

WASHINGTON ROUNDTABLE
ON SCIENCE & PUBLIC POLICY

The Science Isn't Settled

*The Limitations of
Global Climate Models*

By

Dr. Tim Ball

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*Limitations of Global Climate Models**

Dr. Tim Ball

March 21, 2007

Dr. Ball's presentation was co-sponsored by Frontiers of Freedom and the George C. Marshall Institute

Paul Georgia: Good morning. I want to thank everyone for coming today. My name is Paul Georgia. I am the Executive Director for the Center for Science and Public Policy. We are putting on this event together with the George Marshall Institute, and I want to recognize the presence of Jeff Kueter, the President of the Marshall Institute. I want to introduce today our special guest Dr. Tim Ball. Dr. Ball is one of the first Canadians to hold a Ph.D. in Climatology. He wrote his doctoral thesis at the University of London (England) using the remarkable records of the Hudson Bay Company to reconstruct climate change from 1714 to 1952. He has published numerous articles on climate change and its impact on the human condition. Dr. Ball has served on numerous committees at the federal, provincial and municipal levels on climate, water resources and environmental issues. He was a professor of climatology at the University of Winnipeg for twenty-eight years and he has written a regular column on weather in the agricultural magazine *Country Guide* for fourteen years. He is currently working as an environmental consultant and public speaker based in Victoria and has written with Dr Stuart Houston, *18th Century Naturalists on Hudson Bay*, a book on the science and climate of the fur trade. Please join me in welcoming Dr. Ball.

Dr. Tim Ball: Thank you very much. I was preparing for this talk, talking to a fourth-grade class. The students were learning about the weather during the fur trade and you don't understand the fur trade unless you understand how cold it was in the world at that time and the demand for furs. The teacher introduced me as a climatologist and immediately a hand went up. I said, "Do you have a question?" The student said, "How many mountains have you climbed, anyway?" I present that as an introduction to the idea that weather or meteorology is the study of the physics of the atmosphere, while climatology is the study of weather patterns over time or in a particular region. The Greeks were looking at climatology. In fact, the word climate comes from the Greek word for angle; they were talking about the angle of the sun. But then at the turn of the century, we got into meteorology and that became dominant. Meteorology

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is actually a subset of climatology. Climatology is a generalist discipline in a world that specializes. When they say that the U.N. has 22,000 scientists that all agree, we find that they, all of them, have one little piece of the climate puzzle, but none of them really understand the context of climate, and that is one of the things that we are going to look at today. Meteorology is in the public's mind and they know about that, but what is this climate thing? I want to talk about that and about why the whole hysteria about global warming exists; of course, it is in the models. Before I get to that, my career has spanned two climate changes, cooling when I started and now global warming. I hope to live long enough to see the third cycle, because the world is cooling down now. It is predicted to cool by the year 2030 by a considerable amount, yet the whole world is planning a single vast strategy of global warming. So I want to look at that.

But what I have seen beyond that is the application of statistics particularly into the social sciences. One of the things about climate change, and I fought this for most of my career, is that it is taught in the social studies program in the school curriculum, when it should be in the science program. Of course, that means that you end up having discussions in ignorance because the students don't understand the science and the teachers don't understand the science. So we have that dilemma. What we have seen is the application of statistics starting out in the 1930s with the application of averages; climatology was all about average record. But averages are virtually meaningless. One year a farmer called me and said, "What are the chances of average temperature this summer?" I said, "Virtually zero." Someone asked a baseball manager, "What is the batting average of that player?" He said, "I don't know." The person said, "But you're the manager; you should know." He said, "An average to me says that if I put one of his feet in hot water and the other in cold water, he should be comfortable." So averages dominated, but they became essentially meaningless. Of course, you can have the same average with a small range of variability as you have with a large range of variability, and that is one of the issues that we are talking about. It is a very important point.

The other point is that about the 1970s, we got into simple trend analysis. We saw this in all the social sciences. In housing prices, people said, "Oh, it's going up and it will keep on going up." We saw global cooling and people said, "Well, the temperature is going down, so it will keep on going down." Now it is going the other way and everybody is on the "trend wagon," as I call it, screaming for policy. What has been happening more recently, since about 1986, is that the weather has become more variable. We hear about the record warms in Alaska, but they don't talk about the record colds they have had in Alaska, as we had this last winter, so we are getting a bias. What has happened is an increase in variability; that is the third phase. We superimpose on that, of course, the application of models, which are mathematical constructs and take some of that basic statistics into account. So that is where we are.

I want you to understand that all of the forecasts of future climate are based on models, all of them. They are very simplistic models that basically guarantee the outcome because of the way the models are set up. I experienced this when I was serving

as chairman of Boards of Enquiry; the government determined the output of the Board of Enquiry by the terms of reference. Because they set the terms of reference, you have almost no choice but to reach a certain conclusion. That is what happened with the models: what goes into the models determines the outcome. What are models? They are mathematical constructs. Models range from a hardware model that you buy in a toy store and put the pieces together – it is a simulation of a small scale – to very abstract models. For example, an algebraic formula is a model, except that the variables are represented by mathematical symbols. That is what we have with computer models, where mathematical symbols represent all the different components of the atmosphere and the climate and so on. Of course, there are limitations to that. They attempt to predict future climate conditions based on a set of assumptions. Models, like theories, are only as good as the assumptions you make. Einstein said that if nothing goes faster than the speed of light, then ultimately $E = mc^2$. But if you find something going faster than the speed of light, $E = mc^2$ essentially becomes redundant, because it is only as good as that assumption. With the models they have set certain assumptions which are proving not to be correct.

The Intergovernmental Panel on Climate Change models make forecasts about future population, energy use, technological development and so on; they took the climate model and then applied all of these social functions in the UN report. Of course, how accurate those are is really very open to question. People like David Henderson, the former head of economics and statistics for the OECD, have simply torn apart the application of the climate into these particular social functions. In fact, Richard Lindzen at MIT called these economic models children's games. That is really what they are. I am only going to look at the climate models; I am not going to look at the economic models.

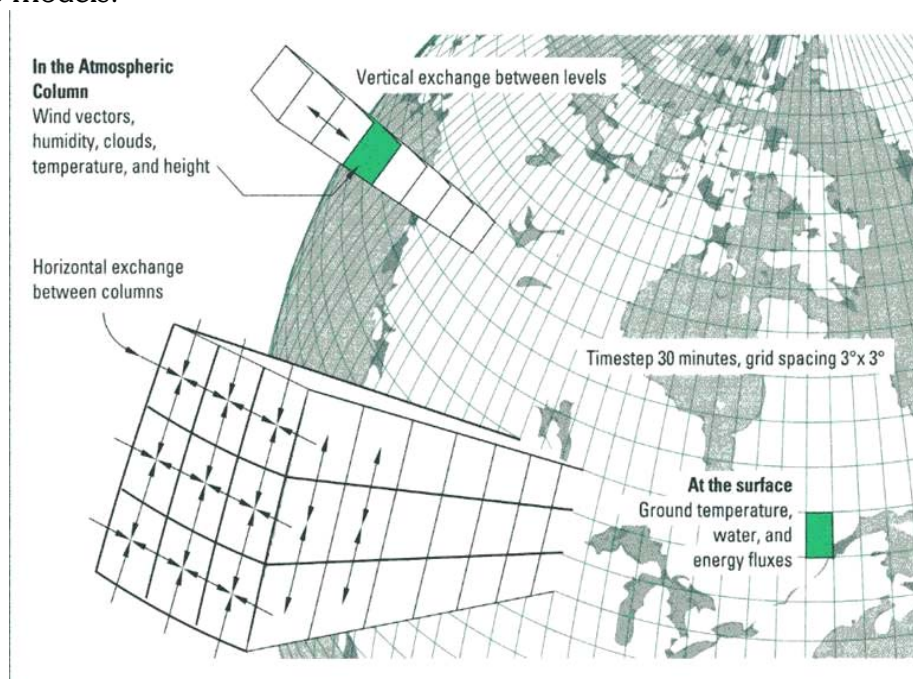


Figure 1

Now the models: Figure 1 is a diagram from the textbook on climate for which I was the lead author. What it shows you is that the climate models divide the world up into those rectangles you see on the surface. Then they divide the atmosphere up into boxes above the surface. The most basic ones take nine layers of the atmosphere. The problem is that for most of the world's surface, we have virtually no data. In each of those squares, we have virtually no data on the surface. When you get above the surface, we have even less. There is virtually no data. The question becomes immediately, what is your model built on? The key word in here is parameterization, which is a fancy way of saying we will estimate the average for each four corners of the square and then apply an average from those estimated four corners to the whole area. It is absolutely incredible. The question then is what is your model built on, and the answer is nothing, especially when you get into three dimensions, because the atmosphere is three-dimensional and very dynamic.

