Climate Change
By the Numbers

John R. Christy
University of Alabama in Huntsville
Alabama State Climatologist

Lecture by Dr. Christy Oct. 4, 2007

Consensus is not Science

Michael Crichton

Michael Crichton said several years ago a very accurate statement that "Consensus is not science".

That's the political notion. I have been on many of these panels. And I assure you that that is a political notion of who can be the biggest bully in the room basically and get across a particular point. And then as time as gone on, especially with these consensus reports, you weed out the people you don't want to contribute to them and so it becomes a consensus to those that agree with the consensus.

2,300 scientist can never agree on anything.

With the IPCC, the final words don't represent the final truth. It is an evolving document that is based on compromise

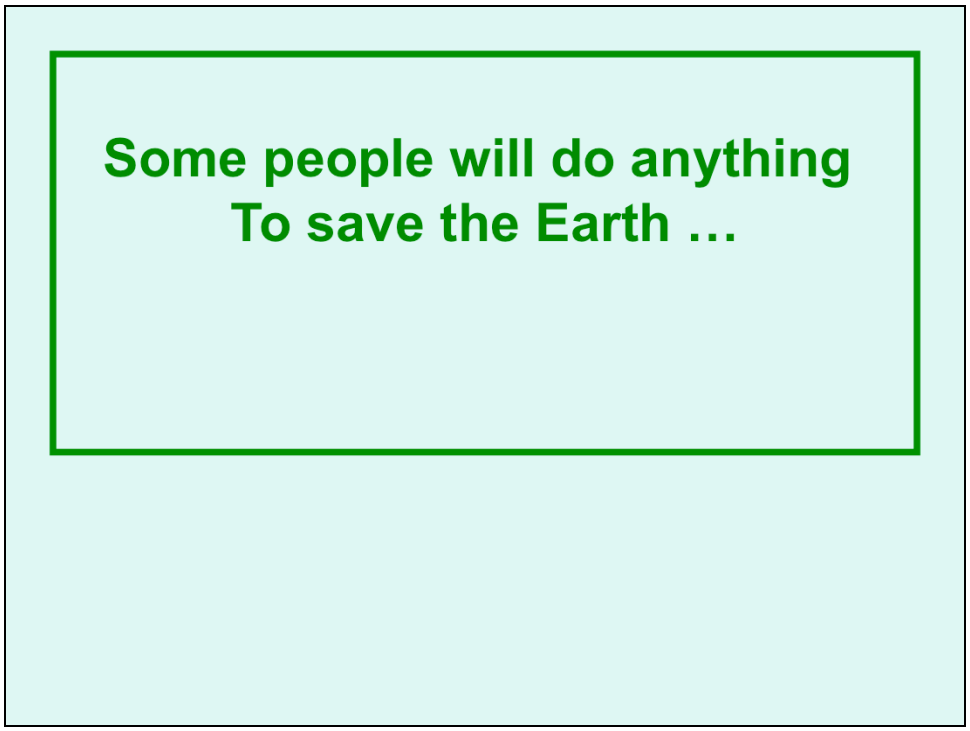
Consensus is not Science

Michael Crichton

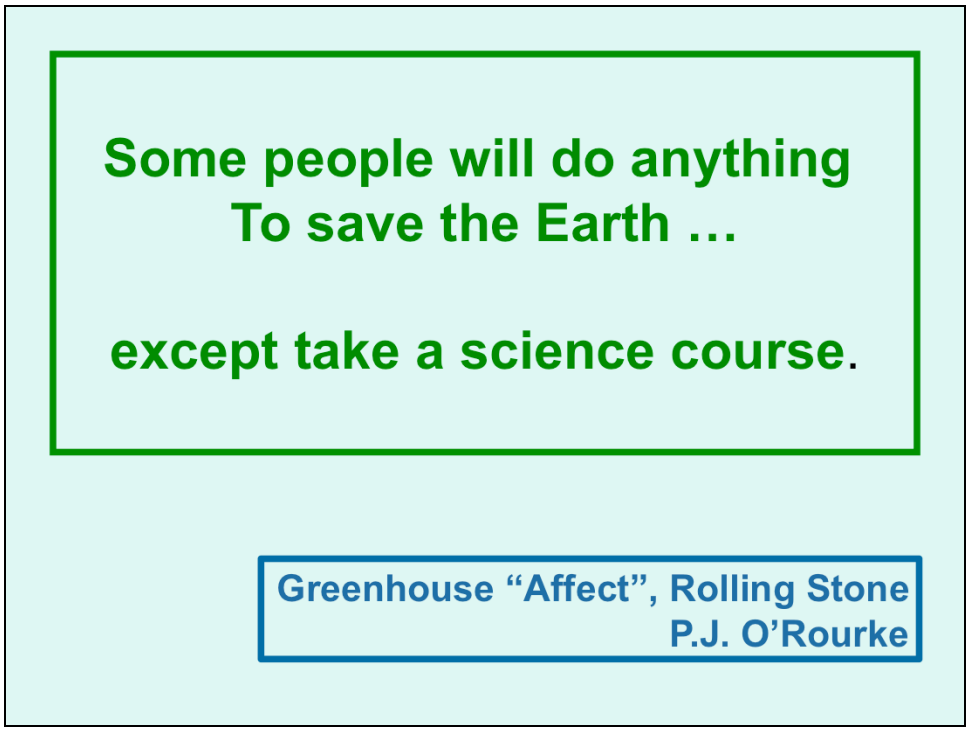
All Science is numbers

William Thomson (Lord Kelvin)

Fortunately, Lord Kelvin told us what science is. And he tells us that all science is numbers. If you want to say something scientific, you really have to put it into a metric. You have to put it into a number.



My Favorite author tells us something.



Science is hard primary because it involves numbers

One of the best predictors about how students will do in graduate school is how they deal with numbers

Quite often when I deal with people about global warming they don't have a background in numbers, but they believe things about the way the world works or their view of the world. And those folks are very difficult to deal with.

The Basic Numbers

- **Carbon Dioxide has increased 38%**

Let's start with some basic numbers about global warming.

Carbon dioxide is a trace gas in the atmosphere. I has increased by 38% in the past 150 years or so do to human progress.

The Basic Numbers

- Carbon Dioxide has increased 38%
- **Global Surface temperature rose 0.7 °C in past 100 years**

The global surface temperature which we will talk about in a minute, rose about 7 tenths of a degree in the past 100 years.

The Basic Numbers

- Carbon Dioxide has increased 38%
- Global Surface temperature rose 0.7 °C in past 100 years
- **Surface temperature response to 2xCO2 increases (alone) is ~ 1 C**

If you just have the physics of the problem and you say, you increase carbon dioxide by double in the atmosphere, the response at the earth's system at the surface will be about 1 degree C. That is if no other processes, feedback or change, no other interactions occur.

The Basic Numbers

- Carbon Dioxide has increased 38%
- Global Surface temperature rose 0.7 °C in past 100 years
- Surface temperature response to 2xCO2 increases (alone) is ~ 1 C
- **The associated feedbacks are where the uncertainties are large (i.e. no confident numbers)**

That is where all the uncertainties come from. Does it change the cloud cover? Does it change the ice distribution? Does it change the color of the plant? All those types of feedback are where the enormous types of warming scenarios that are foisted upon you by the media, come from. A climate model will have a trigger in it that is you add a little bit of heat due to CO2, then the trigger occurs and the heating goes off the chart. So that's where the uncertainties really are.

The Basic Numbers

- **Humans produce about 7 to 8 gigatons of CO2 (carbon mass) per year mainly from energy production**

You and I and the other 6 billion people on the planet produce between 7-8 gigatons of CO2 per year. Mainly because we burn carbon and it creates heat from which we get energy, to our great benefit as you will see.

The Basic Numbers

- Humans produce about 8 to 9 gigatons of CO2 (carbon mass) per year mainly from energy production
- **About 3.5 to 4 gigatons accumulate in the air each year**

About half of that stays in the atmosphere each year. So if we produce 8 gigatons, about half of that absorbed by the plants and the ocean and removed.

The Basic Numbers

- Humans produce about 8 to 9 gigatons of CO2 (carbon mass) per year mainly from energy production
- About 4 to 4.5 gigatons accumulate in the air each year
- **There are about 740 gigatons of CO2 in the atmosphere**

But, the other half stays in the atmosphere and with about 740 gigatons in the air right now.

The Basic Numbers

- Humans produce about 8 to 9 gigatons of CO2 (carbon mass) per year mainly from energy production
- About 4 to 4.5 gigatons accumulate in the air each year
- There are about 740 gigatons of CO2 in the atmosphere
- **CO2 in the atmosphere is increasing around 0.5% per year**

That means that the atmospheric rate is growing at about 0.5% per year. We are up to about 385 parts per million right now of carbon dioxide.

The Basics

- **Carbon Dioxide is essential for all of life**
  - **"Plant Food" is its best definition**
  - **16% increase in world-wide food production due to extra CO2 emitted by human progress**
- **Climate is always "changing"**
  - **Global temperature is rising or falling**
  - **Sea level is rising or falling**
  - **Glaciers are retreating or advancing**

Just a couple basics.

Carbon Dioxide is an essential for all of life. You hear it demonized a lot. But, "plant food" is the best definition of carbon dioxide. In fact 16% of the world-wide food production is simple due to the extra CO2 that we put back into the atmosphere. Wonderful, fantastic benefit that this world has received because of that extra CO2.

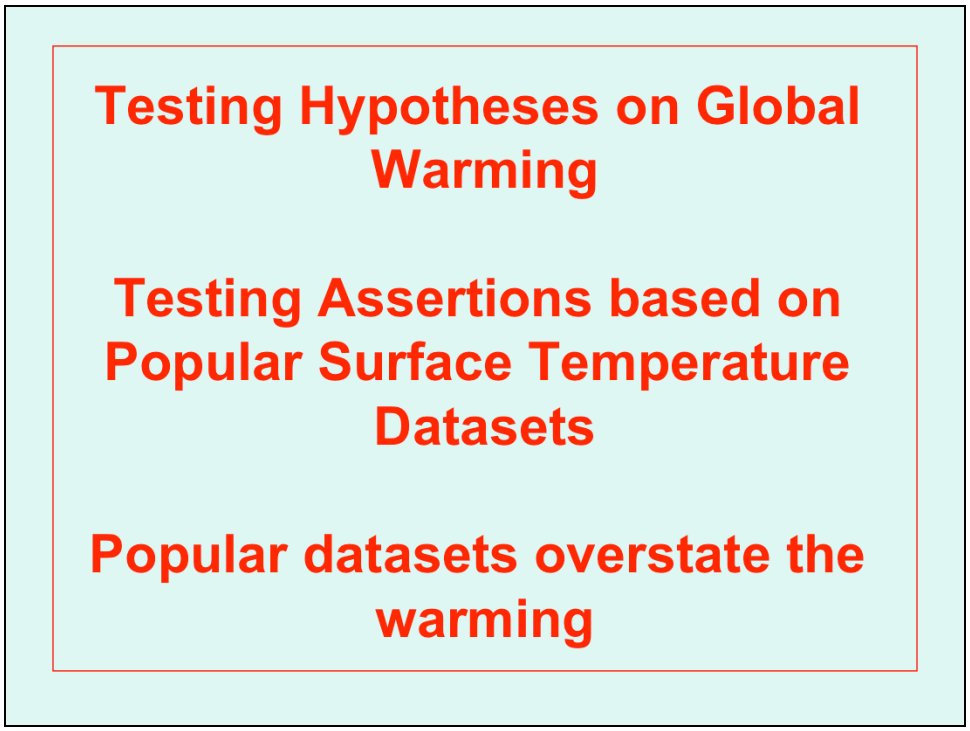
The Basics

- Carbon Dioxide is essential for all of life
  - "Plant Food" is its best definition
  - 16% increase in world-wide food production due to extra CO2 emitted by human progress
- **Climate is always "changing"**
  - **Global temperature is rising or falling**
  - **Sea level is rising or falling**
  - **Glaciers are retreating or advancing**

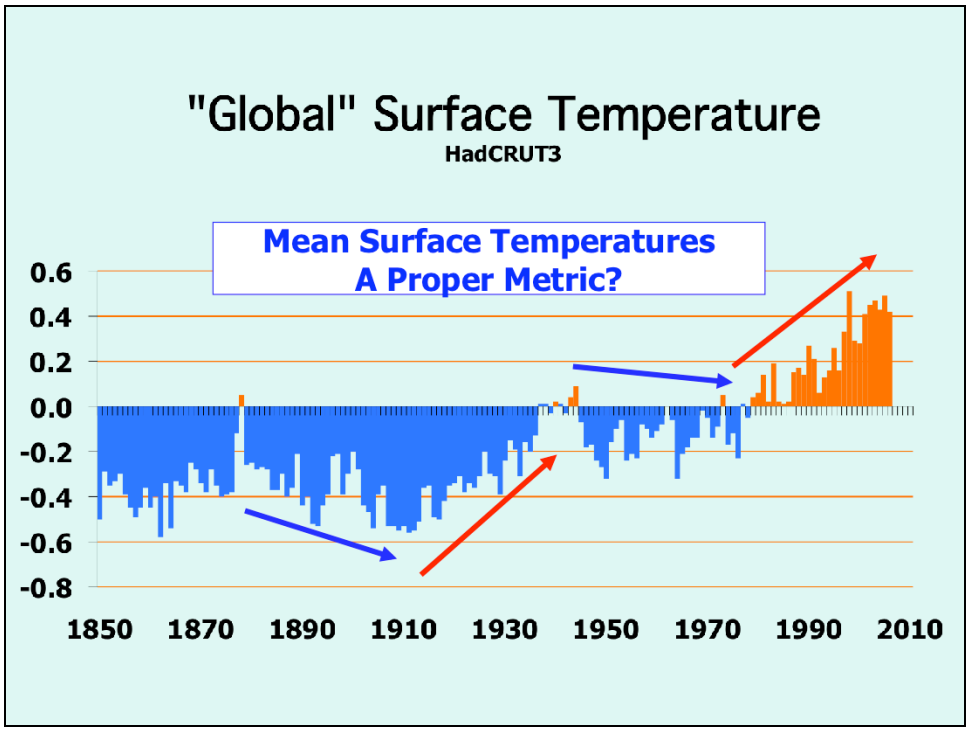
And climate is always changing. Global temperature is never static. It is either rising or falling.

Sea level is either rising or falling

Glaciers are either retreating or advancing. I assure you, or let me just ask the question, "Do you want to live in a world where glaciers are retreating or advancing?" Think about that.



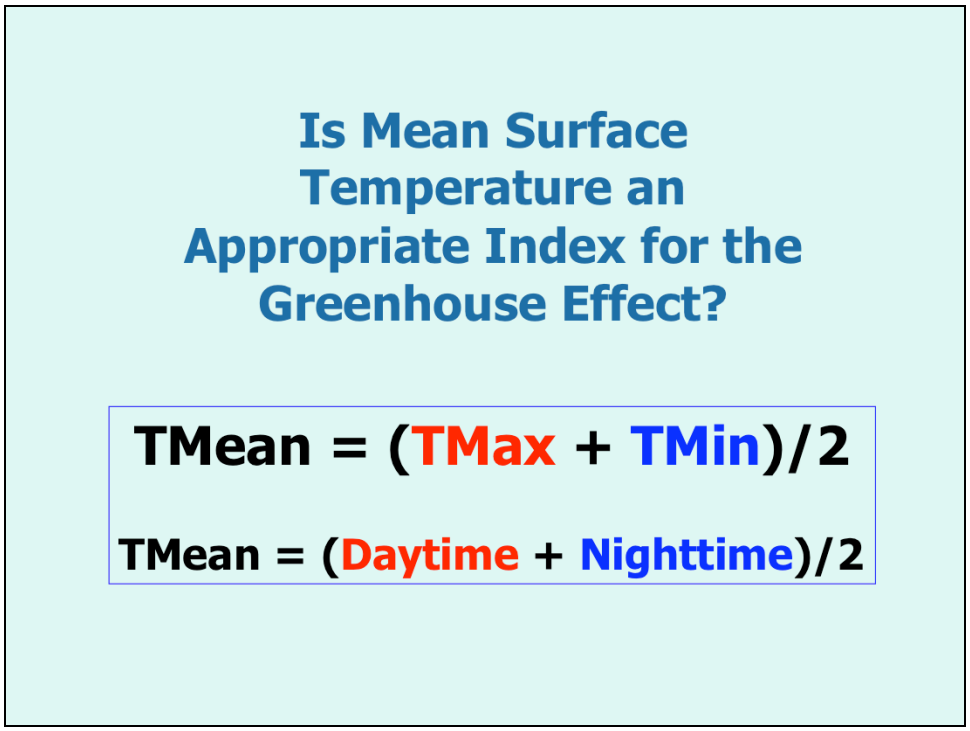
What we do in climate science, the part that I am in, is that we like to test hypotheses, you know assertions that people make about the global climate and about global warming. We in Huntsville are one of the few places in the world that build datasets from scratch. We start with the digital counts from satellites, we start with original balloon releases or from dusty records from an English library or so on. We the data sets from those things to test these assertions.



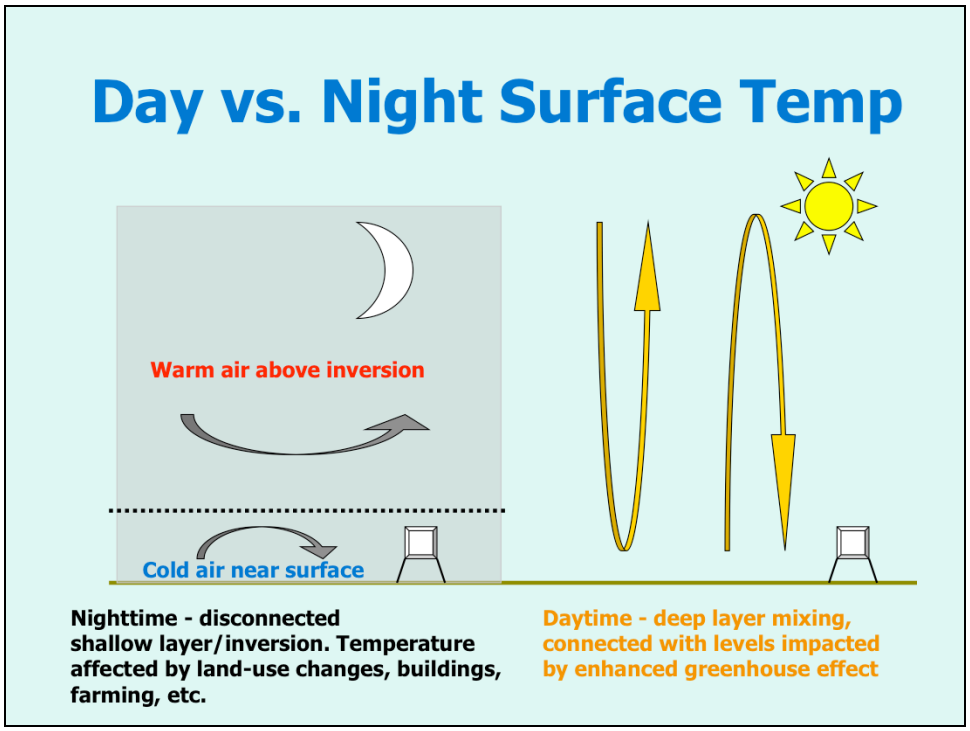
What we have found are that the popular surface datasets overstate what warming is occurring.

For example this is the one that shows the temperature for the last 160 years. We are pretty much told that those first part of that graph are due to Mother Nature, but that last rise is due to human effects.

There is no doubt that carbon dioxide has gone up, that is for sure. And carbon dioxide is a thermal gas and so it will cause warming to some extent. That is one where there really is a consensus about by most people.

