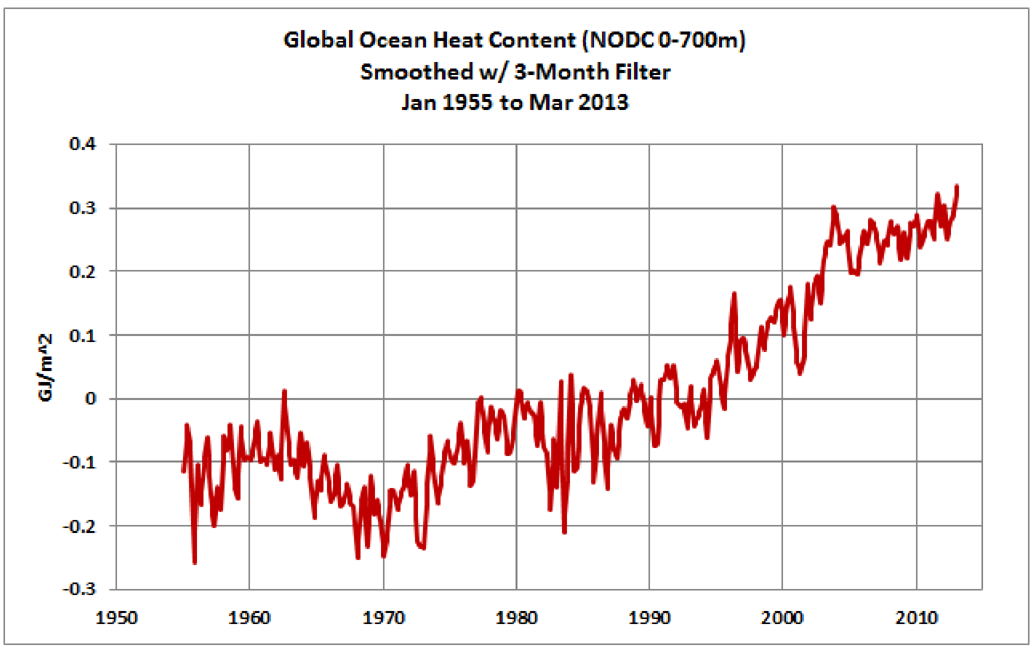


Figure 9-28

Ocean heat content data represents the change in the amount of heat stored in the global oceans. When anthropogenic global warming enthusiasts present ocean heat content data, they only provide graphs of the **global** data. (See Figure 9-28.)

Why do they not present the ocean heat content data broken down into the ocean's sub-regions? The most likely explanation is that when you lump all the ocean heat data into one big graph, the global data then appear to have warmed relatively uniformly and continuously since 1970. The only way the model programmers can force their models to "validate" the assumption that human CO2 causes global warming is with a model output of a simple, gradual upward slope of a long-term warming trend.

As noted earlier, climate modeling groups do not furnish ocean heat content (as opposed to sea surface data) outputs in a consistent format so that they can easily be presented at the KNMI Climate Explorer. As a result, there are no model outputs for ocean heat content data available through the KNMI Climate Explorer or in this book.

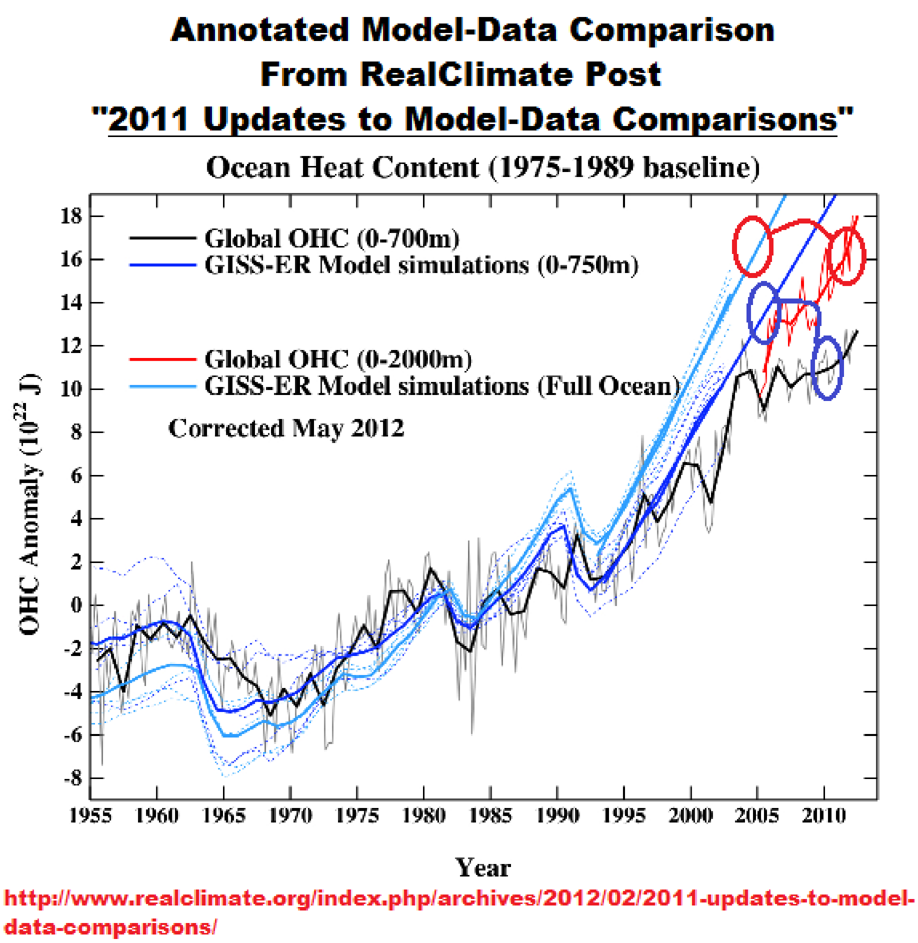


Figure 9-29

However, there is a model-data comparison for ocean heat content available online. (See Figure 9-29.) It is from the RealClimate blog post "2011 Updates to Model-Data Comparisons." The graph includes two comparisons, which could be confusing, so I drew in a couple of links between the two sets of related curves. The contributors to RealClimate are climate scientists. Unfortunately for the model programmers, as shown in that graph from RealClimate, the models cannot simulate the recent slowdown in ocean heat content warming rates; that is, the models show **way** too much warming over the last decade.

Note that the data in recent years have to be "corrected" (adjusted, modified, tweaked, whatever) to show that warming. You'll note that the RealClimate graph indicates that it has been corrected. That's a different correction. RealClimate had made a mistake in their original presentation of climate model outputs for ocean heat content. The basis for the corrections was presented in the RealClimate post "OHC Model/Obs Comparison Errata". The third comment on that thread read:

> *That must (have) hurt: http://www.realclimate.org/images/ohc11.jpg*

The author of the blog post, Dr. Gavin Schmidt of GISS, acknowledged the above failure of the GISS models in a roundabout fashion in his reply (my boldface):

> ***Response:*** *not really. I learnt a long time ago that a) I'm not infallible, and b) that* ***one should never get personally invested in the results of a model****. When things work, one should always remain pleasantly surprised, when they don't there is possibly a reason that can found - which may be interesting. This is why* ***science is fun****.*

"…one should never get personally invested in the results of a model"?

Countries around the globe have cut back on fossil fuel-based sources of energy and invested in alternative energy sources, trying to avoid the climate model-founded prognostications of gloom and doom. Those national investments in those alternative energy sources then place the cost of home energy out of the reach of many pensioners, who in some cases have resorted to burning second-hand books to keep from freezing to death in winter. Yet climate scientists are having "fun" with all of the government grant money.

OCEAN HEAT CONTENT DATA DO NOT SUPPORT THE HYPOTHESIS OF HUMAN-INDUCED GLOBAL WARMING

As a climate skeptic, the following is one of my favorite presentations of data.

I examine the data for two adjoining regions in the Pacific Ocean, the NODC ocean heat content data, for the depths of 0-700 meters, from the same dataset presented by RealClimate in Figure 9-29. The two regions I examine are shown on the map in Figure 9-30. They include the tropical Pacific (24S-24N, 120E-80W) and the North Pacific north of the tropics (24N-65N, 120E-80W). "North Pacific north of tropics" is ungainly so

I call that region the “Extratropical North Pacific.” The ocean heat content data for those two regions are all one needs to counter the claims that manmade greenhouse gases can explain the bulk of the warming of the global oceans.