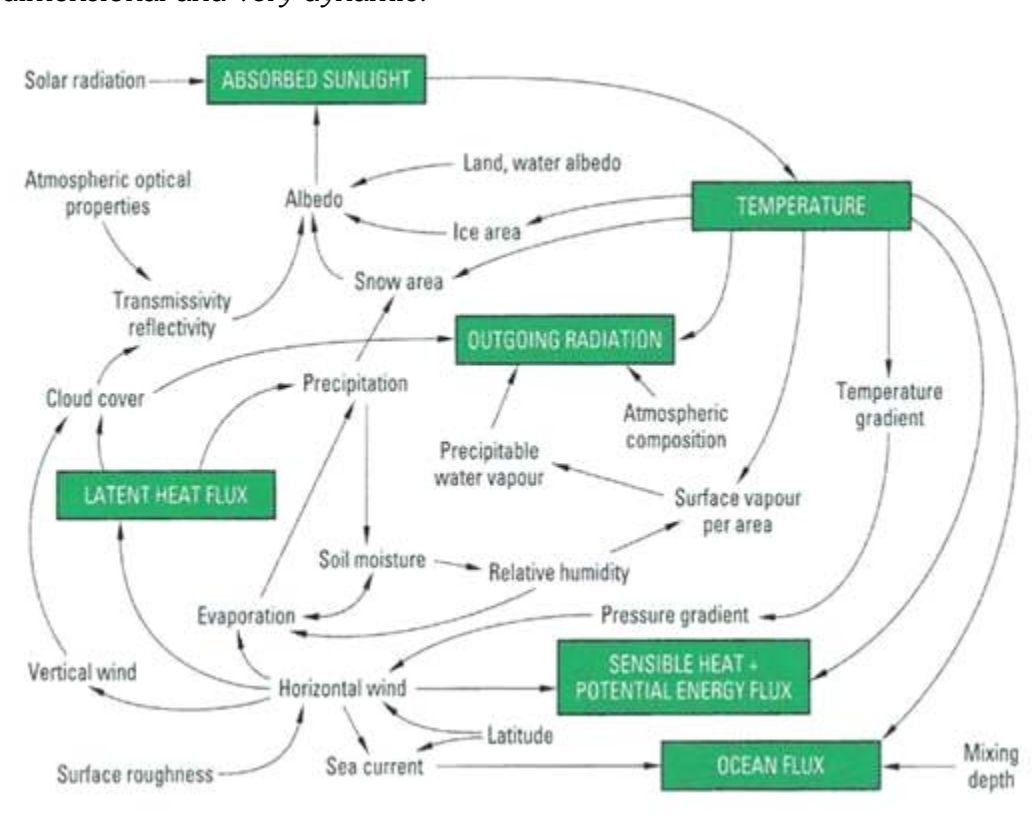


Figure 2

Figure 2 is another diagram that we produced for the textbook and it fits very well here, because the atmosphere is incredibly complex, yet the models are amazingly simplistic. This shows you just a few of the interactions that are going on in the atmosphere. If you change or force any one of these, it immediately has a repercussion in all the others. There is not a computer on the planet with the capacity to come even close to including all these variables, so they simply eliminate them. They just include some of the more basic ones. For example, ocean flux is in the bottom right-hand corner, but we have hardly any information on the surface data, let alone the subsurface

data. Ocean circulations take as much as 10,000 years, with cold water sinking at the poles and emerging at the equator 10,000 years later. None of that is included in the models. This shows you the complexity of what they are trying to model.

Many people don't understand computer inadequacies, so I will give you a quote from Casper Ammann, who is a major modeler. He said that General Circulation Models (GCMs) took about one day of machine time – these are computers operating at millions of calculations a second – to cover twenty-five years, so on this basis it is absolutely impossible to model the Pliocene-Pleistocene transition which, by the way, is a very important transition in the history of the climate of the earth. To model the Pleistocene, which is the Ice Ages (say, for the last two million years), using a GCM would take about 219 years of computer time.¹ If you are a computer modeler and you wanted to do this, you would have to believe in reincarnation to hope to see the result of your model. Of course, like the fellow said, “I don't believe in reincarnation, but then I didn't believe in it the last time I was here, either.”

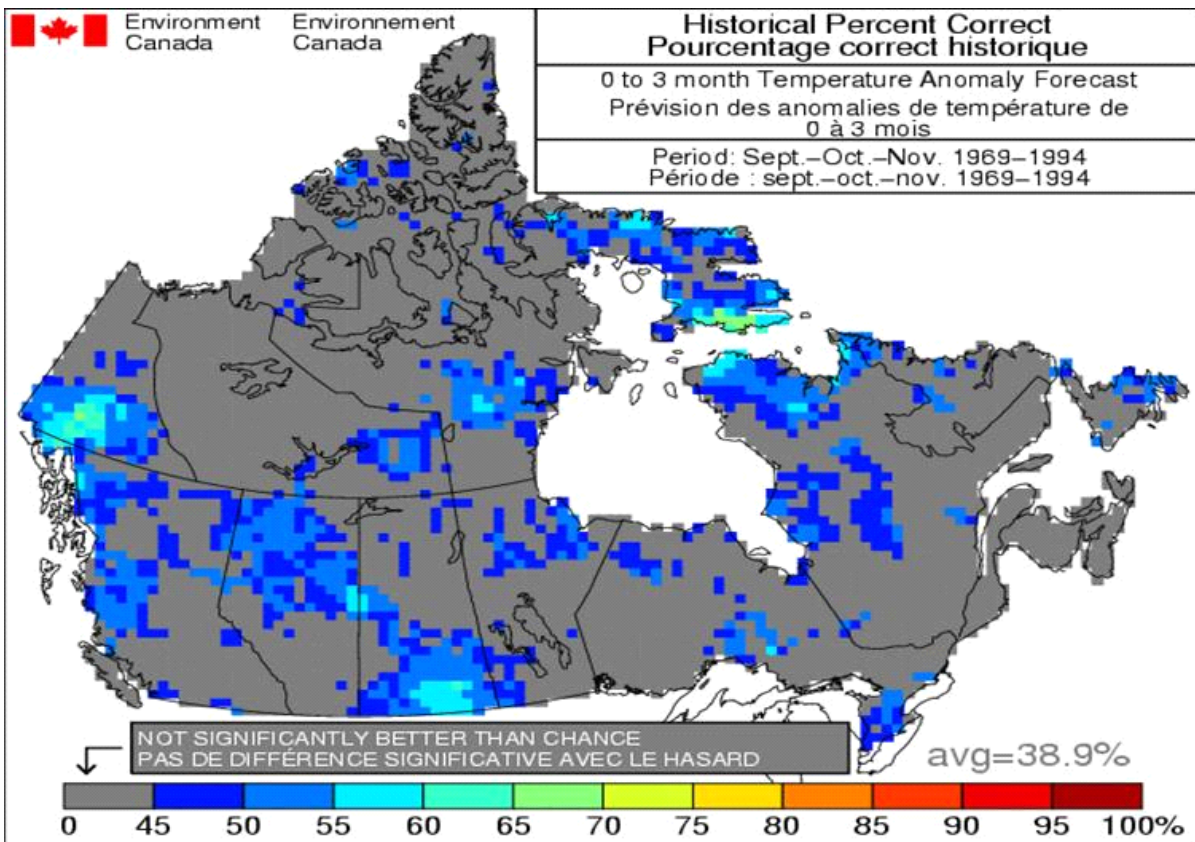
So you can see the difficulties that arise from these computer models. They are an extremely cloudy crystal ball and they oversimplify poorly-understood climate processes, for example, precipitation and transport of energy. One of the problems that we have with the greenhouse analogy is that the earth's atmosphere doesn't work like a greenhouse. But the idea now has become part of our lexicon and it's not going to be put aside. In the greenhouse, the air is heated by conduction; in the atmosphere it is heated by the movement of the air by convection, and of course transport of energy is a major part of that. Even simplistic things are not included in the models and the models ignore major effects, the Milankovich effect which was put forward in the 1950s; the scientific community were talking about components of it back in the 1890s and earlier. This is the idea of changes in the sun-earth relationships. I will show you some of that in a minute.

Different models yield different results. One of the first times I saw a presentation by a modeler was in 1989, when Michael Schlesinger, who was then at Oregon State University, had taken five models, put the same data in each model, and each model gave completely different results. When I say completely different results, one of the models showed North America getting much warmer and the next one showed it getting much colder. His response, when this was pointed out to him, was, “They are qualitatively the same; they all show the earth is warming.” I said, “Well, of course they do, because you have said that as the CO₂ increases, the temperature will go up. You should be surprised if they didn't show that; you programmed them to do that.” So this is the kind of situation that you get with the different results. The same models produce very different results. You can put the same data into the same model seven different times and it will give you a different result each time. What they do is they

¹ Source: McIntyre, Climateaudit, 2005.

average the results, or they will pick two that happen to agree and ignore five others out of the seven. But they don't tell you that.