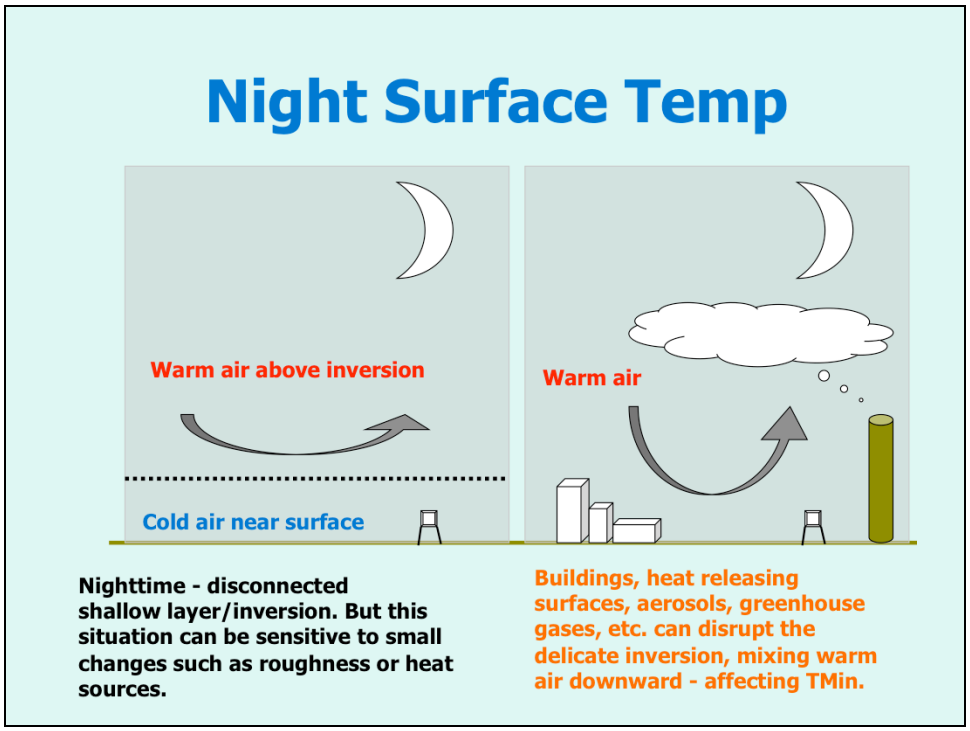


The mean surface temperature is an average of two things. It's an average of the daytime high and an average of the nighttime low. Daytime plus nighttime divided by two. When you show something to congress you have to make it simple. (daytime + nighttime)/2. Then the chairman of the committee asked me, "Dr. Christy, what do you mean by CORRELATION?" Well, where do I start?



So let's look at day versus night temperature.

If you look at the nighttime temperature on the left, what happens is that the air near the surface decouples from the air aloft, quite often. So that very cold, heavy air settles right here and it is disconnected from what happens above. Now the daytime, because the surface is heated, there is lot's of mixing. So if you want to measure what's happening in the upper air, where the greenhouse effect is largest, where the signal is greatest, you would want to measure what happening during the daytime, not the nighttime.



Here is another reason about that.

In the nighttime, like I said, in an undisturbed place, you have warm air, which really doesn't change much from day to night. When you go up a thousand feet, the temperature doesn't change much from day to night. Whereas the temperature at the surface does.

But if you add buildings, if you add aerosols, pollution, many many things actually disrupt this delicate inversion that sets up. And you create a situation where the warm air is mixed down, so the nighttime temperatures show a rapid warming. Not because of anything to do with a greenhouse effect. But, because of the way development has occurred on the surface of the earth.

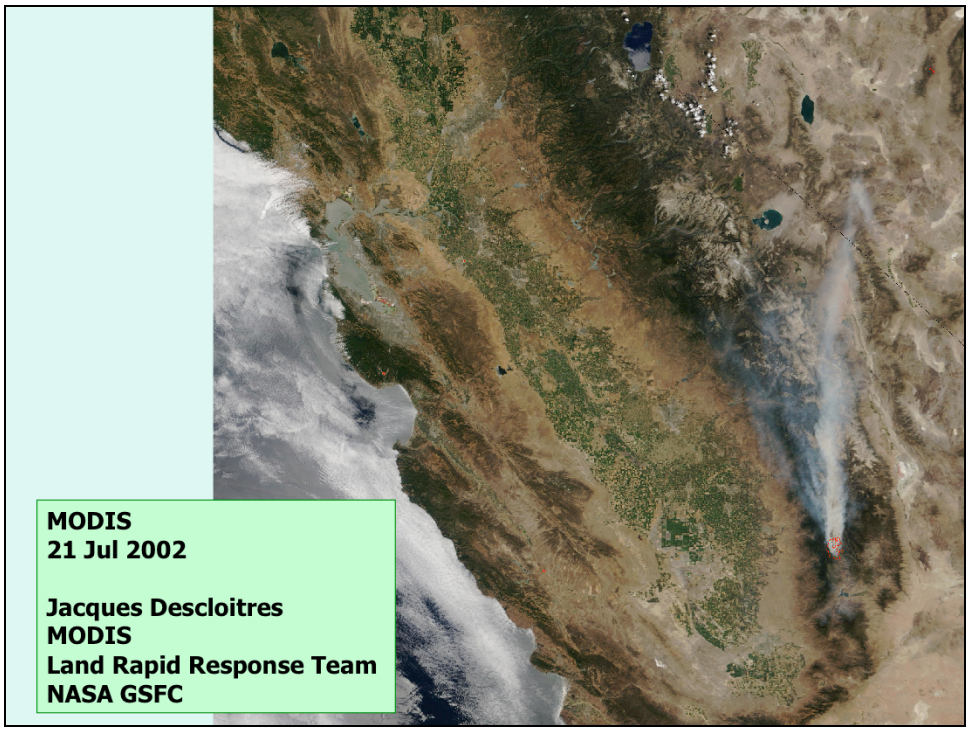
Darwin Glacier, 1908

Darwin Glacier, 2003

Christy et al. 2006, *J. Climate*

Let's go to a place where I was born and raised in California. This is Darwin glacier in Fresno California up in the Sierra's. That is about 4,000 meters elevation. You can see in this situation that in 1908 the glacier looked a lot bigger than it does right now in 2003. That glacier is going away, basically.

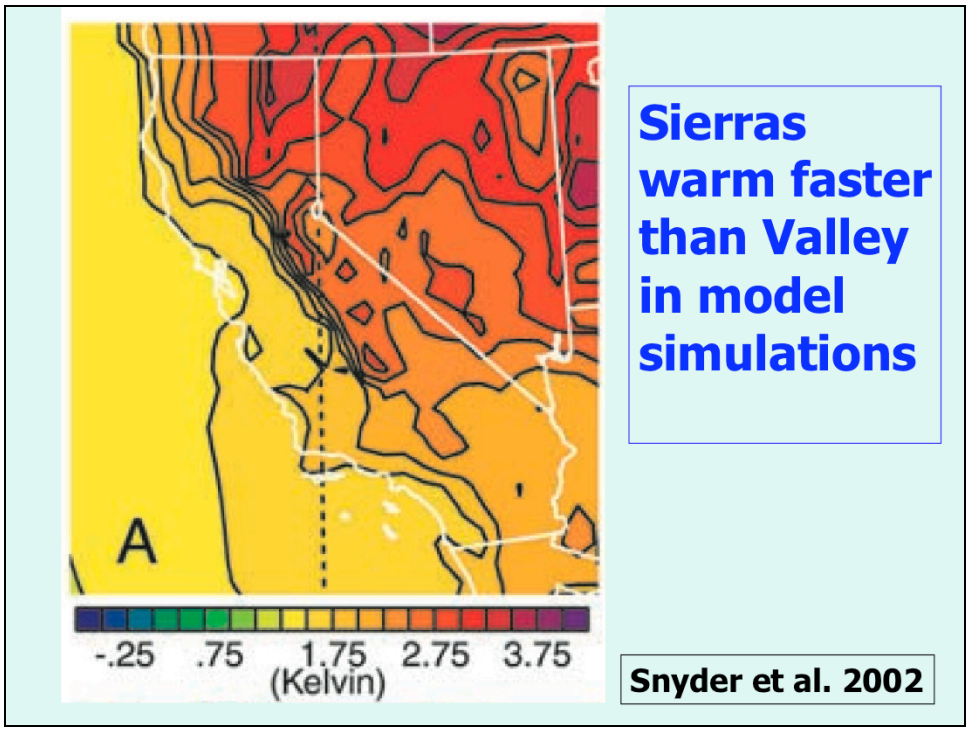
Pictures like this are often shown in climate change stories where they try to excite you about the disaster that is coming and fail to tell you that glaciers like this are about 800 years old. That they didn't even exist a few hundred years before that. Most of the glaciers in the U.S. are less than 5,000 years old. So there are periods, certainly in the last 5,000 years that were much warmer than it is today. But it turns out that glaciers are terrible thermometers.



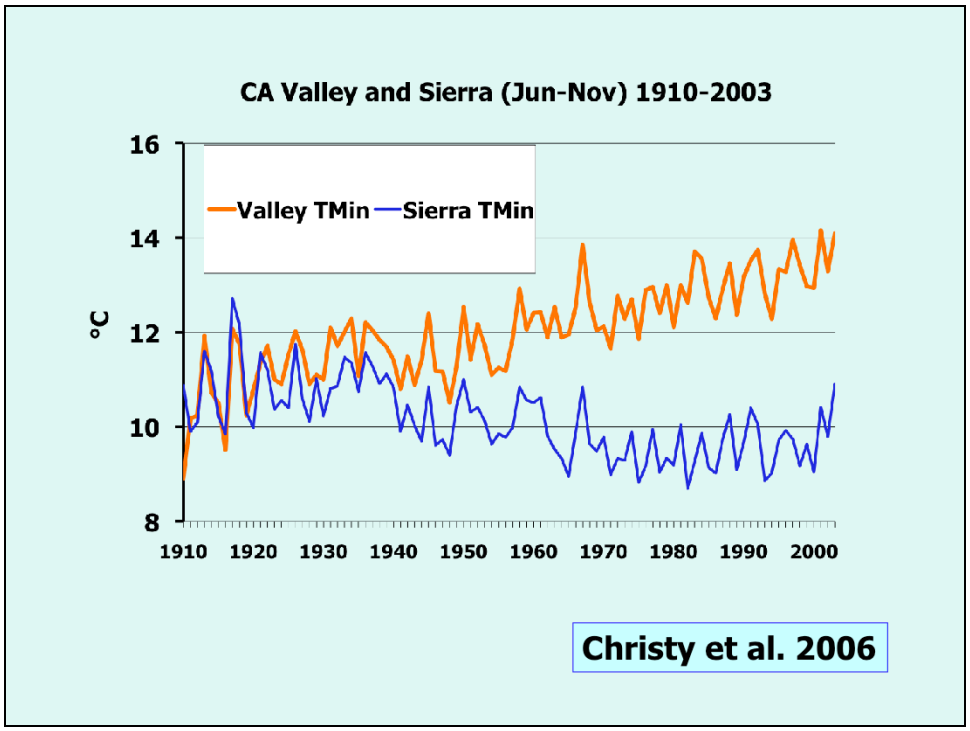
Let's go and look at that surface temperature dataset. That is what we do, we build these from scratch.

Lets, go to – I hope you can recognize California there. This is the central valley of California and there is something very unusual about that in this photograph. This is in July. See all that green? That shouldn't be there. It should be light tan like you see on the edge in the lowest levels of the foothills. That's a desert. Less than 10 inches of rain a year. That's a desert. And yet it is all green because of irrigation. I grew up playing in irrigation canals and riding through forests. We would always ride out bikes on the east side or orchards in the afternoon, because the wind would blow from the west and blow through the orchard and it would be cooler because of the irrigation. It's always 105 or something like that normally.

So irrigation has really changed the landscape there and the development of the surface. That should have an impact.

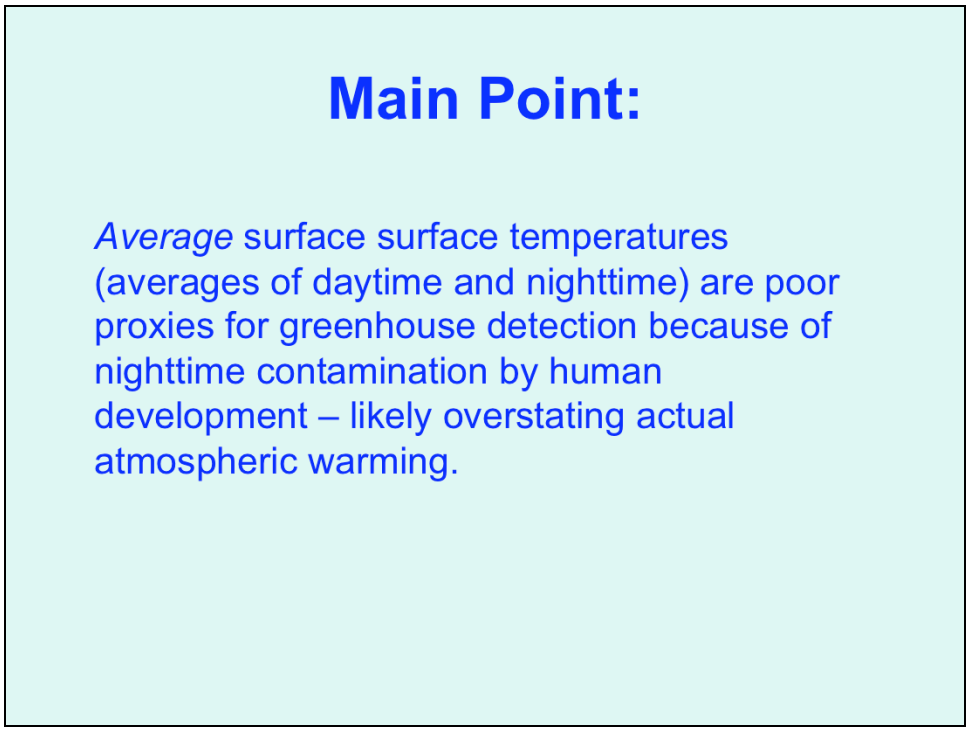


Now, if you go to climate change models. All of them show this feature right here. Where it says, "if greenhouse gas warming is occurring in California, the mountains should warm much faster than the lowland areas." The mountains should warm much faster than the lowland area, well let's go to the data.



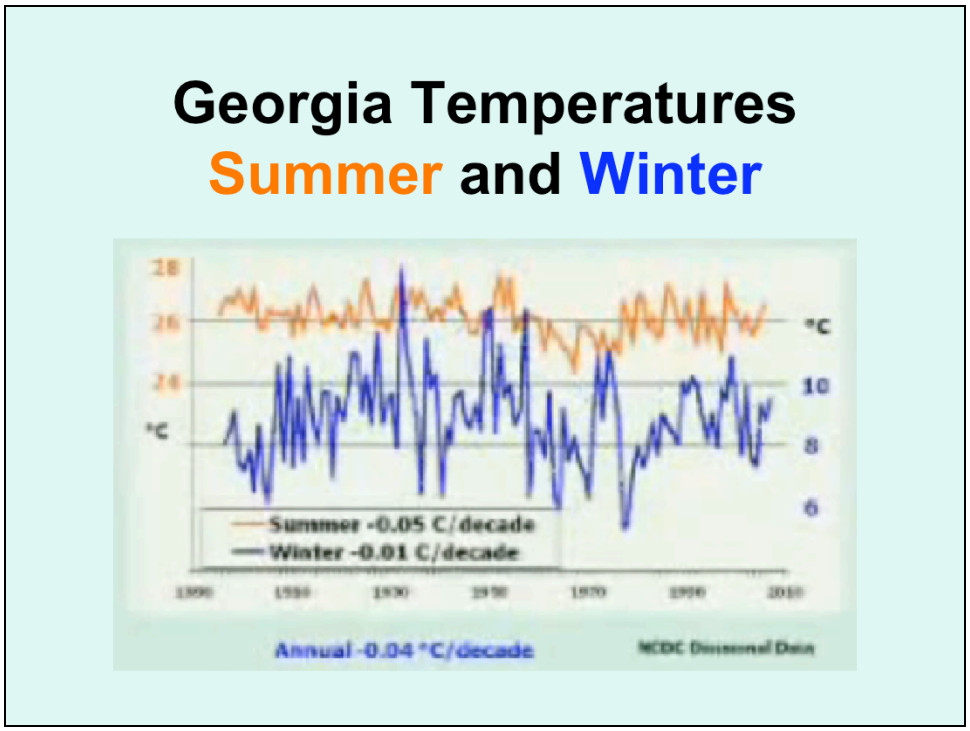
This was a paper published last year. It was very complicated work on trying to create the most robust, statistically verifiable time series of temperatures in the valley and the nearby Sierra foothills. The orange is what we got for the Sierra foothills - rapid rise. This is on the order of 5 degrees C rise per hundred years. This is a tremendous warming. In the very adjacent foothills the temperature has a slight decline. That tells you right there that this is not a greenhouse gas effect. It's going in the opposite way that greenhouse theory indicates. What it does indicate is what I was showing you 2 slides before – changing the surface character, changes the way that nighttime temperature cools. And because of the urbanization and irrigation it has changed that whole valley to a dark, moist, vegetative plain that the nighttime temperatures just can't cool off like they used to. And so that is in a sense a false signal. It's not greenhouse warming that is occurring there, it is development of surface warming that is occurring. It is human, there is no question about that. Humans are causing that rise, but it is not greenhouse that is affecting it.

I deal a lot with California, being a native of that area, and their governor has a very strong feeling that this greenhouse thing is something that must be attacked and dealt with and so on. The science here that is published says that if you want to change the temperature, depopulate the valley and return it to a desert. You will change the temperature back to what it was if you do that. ~~Dealing with greenhouse gases will have no consequence at all. And yet what~~ orders are being signed now in California and Florida are orders to deal with greenhouse gas production.

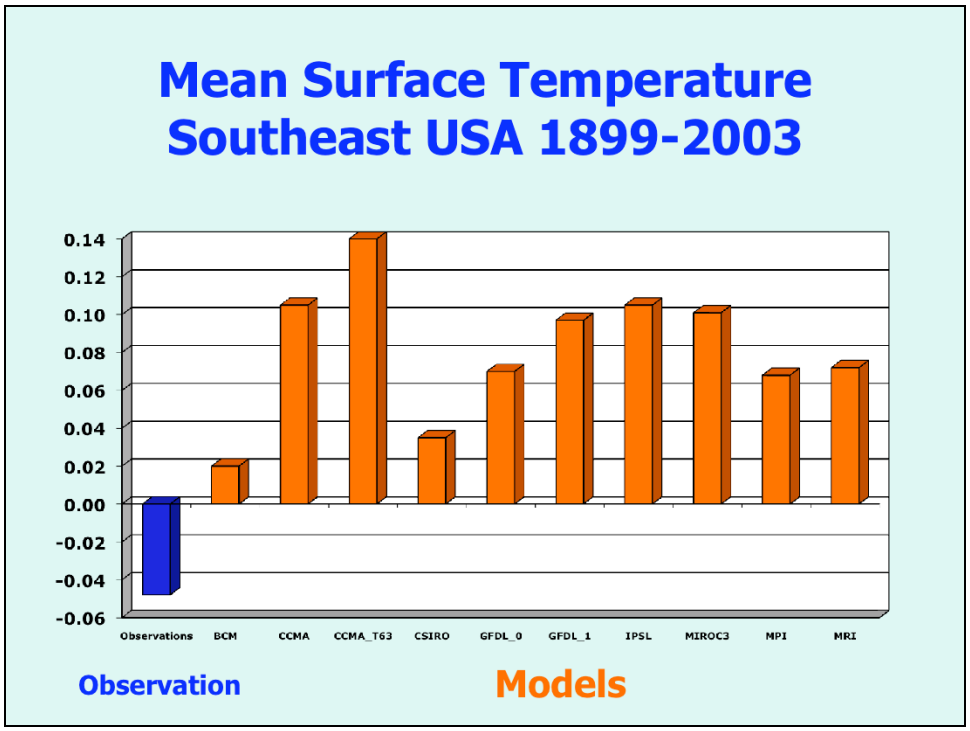


Here is the Main Point.

Average surface surface temperatures (averages of daytime and nighttime) are poor proxies for greenhouse detection because of nighttime contamination by human development – likely overstating actual atmospheric warming.