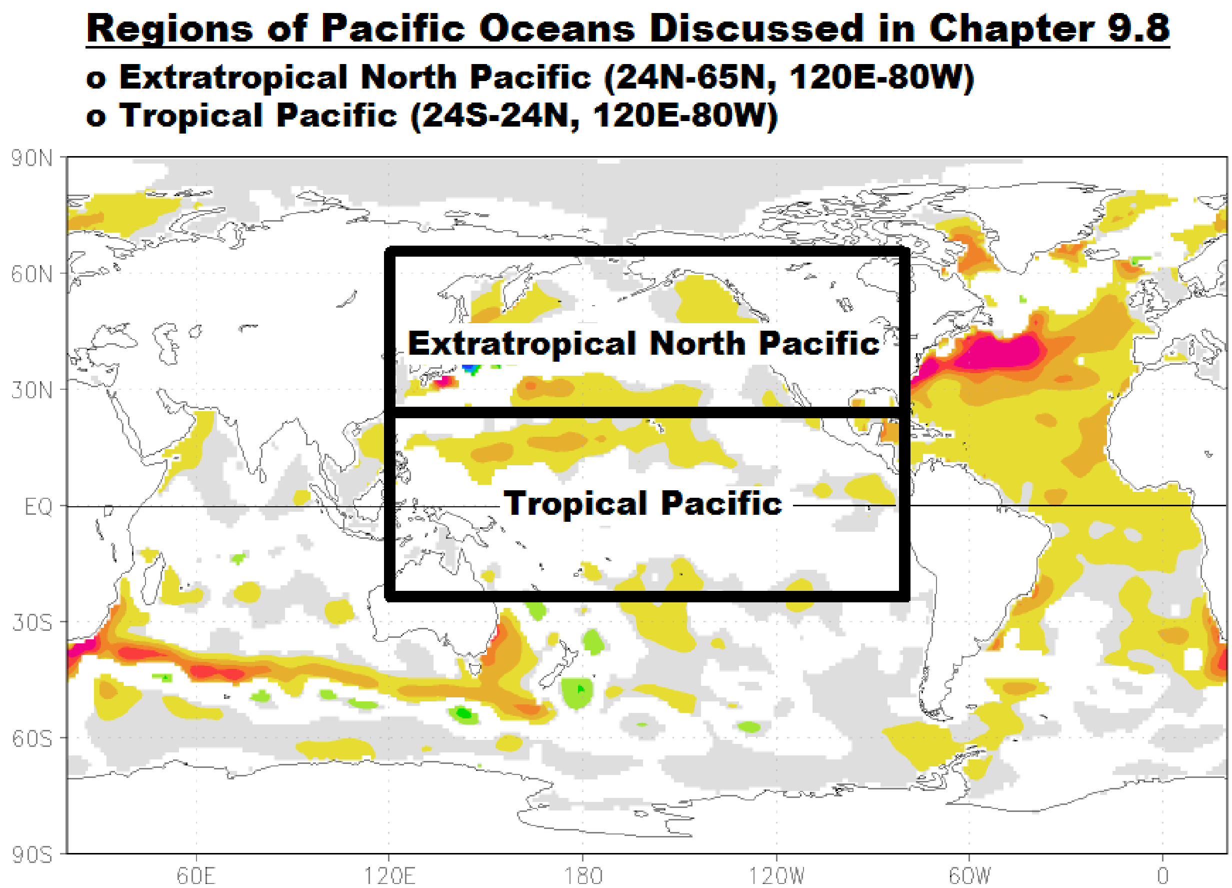


Figure 9-30

I discussed the ocean heat content of the tropical Pacific in great detail above in Chapter 9.2. As shown in Figure 9-31, the 3 three-year La Niña events of 1954-56, 1973-76, and 1998-01 and the strong 1995/96 La Niña were the principal causes of the warming there. The warming that occurs during La Niñas is fueled by the sun. The data highlighted in blue capture the periods between the major La Niña events and after the most recent 3-year La Niña. The trend lines, also in blue, confirm that the tropical Pacific cooled during those periods. They also indicate that the ocean heat of the tropical Pacific would have cooled since 1955 if the long and strong La Niña events had not happened, further evidence that the warming was completely dependent on those sunlight-supplying La Niñas.

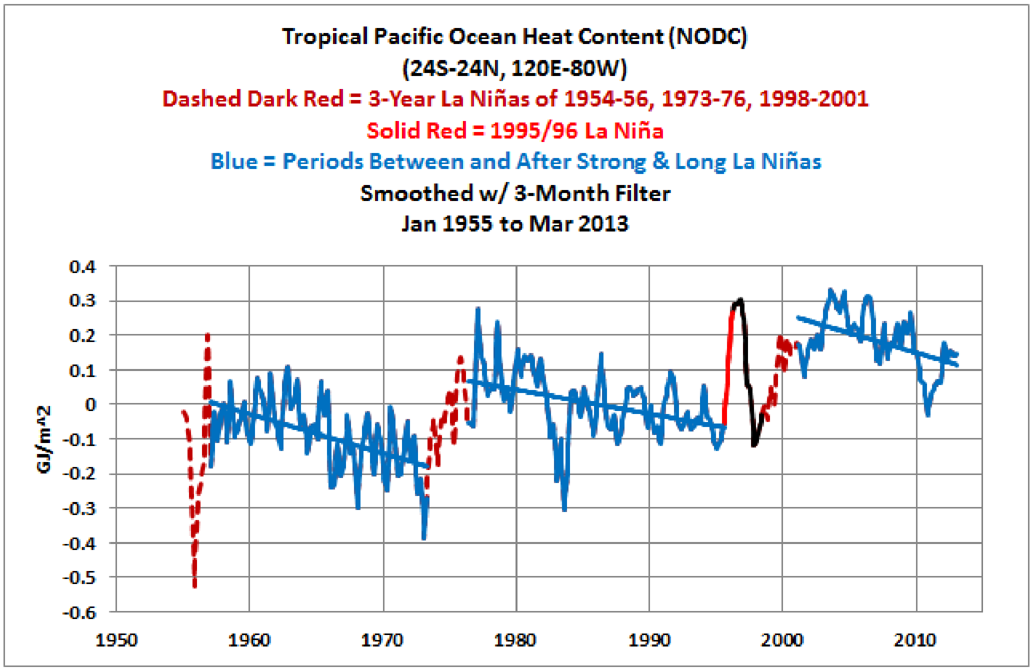


Figure 9-31

Scientists are very familiar with the fact that climate models cannot simulate the basic processes of El Niño and La Niña events. Guilyardi et al. (2009) note that climate modelers do not handle sunlight correctly in their attempts to simulate La Niñas. Therefore, for now, climate models cannot simulate the sunlight-driven warming of the ocean heat content of the tropical Pacific — or the multidecadal cooling that takes place between the long and strong La Niñas. And there is not one peer-reviewed, climate model-based, study that explains how, when, and why the ocean heat content of the tropical Pacific warmed and cooled as it did.

Global warming enthusiasts assert that manmade greenhouse gases provided a non-stop-and-accelerating warming of the tropical Pacific, but, for multiple multidecadal periods, the ocean there cooled to depths of 0-700 meters.

The graphs of the **global** ocean heat content data show an almost monotonous warming since 1970. At first glance, that appears to support the speculation that manmade greenhouse gases caused the global oceans to warm continuously. Please scroll up to Figures 9-28 and 9-29. Now that you have those images planted firmly in your mind I will examine the ocean heat content data for the Extratropical North Pacific (24N-65N, 120E-80W), Figure 9-32.