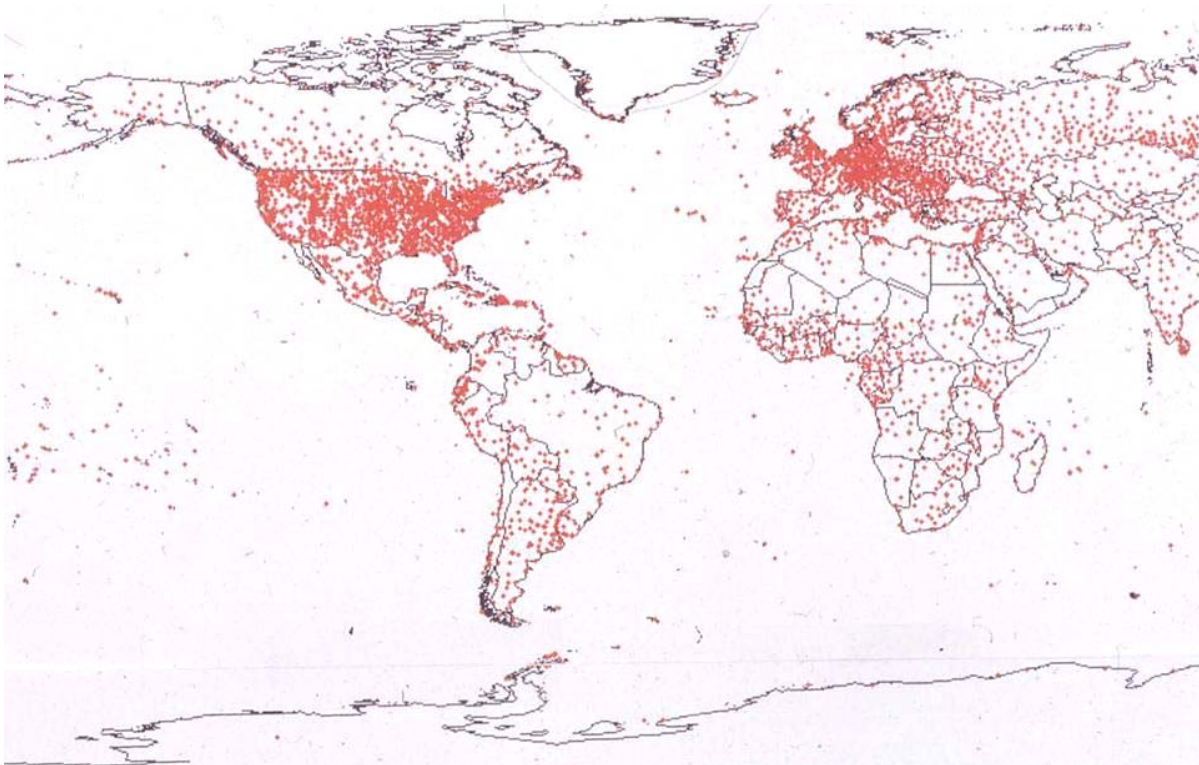
They have an inability to hindsight forecast. Hindsight forecasting is when you run the model from present conditions and have it going backwards and say, "How well does it recreate past conditions?" The models can't do that. They can't recreate the Medieval Warm Period of 1,000 years ago and they can't recreate the Ice Ages. In other words, they don't work going backwards, so the question then is how well they work going forward. The answer is, they don't. Again, that is part of the problem with the models. The models have been wrong on every single forecast to date. All their predictions about global temperature and where we are going with the global temperature in the thirty years that we have been writing about, every single forecast has been wrong. When I talk to farmers who are directly affected by what is going on with the weather, I call the government and say, "What is the weather going to be like a year from now?" The government will say, "We don't do long-term forecasts." The next day I say, "What is it going to be like 100 years from now?" They answer, "Warmer." Of course, if you are in that kind of industry, the one-year forecast is enormously important to you, and yet they are not able to do that.



Source: Environment Canada. This shows that for 90% of Canada the forecast accuracy was less than chance. Computer models are based on laws of physics yet they are not accurate beyond 10 days yet policy is based on 50 and 100 year predictions.

Figure 3

I just want to show Figure 3 as an example. This comes from Environment Canada, our national weather service. This is their own measure of how accurate their forecasts were over a thirty-year period. This is a zero-to-three month forecast of temperature. The gray area is less than chance; in other words, you could toss a coin. The only thing you have to admire is that they have the chutzpah to put it on their website! I think they have to justify their existence. But these are the same models that are being used by Canada to do global warming forecasts. I guess you could say that that light blue area in southern Saskatchewan, which is about 60 percent possibility, and that area up in the Yukon and the south end of Baffin Island – I don't know what you could grow up there – that is where you get a reasonably accurate forecast.



Surface weather stations: Note concentration in US and western Europe. Vast areas of the world with no coverage. Ocean 70% of surface.

Figure 4

Figure 4 is a plot of the weather stations around the world. You see the dominance of the United States and Western Europe. In most of the world, we don't have adequate station coverage for temperature and even less for precipitation. I will come back to that in a minute. When you consider what they are building the models on, you see 70 percent of the world is ocean, where we have virtually no data. The Arctic, the Antarctic: virtually no data. In Africa, they ran two computer models on precipitation because they wanted to forecast the drought situation. One said there is going to be no drought; the other said there would be a severe drought. It turned out that in Africa, there are not enough stations to meet the World Meteorological Organization's density network for precipitation stations. Yet, they are going to use these models for

policy. It is incredible. If this were presented as a doctoral thesis, how would it hold up? The answer is “Sorry. Go get your degree somewhere else.”

Let’s talk about the data. The U.S. National Research Council reported on February 3, 1999 that

“Deficiencies in the accuracy, quality and continuity of the records place SERIOUS limitations on the confidence that can be placed in the research results.”

Things haven’t changed since the time of this quote. By the way, at the time this comment came out, Kevin Trenberth, one of the lead authors on the recent U.N. report on climate issued in Paris, said, “It’s very clear we do not have a climate observing system...This may come as a shock to many people who assume that we do know adequately what’s going on with the climate but we don’t.” He is out there advocating global warming and that we have to change the world, yet this is his statement about the situation in 1999. In the 2001 Third Assessment Report, the IPCC said “The global average surface temperature has increased by $0.6 \pm 0.2^{\circ}\text{C}$ since the late 19th century.” To illustrate the point even further, we have some smoking guns that have been presented about climate change and global warming. This is one of the smoking guns; this quote presents the argument that the earth’s temperature has increased by 0.6°C since the late 19th century. But what I want you to notice is that it is a 0.6°C increase in 130 years, but it is plus or minus 0.2°C . In other words, the range of the error is 0.4°C on a number of 0.6°C . This is a 66 percent error factor! Now what do they do when they do a political poll? They say it is accurate within plus or minus 5 percent. This is accurate plus or minus 66 percent. Yet that number is put out there and people say, “This is the most dramatic warming and this has to be human, because nature doesn’t change that quickly.” The number itself is rubbish and I can show you in the historic record that nature changes much more rapidly. But that is one of the smoking guns. The thing about that number is that Phil Jones, who is at the Climatic Research Unit in East Anglia, U.K., was asked to disclose how he came up with that number, what readings did he take, how did he adjust them. He said in an email

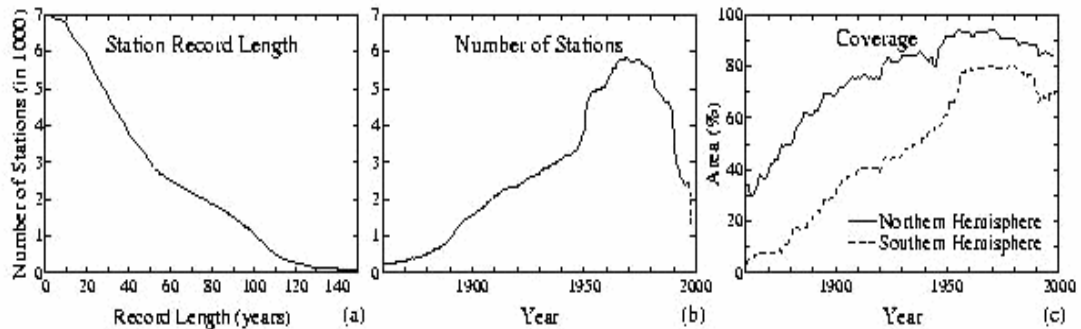
“We have 25 or so years invested in the work. Why should I make the data available to you, when your aim is to try and find something wrong with it?”

*– Jones’ reply to Warwick Hughes, 21. February 2005;
confirmed by Jones when asked by Von Storch.*

Yet this number is being used to convince the whole world that the world is warming more rapidly than ever before. I think it is unconscionable, particularly because the data and his work is paid for by the taxpayer. I think that that is an illustration of what the problem is.

The figures below indicate

- a. the number of stations with record length at least N years as a function of N,
- b. the number of reporting stations as a function of time,
- c. the percent of hemispheric area located within 1200km of a reporting station.