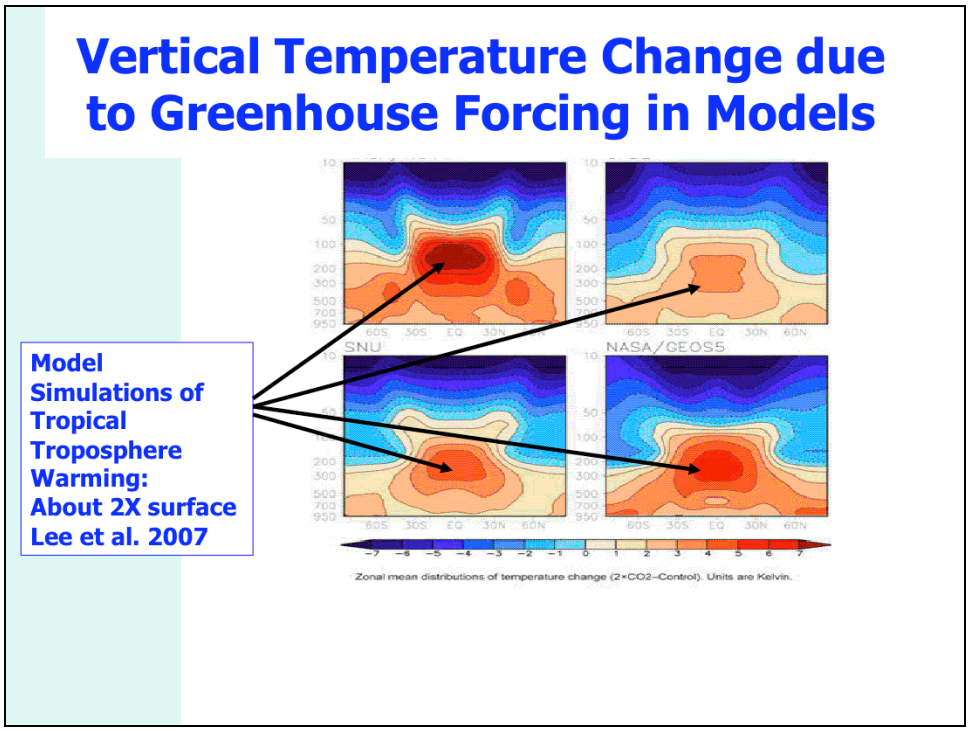


Now this is Georgia to show you that the same thing Is happening in Georgia. The temperatures have been slightly declining in that state as well. Both summer and winter.



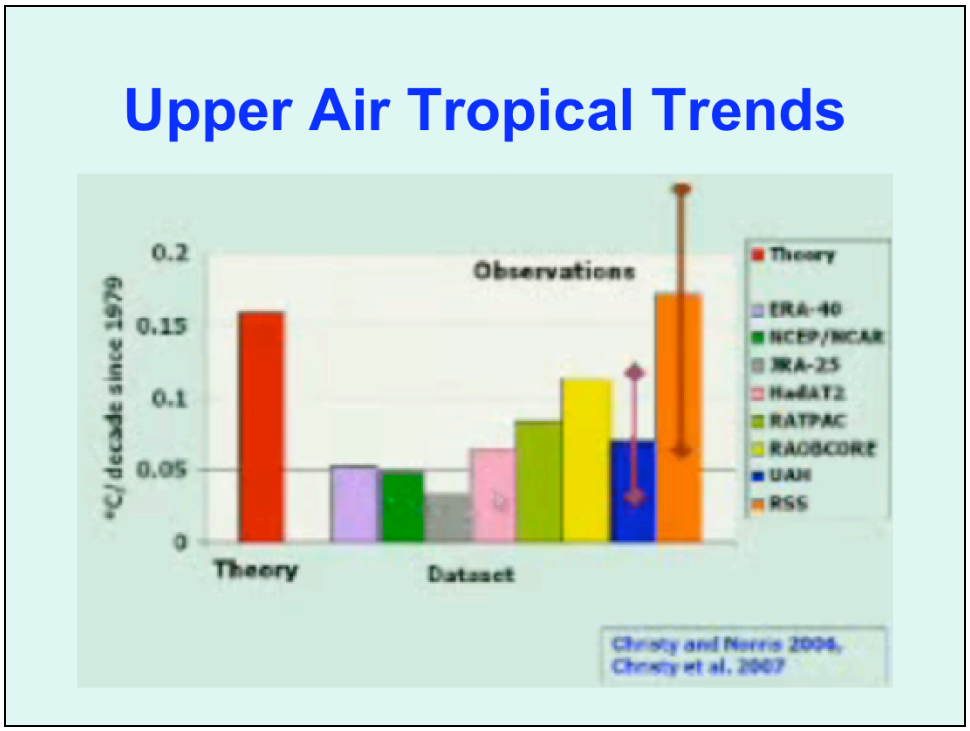
What do models suggest for the southeastern United States? The observations I have shown you have a declining temperature. So several models were taken and tried to reproduce the last 100 years or so of southeastern climate. Every single one (and there is more than this that I could have shown) every single one says that the temperature of the southeast should have risen and it didn't. One of the modelers said, "My model is right, it is the world that is wrong".

Let's go to the upper air temperature. Because I told you that the day time temperature, because of the mixing with the air above is a better proxy for what is happening in the upper air.

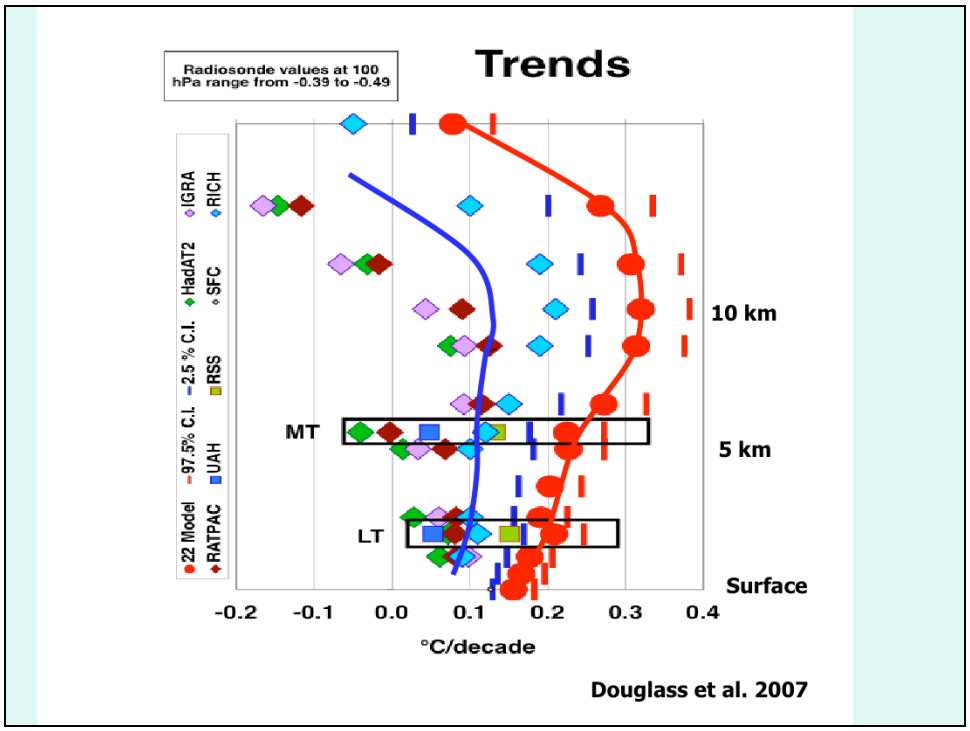


This is the reason. These four panels from four different models. If you look at just one panel it goes from south pole to north pole on the horizontal axis and the atmosphere is on the vertical axis. The stratosphere at the top and the lower atmosphere (we call the troposphere) on the bottom. These are greenhouse gas simulations. This is the difference between a control run and a greenhouse run in a climate model. These are four different models and they all show basically the same thing. That the biggest signal you can find is in the tropics and in the troposphere. That is were the signal, in other words the change in temperature vs. the background noise is by far the strongest.

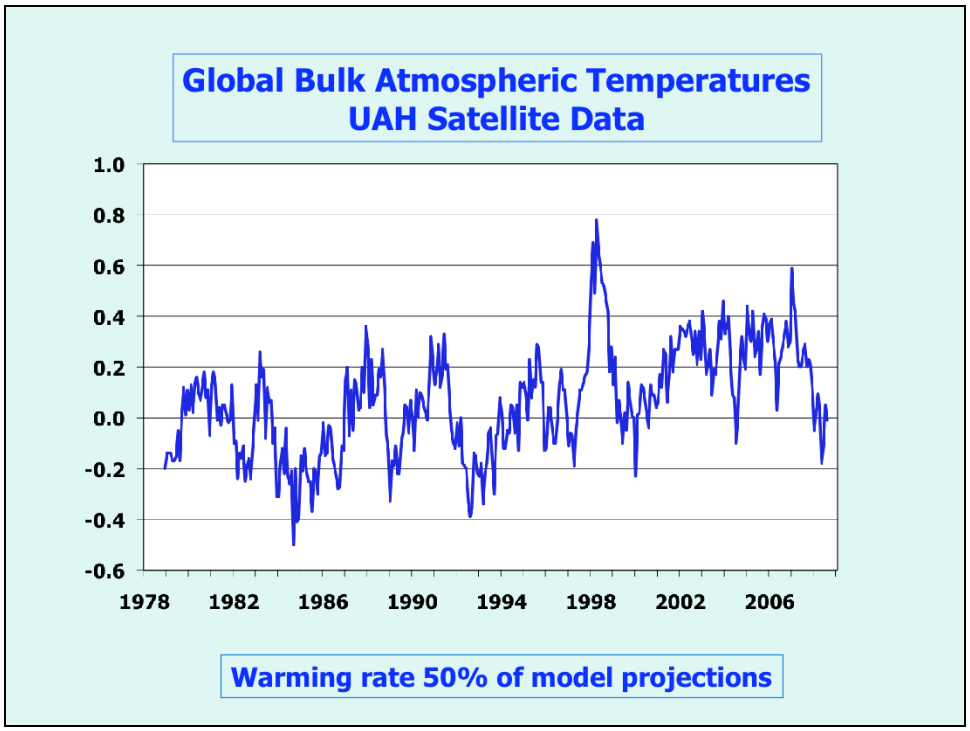
So if you want to look for a place where the greenhouse effect is suppose to be occurring and most clearly delineated, you go to the tropics and the upper atmosphere there.



Well we do that. I have a number of papers. Just published one this past February in fact. Here is the theory and here are all the observational data sets of how fast the temperature is changing in the upper air. And they are all except this one (RSS) much below. And this blue one is the University of Alabama Huntsville (UAH), our production and you can see from these other independent data sets that we really nailed the median and have by far the most consistency with independent data. This other satellite data (RSS) we found as we examined it carefully that it had a huge error characteristic to it and so it has a very large error bar to it as well. So, easily the observations show that what it happening with the temperature is not what you see in climate models.



This is a comparison of what is claimed by the models for upper atmosphere heating vs. what the measurements show. The data does not agree with what the model's claim will happen. What are we to trust? The actual measurements or the models?

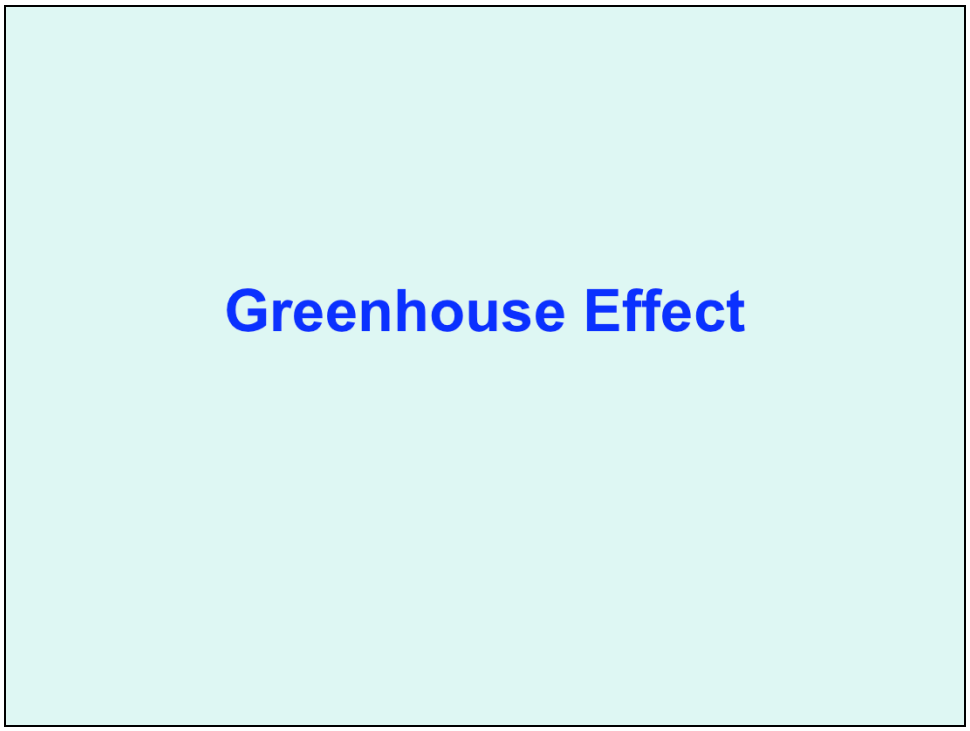


This is our satellite data set and I have updated it through September, 2007 [this chart Sept 2008]. You can see that since the El Nino of 1997-98 that it has just been bouncing around a little bit. There is an upward trend in it. I suspect that it is due in part to the extra greenhouse gases, but the magnitude is much less than what models have suggested.

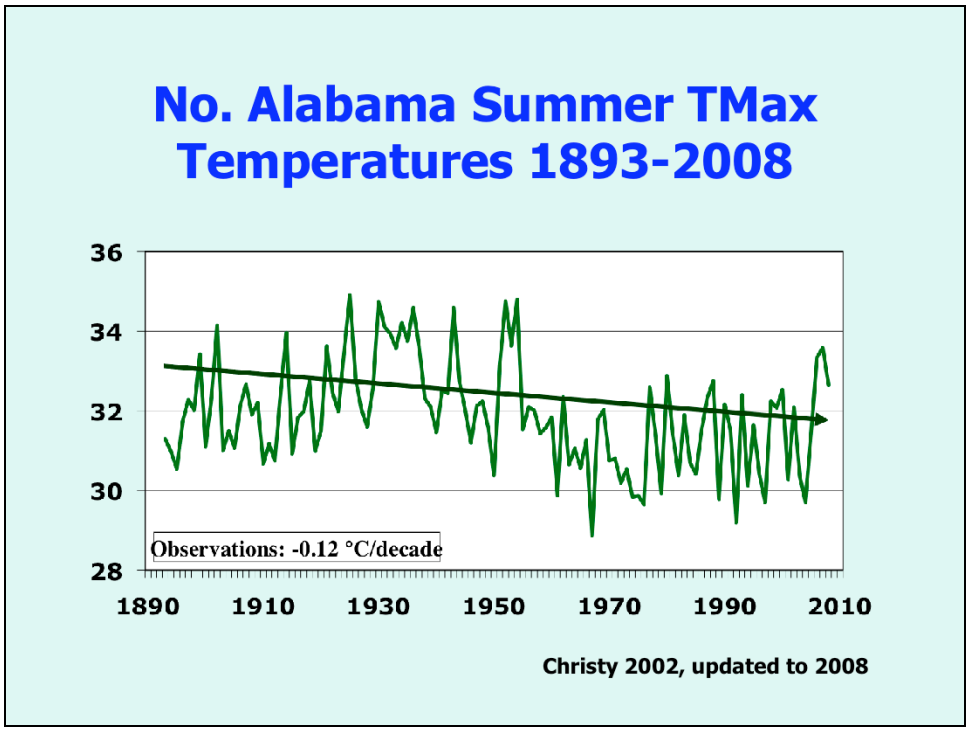
Main Point:

Better proxies (daytime surface temperature and tropospheric temperatures) show only modest changes, and no change in the Southeast, neither of which is reproduced well in models.

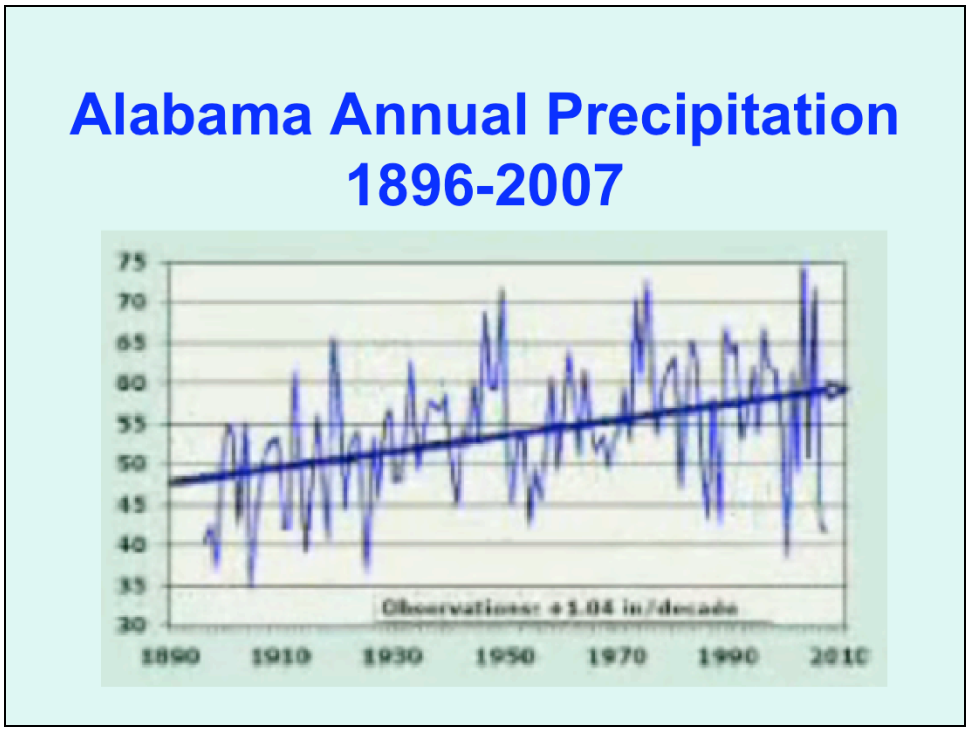
So the main point here is that better proxies (daytime surface temperature and tropospheric temperatures) show only modest changes, and no change in the Southeast, neither of which is reproduced well in models.



So, what about the greenhouse effect?

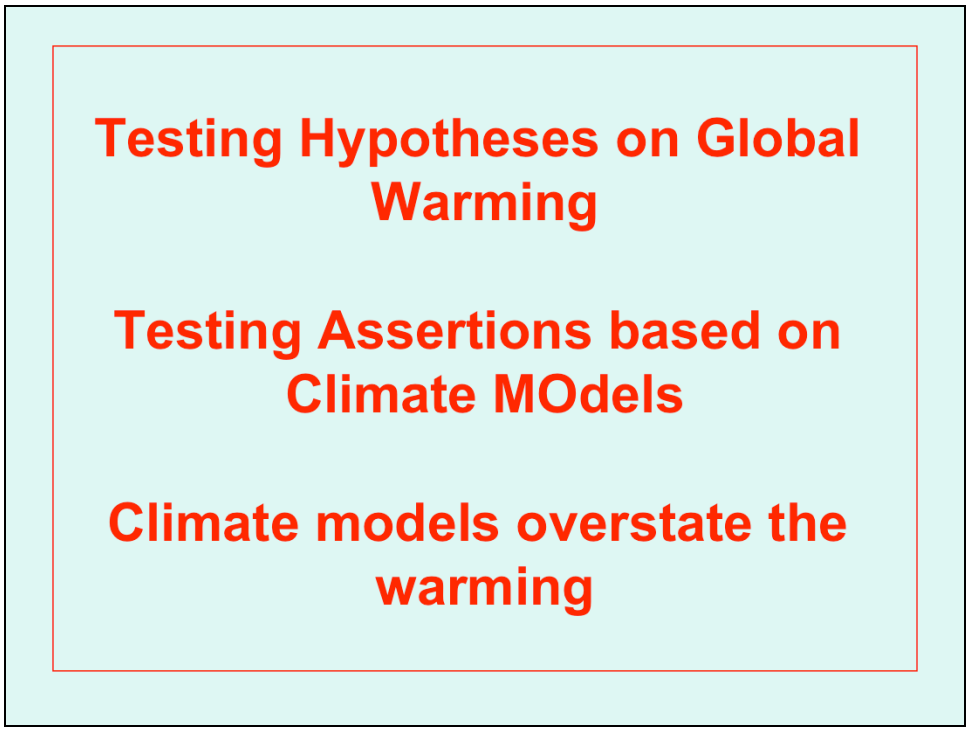


Let's look at Alabama. This is a paper I published in '02, and is updated to include 2007 to include our very hot and dry summer. We see that the day time temperatures here (and this is true for all of Alabama, not just northern Alabama). This is just a very specific kind of study. But the temperatures here have been falling. I Alabama, in our state, the temperatures have been falling for the last 115 years. There used to be a citrus industry down in Baldwin county. Now you have to go to Orlando, or south to find the citrus industry. And many things are available to show that it is not as hot as it was back in the 20s, 30s and 50s or early 50s.