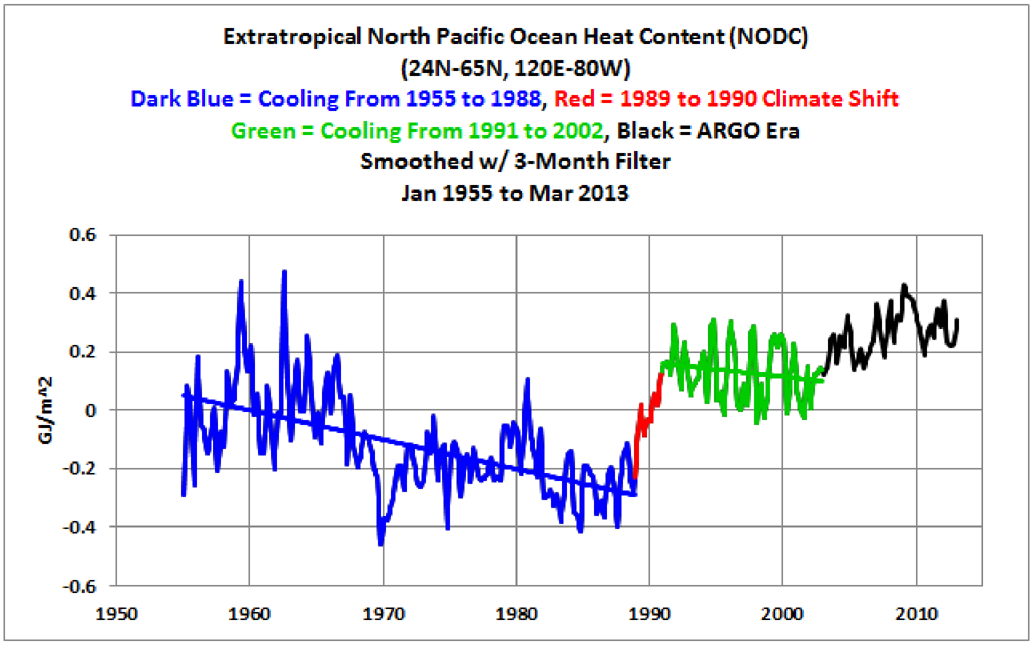


Figure 9-32

The ocean heat content for the top 700 meters of the Extratropical North Pacific cooled from 1955 to 1988 (highlighted in dark blue along with the linear trend line). No anthropogenic global warming component appears in the ocean heat content data of the Extratropical North Pacific for the first 34 years of the data, because that part of the Pacific (to depths of 700 meters) cooled during that time. And it cooled once again for a little more than a decade, from 1991 through 2002 (highlighted in green with the linear trend line). Yet, we've been told the "human influence is systematic and persistent" (Trenberth and Fasullo (2012)).

Between those 2 cooling periods is an obvious upward shift that took only 2 years (highlighted in red). If one were to remove those two years of data (1989 and 1990), the ocean heat content of the Extratropical North Pacific would obviously cool from 1955 to the present. That is, the overall warming of the Extratropical North Pacific depends on only 2 years of data. There is no "systematic" or "persistent" influence of any kind on the warming of the ocean heat for the Extratropical North Pacific.

There are no peer-reviewed climate model-based studies that explain how and why the ocean heat content of the Extratropical North Pacific warmed and cooled when it did, but there is a paper that discusses what caused a similarly timed upward shift in the sea surface temperatures and sea level pressures of the North Pacific. One of the authors is, once again, Kevin Trenberth of NCAR. Almost 2 decades ago, Kevin Trenberth discussed the same wind pattern-based upward shift in the sea level pressure of the Extratropical North Pacific. (See Trenberth and Hurrell (1995) Decadal Coupled Atmosphere-Ocean Variations in the North Pacific Ocean.) Below, their Figure 6 is my

Figure 9-33. It shows the sea level pressure of a portion of the Extratropical North Pacific.

Figure 6 from Trenberth and Hurrell (1995) "Decadal Coupled Atmosphere-Ocean Variations in the North Pacific Ocean"

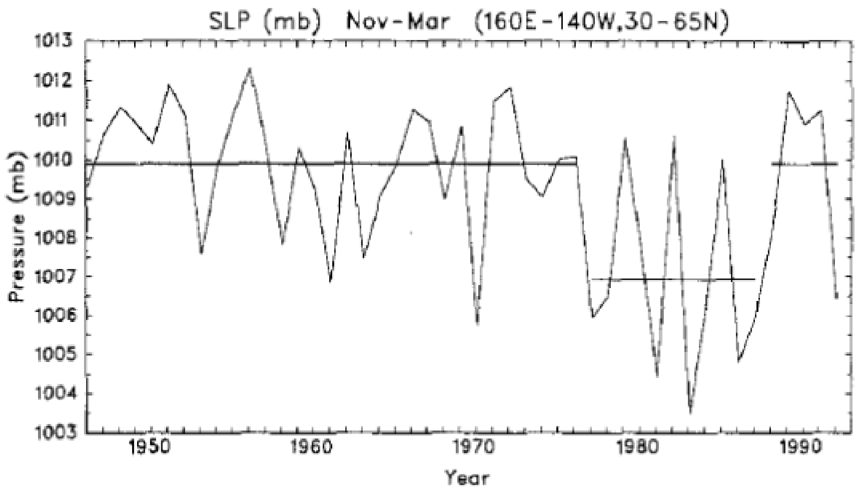


Fig. 6. Time series of mean north Pacific sea level pressures averaged over 30 to 65°N, 160°E to 140°W for the months November through March. Means for 1946–1976 plus 1989–1992 and 1977–1988 are indicated (where 1988 refers to the 1987–88 winter)

http://www.cgd.ucar.edu/cas/jhurrell/Docs/trenberth.decadal_variations.climdyn94.pdf

Figure 9-33

The final paragraph of Trenberth and Hurrell (1995) reads:

> *Whether the unusual 1976-1988 imbalance can be ascribed to any cause, or is merely a part of natural variability is a very difficult question to answer. The major change that occurred in March-April 1988, with a transition from El Niño to a very strong La Niña (Fig. 17, and Trenberth et al. 1989), apparently ended the climate regime although the underlying ocean currents and heat storage must be still perturbed and the pattern could reemerge. Indeed, the recent 1991-92 ENSO event was noted for exceptionally warm water along the west coast of both North and South America in early 1992.*

That great shift in the ocean heat content of the Extratropical North Pacific appears simply appears to be the lagged response to the transition from the multiyear 1986/87/88 El Niño to the strong 1988/89 La Niña. If the climate science community would return to examining data, as they did in the past, they might begin to understand why the oceans warmed.

Those two Pacific Ocean subsets cool for multidecadal periods and then warm suddenly in response to natural events. Individually, they strongly challenge the claim that ocean warming can only be explained by the increased emissions of anthropogenic greenhouse gases. But, the existence of two large subsets that show multidecadal periods of cooling and sharp (naturally caused) warming events does the hypothesis irreparable damage. Carbon dioxide is well mixed in the atmosphere. CO2 can't avoid the tropical Pacific and Extratropical North Pacific for multidecadal periods, and then provide short blasts of warming at separate times in different locations. If human CO2 has an influence on any part of the global oceans, it has to have an impact everywhere. Carbon dioxide cannot pick and choose where and when it impacts the global oceans. Contradicting all of the human CO2-driven climate models, the ocean heat content data for both the tropical Pacific and the Extratropical North Pacific show **no evidence** of an anthropogenic global warming component. Zero, zip, nada.

The best part of this presentation of ocean heat content data is yet to come.

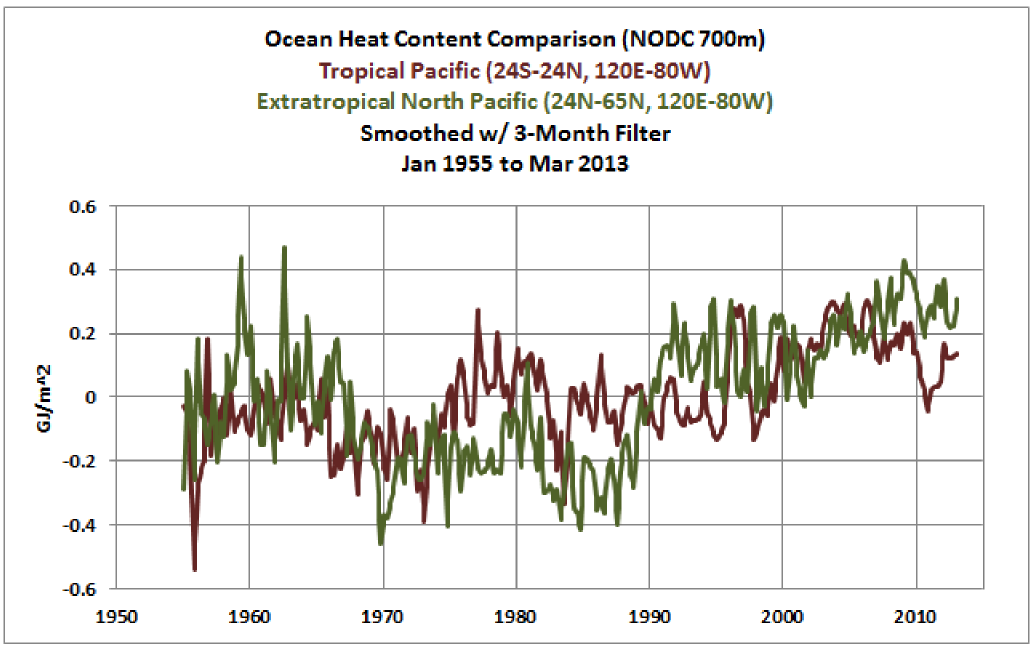


Figure 9-34

I compare the ocean heat content for the tropical Pacific and the Extratropical North Pacific in Figure 9-34. The data cover the time period of January, 1955 to March, 2013 and they reach into the Pacific to the depth of 700 meters (about 2300 feet). Because both of these subsets cool for multidecadal time periods, they are not consistent with the "systematic and persistent" "human influence" of human-induced global warming conjecture. Both Pacific sub-regions not only cooled for multidecadal periods, they also warmed as a result of short-term natural causes. If the warming impacts of those short-term naturally occurring events had not happened, both data subsets would have shown long-term cooling in those regions of the Pacific Ocean, from 1955 to the present.