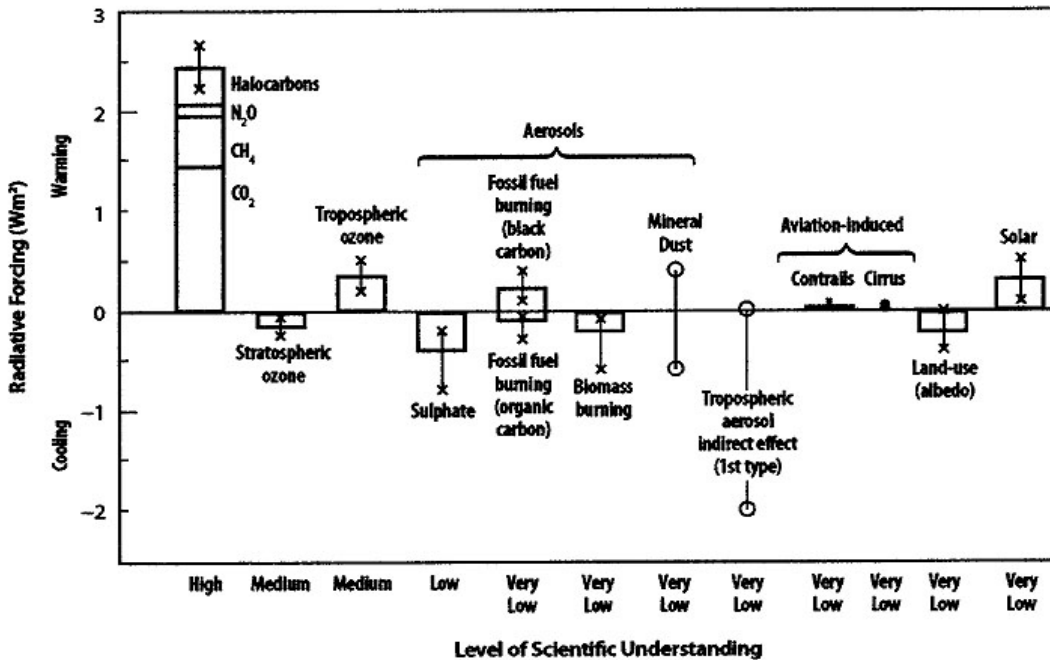
Goddard Institute of Space Studies (GISS) P.D.Jones

Claim an accurate record for the last 130 years, but note there are less than 1000 stations with 100 years of record. We have less stations now than in 1960.

Figure 5

Just to illustrate the problem even further, Figure 5 shows a few graphs from the Goddard Institute for Space Studies used by Jones and by James Hansen at NASA. On the left side you see the red line across is a thousand stations. The blue line shows 130 years. They are telling you that this is the temperature increase for 130 years, but how many stations are 130 years old and have a continuous record? Virtually none. So what is the sample size? The answer is, inadequate for a doctoral thesis. Then you see in the center graph the number of stations. We have fewer weather stations now than we had in 1960. In Canada, we close weather stations. Why? Because we spend all the money on propaganda about global warming. We have less data now to get an accurate measure of what is really going on because we spent the money in the wrong area. Data collection is a primary function of government and the data should be available, fully audited, to everybody. But that is not happening. As I said, you see the global coverage has decreased since 1960. Part of this was because they assumed the satellite was going to come in and replace all the surface stations. Then they suddenly discovered the satellite couldn't measure how much rain there was or whether it was rain or snow. It couldn't see through the clouds. There was a lot of information it couldn't provide, so they made a move based on technology that turned out to be a very bad move. They have scrambled around the world; they are using automatic weather observing stations, which are horrendously inaccurate, to try to fill in the hole because of major problems.

Figure 1: Level of confidence assigned to identified components of climate change



Source: Houghton et al., 2001: 8.

Figure 6

Figure 6 is from the 2001 IPCC report. Sir John Houghton, who was the head of the IPCC and head of the UK Meteorological Office, states that this is the level of confidence assigned to identified components. On the left side are the greenhouse gases, but one is missing: H₂O. Water vapor is the most important greenhouse gas; it is 95 percent of the greenhouse gases, but it is not even on the chart. It is absolutely incredible. On the right side you see solar. They say the level of scientific understanding is very low. But they should talk to the solar physicists; they know an awful lot about the sun and its relation to climate. But that's not what they do. All of those things in there, by the way, are all human-related, because the objective here is to blame humans for every single climate change or change in events at all, ignoring natural variability. Until you know how much climate change is natural, you don't have a hope of separating out the human portion of it. Yet they are ignoring the natural portion in this kind of diagram. One of the ones they ignore is solar variability. The sun's energy at the earth is changed in three ways. The only one that the IPCC looks at is what is called electromagnetic radiation: heat and light. But even allowing for that, they say electromagnetic radiation has varied by 0.17 percent in the period of record we have, and 0.17 percent out of 100 percent is nothing. But in the same models, you can vary solar energy by 6 percent and that explains all the temperature that has ever occurred on the surface of the earth. So the 0.17 percent isn't of 100 percent, it is of 6 percent. It is significant. Even the U.N. admits that it explains 50 percent of the temperature in the last 130 years. But the focus is on CO₂.

Sun-earth relationships and Milankovich effects are not even included in the computer models. Variation in corpuscular radiation, the solar wind are not even included in the computer models. By the way, I flew search-and-rescue in the Arctic for five years and we always relied on the aboriginals for weather forecasts, because they were always much more accurate than the government ones. They used the Aurora Borealis, for incredibly accurate forecasts. Of course, the government guys say, "That has nothing to do with the weather." But I know who my money is on; I have to go fly in that stuff.

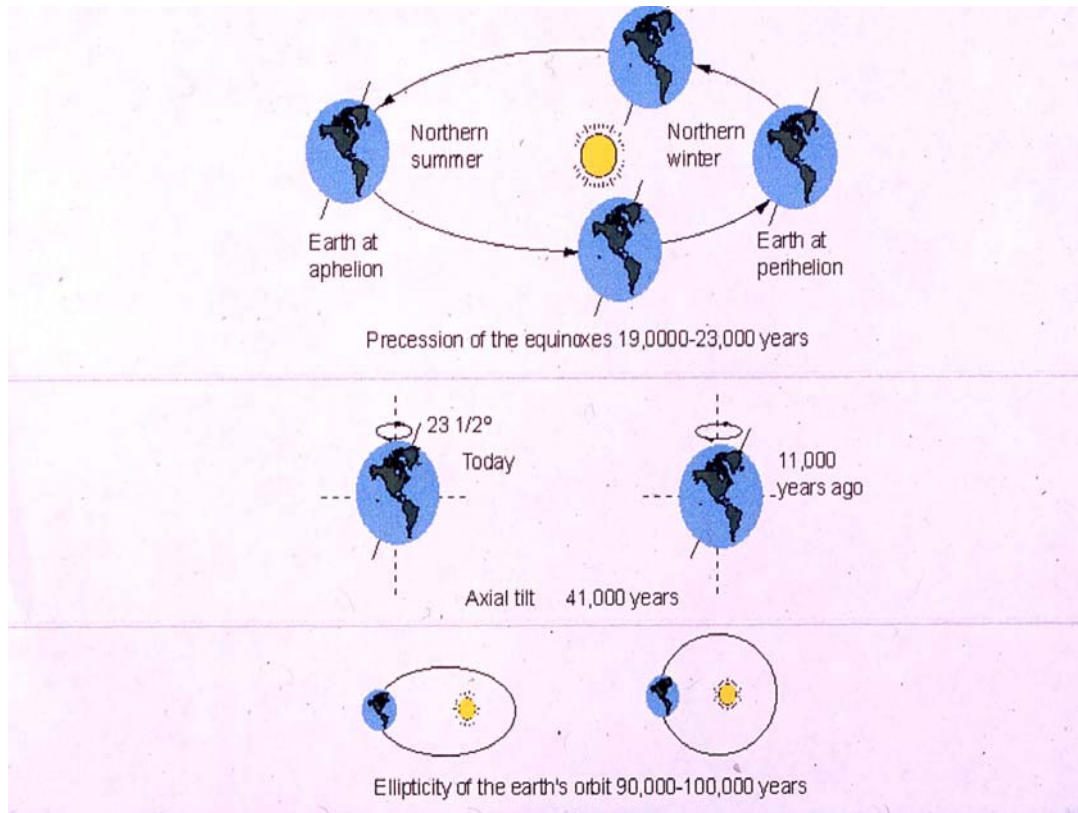


Figure 7

Figure 7 shows the Milankovich effect; the diagrams that you want to look at are the bottom two. On the right side you see the earth going around the sun in an almost circular orbit; that is what is in the textbooks in the schools. But on the left is what is not in the textbooks in the schools, and that is how the orbit was just 22,000 years ago. At the present elliptical orbit, when we are closest to the sun (on January 4) we have about +3.5 percent of the average energy from the sun. When we are furthest away on the other side (on July 4) we have -2.5 percent, so the total range of energy now would be, with the elliptical orbit, is about 7 percent. That, by the way, is one of the reasons that the Northern Hemisphere winters are warmer, because we are closer to the sun in the Northern Hemisphere. On the left is the orbit 22,000 years ago. So when we were closest 22,000 years ago, it was +8.5 percent and when we were farthest away, it was -8.5 percent, for a total range of 19 percent in energy. That is in just 22,000 years. What is causing these changes? The gravitational pull of the planet

Jupiter distorting the orbit. We have known about that for 150 years, but it is still not in the school textbooks. Why? That is a very important question to ask. In the middle you see the axial tilt is up 23.5 degrees. (It isn't 23.5 degrees, but that is close enough for government work. The tilt actually changes from 24.4 to 21.8, and I am not talking about wobble, I am talking about actual change in tilt.) That also changes the climate, so every single year the climate is different because the orbit is different; the climate is different because the tilt is different. None of that is in the computer models. When you ask them why, they say, "Well, it is too slow a change." It may be, from year to year, but if you are doing fifty and hundred year forecasts, these changes are more significant than any human input. But it is not in the models. These are some shortcomings.