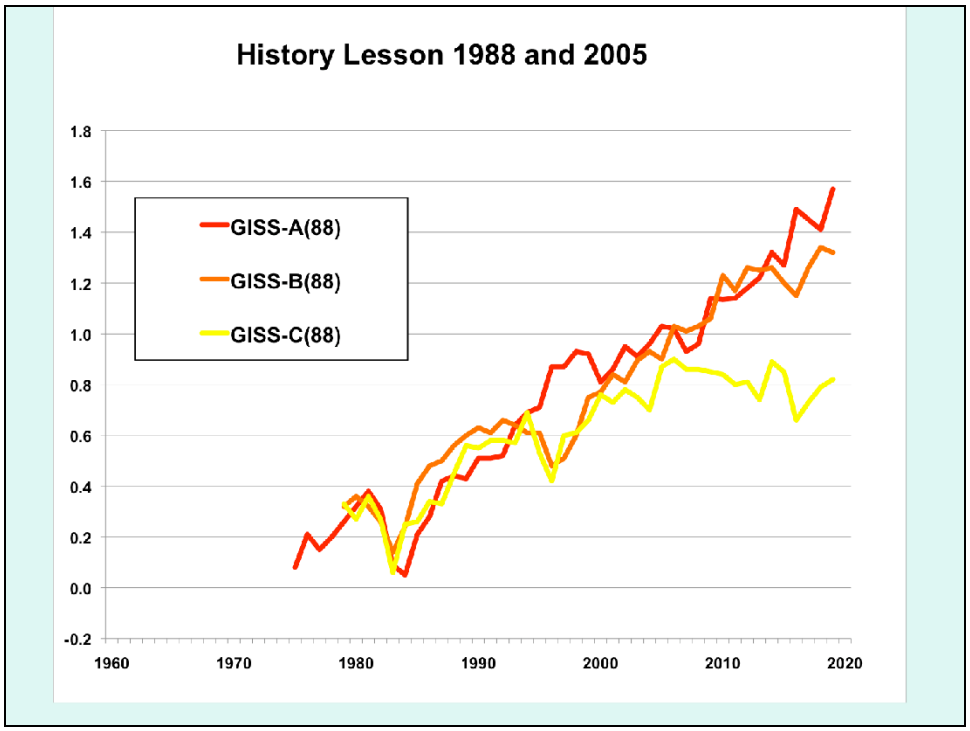


In fact, here's something else. Rainfall has risen in the past 115 years. Now we have had a couple dry years you can see on the end 2006 and 2007. As a state climatologist I have to be on conference calls all the time to define the drought indices for our state from which federal disaster declarations are made and so on. We are having a dry spell right now for sure, but that is a departure from the long-term trend. And I think I saw something that came out of Auburn that said that we expect to get drier and hotter, when the evidence shows that we are getting cooler and wetter.

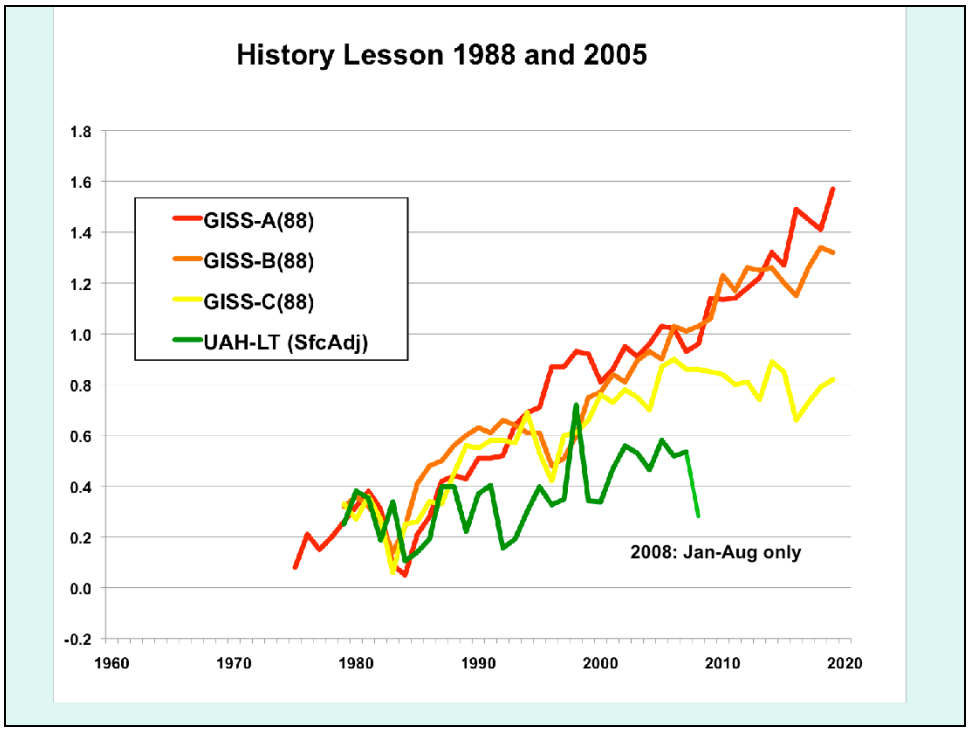
So don't extract yourself from the real data whenever you start thinking about climate change. O.K. so we are getting wetter and cooler here . . .



Another thing we do is test hypothesis about global warming by testing assertions based on climate models. What we have found is that climate models overstate the warming. One of the things you have to remember when models match the temperature for the last 100 years. This is why that is not an experiment in science. Every modeler knew the answer ahead of time. So it should not surprise you at all that the models reproduce what has occurred in the past. But we have checked them out a little different way.



These are the 1988 predictions by Jim Hansen where he showed what the temperatures would do on the planet and that yellow line was what would occur if there was a drastic reduction in CO2 emissions. That is an hypothesis, that is an assertion. Now we can compare that with real data, that kind that we build. That yellow means that you cut off CO2 emissions about 2000.



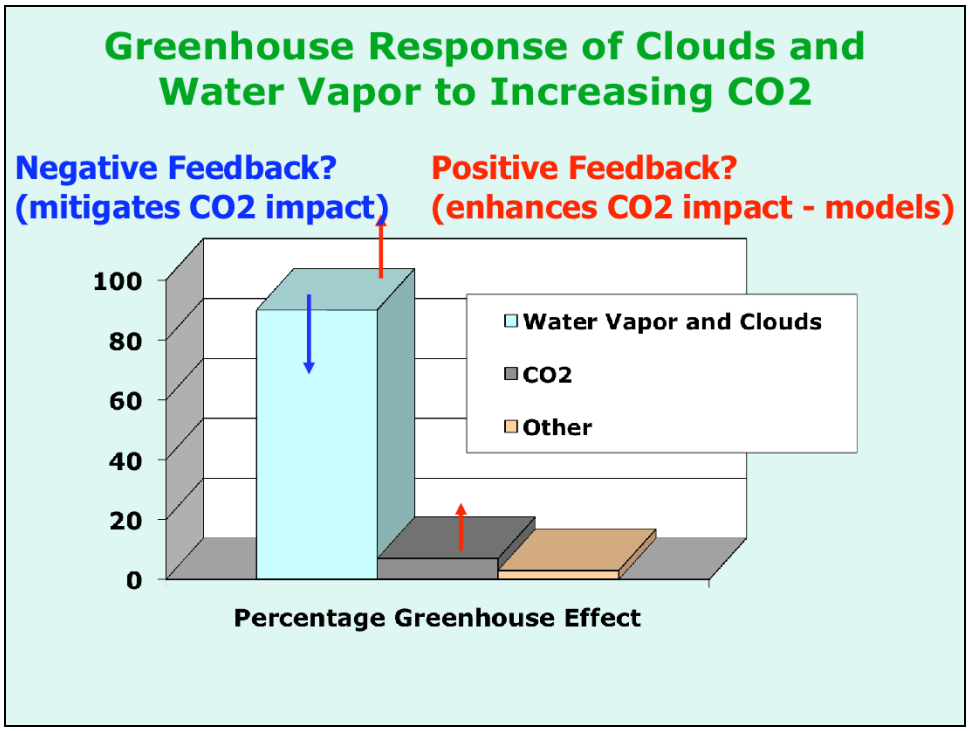
Here is what really happened in the world. And you see that even the actual temperatures fell far below even the scenario that did not happen.

Total Greenhouse Effect

- **Water vapor and Clouds dominate**
- **The doubled CO2 effect alone is 1°C**
- **Total Greenhouse Effect is variable**
- **Climate models show strong water-vapor/cloud *positive* feedback with increased CO2**

Here is something that I hope you will take away with you. There are four or five punch lines that I hope you take away. This is one of them. Water vapor and clouds dominate the greenhouse effect. Water vapor and clouds **by far** dominate the greenhouse effect. And they are variable. I mean the vary, the greenhouse effect of clouds and water vapor vary more than the whole CO2 effect. O.K.?

Climate models show this – that when you add CO2 the cloud and water vapor effect multiply the effect of CO2. In other words it is a positive feedback. You add a little CO2, clouds and water vapor effect gets real big, and so the whole thing adds up to a higher and higher temperature.

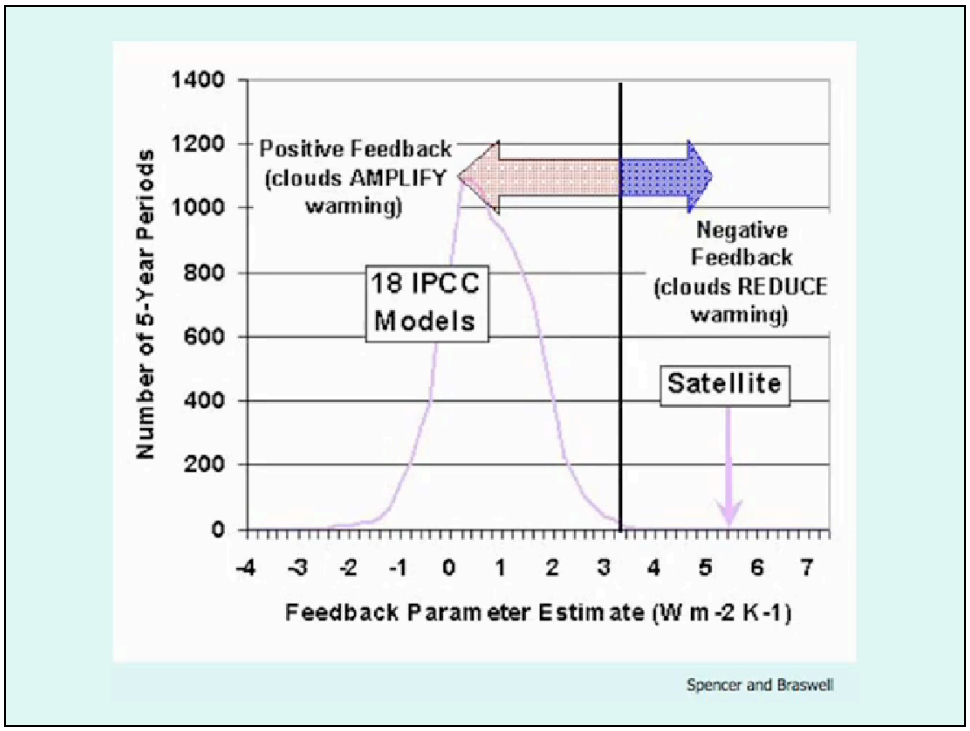


Show just for a picture. This shows the clouds and water vapor, then CO2 and the other gases.

The thing I want to show here is the role of clouds and water vapor.

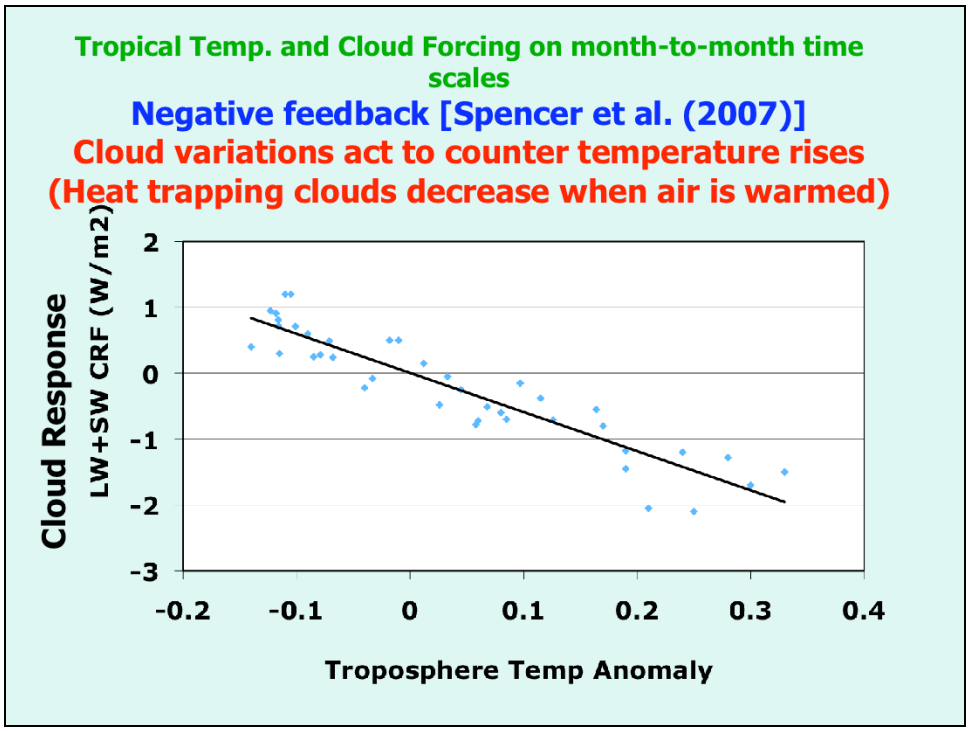
Water vapor and clouds do force the climate. They can be the cause of things that ultimately happen. They are not just responders to things that happen, they can actually do things. I want to show you that clouds and water vapor have a huge huge impact on whether the earth warms or not. Carbon dioxide is down here and growing. We should expect some rise in temperature because of the extra CO2 we are putting back into the atmosphere. But the question up here is, If we add some CO2 and warm up the planet somewhat does this (clouds and water vapor) get bigger or smaller. In climate models it gets bigger, that is how they get these large warming rates out for the next century. They do things like shrink the cloud cover and make more sunlight heat up the earth.

What happens if the real world actually responds in a different way? And actually acts against that heating so to speak. And has a thermostatic effect.



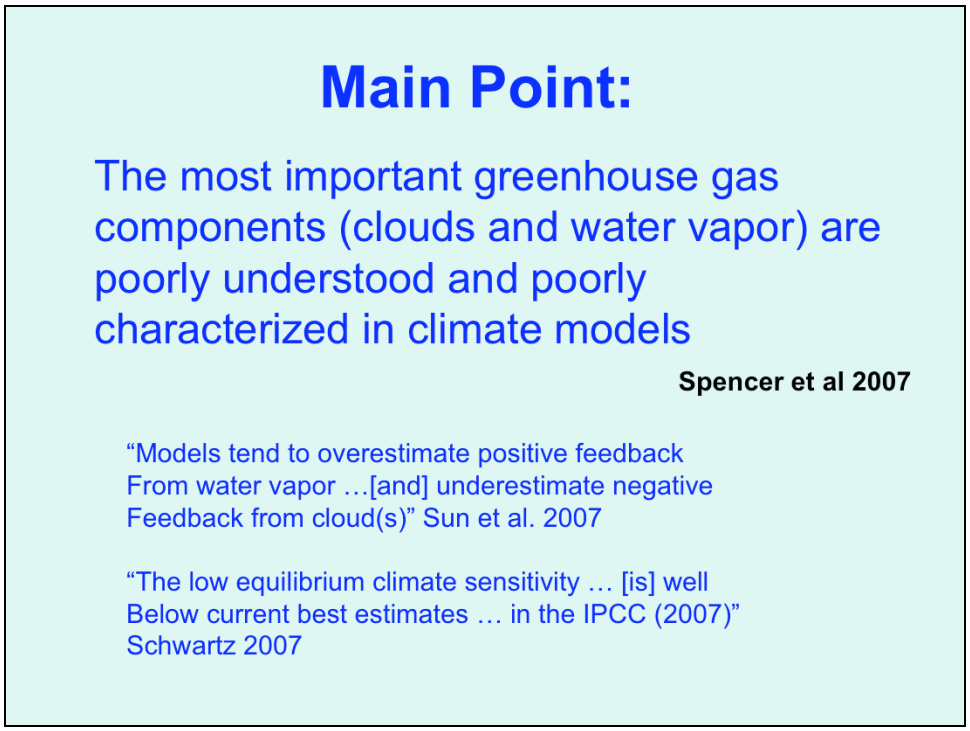
Using real data from satellites, we found that to be the case. This is a picture the describes how much energy it takes to warm up the climate by a degree.

In the climate models (and this is like a thousand runs of 18 different models) they are down here which indicates that it doesn't take much energy to make the temperature rise. Or that the climate is very sensitive to something like CO2. What we find from real satellite data (and this has been repeated with another satellite) and the answer comes out that it takes a lot of energy to make the temperature go up because of all the things that happen in the climate system that work against a warming effect.



Roy Spencer was a lead author on a paper that we published, in which we got the satellite data to show every type of cloud and precipitation system that goes on in the tropics and how they vary with temperature. And it turns out that there is a negative feedback. In other words, as temperature rises, the way the clouds respond, is to cool the climate. It is like a thermostat. It turns out that the clouds that cause warming (cirrus clouds) shrink whenever the temperature goes up and that allows radiation to escape into space. And so it is an automatic kind of cooling mechanism. This is in the opposite direction of climate models and missing a feedback like that will lead you astray very quickly. There is still more research to be done on this, and Roy is working on some further papers that he has already submitted to show how difficult it is in climate models to present how the real world operates. I mean think about it. The climate system of the real world has millions of degrees of freedom. Do we understand every single one of those **so well**, and represent the equations **so accurately** that we can forecast into the future? My point of view is the answer is no and partly because of the data sets we built and compare with climate model output.

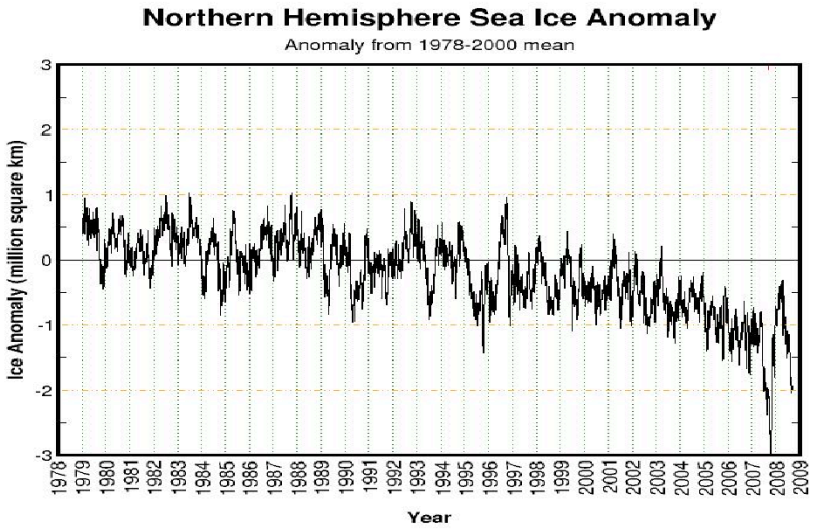
By the way, there are very few people in the world that actually build the data sets from scratch like we do up in Huntsville.



O.K. the main point there is the most greenhouse gas components (clouds and water vapor) are poorly understood and poorly characterized in climate models. In fact there is a paper that come out just last week, Thun et al. in which he did a different study, but showed that models overestimate that feedback. And that's why they show this warming about which everyone gets so excited.