In Figure 9-35, I combine the ocean heat content data for the tropical Pacific and the Extratropical North Pacific into one dataset, with the coordinates of 24S-65N, 120E-80W. The data are volatile, but they show an almost continuous warming from 1970 to present. Do you recognize the curve?

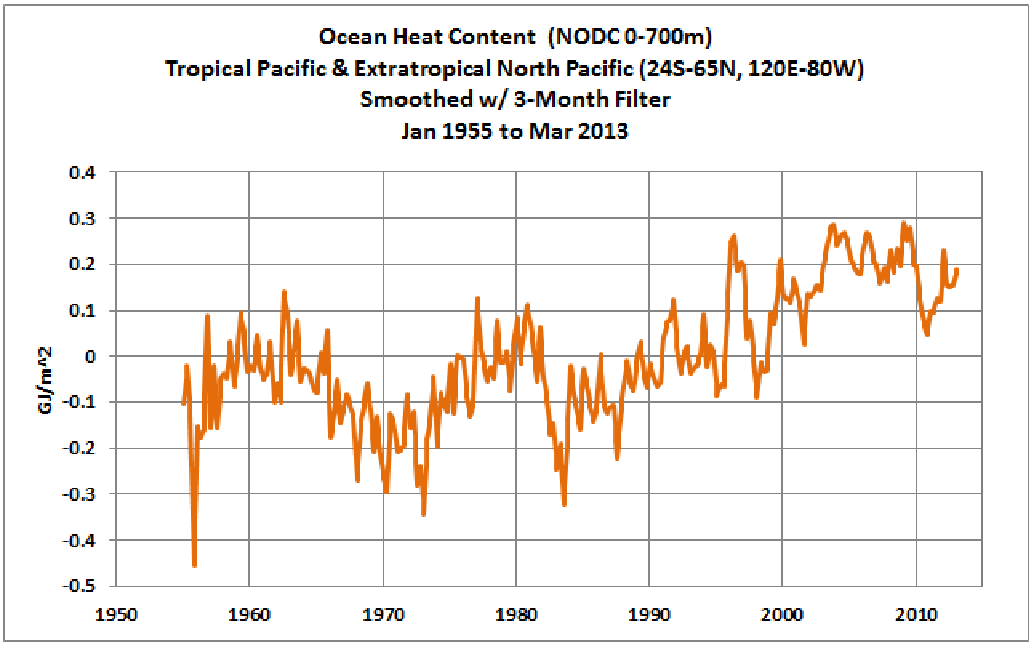


Figure 9-35

The combined data for the tropical Pacific and the Extratropical North Pacific basically have the same curve as the global ocean heat content. (See Figure 9-36.) The combined tropical Pacific and Extratropical North Pacific data are more volatile than the global data because El Niño and La Niña events impact the Pacific data directly. The two datasets diverge a bit from time to time, but, overall, the global ocean heat content data mirror the annual and decadal variations in the combined data of the tropical Pacific and the Extratropical North Pacific.

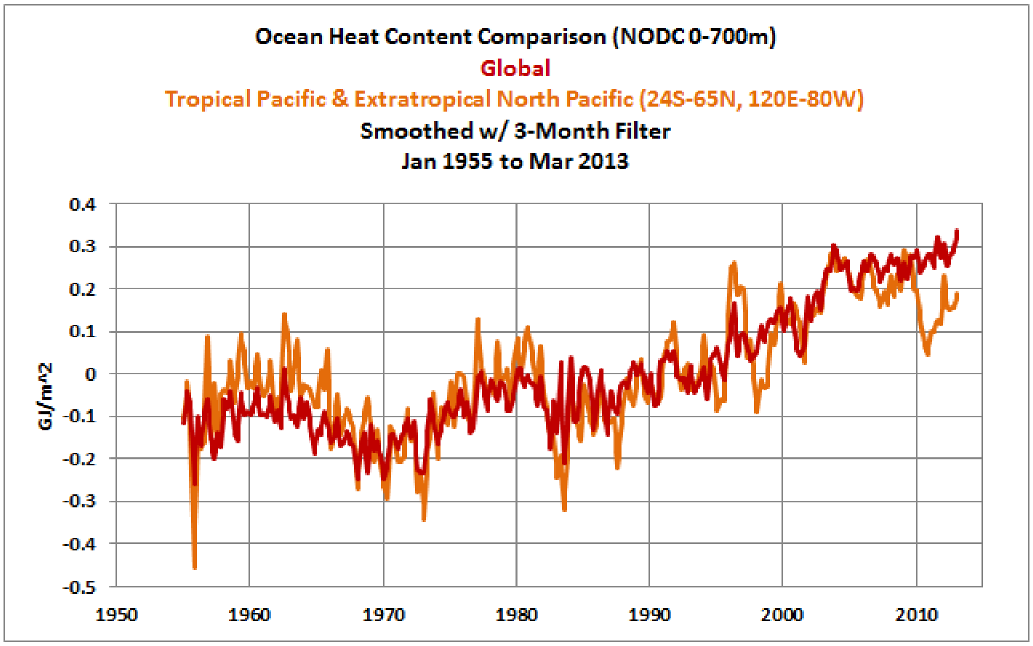


Figure 9-36

That is, when the tropical Pacific and the Extratropical North Pacific subsets are combined, they present a more gradual long-term warming that is mirrored by the global ocean heat content data. That's to be expected because the tropical Pacific and the Extratropical North Pacific make up such a large portion of the global data.

It is now quite obvious: (1) why human-induced global warming enthusiasts will only present the ocean heat content data on a global basis; and (2) why they have yet to present separately the data for the tropical Pacific and the Extratropical North Pacific.

SOMETHING TO CONSIDER

How the heat content of the global oceans are measured changed fairly recently with the introduction and use of ARGO floats. ARGO floats began to have moderately complete coverage of the global oceans around 2003/04. Before then, the sampling of the subsurface ocean temperature and salinity measurements depended on where research was taking place. Unfortunately, there were very few measurements taken in the Southern Hemisphere oceans south of the tropics. This means the NODC ocean heat content data (all ocean heat content datasets) are primarily tropical and Northern Hemisphere datasets before 2003.

THE NORTH ATLANTIC

The ocean heat content for the depths of 0-700 meters in the North Atlantic warmed much faster (about 2.5 times faster) than the global oceans since 1955. But, that warming stopped about 2004. These two facts can be seen easily in the comparison of ocean heat content for the North Atlantic and global oceans, Figure 9-37. Since about 2004, the ocean heat content of the North Atlantic has cooled rapidly. Prior to that, it warmed rapidly.

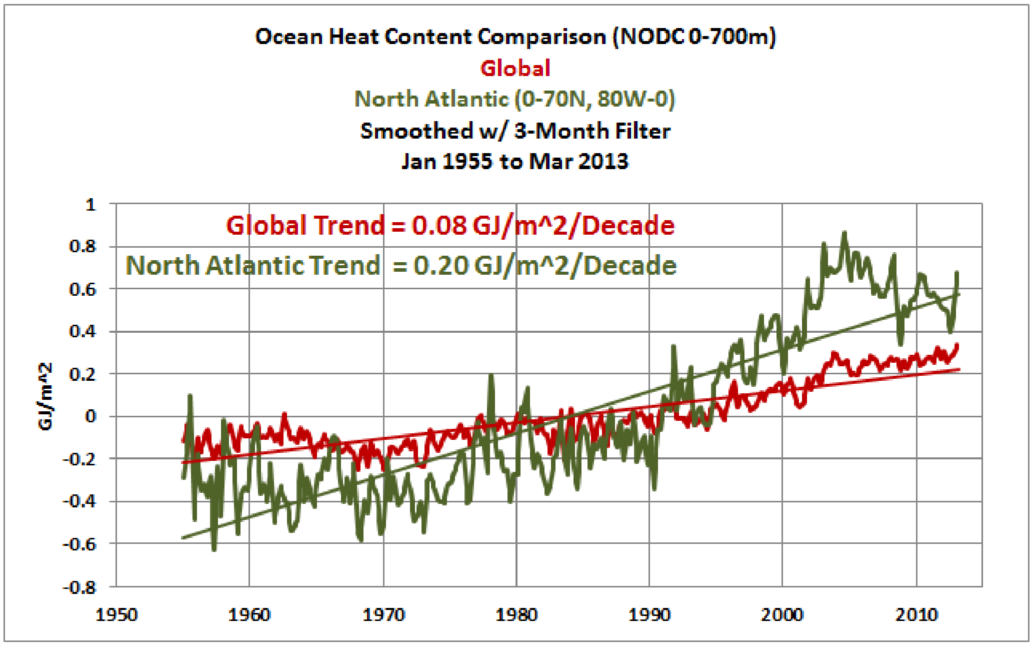


Figure 9-37

Because of the excessive warming rate there, one would think it would be more difficult to explain the North Atlantic warming than the rest of the global oceans.