The bottom image on Figure 7 is the changing orbit, and then the changing because of what is called the precession of the equinox. This is an important idea. We are led to think that change is gradual over long periods of time, yet we know it isn't. We have calendars that are fixed, but nature is changing. Every once in a while we have to adjust the calendars to catch up with what nature is doing. In 1752, the British government simply said, "We are going to subtract eleven days from the calendar." You can go and look at the journals of the Hudson Bay Company, and September 2 is followed by September 13. People died in the resulting riots in England; they were furious that the government was shortening their lives by eleven days! As I said, that is an illustration of how the calendar is fixed, but nature is changing, and we have to adapt to that change.

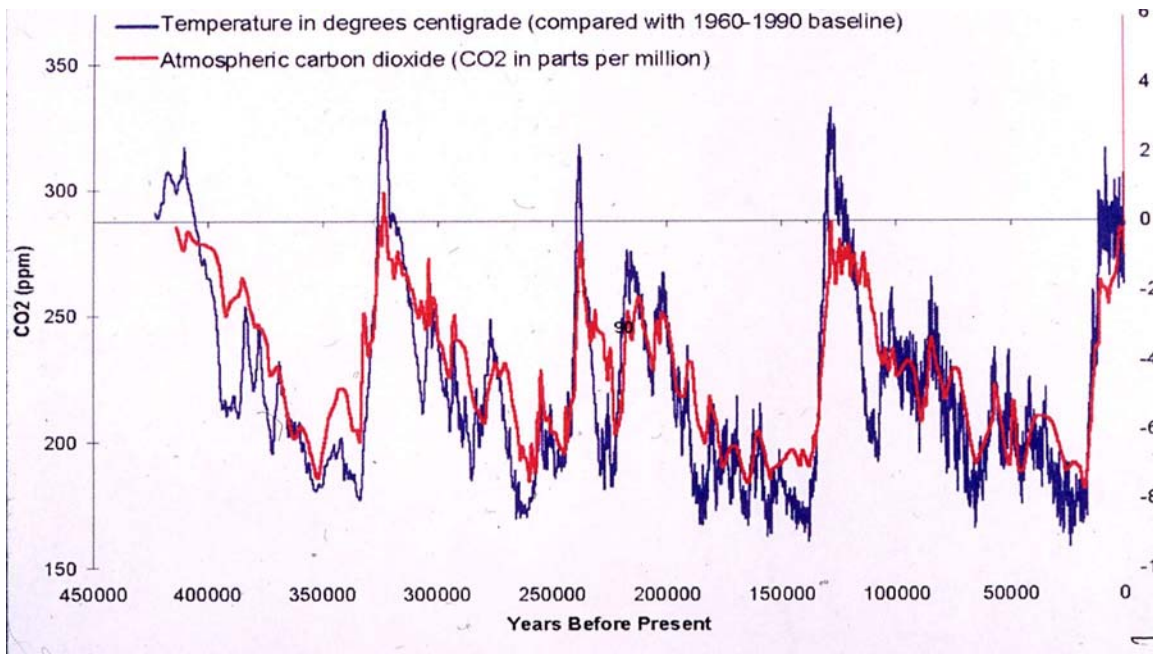
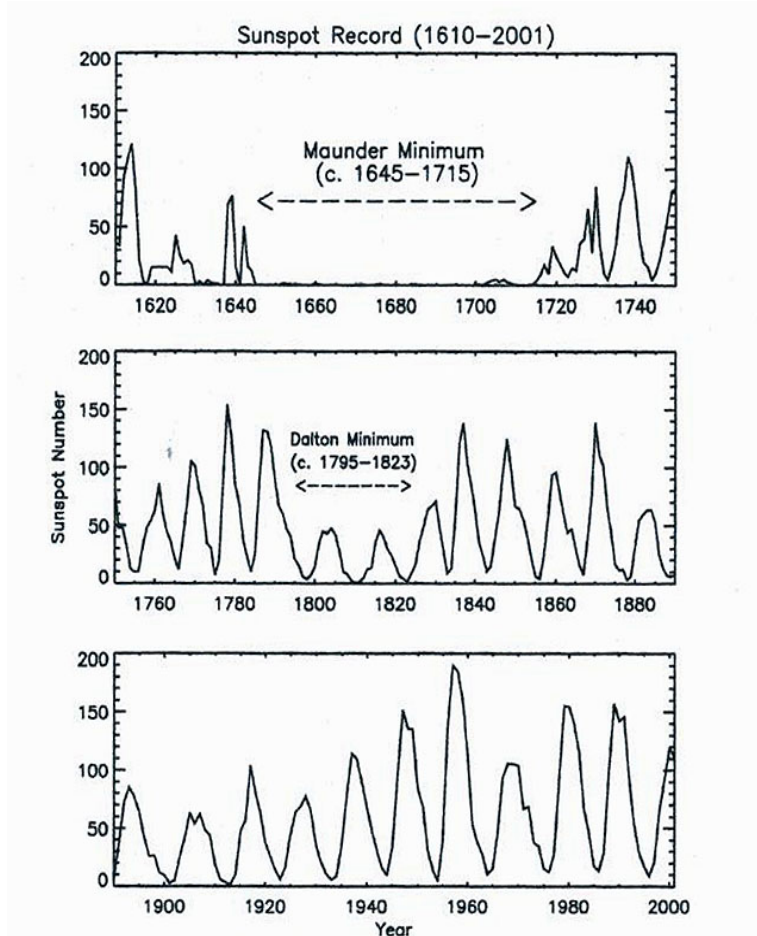


Figure 8

Figure 8 shows the ice core record and it shows 420,000 years. The blue is the temperature line of the present temperature on the right. I want you to no-

tice that 130,000 years ago, the earth was warmer than it is today. 320,000 years ago it was warmer than it is today. These changes, this sort of saw-tooth pattern, about 85 percent of that is explained by the changing orbit and changing tilt. That is not in the computer models, and yet here it is. The other thing that is significant about this is that the blue is the temperature and the red is the CO₂. This shows, without any question, that the temperature changes before the CO₂, not the other way around. Remember I was talking about assumptions? A fundamental assumption in the models is that if the CO₂ goes up, the temperature will go up. The evidence shows that that is exactly wrong. Nobody is arguing about that. By the way, the scientist that produced these graphs originally, a Frenchman by the name of Jouzel warned, "Don't rush to judgment on this." What do they do? They rush to judgment, because it fit their thesis to say, "The temperature has gone up and down and the CO₂ has gone up and down." The fact that it was the opposite way of what they wanted was ignored: "Don't confuse me with facts. My mind is made up on this issue."



Sunspot records begin with Galileo in 1610. That is cycle 1. We are currently entering cycle 23.

Basically, when Sunspot number is low the earth is cold, when it is high the earth is warm.

Source: Wei-Hock Soon, 2004

Figure 9

Figure 9 is the sunspot data starting in 1610, on the top left side. We start then because that is when Galileo turned his telescope on the sun and identified sunspots.

The pattern there is the eleven-year sunspot cycle called the Schwab cycle after the gentleman who discovered it. In the middle of the top is the Maunder Minimum, a period when there are virtually no sunspots. It is an interesting historic fact that the life of Edmund Halley, one of the great astronomers of all time, happened to span that 70-year period. When he was eighty, there were reports of Aurora Borealis in the north, which they knew were related to sunspot activity. So he traveled up to Scotland and he wrote an article in which he said he thanked God for being allowed to live long enough to witness this phenomenon. He knew about it because he read the literature.

You see that the number of sunspots decreases, the decrease in the Dalton Minimum around 1800-1820. That is when Dickens was writing, and what was Dickens' view of the world? *A Christmas Carol*, cold and snow and harvest failures because the temperatures were dropping. When Dickens was living in London, it snowed every winter and the snow stayed on the ground for three months. That certainly doesn't happen today. So you can see the sunspot numbers increasing. The sunspot record begins in 1610; cycle 1 is that first one. We are currently in cycle 23, entering 24 (Figure 10). Basically, when the sunspot number is low, the earth is cold and when it is hot, the earth is warm. The sunspot numbers have been at a peak for 1,000 years, most recently. None of that is in the IPCC models, none of it.