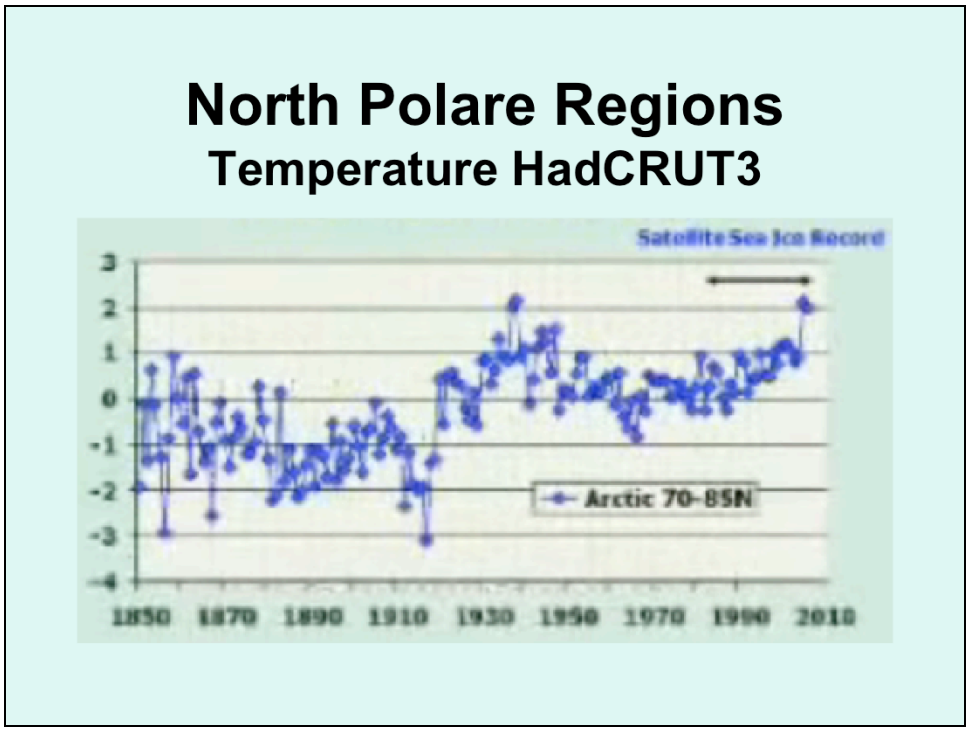
Well, let's look at some data. And I love this part – Cold Places. What about cold places?

Arctic Sea Ice

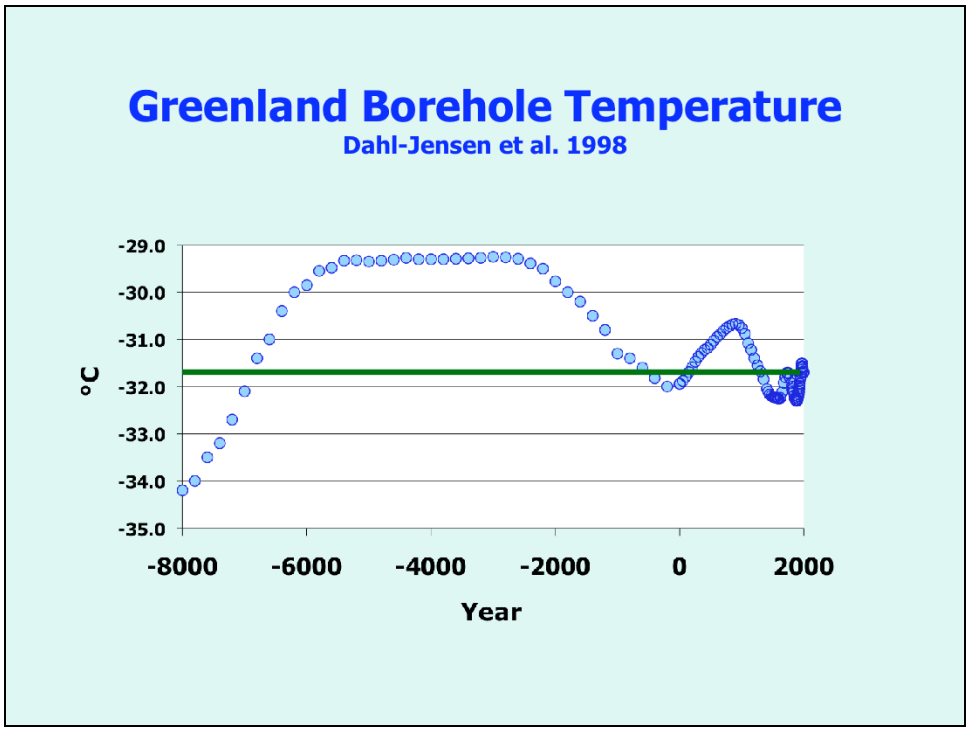


Chapman, U.Illinois

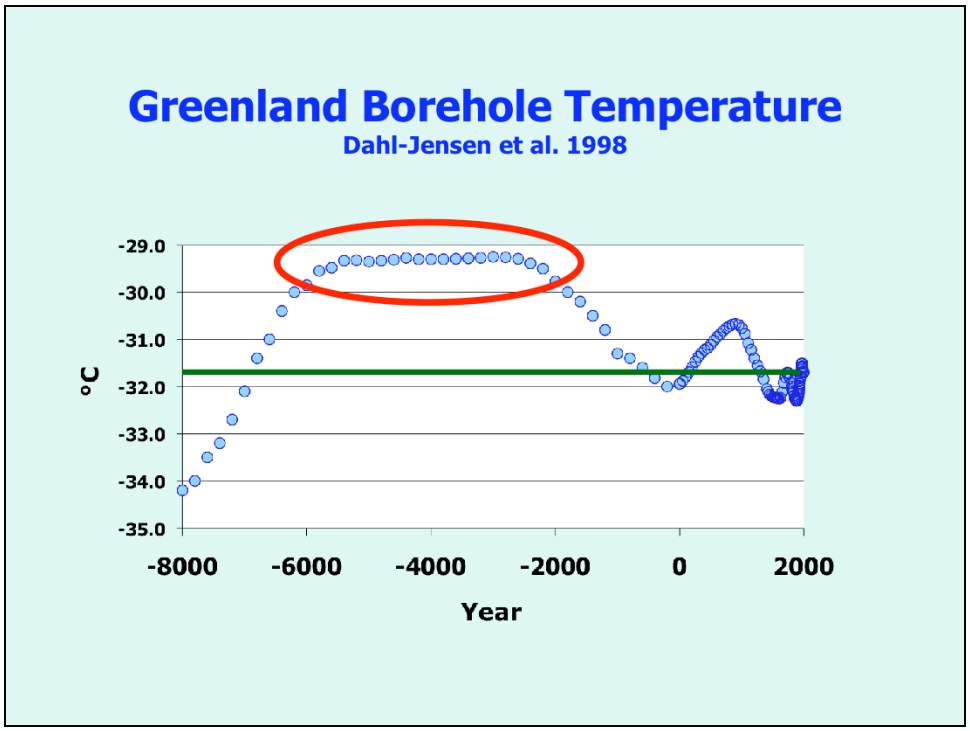
You have been inundated with information about the arctic sea ice. The arctic sea ice has declined in the past 30 years or so. And especially in this past year it is the lowest that it has ever been measured by satellite. [The 2007 presentation didn't use this graph with includes 2008] As you can see from this daily chart that shows the anomalies of the arctic. This is the northern hemisphere up near the north pole.



Here is a temperature record of the arctic. Well it turns out that it has been hotter just in the past century than it is today in the arctic. Back in the late 30s. But we only have a satellite record from that bar on the top, so we are not sure when this rapid warming occurred [1910-1930] in the arctic, what happened to the sea ice? Did it then expand as the temperature fell [1930-1970]? And we are watching it during this period of rising temperature. So having a consistent data set for a long time is the gold standard of climate work. And we just don't have it for this arctic sea ice. We do however know that the north pole regions were about 4 and 5 degrees C warmer about 5 to 6,000 years ago. The forest went all the way to the edge, to the arctic sea.



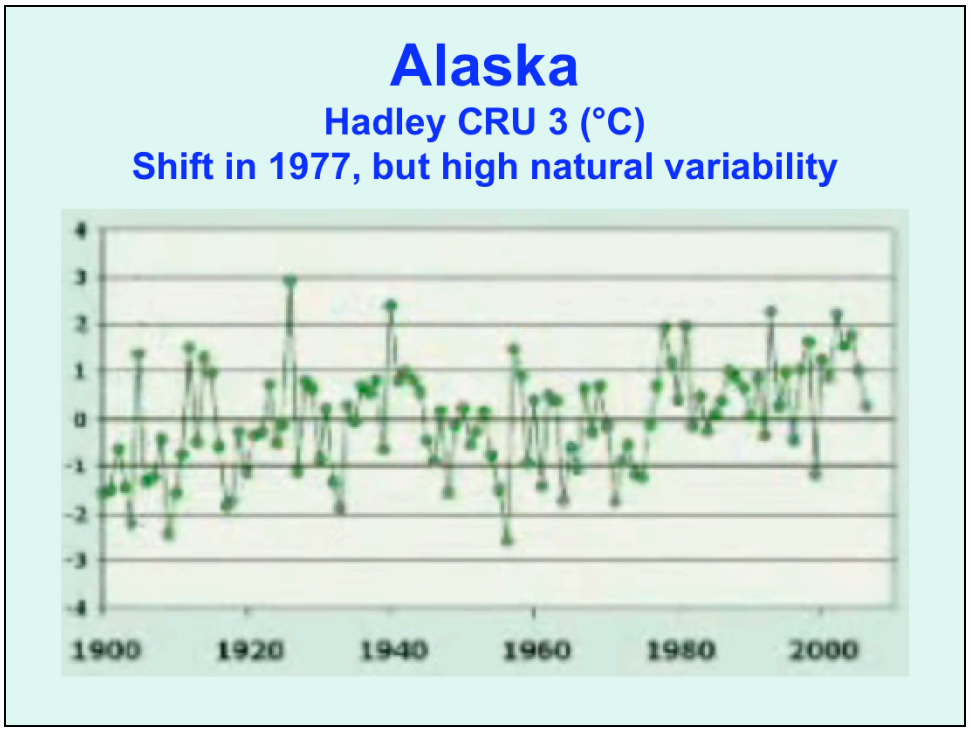
We have the same if we go to Greenland. I have a lot of confidence in this. Look at a thousand years ago (this is a ten thousand year record). Here is the thousand years ago bump that was warmer than it is today



But look at that up there. 4,000 years in Greenland in which the temperature was much warmer than it is today and Greenland did not melt.

One of the requirements for rapid sea level rise (which I don't hear a lot of people talking about) is that Greenland melts **rapidly**. But Greenland is melting slightly, sea level is rising, and will continue to rise because we are in an interglacial. There is still more land ice to melt. As I always tell our folks down on the coast, be prepared, as the sea level is rising about an inch per decade. I don't see anything stopping it until the next ice age comes.

It is not the inch per decade that is the problem though. It is the 20 feet with the next hurricane Ivan. If you can handle the 20 feet in 6 hours from the hurricane, then the inch per decade is not your problem.

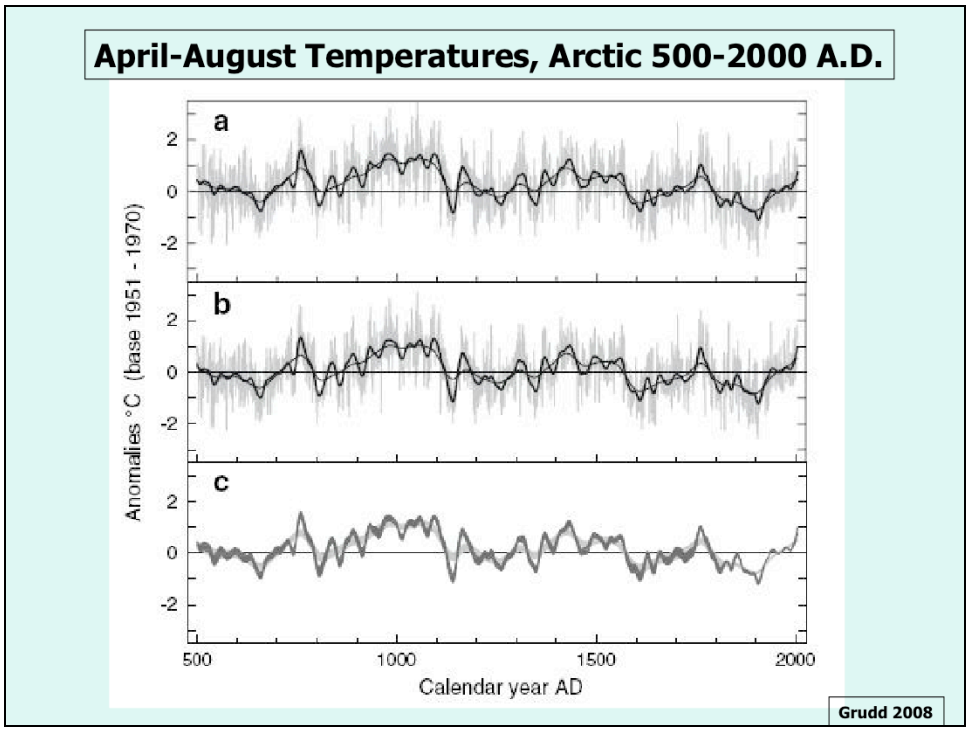


Let's go to Alaska. The temperature goes up and down in Alaska quite rapidly. And this is a situation in which polar bears tend to come in

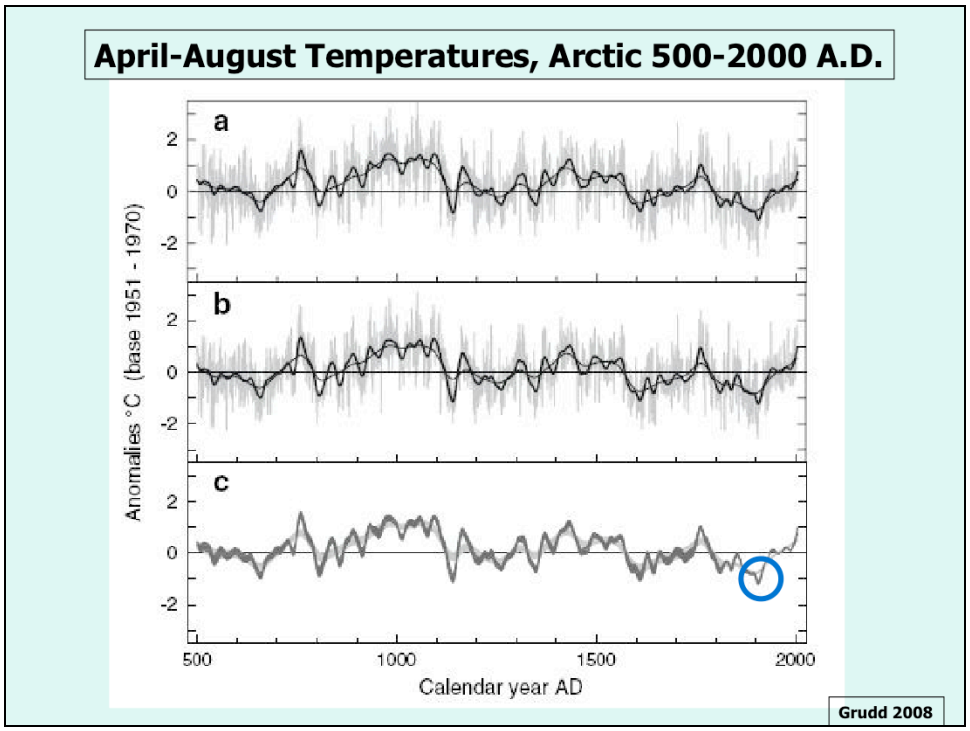
Polar Bears

- 1960's 6,000 to 10,000 bears
- Snow mobiles and high-powered rifles
- 1972 Marine Mammal Protection Act
- 1974 International Agreement for Conservation of Polar Bears
- Today 24,200 polar bears
- ~800 legal kills per year
- Status (scientifically) non-threatened, most subpopulations growing

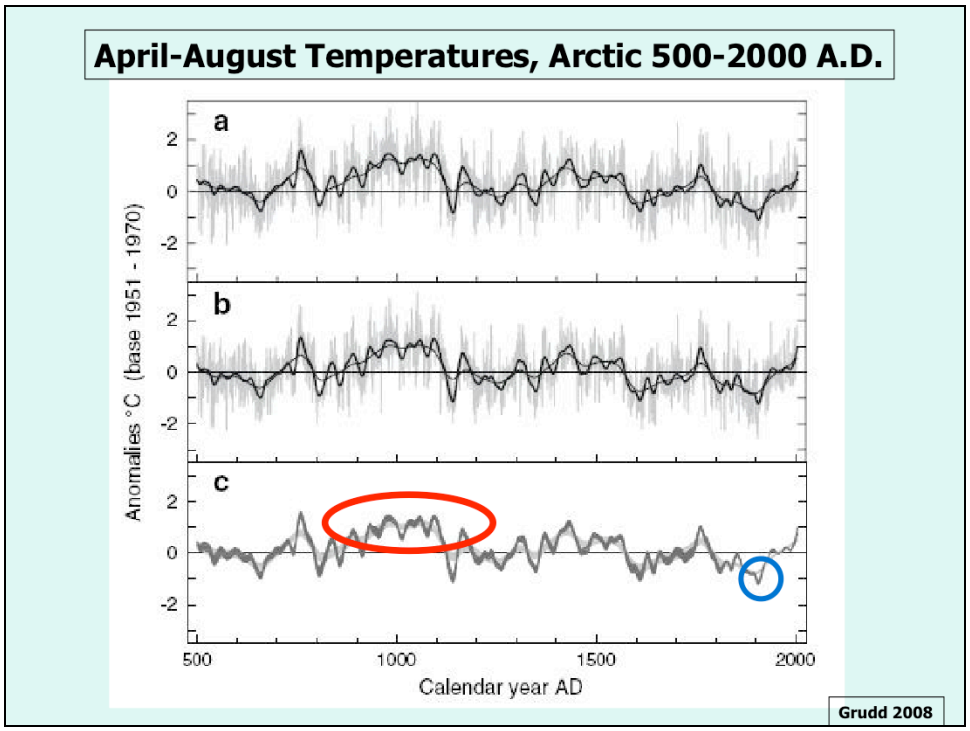
. it turns out polar bears do real well whether it is warm or cold. There numbers have risen by about a factor of three in the last forty years. It is not because of climate. It is because of the Wildlife act and the quota system that was established. Once the Eskimos, or the intuits had the ability to use high powered rifle, the polar bear population just plummeted. And they might have gone extinct, but with the Wildlife Act, I think it was in 1972, the quota system was established, then the polar bear recovered. There are now many, many more than there were forty years ago. They are pretty hard to count, but we do know the places where they are being counted that the populations are healthy.



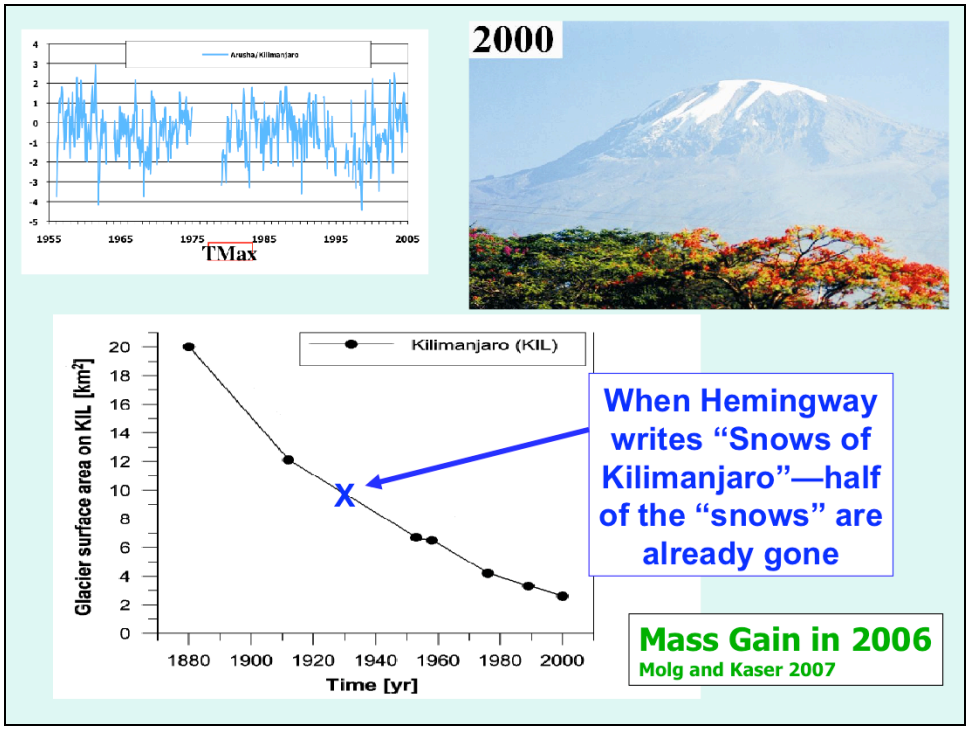
Here is just one of many of the proxy records for the past 1,500 years. These are from tree rings actually. What you see here is a scattered picture, but notice that **yes**, this last century in which we are in has seen warming in the arctic, quite a bit



It started at the coldest spot in the mid 19th century. So we are bouncing back from a very cold spot

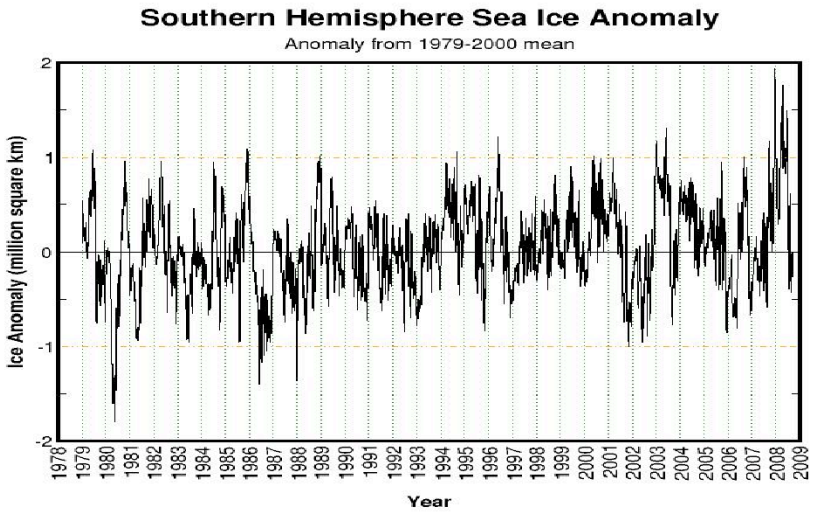


And it doesn't even reach what we had even a thousand years ago in this particular record.