But, a January, 2008 article in ScienceDaily titled "North Atlantic Warming Tied to Natural Variability" indicates otherwise. That article refers to the Lozier, et al. (2008) paper "The Spatial Pattern and Mechanisms of Heat-Content Change in the North Atlantic". The article about Lozier, et al. (2008) includes:

> *"We suggest that the large-scale, decadal changes…associated with the NAO [North Atlantic Oscillation] are primarily responsible for the ocean heat content changes in the North Atlantic over the past 50 years," the authors concluded.*

For those not familiar with the North Atlantic Oscillation, I borrow a paragraph from my ebook ***Who Turned on the Heat?***

> *The **North Atlantic Oscillation** is an atmospheric climate phenomenon in the North Atlantic. Like the Southern Oscillation Index described in **Chapter 4.3 ENSO Indices**, the North Atlantic Oscillation is expressed as the sea level pressure difference between two points. The sea level pressures in Iceland, at the weather stations in Stykkisholmur or Reykjavik, can be used to calculate North Atlantic Oscillation Indices. Which Iceland location they elect to use as the*

high-latitude sea level pressure reference depends on the dataset supplier. The other point captures the sea level pressure at the mid-latitudes of the North Atlantic, and there are a number of locations that have been used for it: Lisbon, Portugal; Ponta Delgada, Azores; and Gibraltar. The North Atlantic Oscillation Index is primarily used for weather prediction. The direction and strength of the westerly winds in the North Atlantic are impacted by the sea level pressures in Iceland and the mid-latitudes of the North Atlantic, which, in turn, impact weather patterns in Europe and the East Coast of North America. If you live in those locations, you'll often hear your weather person referring to the North Atlantic Oscillation. As will be discussed, winds in the North Atlantic can also impact Ocean Heat Content.

Returning to the ScienceDaily article, they write:

By contrast, NOA-driven winds served to "pile up" sun-warmed waters in parts of the subtropical and tropical North Atlantic south of 45 degrees, Lozier said. That retained and distributed heat at the surface while pushing underlying cooler water further down.

Thus, changes in wind patterns can also be a cause of warming the depths of the global oceans, refuting the propaganda that only manmade greenhouse gases are the main driver of ocean warming.

Lozier, et al. (2008) wrote in the abstract (my boldface):

The total heat gained by the North Atlantic Ocean over the past 50 years is equivalent to a basinwide increase in the flux of heat across the ocean surface of 0.4 ± 0.05 watts per square meter. We show, however, that this basin has not warmed uniformly: Although the tropics and subtropics have warmed, the subpolar ocean has cooled. These regional differences require local surface heat flux changes (±4 watts per square meter) much larger than the basinwide average. Model investigations show that these regional differences can be explained by large-scale, decadal variability in wind and buoyancy forcing as measured by the North Atlantic Oscillation index. ***Whether the overall heat gain is due to anthropogenic warming is difficult to confirm because strong natural variability in this ocean basin is potentially masking such input at the present time.***

That is, if there is a manmade global warming component in the ocean heat content of the North Atlantic, Lozier, et al. (2008) could not find it. Lozier, et al. (2008) found that the warming, not only the excessive warming, but the overall warming in general of the ocean heat content of the North Atlantic was caused primarily by natural changes in wind patterns.

ADDITIONAL DISCUSSIONS OF OCEAN HEAT CONTENT DATA

Even though surface temperature warming ceased years ago, members of the climate science community are still loudly claiming that global warming is still happening, but, they assert, one has to look to the deep oceans to find it. To "find" that "missing heat" in the deeper parts of the oceans, they use ocean heat content data. But ocean heat content data is rife with problems. The "scientific" papers that speculate about this deep ocean warming are also full of monumental uncertainties caused both by the problematic data and by the researchers' portrayal of how the oceans are warmed. I've addressed the problems with ocean heat content data and the search for the "missing heat" in a series of blog posts. The following are the links to the posts at my blog, with the links to the cross posts at WattsUpWithThat in parentheses. The cross posts at WattsUpWithThat are provided for those readers who also wish to review the comments. WattsUpWithThat has much more web traffic than my website and, therefore, many more comments.

(The first article is a very detailed discussion of ocean heat content data.)

- Is Ocean Heat Content Data All It's Stacked Up to Be? (WattsUpWithThat cross post here)
- NODC's Pentadal Ocean Heat Content Data (0-2000m) Creates Warming That Doesn't Exist in the Annual Data – A Lot of Warming (WattsUpWithThat cross post here)
- Trenberth Still Searching for Missing Heat (WattsUpWithThat cross post here)
- More on Trenberth's Missing Heat (WattsUpWithThat cross post here)
- A Different Perspective on Trenberth's Missing Heat: The Warming of the Global Oceans (0-2000 Meters) in Deg C (WattsUpWithThat cross post here)
- Ocean Heat Content (0-2000 Meters) – Why Aren't Northern Hemisphere Oceans Warming During the ARGO Era? (WattsUpWithThat cross post here)
- Even More About Trenberth's Missing Heat – An Eye Opening Comment by Roger Pielke, Sr. (WattsUpWithThat cross post here)
- Rough Estimate of the Annual Changes in Ocean Temperatures from 700 to 2000 Meters Based on NODC Data (WattsUpWithThat cross post here)

The last blog post includes the following closing comments:

> *To account for the slowdown [in] the warming of surface temperatures and in the heat content of the upper 700 meters of the global oceans, the climate science community is claiming manmade global warming is bypassing those levels and warming the oceans at depths below 700 meters. But that warming of the subsurface temperatures of the global oceans from 700-2000 meters represents variations measured in* ***thousandths*** *of a deg C. It is not reasonable to think we*

can measure the temperatures of the global oceans to that accuracy. Now consider that ocean heat content data have to be adjusted — tweaked, modified, corrected, whatever — in order for it to show warming during the ARGO era. (The UKMO EN3 data in the graph here should represent the uncorrected ARGO era data for depths of 0-2000 meters.)

The vertically averaged temperatures for the depths of 700-2000 meters can be approximated from their data for the depths of 0-700 and 0-2000 meters. It shows a very sudden shift in the rate of warming for depths of 700-2000 meters. The shift coincides with the introduction of the ARGO floats to rarely sampled portions of the global oceans — the mid-to-high latitudes of the oceans of the Southern Hemisphere, for example. This suggests that the warming presented by the data at those depths may result from the more-complete sampling of the global oceans.

CHAPTER 9.8 SUMMARY

Similar to sea surface temperature data, ocean heat content data for depths of 0-700 meters also indicate that the global oceans warmed without the influence of manmade greenhouse gases. With the ocean heat content data, this obviously natural warming extends from 1955 to the present. Also, like the sea surface temperature data, the global oceans only need to be divided into logical subsets in order for the natural influences to be plainly distinguished.

The data indicate that regions of the global oceans cool for multidecadal time periods and only warm in the short blasts associated with natural processes. Human greenhouse gases cannot pick and choose where and when they might cause global warming.

The hypothesis of human-induced global warming is fatally flawed.

Chapter 9.9 – The Easiest Way to Understand Those ENSO-Caused Upward Steps in the Sea Surface Temperatures

Section 9 (and elsewhere in this book) provides a reasonably detailed explanation of the processes of El Niño and La Niña events and how, together, they cause the sea surface temperatures of the Atlantic, Indian, and West Pacific Oceans to warm in upward steps, shifts, or "big jumps".