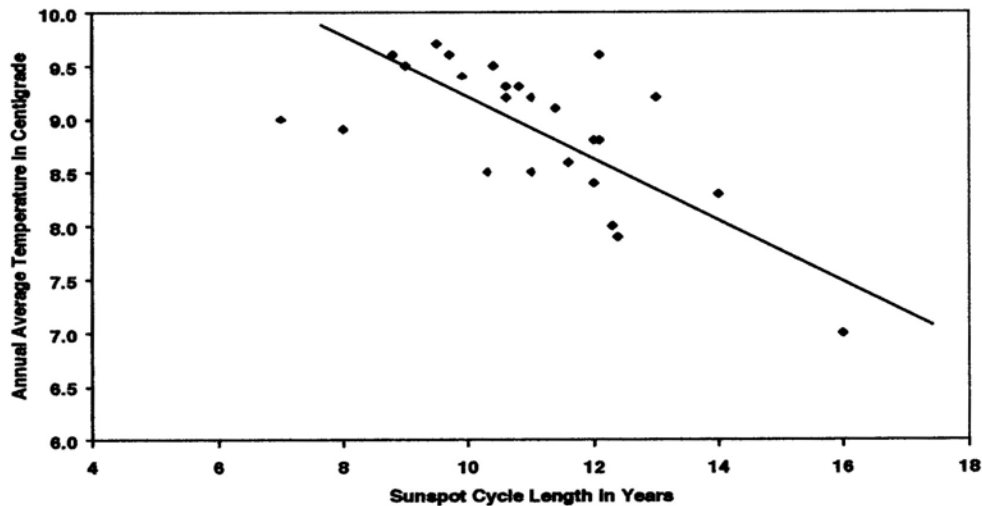
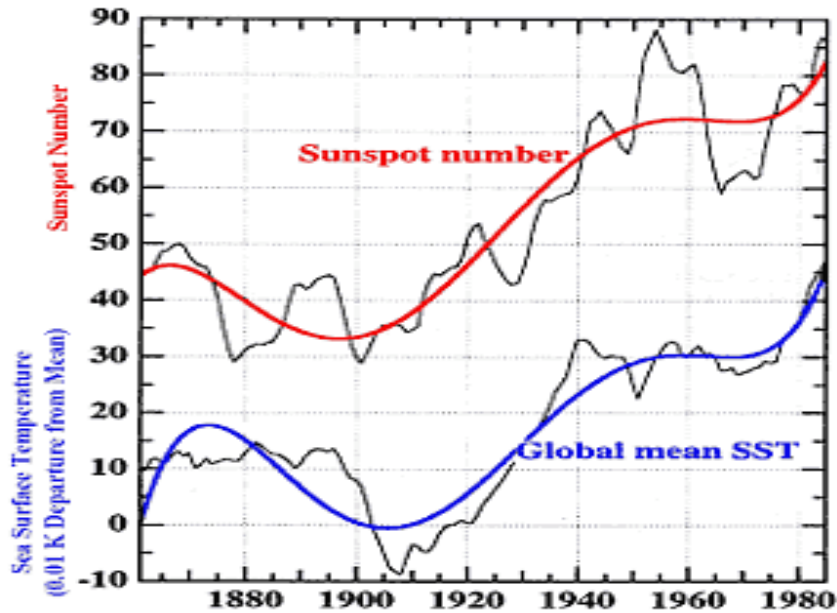


Figure 5: Sunspot Cycle Length relative to Temperature 1705 to 2000

This figure shows the strong correlation between sunspot cycle length and average annual temperature at De Bilt, Netherlands.

Based on the projection of amplitudes of about 50 for solar cycles 24 and 25, the correlation in Figure 5 derives a temperature fall of 1.5°C relative to the recent cycles 22 and 23, which had maxima of 157.6 and 119.6 respectively.

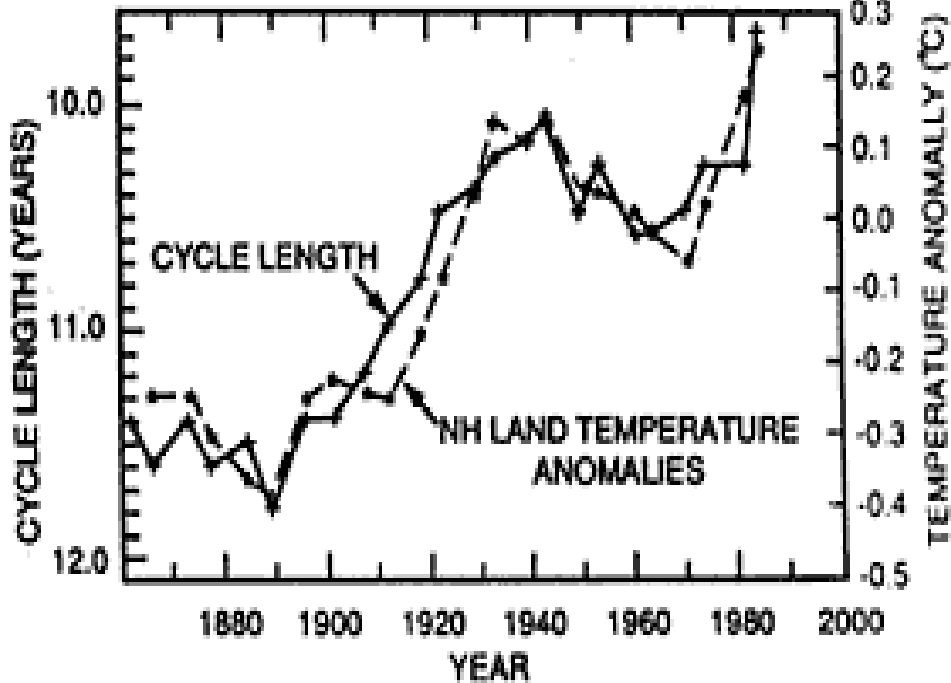
Figure 10



The globally averaged sea surface temperatures are plotted with the sunspot numbers (Reid; 1999). Both sunspot number and solar cycle length are proxies for the amount of solar energy that Earth receives. The similarity of these curves is evidence that the sun has influenced the climate of the last 150 years.

Figure 11

Figure 11 shows the relationship between sunspot cycle length and temperature from Holland. You see a very high positive relationship between the two.



The Northern Hemisphere land temperatures are plotted with the solar cycle length (Friss-Christensen and Lassen; 1991).

Figure 12

Figure 12 is before Svensmark's study on cosmic radiation. This shows you the solar cycle and Northern Hemisphere land temperatures. You see the correlation is extremely high. But as I said, none of this is included in the models. So what do we have here? We have models built on a hypothesis or assumption that CO₂ is a greenhouse gas that traps heat and atmospheric CO₂ has increased from human activities. These are the assumptions they make, just like Einstein made his assumptions. Because of the CO₂, global warming would occur. The temperature will continue to rise as long as humans continue to add CO₂. That is what we are hearing: shut down the industry, stop the adding of CO₂ which is causing global warming. The pre-industrial level was set at 280 parts per million (ppm) of CO₂ in the atmosphere. We are currently at 385 ppm; the assumption is that that is a rise from a 280 ppm pre-industrial level. An article published the day before yesterday (I will show you bits of it) shows that the pre-industrial level of CO₂ was in fact closer to 360 ppm.

The other thing with the models is that they do an instant increase. They don't add CO₂ year by year; they just said, "Bam! We are doubling CO₂," an instant increase in the models, instead of saying over the next year, ten years, twenty years, thirty years, we will simply assume an increase in the level of CO₂ and gradually ratchet that up. Which is, of course, completely unnatural, but that is what is happening. They assume CO₂ would double. I have yet to find anybody who can tell me why they assume that. "Well, we have to assume something about gas, so let's just assume it's going to double." Now we are stuck with that; every model has to assume a doubling, because otherwise you can't compare your results with the results of other models. They are locked into that.

Most people are unaware water vapor is by far the most important greenhouse gas

Anthropogenic (man-made) Contribution to the "Greenhouse Effect," expressed as % of Total (water vapor INCLUDED)

Based on concentrations (ppb) adjusted for heat retention characteristics	% of All Greenhouse Gases	% Natural	% Man-made
Water vapor	95.000%	94.999%	0.001%
Carbon Dioxide (CO ₂)	3.618%	3.502%	0.117%
Methane (CH ₄)	0.360%	0.294%	0.066%
Nitrous Oxide (N ₂ O)	0.950%	0.903%	0.047%
Misc. gases (CFC's, etc.)	0.072%	0.025%	0.047%
Total	100.00%	99.72	0.28%

Source: F. Singer, 2003

Figure 13

Figure 13 is the chart showing that water vapor is 95 percent of the greenhouse gas. Remember, on the chart I showed you, water vapor wasn't even there. Then of course, CO₂ at 3.618 percent. Then we show you the percentage of man-made CO₂, so that 0.117 percent is of 3.618 percent, so it is just a fraction. Don't forget, these are estimates; there is no real measure. These are estimates; everything is an estimate.