Lets go further south to Kilimanjaro. I was a missionary in Africa for a while and I saw Kilimanjaro a number of times. I taught physics and chemistry to high school students in an area of Kenya. The temperature in east Africa is not rising at all. But if you look at that graph right here, this is the snow coverage for Kilimanjaro. It is definitely going down, there is no question about that. It is 10 percent of what it was back in 1880 when the first surveys were taken. When Hemingway wrote the "Snows of Kilimanjaro" it was already half gone. And it is hard to blame any of this on human effects. It turns out this is the natural variability of this system. That ice has melted completely away before in the past 12,000 years and come back a number of times. In fact this past year (2006) they had a huge dump of snow and it buried one of the meteorological instruments up there. Who knows but that might be a change back to more normal conditions. Because it is always below freezing up there. The situation here is likely one of cloudless and snow fall up there and so it is a natural variability.

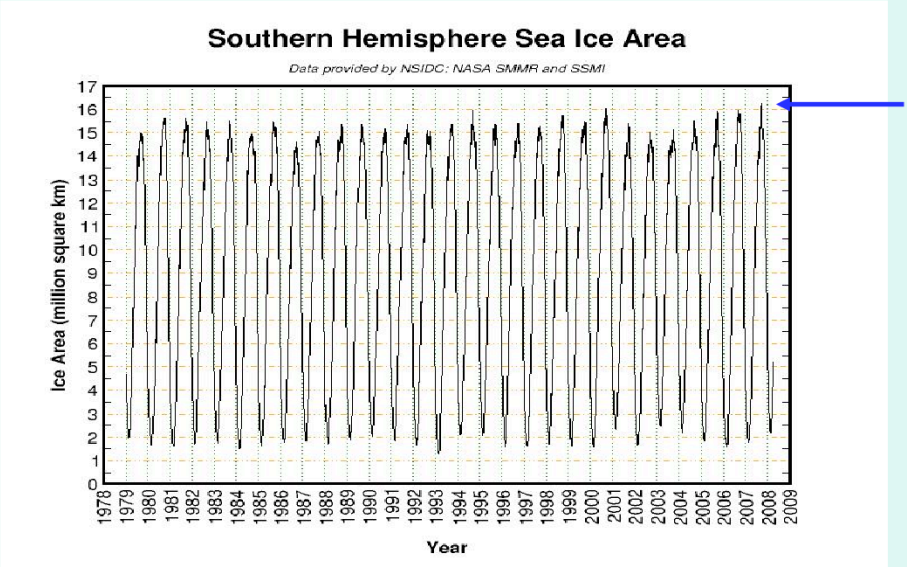
Antarctica Sea Ice



Chapman, U.Illinois

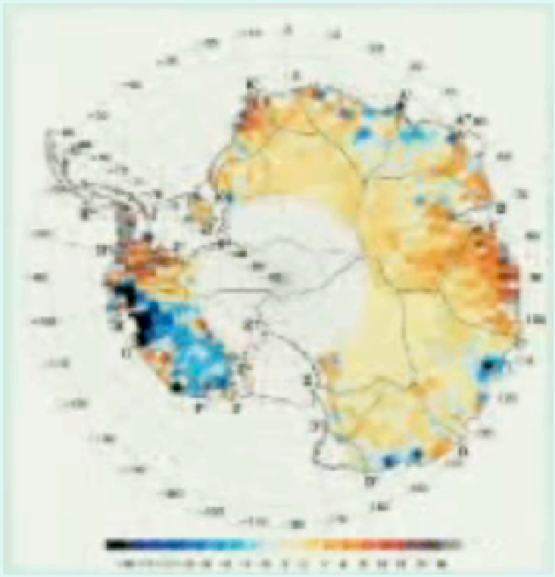
Now let's go to another favorite place of mine. This is the Antarctic sea ice. There is actually an upward trend in the sea ice of Antarctica. This is a story **you will not hear about** in the newspaper or on a show that wants to scare you about global warming.

Antarctica Sea Ice



Chapman, U.Illinois

The sea ice in Antarctica is not only rising, but two weeks ago it reached it's all time maximum extent. It has never been (at least in the satellite record) this large before. Now why wasn't there a front page story in the New York times telling you that the sea ice in Antarctica reached it's all time maximum extent, when just a few months ago there was a story about the arctic reaching it's all time low? No climate model can reproduce this at all. Why is it getting colder in Antarctica and the sea ice increasing?



Anctarctica snow accumlation trends cm/yr

1992-2003

Davis et al. 2005

See also:
Monagham et al. 2006
Van de Berg et al. 2006

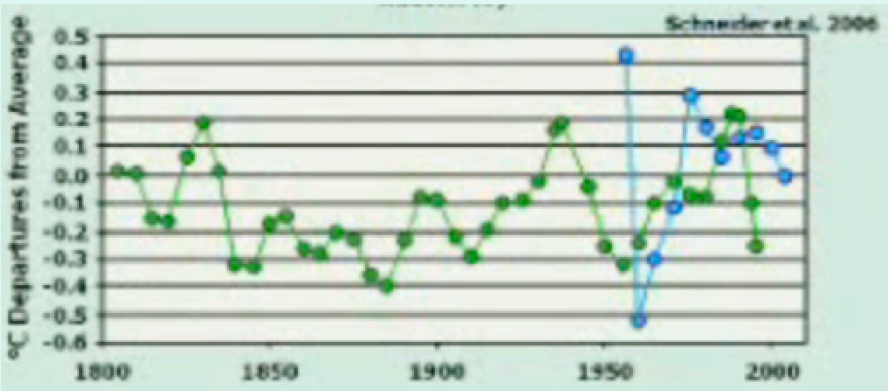
Snow Fall, if you see warm colors there, that is where snow fall is increasing and it is definitely freezing. Most of Antarctica is accumulating snow, which means it is contributing to a sea level drop.

Antarctica

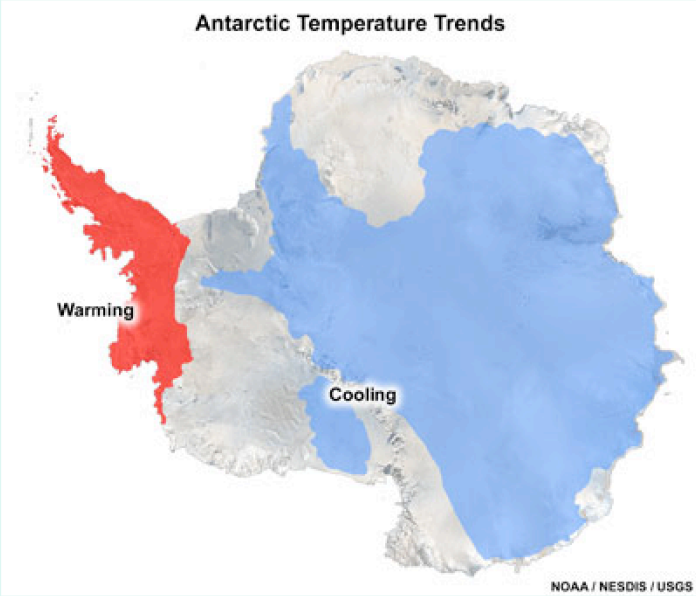
Ice Cores Thermometers

Antarctica Temperature Variations

Isotopes (green, Schneider et al. 2006), Thermometers (blue, HadCRUT3)

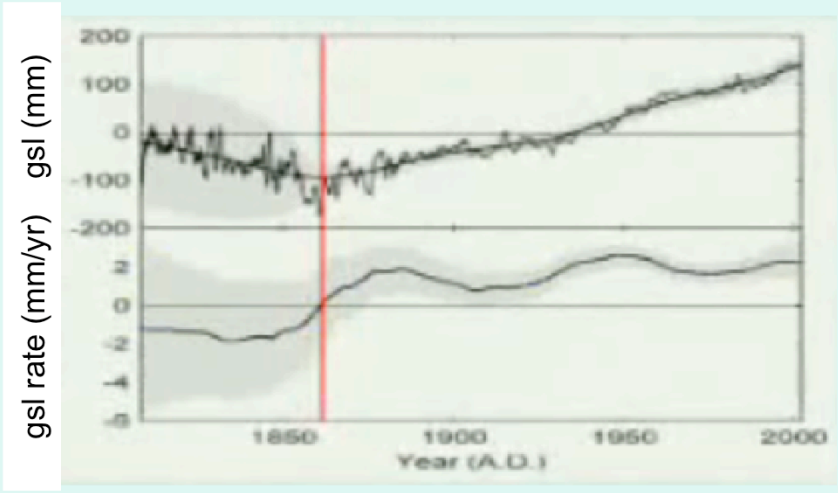


Temperature of Antarctica, the point here is that in the last four decades, the temperature has fallen.



Surface Temperature Trends 1972-2004, NOAA

Sea Level Rise?



Global Sea Level (gsl) elevation (mm) and growth rate (mm/yr) – Jevrejevea et al. 2006

It is always rising or falling and it has a slow rise right now of about an inch per decade.

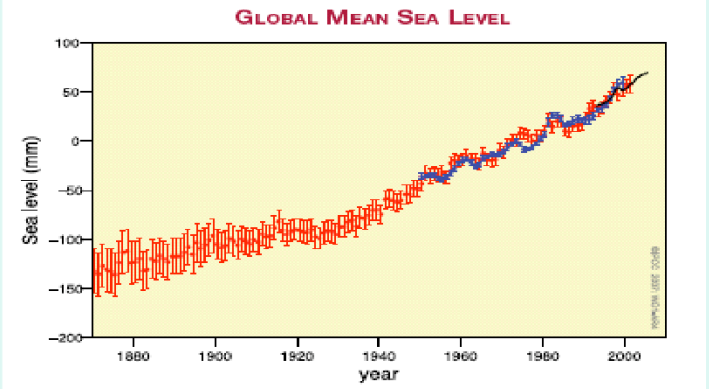


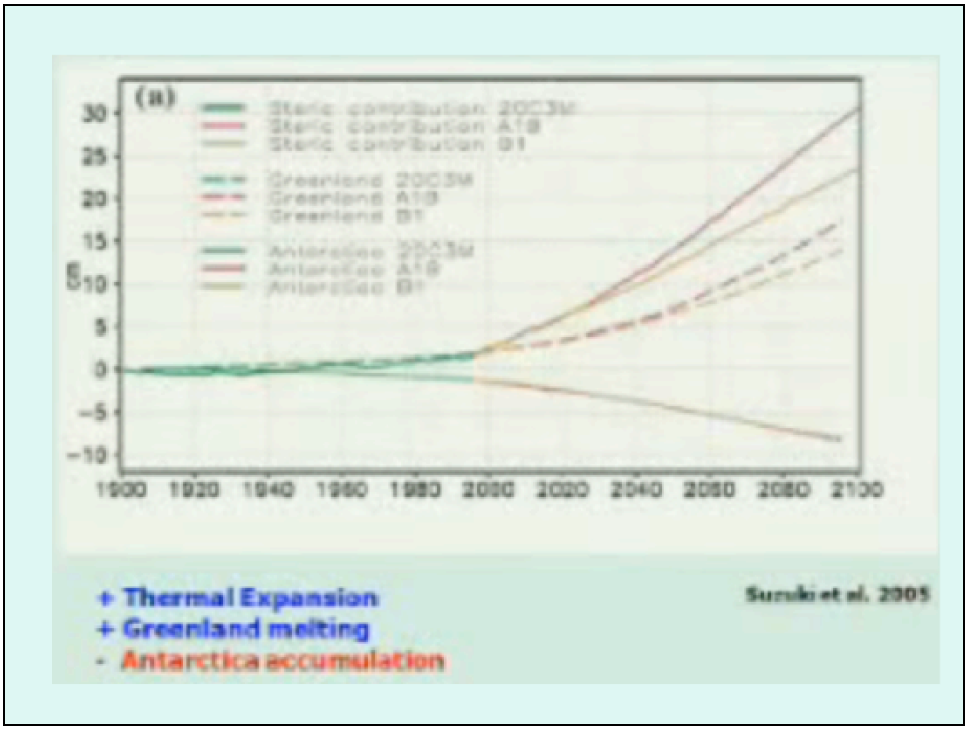
Figure TS.18. *Annual averages of the global mean sea level based on reconstructed sea level fields since 1870 (red), tide gauge measurements since 1950 (blue) and satellite altimetry since 1992 (black). Units are in mm relative to the average for 1961 to 1990. Error bars are 90% confidence intervals. [Figure 5.13]*

Rate of rise for last 50 Years:

IPCC 2007 9″ / Century

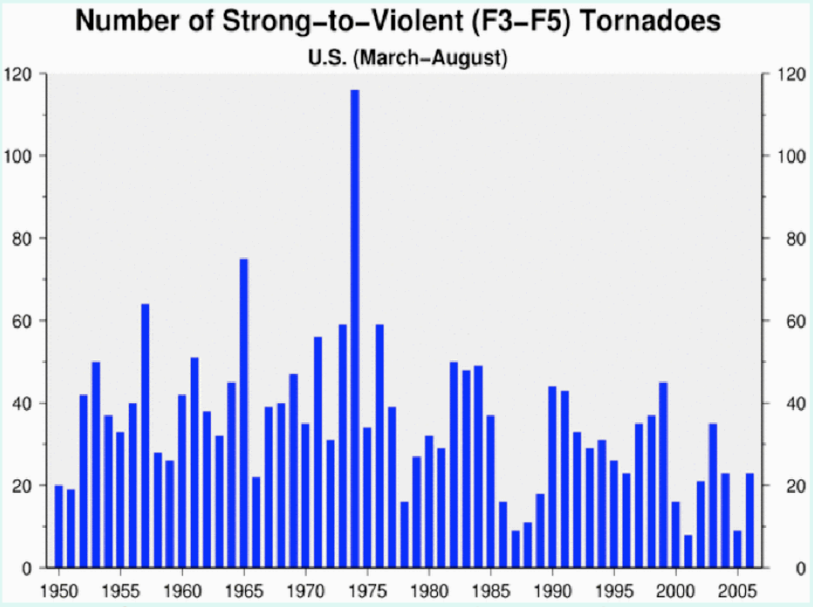
Jevrejeva et al. 2006 9″ / Century

Woppelmann et al. 2007 6″ / Century



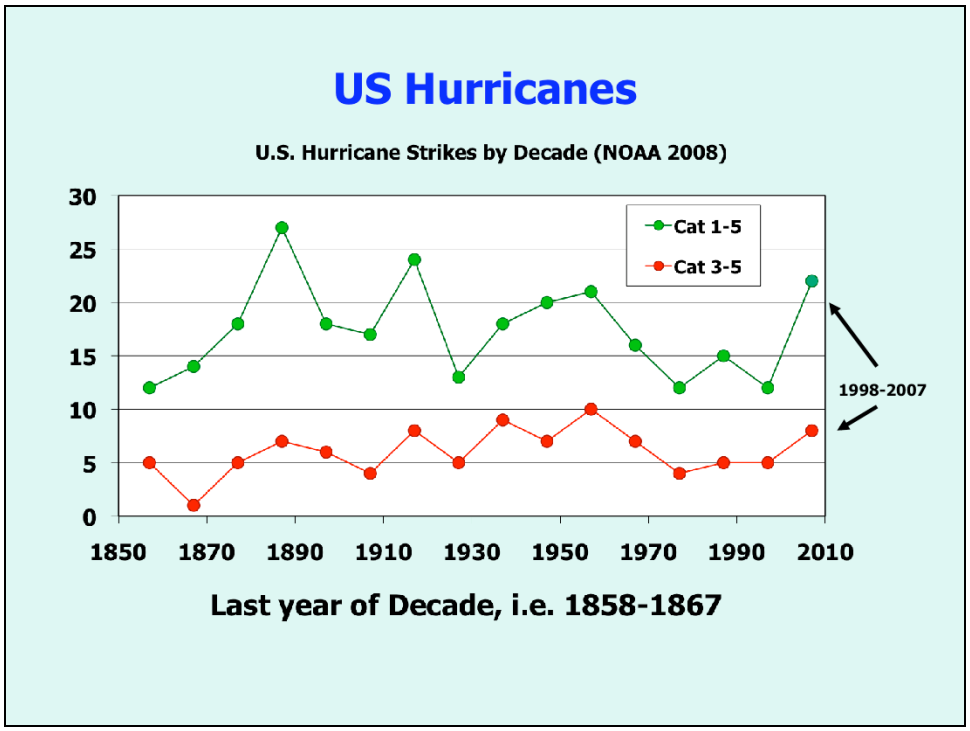
This is the future projections. Antarctica is projected to suck up water and dump it on the continent and therefore contribute to sea level fall, while Greenland is suppose to melt a little bit and contribute to sea level rise.

What about extreme weather?



Oklahoma - record long period (> 100 days) without a tornado 2003-04

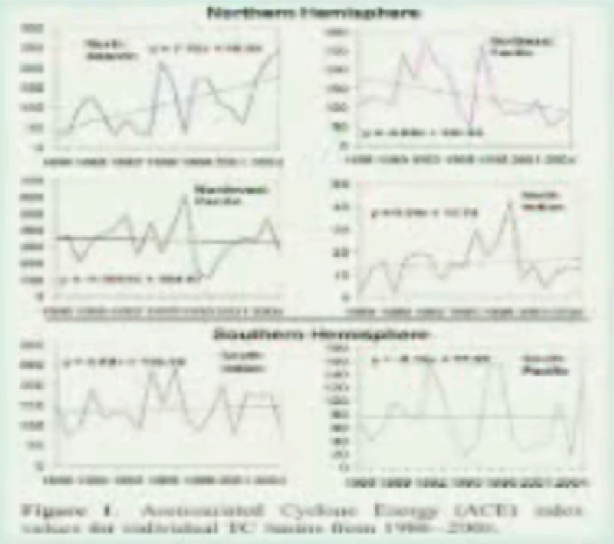
Here is a tornado history. You have heard many times that tornadoes are going to get worse because of global warming? The evidence says the opposite. With warming the tornado frequency is going down.



Hurricanes, they go up and down and there is not direction really either way. They're cycles in hurricanes, but there are no real trends of frequency or intensity, either way. But let me tell you this. Will the damage from hurricanes increase? Absolutely. We just put more stuff in the way of hurricanes down on the coast and we are saying, "Come on hit me." And as a state climatologist, I deal all the time with people that have design criteria and so on for building something on the coast, and I just say, "Don't Do It." A hurricane will come. Here's Frederick, here's Ivan, here's Opal, here's Katrina. It's going to happen. I was pleased to see that Tyson put their plant further north of Mobile to try and avoid a lot of the problems. Look, hurricanes happen and we are going to see some big tragedies in the future when Miami gets hit by a category 4 or 5 or something like that. Katrina was a category 3 when it hit New Orleans. That's typical, so we have some accidents waiting to happen out there.