I will now present a simple way to understand those upward shifts.

I focus on the 1997/98 El Niño for three reasons: (1) it was the strongest El Niño in recent years; (2) it was so strong that it was able to overcome almost all of the weather noise that is seen in the sea surface temperature responses to lesser El Niños; and (3) there were no large explosive volcanic eruptions which could have to skewed the responses of sea surface temperatures to that El Niño event.

The effects of the 1997/98 El Niño on the sea surface temperatures of the entire East Pacific Ocean are highlighted in Figure 9-38.

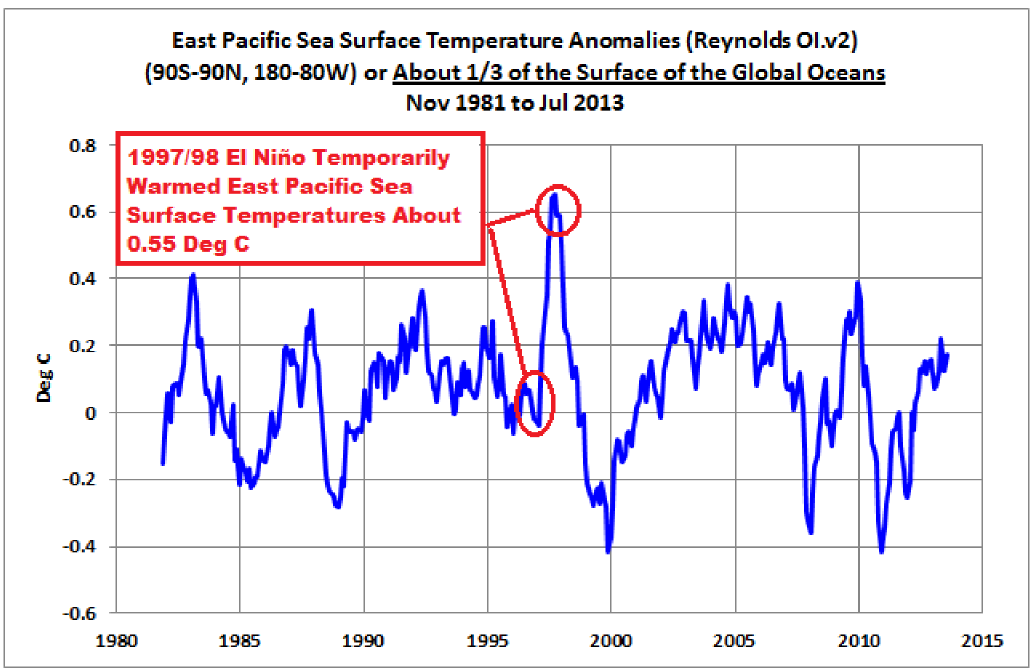


Figure 9-38

The 1997/98 El Niño released a monstrous volume of sunlight-created warm water from beneath the surface of the West Pacific Warm Pool, located in the western tropical Pacific. It released so much warm water and spread so much of that warm water across the surface of the East Pacific Ocean that sea surface temperatures there warmed about 0.55 Deg C. Bear in mind that the East Pacific Ocean covers about 1/3 of the surface of the global oceans.

At the end of the El Niño, the leftover warm water flowed into the Atlantic, Indian, and West Pacific Oceans, which cover the other 2/3 of the surface of the global oceans. The ocean's sea surface temperatures must warm as soon as that leftover warm water reached the Atlantic, Indian and West Pacific Oceans.

If it was strictly a one-third/two-thirds relationship, **and it definitely is not**, the sea surface temperatures of the Atlantic, Indian and West Pacific Oceans would have warmed 0.275 deg C.

WHEN THE RESIDUAL WARM WATER FROM THE EL NIÑO LEFT THE EAST PACIFIC

When that warm water released by the 1997/98 El Niño flowed into the 2/3 portion (the Atlantic, Indian, and West Pacific Oceans), sea surface temperatures there warmed about 0.19 deg C and remained at that level until the next strong El Niño in 2009/10. (See Figure 9-39.)

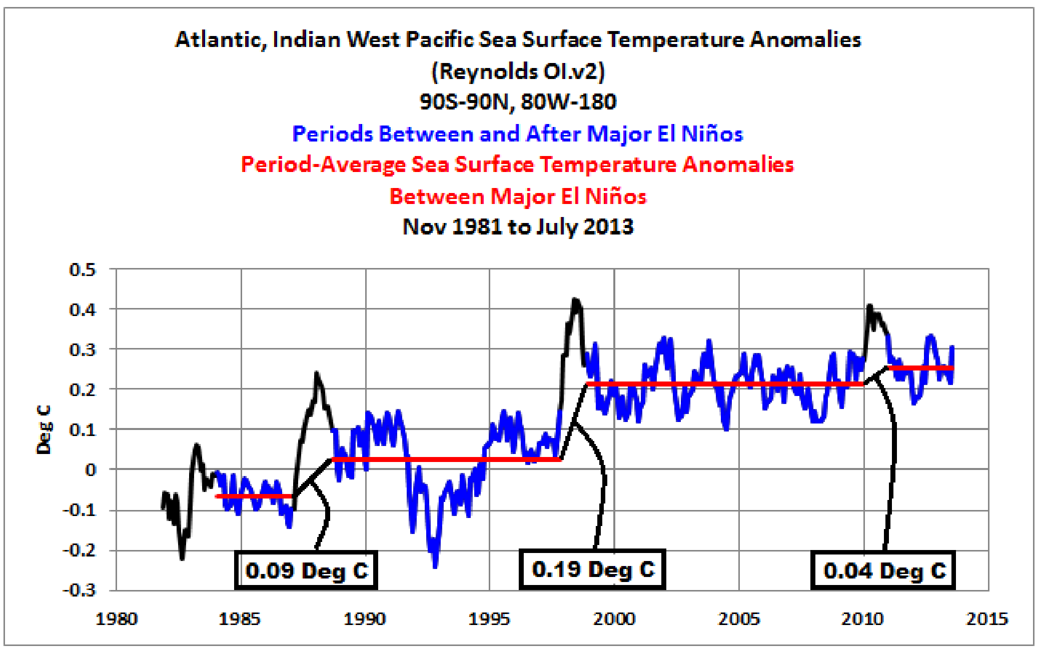


Figure 9-39

With the exception of the dip-and-rebound associated with the 1991 eruption of Mount Pinatubo, sea surface temperatures between and after the strong El Niño events were relatively stable. It appears as though the sea surface temperatures of the Atlantic, Indian, and West Pacific Oceans reached a new balance point, a new "happy medium," with each strong El Niño.

The curve in Figure 9-39 is reminiscent of the temperature record of a room thermostat where someone raised the thermostat setpoint at three different times. After each change in setpoint, the room temperature overshoots its mark, then returns to the setpoint and remains there until the next change in setpoint.

TRENBERTH'S "BIG JUMPS" AND "MISSING HEAT"

The work of NCAR's Kevin Trenberth has been referred to numerous times throughout this book. On May 22, 2013, the Royal Meteorological Society published at their website an article by Dr. Trenberth titled: "Has Global Warming Stalled?"

Trenberth included an annotated graph of global surface temperatures since 1971. I've replicated it in my Figure 9-40.

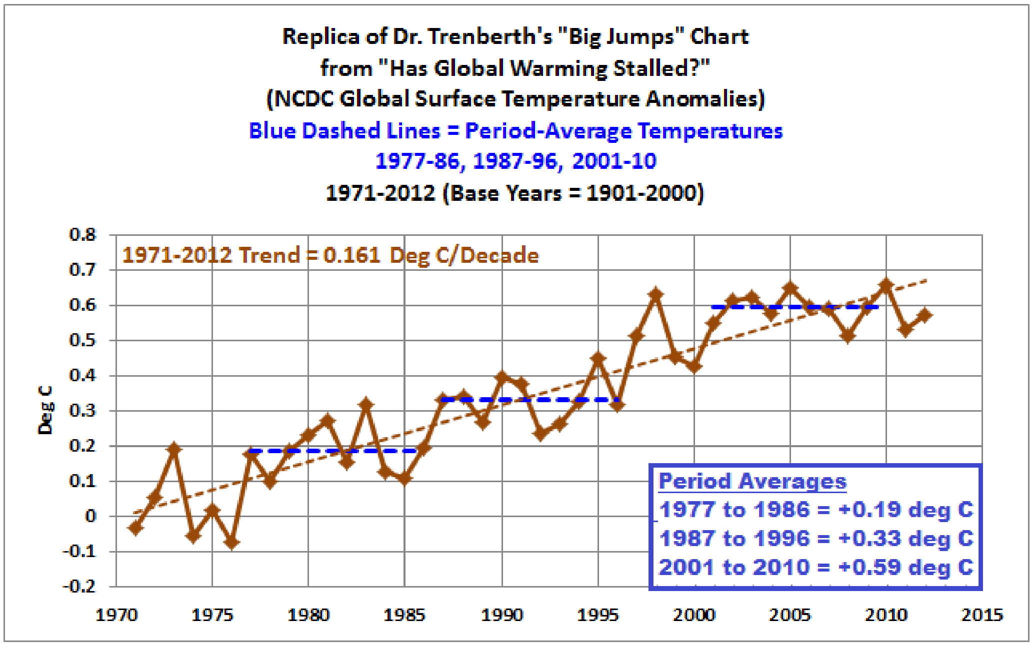


Figure 9-40

About that graph, Trenberth writes (my boldface):