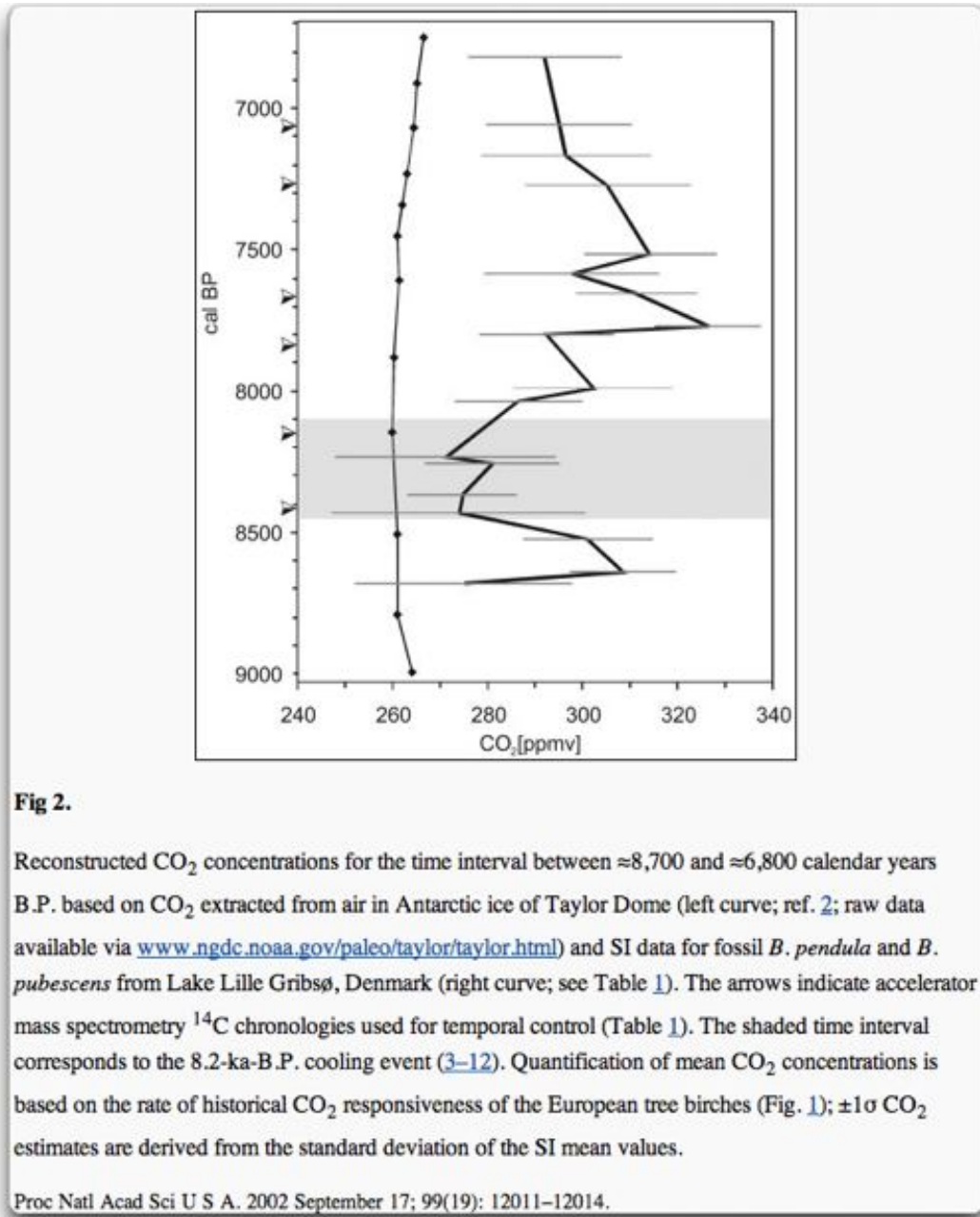


Figure 14

I want to show you this particular graph in Figure 14 because I talked about the 280 ppm pre-industrial level. On the left side, the line with the dots on it is the ice core record of CO₂. Look how smooth it is. What they did was eliminate all the high

readings and then they took a long-term moving average to smooth the line out to that level. Again, a Ph.D thesis? Sorry, you fail. On the right is the CO₂ levels as determined by the stomata (pores) of leaves, because plants live on CO₂ and the size of the pores on the leaves is directly related to the amount of CO₂ in the atmosphere. The graph on the right shows you the varying stomata sizes and therefore the varying CO₂ in the atmosphere. You notice that there is about 320 ppm and it is extremely variable from year to year, which is another of the problems which we have with the models.

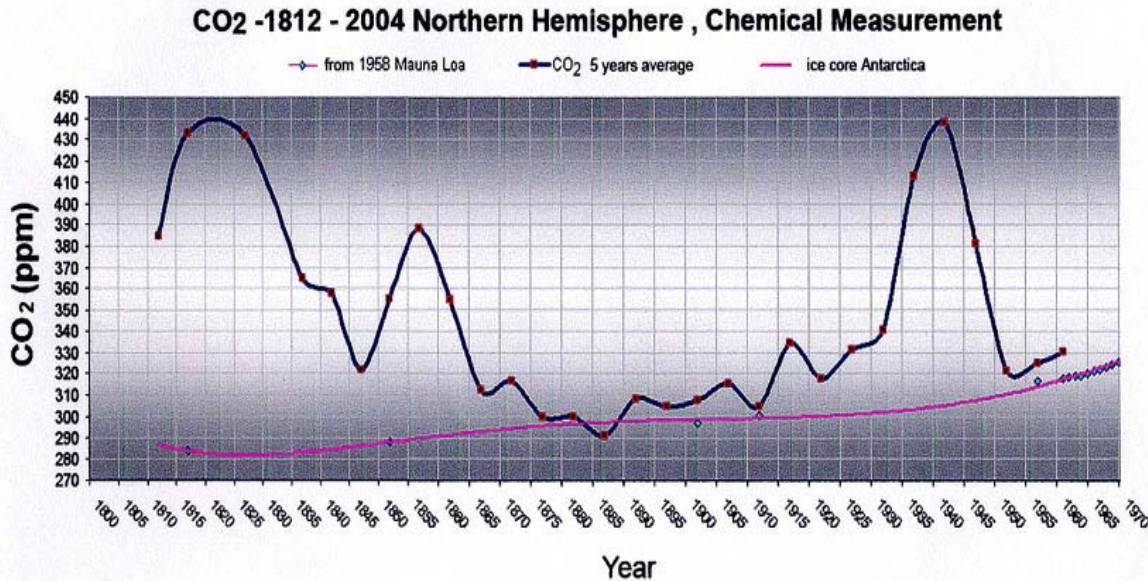


Fig. 2 138 yearly averages of local effective atmospheric CO₂ concentration from 1812 up to 1961 by chemical determination, smoothed as 5 years average (raw data); icecore reconstruction (Neftel et al. (13,14,15)) and Keeling measurements in Mauna Loa from included.

Figure 15

Figure 15 is one of the graphs that appeared in a draft copy of the article. The red line is the CO₂ from the ice core record, a completely unnatural, flat, smooth line. The black line is 90,000 direct atmospheric readings of the atmosphere by scientists, which go from 1812. Priestly had just discovered oxygen and scientists were desperately trying to find out what percentage of all the other gases there were, so they were taking direct air samples to determine the amount of CO₂ in the atmosphere. The ice cores have about ninety years before the ice is trapped in a bubble and it is contaminated as that happens. So you see the incredible variability. Why do we think that that is the case today? Because in 1958, they had the Mauna Loa readings, the only readings for the whole globe. They got it by saying, “Well, it is only one sample station, but CO₂ in the atmosphere is uniformly distributed and it doesn’t change much from year to year.” What a fudge factor!

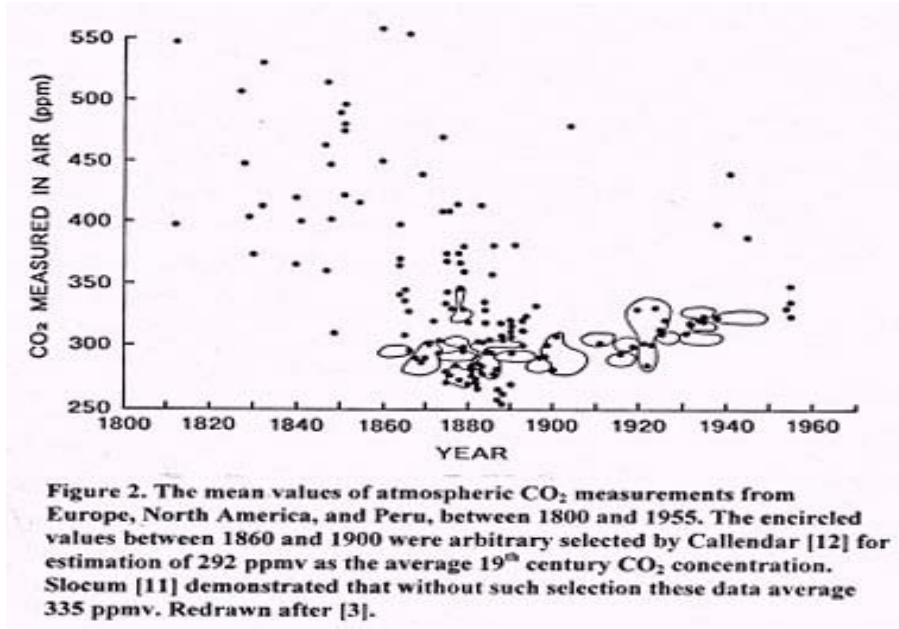
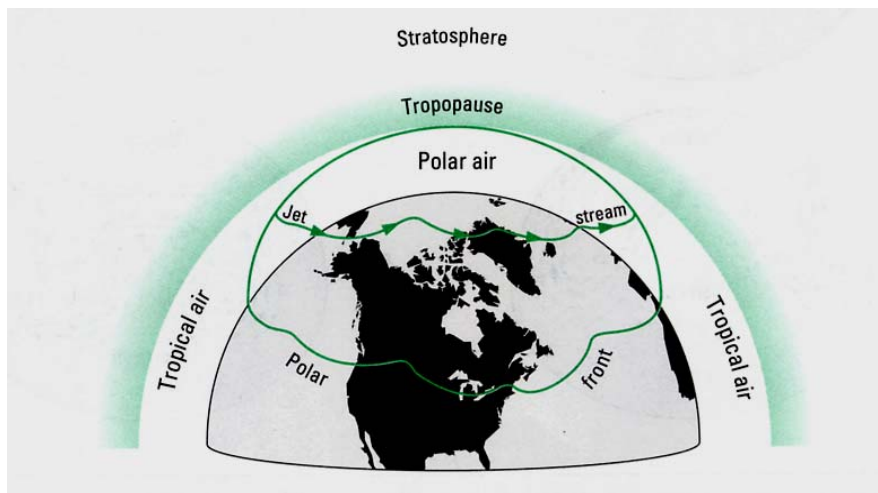