Global Hurricane Activity

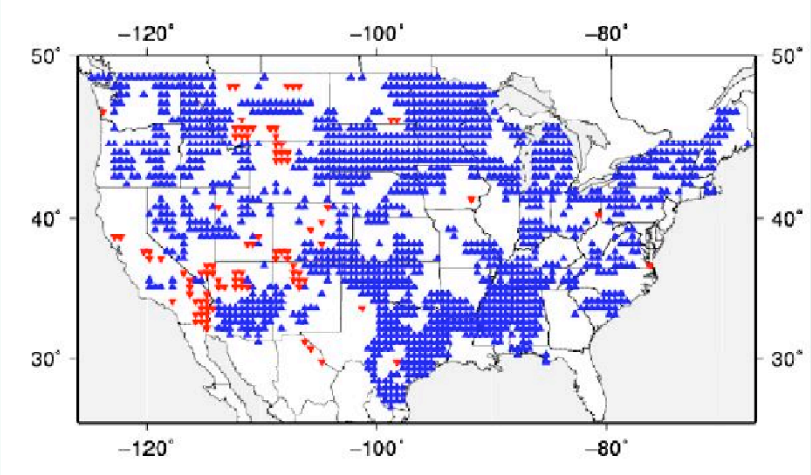
There has been no significant change in global net tropical cyclone activity (Klotzbach 2006)



There are about 95 hurricanes in the world and that number has stayed steady. Some basins show rising, some basins are falling.

Droughts?

US: Blue = Fewer and Shorter



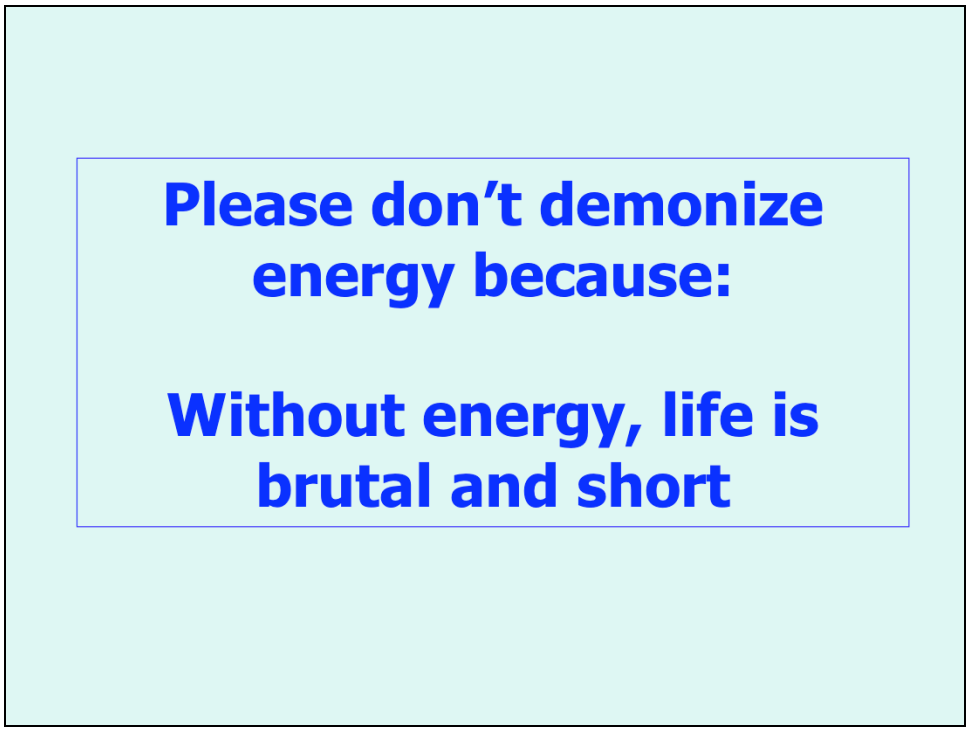
Andreadis and Lettenmaier 2006

This is droughts, and if you see blue on that chart this means that they are getting fewer and less frequent. I see a lot of blue on that chart. I hear the phrase all the time about being scaring about greater droughts, worse droughts. The evidence, the observations, do not go along with that.

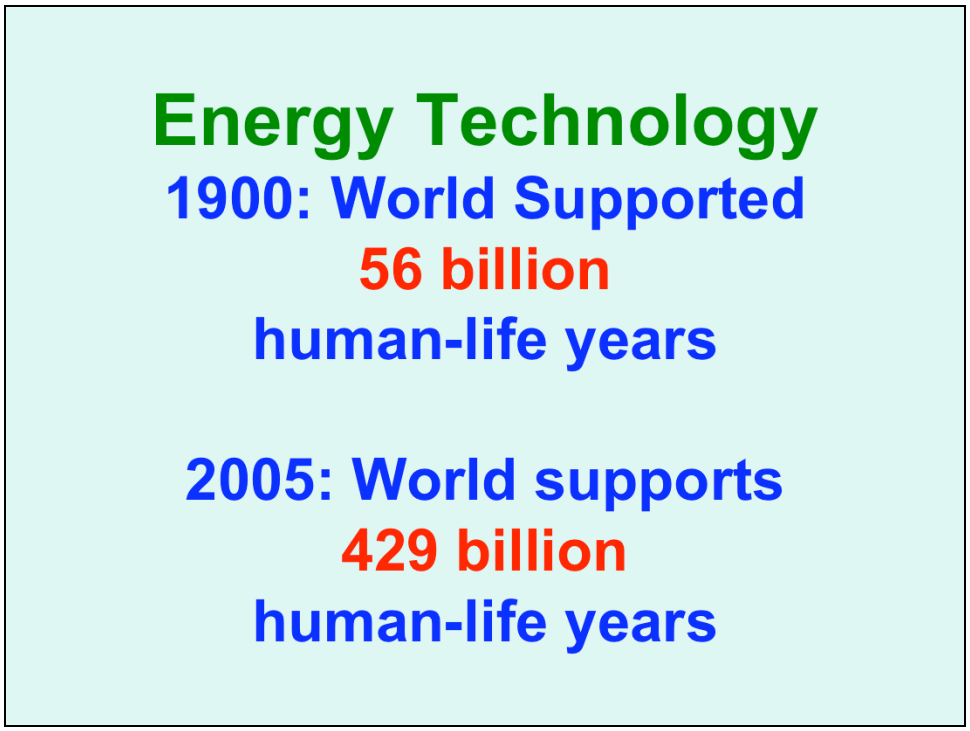
Evidence Thus Far

- **Global surface temperature is rising, but in a way inconsistent with model projections of GHG forcing**
- **Overall decline in ice mass, with sea level rise of about 1" per decade**
- **Severe weather not becoming more frequent**

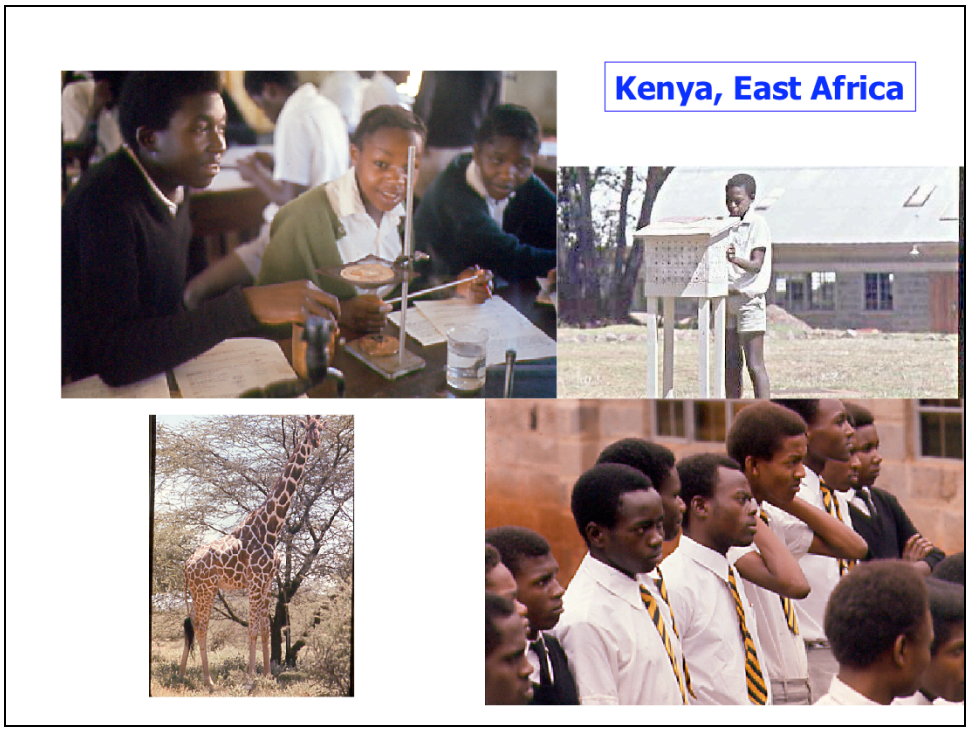
So I don't think global temperatures are rising to an extent that is really that remarkable. Sea levels are going up about an inch per decade. You better be ready for that. And severe weather is not becoming more frequent at all.



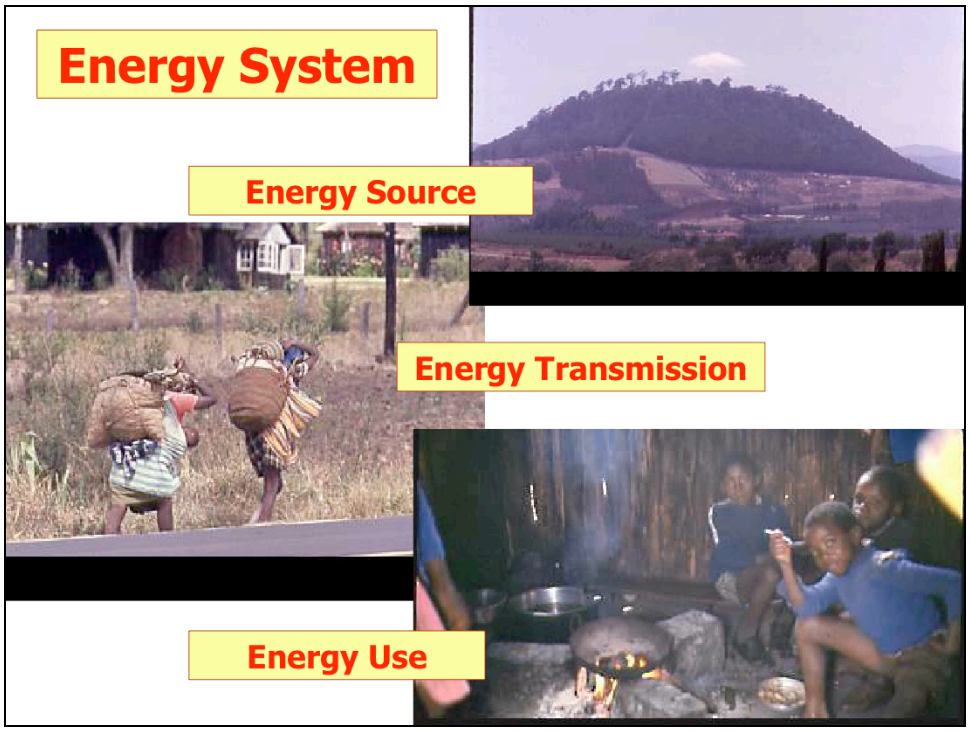
Especially when I am before congress and speaking before the energy committee. I just resist this notion of demonizing energy. Especially after my time in Africa. The **simple fact** is that life without energy is brutal and short. I can assure you that is the case. In 1900 we had 56 billion human life years



In 1900 we had 56 billion human-life years with the energy technology of the day. 1.6 billion people times 35 year life expectancy. Today it is 8 times greater. Now to me that is a spectacular achievement, and I saw that as a grandfather, I happen to know that (grandson that wears his little Auburn thing every fall), when he comes up and grabs my knees and smiles at me like that, I am experiencing something in life. That a hundred years ago you would be very unlikely to experience. Because of what has happened with the energy technology of the day. We life longer and we live better. That is the benefit that demonizing energy never takes into account. I find it incredibly presumptuous to just claim that we need to use less energy, we need to get rid of our energy use and we need to go back to living a primitive lifestyle.



As I say, I lived in Africa for a while and taught physics and chemistry. And I taught people that were just delightful. They really worked hard, I was really impressed with the folks that were there.



Here is the energy system in Kenya. In the upper right is the energy source. Here is the energy transmission system, the backs of women. You would be amazed that each day the load that they carry is 40 pounds. And the length is 5 kilometers per day. And then that wood is burned. This is the tragic part. The wood is burned inside the hut and the kids breath that smoke and contributes (the U.N. estimates) between 1.8 and 5 million deaths per year. And that is how many kids are dying now because of respiratory illness that are caused by this energy system.

The Dilemma of "doing something about global warming"

- **Meet significant growth in energy demand**
- **Supply affordable energy**
  - **Benefits of energy are ubiquitous and innumerable. People want energy.**
  - **Health, security and longevity enhanced by affordable energy**
- **Reduce CO2 emissions substantially so as to have a detectable impact on emissions (massive reductions) and thus "manage the climate"**

Suppose you do want to do something about global warming. I understand that many of you think that global warming is a serious problem and so something must be done about it. And here are your constraints. You still have to supply affordable energy.

The Dilemma of "doing something about global warming"

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- **Supply affordable energy**
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Energy demand is still growing like crazy. And so that has to be one of the constraints

The Dilemma of "doing something about global warming"

- Meet significant growth in energy demand
- Supply affordable energy
  - Benefits of energy are ubiquitous and innumerable. People want energy.
  - Health, security and longevity enhanced by affordable energy
- Reduce CO2 emissions substantially so as to have a detectable impact on emissions (massive reductions) and thus "manage the climate"

And your other constraint is that you must reduce CO2 emissions substantially.

What did California do?

- **Force a limit on emissions of Light Duty Vehicles**
- **California AB 1493 seeks to reduce tail-pipe emissions of CO2 by 26% by 2016**
- **11 NE States adopted AB 1493**
- **Trial in Federal Court (Burlington VT) to address the engineering, legal and climate issues of AB 1493, April-May 2007**

Lets see what California did. They passed a law

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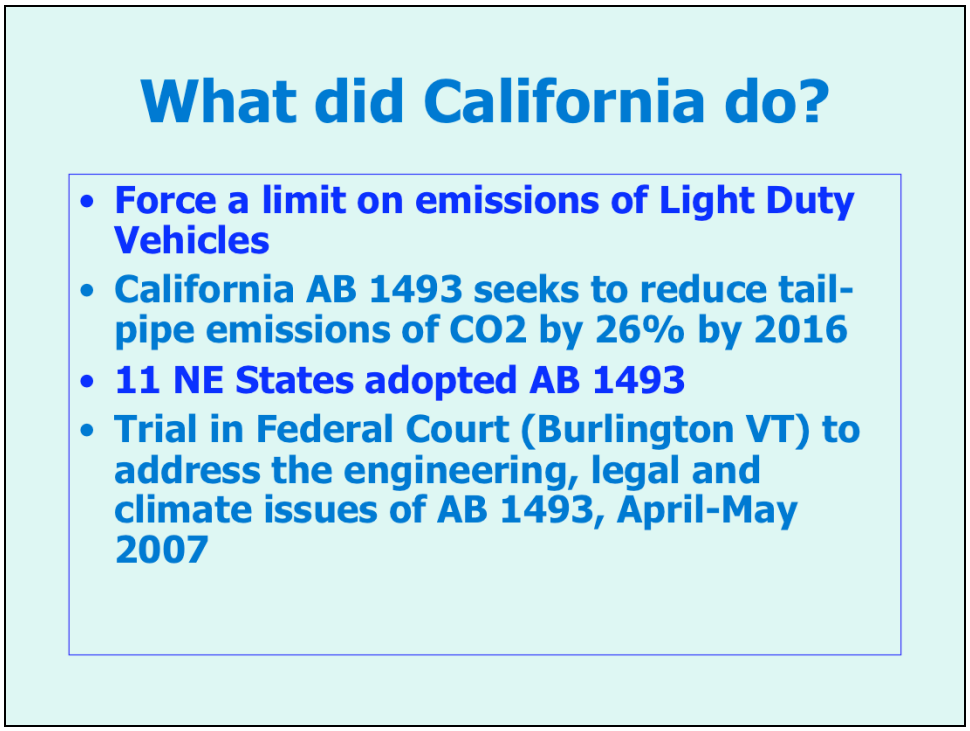
To reduce emissions by 26% which is like 43 miles per gallon

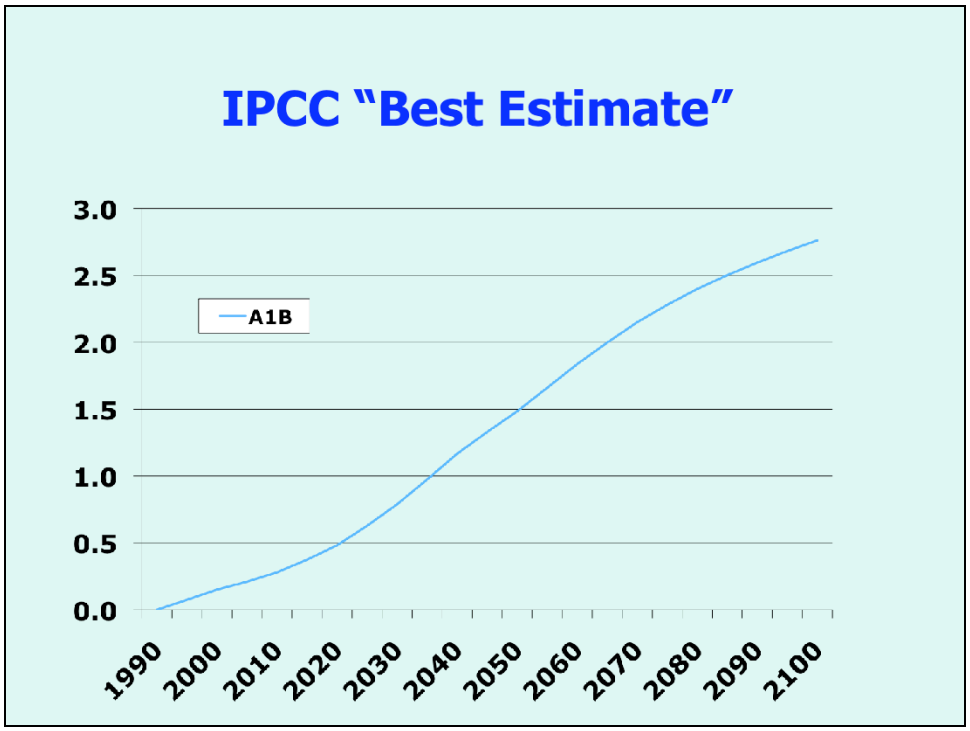


Like I said the trial was in Vermont, April-May of this year.