> *Coming back to the global temperature record: the past decade is by far the warmest on record. Human induced global warming really kicked in during the 1970s, and warming has been pretty steady since then. But while the overall warming is about 0.16°C per decade, there are 3 10-year periods where there was a hiatus in warming. From 1977 to 1986, from 1987 to 1996, and from 2001-2012. But at each end of these periods there were **big jumps**.*

Trenberth never explained the "big jumps". Note the timings of the "big jumps." Two of them coincide with the 1986/87/88 and 1997/98 El Niños, which I've discussed in depth in Section 9 and elsewhere in the book. The "big jump" in 1976/77 is associated with the Pacific Climate Shift of 1976, which I discussed in Chapter 5.2. Trenberth mentioned the "big jumps" but didn't bother to mention the fact that they were responses to natural processes. He chose instead to assert that they were caused by manmade greenhouse gases.

Trenberth did not bother to explain the "big jumps" to the Royal Meteorological Society, but, I did. (See my detailed post "Open Letter to the Royal Meteorological Society Regarding Dr. Trenberth's Article 'Has Global Warming Stalled?'" The WattsUpWithThat cross post is here.)

While discussing his RMS article, Trenberth's concluding remarks are worth noting:

> *So the current hiatus in surface warming is a transient and global warming has not gone away: there is a continuing radiative imbalance at the top of atmosphere. But the global warming is manifested in a number of ways.*

Based on the instrument temperature record, "hiatus" periods can last for 30 years, so they are not what one would normally think of as "transient".

Additionally, whenever the current generation of climate scientists mentions "radiative imbalance" or the problems they are having finding "missing heat", I'm reminded of a climate researcher from an earlier generation, one of the all-time greats: Carl-Gustaf Rossby. Rossby waves are discussed a number of times in this book. They are named after Carl-Gustaf Rossby, a Swedish-U.S. meteorologist. According to Wikipedia's webpage about Rossby, he was first to explain "the large-scale motions of the atmosphere in terms of fluid mechanics."

Rossby (1959) is the opening chapter of the book *The Atmosphere and Sea in Motion* edited by Bert Bolin (1959). That chapter is titled "Current Problems in Meteorology". In it, Rossby made a pertinent statement about global energy balance:

> *The assumption that our planet as a whole stands in firm radiation balance with outer space cannot be accepted without reservations, even if periods of several decades are taken into account.*

It seems that 1959's "Current Problems in Meteorology" are today's problems in "climate science." Each of the three strong El Niños discussed throughout this section had a major impact on the Earth's energy balance. They released immeasurable amounts of heat into the atmosphere through evaporation and shifted upward the sea surface temperatures of the Atlantic, Indian, and West Pacific Oceans in measureable amounts.

That was apparently one of the primary points Trenberth was trying to make in his infamous "travesty" email from the Climategate emails. Trenberth wrote:

> *Where did the heat go? We know there is a build up of ocean heat prior to El Nino, and a discharge (and sfc T warming) during late stages of El Nino, but is the observing system sufficient to track it? Quite aside from the changes in the ocean, we know there are major changes in the storm tracks and teleconnections with ENSO, and there is a LOT more rain on land during La Nina (more drought in El Nino), so how does the albedo change overall (changes in cloud)? At the very least the extra rain on land means a lot more heat goes into evaporation rather than raising temperatures, and so that keeps land temps down: and should generate cloud. But the resulting evaporative cooling means the heat goes into atmosphere and should be radiated to space: so we should be able to track it with CERES data. The CERES data are unfortunately wonting and so too are the cloud data. The ocean data are also lacking although some of that may be related to the ocean current changes and burying heat at depth where it is not picked up. If it is sequestered at depth then it comes back to haunt us later and so we should know about it.*

Trenberth has never explained how the heat could come back to haunt us.

CERES stands for "Clouds and Earth's Radiant Energy System." These are the satellites that measure the Earth's TOA (Top of the Atmosphere) energy imbalance. The climate science community, and Trenberth in particular, obviously do not think highly of their results. The basic problem was discussed in Hansen, et al. (2011) "Earth's Energy Imbalance and Implications":

> *The precision achieved by the most advanced generation of radiation budget satellites is indicated by the planetary energy imbalance measured by the ongoing CERES (Clouds and the Earth's Radiant Energy System) instrument (Loeb et al., 2009), which finds a measured 5-yr-mean imbalance of 6.5Wm−2 (Loeb et al., 2009). Because this result is implausible, instrumentation calibration factors were introduced to reduce the imbalance to the imbalance suggested by climate models, 0.85Wm−2 (Loeb et al., 2009).*

As is standard operating procedure with the current climate science community, when the dataset does not agree with climate model-based understandings, the dataset is changed to reflect the output of climate models — in a kind of self-fulfilling virtual-reality game.

As I noted many pages ago in the Introduction, according to Stephens, et al. (2013) "An Update on Earth's Energy Balance in Light of the Latest Global Observations," Earth's energy imbalance is now assumed to be in the neighborhood of is 0.6 **+/- 17** watts/meter^2 at the surface, not the 6.5 watts/meter^2 found by satellites.

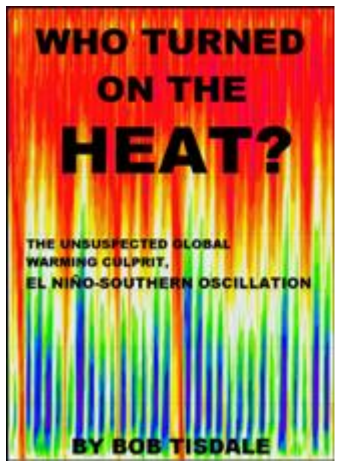
In view of what Rossby wrote so many decades ago, one could plausibly conclude that one of the focal points of climate science —radiative imbalance— may be a nonexistent problem. Further, as Trenberth noted in that infamous “travesty” email, climate scientists cannot account for the obvious, powerful, natural contribution of ENSO to the alleged “radiative imbalance.”

CHAPTER 9.9 SUMMARY

It is obvious that the residual warm waters left over from strong El Niño events had a very strong impact on the warming of sea surface temperatures for the Atlantic, Indian, and West Pacific Oceans over the past 3+ decades. In fact, it’s impossible to overlook those “big jumps” in sea surface temperatures. NCAR’s Kevin Trenberth acknowledged their existence in his article for the Royal Meteorological Society, but he did not try to explain the processes that caused those upward steps.

Finally, “radiative imbalance,” a hot topic with the climatologists, looks to be a non-issue. It can’t be measured, so climate scientists assign it a fantasy value based on the virtual worlds of climate models.

Chapter 9.10 - *Who Turned on the Heat?* and the Videos "The Natural Warming of the Global Oceans"



I referred to my other book ***Who Turned on the Heat?*** a number of times throughout this one. ***Who Turned on the Heat?*** expands on the discussions in Section 9. That is, ***Who Turned on the Heat?*** provides a much more-detailed explanation of the processes of El Niño and La Niña events and how they caused the rise in satellite era sea surface temperatures, and also how El Niños and La Niñas contributed to the warming of the oceans to depth as indicated by ocean heat content data since 1955.

For a very basic introductory explanation of the processes of El Niño and La Niña events, I created a series of 29 cartoon-like illustrations for ***Who Turned on the Heat?*** An example (the 12th illustration in the series of 29) follows.