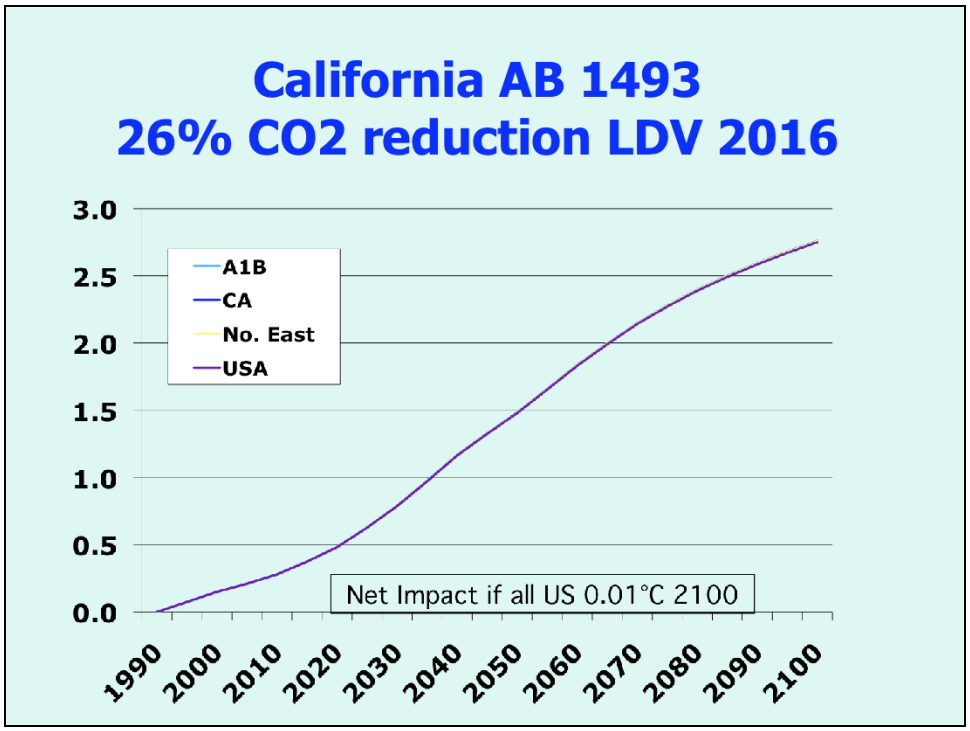
Question

- **What would be the impact on global surface temperatures of adopting and adhering to AB 1493?**
- **Start with IPCC AR4 "Best Guess" scenario (A1B "business as usual")**
- **Adjust CO2 emissions to reflect adoption and adherence by (a) California, (b) the Northeast and (c) all of U.S.**
- **Perform calculations so as to *overestimate* impact, not underestimate impact**

So I was asked to answer these questions. What would be the impact on global surface temperatures of adopting and adhering to AB 1493? Now California is famous for passing laws that they never follow. Europeans are very good at this. They pass laws, pound their chest and say how good we are and then never adhere to what they got. But I am assuming that the law is passed and adhered to. I did some very conservative things. I made sure I was **overestimating** the impact of this law, so that no one could challenge the numbers.



This is the best estimate of temperatures from the IPCC for the next 100 years. I don't trust it, but let's just assume that this is the best estimate of what the temperatures are going to be for the next 100 years. I applied AB 1493 to the entire country. And I am going to overlay the results on this picture. So watch carefully.



That's the result of AB 1493, in other words there is no result. In fact if the **entire world** adopted AB 1493, the difference would be 3 hundredths of a degree. Am amount that we can't measure and cannot detect. So I'm thinking like a scientist. You know dumb me. I'm in a court and I am thinking like a scientist. The evidence shows that this law has no effect. So what am I going to conclude? The law should be thrown out, right? I mean, that is what I would do.

Answers

- The answers indicated the impact would be so tiny as to be undectectable and immeasurable
- If applied to the entire world, the net impact by 2100 would be no more than 0.03 °C, again, an undetectable amount
- The impact on sea level rise would be 1 mm by 2100 if all the U.S. adhered

So the answer is just what I showed you that there is essentially no detectable effects.

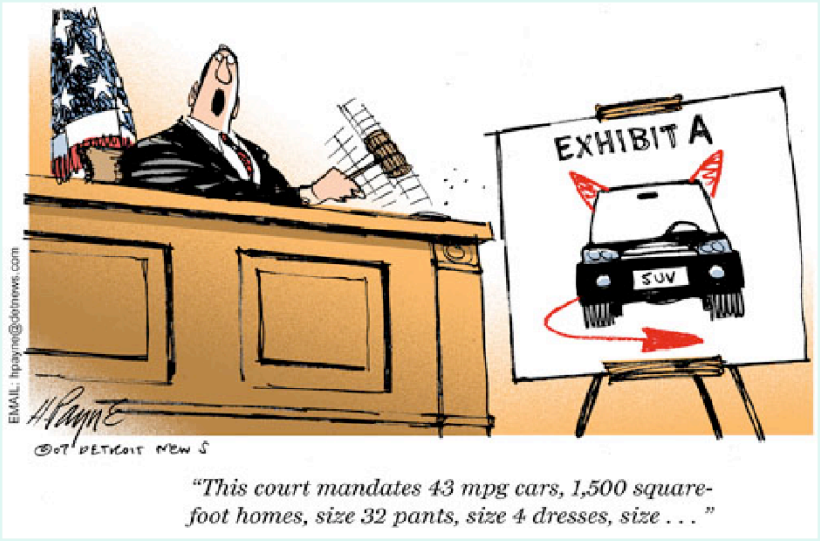
Judge William Sessions III Ruling 12 Sept 2007

AB 1493 is legal

Pg 46

"Plaintiffs' expert Dr. Christy estimated that implementing the regulations across the entire United States would reduce global temperature by about 1/100th (.01) of a degree by 2100. Hansen did not contradict that testimony."

Well Judge William Sessions ruled just about 3 weeks ago that AB 1493 is legal and can be enforced. And I am thinking, "What is going on"? And in the decision on page 46 he has this in there. "Plaintiffs' expert Dr. Christy estimated that implementing the regulations across the entire United States would reduce global temperature by about 1/100th (.01) of a degree by 2100. Hansen [who was the expert that testified on behalf of the defense] did not contradict that testimony." I mean the numbers I did were just solid. So, though he recognizes the science and the evidence, he went on with the decision that contradicted what the evidence shows. But when it gets into a court system, You really can't control it.



This is a funny cartoon that came out in the Detroit Free Press. "The court mandates 43 mpg cars, 1,500 square foot homes, size 32 pants [and I'm out-a there], size 4 dresses, size . . ." It is interesting when courts start mandating science and physical law. We hope that wouldn't happen, but there you have it.

Questions

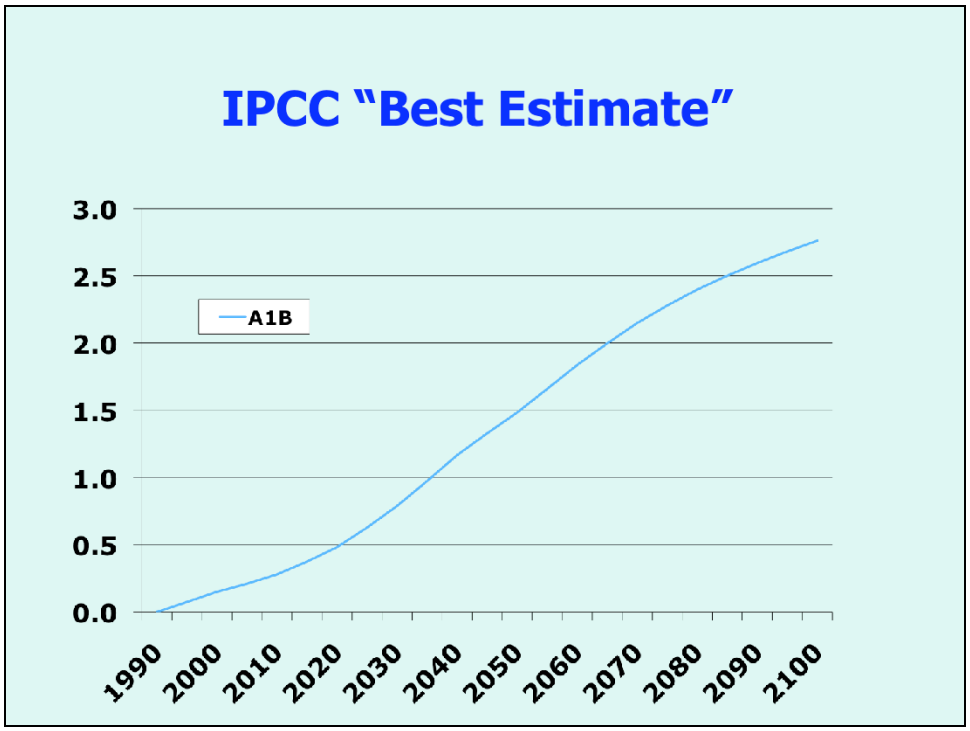
- **What *could* make a "dent" in forecasted global temperatures?**
- **What would be the impact of building 1000 nuclear power plants and putting them on-line by 2020?**
  - **(average 1.4 gigawatt output each)**

But ask the question. "What could make a dent?" Can you make a dent in the CO2 emissions. Because remember, energy demand is growing. It will grow because it means so much to life, because without it life is brutal.

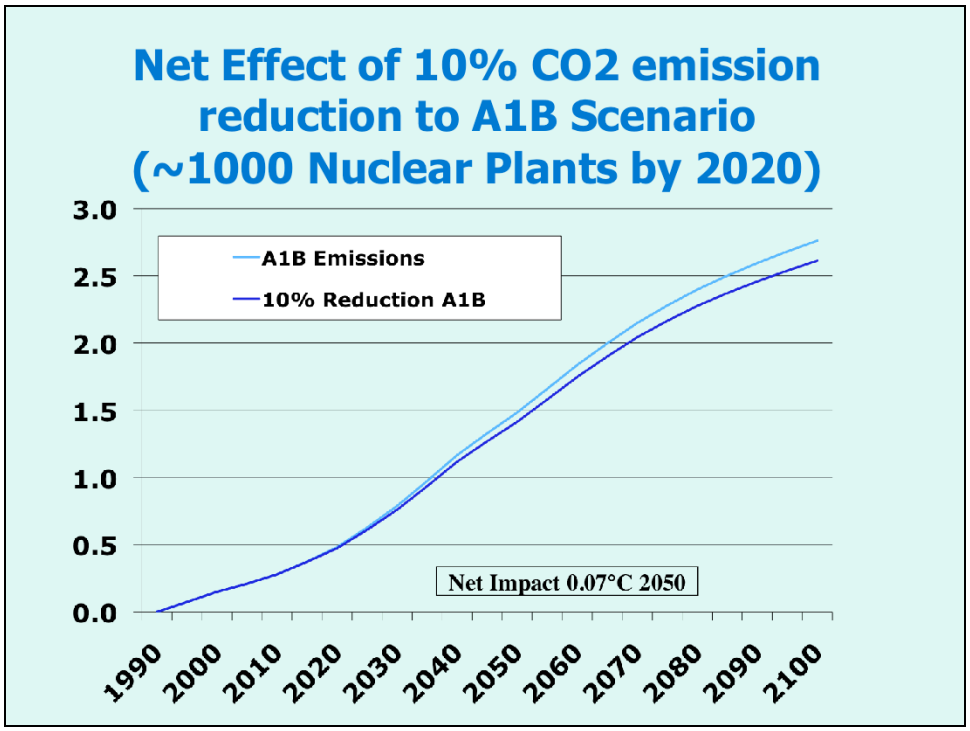
Questions

- What *could* make a "dent" in forecasted global temperatures?
- **What would be the impact of building 1000 nuclear power plants and putting them on-line by 2020?**
  - **(average 1.4 gigawatt output each)**

Well, let's built a thousand nuclear power plants, 1.4 gigawatts each and put them online by 2020. The one that Browns Ferry just started up here, that was a 1.2 gigawatt nuclear plant.



So here is the best estimate of what a thousand nuclear plants would do.



About a tenth of a degree reduction by 2100. This is at the level that we can almost measure. Right at the level we can measure. So to get the first detectable thing, you need to be at the level of about 1,000 nuclear power plants right now. Start building them now and have them ready by 14 years from now.

Main Points:

Without energy, life is brutal and short.

Proposed "do-something-about-global-warming" initiatives will not detectably alter whatever the climate is going to do.

Making energy more expensive is a regressive tax and an economic development inhibiter

So the main points: Without energy, life is brutal and short.

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Without energy, life is brutal and short.

Proposed "do-something-about-global-warming" initiatives will not detectably alter whatever the climate is going to do.

Making energy more expensive is a regressive tax and an economic development inhibiter

Do something about global warming initiatives, when you get down to the science when you adopt this initiative and you see that nothing is going to happen or affect whatever the climate is going to do.

Main Points:

Without energy, life is brutal and short.

Proposed "do-something-about-global-warming" initiatives will not detectably alter whatever the climate is going to do.

Making energy more expensive is a regressive tax and an economic development inhibiter

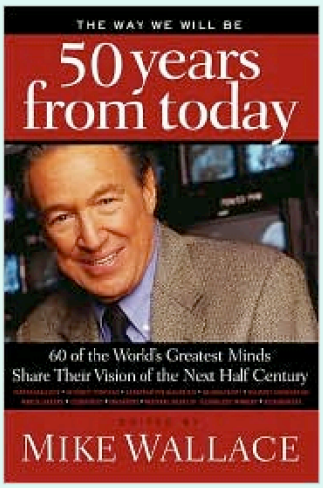
A rational approach I think is to adapt to what you observe.

A MORE RATIONAL APPROACH?

- **In 50 years will we learn that the most cost-effective path was to adapt to changes we actually observed and measured, rather than try to outguess Mother Nature's course?**
- **In 50 years will we be surprised not by climate change but by the inventive minds of our scientists and engineers, unfettered by mandates, as they discover profitable and affordable ways to generate energy without carbon emissions?**

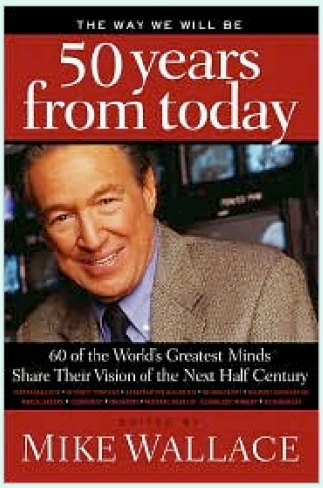
Observe the climate, what it's doing, adapt to that. And that is where you spend your money because then you know you are getting your money's worth. Because you are spending on what's actually happening.

I think in 50 years we are going to be surprised, not by climate change, but by the inventive minds of our scientists and engineers unfettered by mandates, as they discover profitable – remember as you discover new ways to get energy you are going to get rich. So greed really does motivate a lot of things. We are going to find ways to generate energy without carbon emissions. I am astounded by my son who is a graduate student in physics at what is available to him to do his research today, compared to what we had when we were in graduate school. You know the punch cards at best, and then the paper tapes and so on. I mean we had a 110 baud printer and we thought that was the greatest thing in the world. So we are going to see some fantastic things coming.



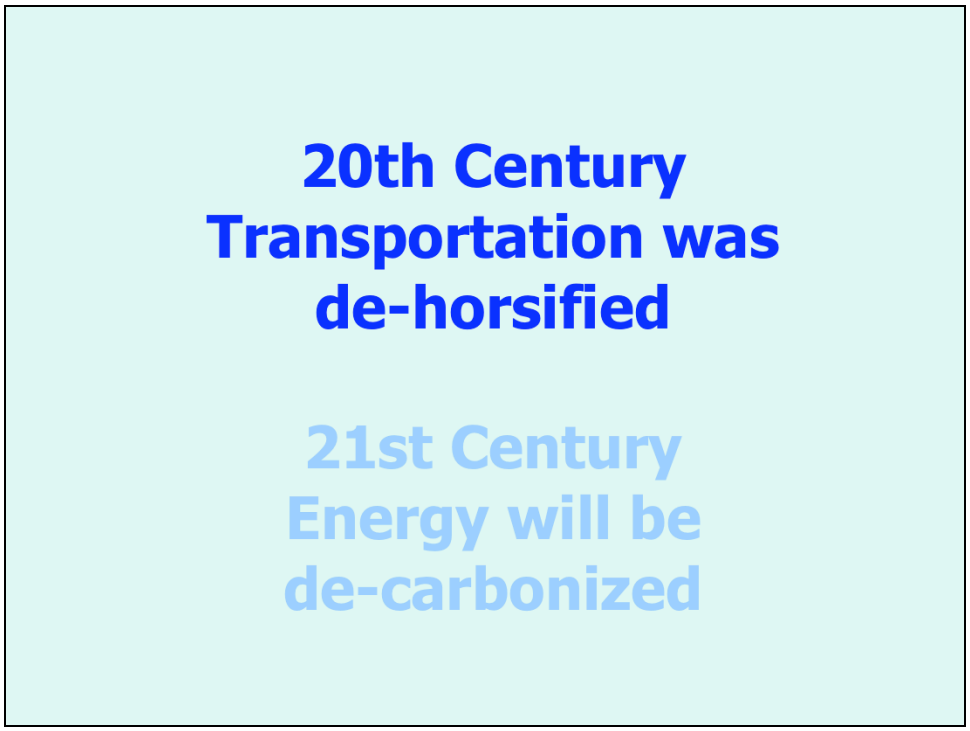
Chapter 5
John Christy

"In summary, I can not know what the trajectory of the climate system will be well enough to advise policy makers today on what specific course it will take, or well enough to help them know what they could possibly do to tweak it toward a direction deemed 'safe,' or even well enough to appear exceptionally prescient to those reading this in the future.

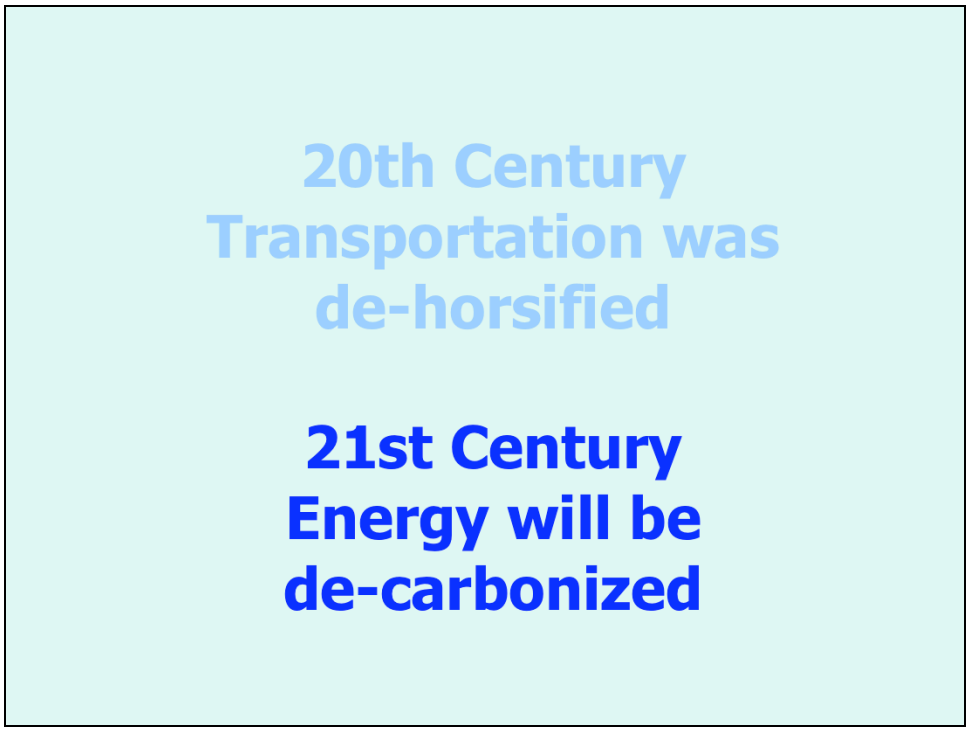


Chapter 5
John Christy

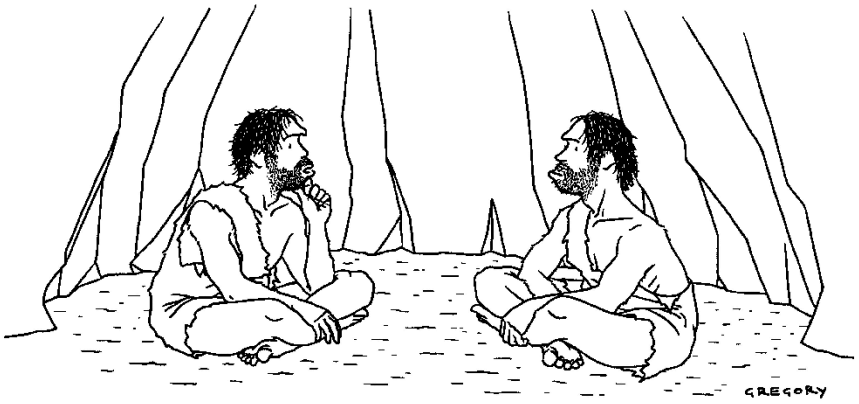
"But I do believe that the accumulating economic development throughout the world will not be sidetracked by calls to 'stop global warming,' which are ultimately designed to inhibit access to affordable energy. As a result, I believe more and more people will experience better health and security and that this will be accompanied by the additional bonus of a better-preserved natural environment."



So in the 20th century, transportation was de-horsified.



I think in the 21st century, energy will be de-carbonized.



"Something's just not right—our air is clean, our water is pure, we all get plenty of exercise, everything we eat is organic and free-range, and yet nobody lives past thirty."

This is my last slide. Two cave me are sitting there, "Something's just not right – our air is clean, our water is pure, we all get plenty of exercise, everything we eat is organic and free-range, and yet nobody lives past thirty."

That's the difference between having energy and not having energy.