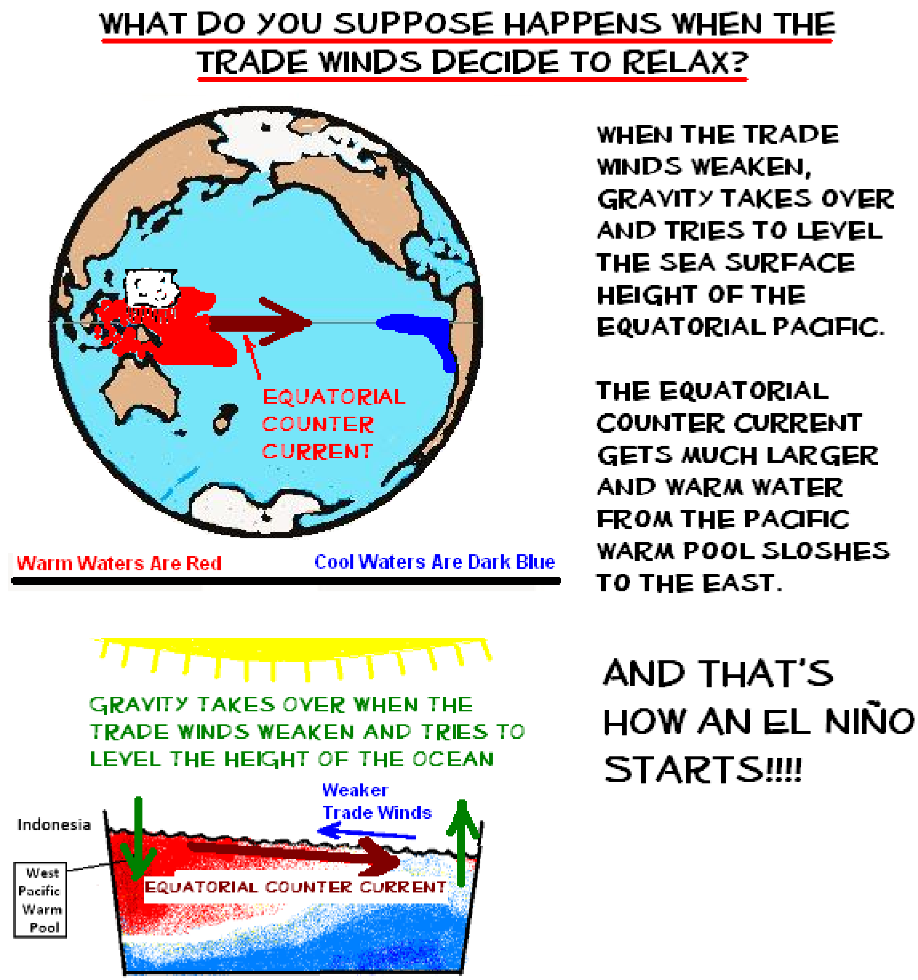


Figure 1-12

Bob Tisdale

Who Turned on the Heat? is only available in .pdf form. A preview is here.

Who Turned on the Heat? is described further in, and is available for sale through, my blog post "Everything You Ever Wanted to Know About El Niño and La Niña". It costs only US$8.00. **Please buy a copy of *Who Turned on the Heat?*** Transactions are handled through PayPal, but **you do not have to have a PayPal account**. Simply scroll down to the "Don't Have a PayPal Account" purchase option.

I prepared animations for ***Who Turned on the Heat?*** They allow you to view the impacts of ENSO on a number of variables. They can be found linked at my blog post appropriately titled Animations Discussed in "Who Turned on The Heat?"

Additionally, for those who like to watch and listen, I prepared a 2-part series of narrated YouTube videos titled "The Natural Warming of the Global Oceans". Part 1 is here and Part 2 is here.

Closing – When Will Climate Models Be Credible Tools?

Climate Models Fail illustrated and discussed the many flaws inherent in climate models. These included the fact that they do not properly simulate surface temperatures, precipitation, and sea ice area.

You may be asking yourself, "*If the models perform so poorly, how can there be hundreds, if not thousands, of climate studies which show models performing well?* "

First, not all climate model-based studies include the model runs stored in the archives that are used by the IPCC. Some papers are based on special model runs that are tuned specifically for a given study, so they are different than the simulations used for the IPCC hindcasts and projections. Second, the CMIP archives include the model outputs from dozens of modeling groups, and some of the modeling groups submit more than one type of model to the CMIP archives. Each model performs some functions well in specific regions — with some models performing better than others. But, that does not mean any of the models simulate all metrics well in all regions…or globally. The modelers understand the strong points of individual models. So, for any particular climate study, they pick and choose from a smorgasbord of climate models and runs. One study about metric "a" in location "a" may include 3 different models, the next study of metric "b" in location "a" may utilize 2 other models, while yet another study of metric "b" in location "b" may be based on a completely different model that wasn't presented in the other two studies. The climate modeling groups are obviously only going to present their models in favorable lights.

Thankfully, there are scientific research papers that expose climate models' serious flaws. As presented in *Climate Models Fail*, those studies found that current climate models (CMIP5) are not able to properly simulate:

- The coupled ocean-atmosphere processes of El Niño and La Niña, the largest contributors to natural variations in global temperature and precipitation on annual, multiyear, and decadal timescales.
- Responses to volcanic eruptions, which can be so powerful that they can even counteract the effects of strong El Niño events.
- Precipitation — globally or regionally — including monsoons.
- Cloud cover.
- Sea surface temperatures.
- Global surface temperatures.
- Sea ice extent.
- Teleconnections, the mechanisms by which a change in a variable in one region

of the globe causes a change in another region, even though those regions may be separated by thousands of kilometers.
- Blocking, which is associated with heat waves.
- The influence of El Niños on hurricanes.
- The coupled ocean-atmosphere processes associated with decadal and multidecadal variations in sea surface temperatures, which strongly impact land surface temperatures and precipitation on those same timescales.

According to one of the papers, the current generation of climate models (CMIP5) are worse at simulating past global climate than the previous generation of models (CMIP3); i.e., the models are making giant leaps, but in the wrong direction.

Additionally, I showed quite clearly that the models cannot accurately simulate:

- Polar Amplification.
- Daily maximum and minimum temperatures and the diurnal temperature range.

And I illustrated and discussed why it is of paramount importance for models to accurately simulate the coupled ocean-atmosphere processes that express themselves as:

- Multidecadal variations in the sea surface temperatures of the Northern Hemisphere.
- El Niño and La Niña events — and the multidecadal variations in the dominance of those phases.

I also prepared a blog post that presents step-by-step instructions for creating a model-data comparison graph. That post is linked within *Climate Models Fail*. Using those instructions, anyone can verify the results presented in this book. [See the post here.]

Climate models have a number of tremendous hurdles to overcome, and the highest are coupled ocean-atmosphere processes. Satellite-enhanced sea surface temperature data reveals that two ocean basins are responsible for the cessation of global warming: the Southern Ocean surrounding Antarctica and the largest ocean basin on Earth, the Pacific. The fundamental coupled ocean-atmosphere processes that are driving the warming plateau are associated with ENSO (El Niño-Southern Oscillation). Yet, it is well-known that climate models cannot simulate ENSO.

Because El Niño and La Niña processes are the primary causes of the variations in surface temperature and precipitation on annual, multiyear, decadal, and multidecadal bases, and because the instrument temperature record shows that sunlight-fueled El Niño and La Niña processes are the primary causes of the long-term warming of the oceans, ENSO should be an area of intense modeling efforts.

The coupled ocean-atmosphere processes that drive multidecadal variations in sea surface temperatures will be more of a problem. The sea surface temperature record is globally complete only during the satellite era — the last 30 years. Further, the subsurface temperature and salinity records of the oceans are globally complete for only the past decade or so; moreover, the subsurface data are riddled with problems. It will be decades before the climate science community can hope to **begin** to have a data-based understanding of subsurface ocean "weather" and its interactions with ocean-atmosphere processes.

Growth in climate science has been stunted by the IPCC's politically-driven addiction to conjectures about anthropogenic climate change. Decades after it began, climate science is still in its infancy. Yet, it is portrayed as a well-established, noble, bastion of solid research, the flawless jewel of Earth sciences that can do no wrong. Worse, climate science has been ruthlessly exploited by environmental groups and politicians and even by many of the scientists themselves.

The primary obstacles for the climate science community in the years and decades to come are: (1) the expectations of government funding agencies, which are obviously tied to political agendas; and (2) the anchoring effect of the fanatical beliefs of those members whose careers and funding skyrocketed as a result of their drum beating for the IPCC.

The people of the world rely on the findings of the climate science community, and in order for climate science to move forward, that community will have to be honest within itself and with the public. Hopefully, that will occur in my lifetime, but I'm not holding my breath.