Figure 16

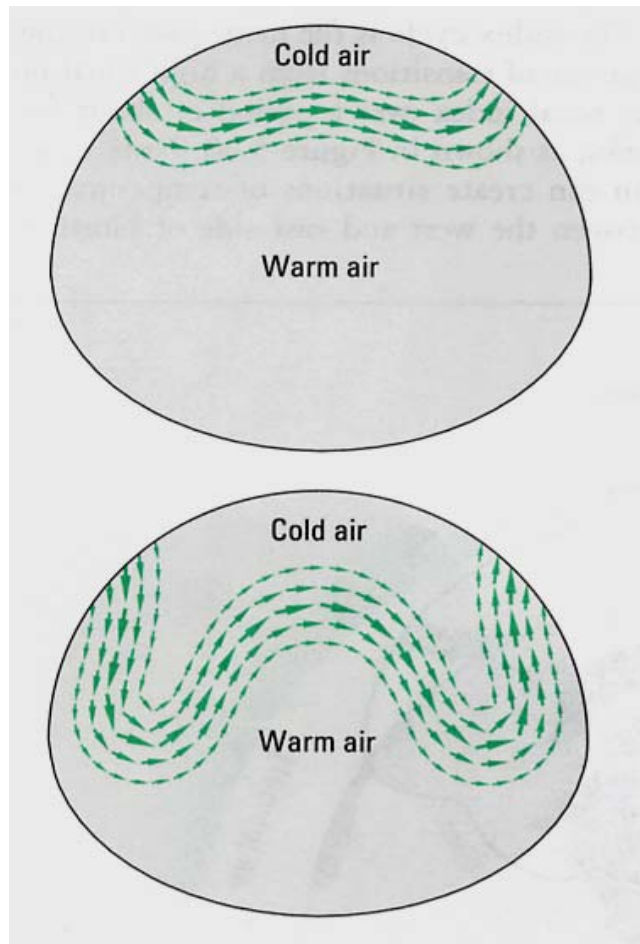
Figure 16 is a plot of those readings of atmospheric CO₂ from the 19th century. This was done by Callendar, who got a Nobel Prize for this work. The points that are circled are the ones that he chose to establish the 280 ppm atmospheric level of CO₂. I am not going to comment on this; I will leave that for you to judge how much cherry picking is going on here. But they had to get it to 280 ppm so they threw out all of the higher readings. It is absolutely amazing. In the article I mentioned which was published two days ago, the author Beck looked at every single set. He has looked at the instruments that were used, the methods that were used, and thoroughly checked it out and these are very, very accurate readings. They were not taken to prove global warming or any political agenda, but because they simply wanted to get accurate measure of gases in the atmosphere. And you see what has happened.



Basic Air Masses - Northern Hemisphere

Figure 17

Figure 17 shows the major air masses in the globe. You see the jet stream, the boundary between the cold polar air and warmer tropical air. That polar front marks the total difference between those air masses; that is where all the severe weather occurs, other than hurricanes, along that polar front. You hear stories that there will be more severe weather; Al Gore has that in his movie and the insurance companies have it on their websites. In fact, with global warming there will be less severe weather because the severity of the weather is determined by the temperature contrast across that line. It is called the zonal index. Global warming theory tells you that the cold air is going to warm up more than the warm air. In other words, the difference between the two will be reduced, therefore there will be less severe weather, not more. It is a completely false scientific assumption that they have made about severe weather. We know from the historic record that when the world is cooling down, that cold air is getting colder, as happened in, say, Elizabethan times, the storms are much worse. The storm that destroyed the Spanish Armada has never been equaled in the modern record, in terms of severity. As I said, the talk about more severe weather is absolute nonsense.

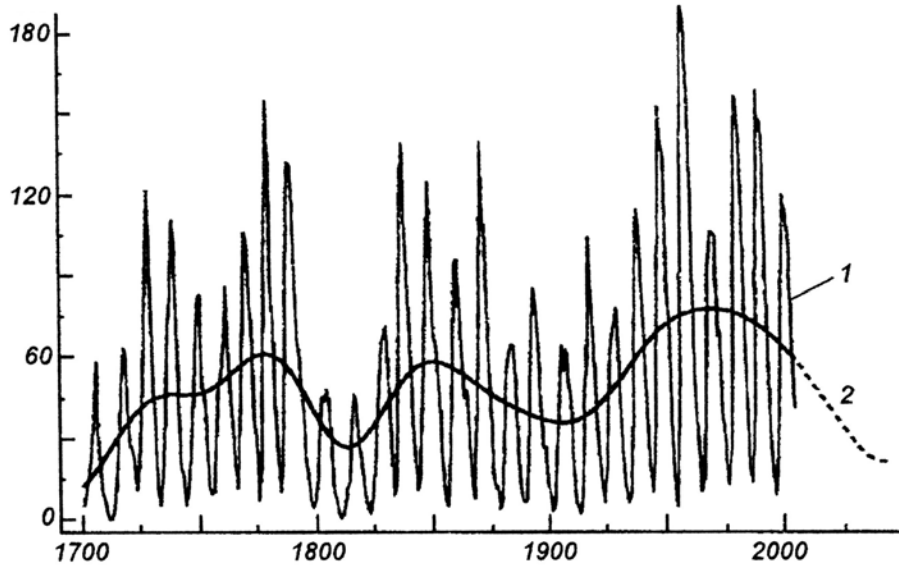


Rossby Waves: Zonal Flow (top) and Meridional Flow (bottom)

Figure 18

We see an increase in variability of weather, and that is what I started talking about statistics applied to the weather pattern. What you see at the top of Figure 18 is what is called zonal flow. That is looking at 1940 to 1970, when the world was cooling down. The weather was quite stable, quite predictable. What we have had since 1986 is the bottom diagram of the jet stream movement, called meridional flow. See how that changes the wind patterns in the middle latitudes? In the top diagram, you have northwest in the winter and southwest in the summer. The weather from one season to the next is not that dramatically different. But when you go to the meridional flow, you have north winds, south winds, you have warm air going right up into Alaska, you have cold air going right down to Florida and destroying the citrus crop. That is the situation that we have had since 1986. Why? Because this pattern is determined by changes in the solar wind, the sunspot data. Again, none of that is included in the climate models, so there is perfectly logical scientific explanations for the pattern of weather that we are experiencing. But we all know this is the worst weather we have ever seen! I can show you virtually any year in history and show you worse weather. 1905 was the worst year for tornado deaths in the U.S.; 254 people died, and there weren't many people living in the tornado alleys in those years. But the media and global warming propaganda ignores that, as I said.

The “precautionary principle” raises the question, what if there is a problem? This is the canard that they throw out. “Oh, well, what if we're wrong?” Okay, but it assumes that there is some basic correctness to what you're doing scientifically and I have shown that there is an enormous problem with that. Here is the problem: I, as a scientist, can stand up here all afternoon and with scientific facts frighten you with impending doom. When I went before the Canadian Parliament on the ozone issue, I threw out my presentation because I realized they didn't understand how science works. I said, “Look, let me give you an example. The earth's magnetic field has been weakening for a thousand years. If it continues to weaken at the current rate, there will be no magnetic field 120 years from now. We know from the historic record, when there is no magnetic field, mass extinction on the planet occurs from radiation from the sun penetrating to the surface. I want to know what my government is going to do about this.” I am just reciting facts. The latest one is that an asteroid is going to hit the earth, but don't worry; it is going to hit Australia and nobody will notice. What was interesting about that was that one of the members of Parliament was furious and got all excited. He said, “We are here to talk about ozone.” I said, “I am trying to illustrate that the ozone, through CFCs, is no different. It is pure speculation on a few facts.” One of the members who had done a little bit of science understood what I was trying to say. He said, “You have studied this magnet problem; what do you suggest we do?” I said, “We get a government grant, we take all the Canadians down to the equator and we will all throw ourselves in one direction, to halt the rotation of the earth.” The more serious members were not amused.



Russian plot of sunspot cycles with superimposed longer trend.

Figure 19

Figure 19 shows you the Russian plot of sunspots starting in 1700. The Russians, by the way, are some of the best climatologists in the world, really superb climatologists. I have worked with people like Borisenkov. You see that around 2000, the declining numbers that form the line Number 2.

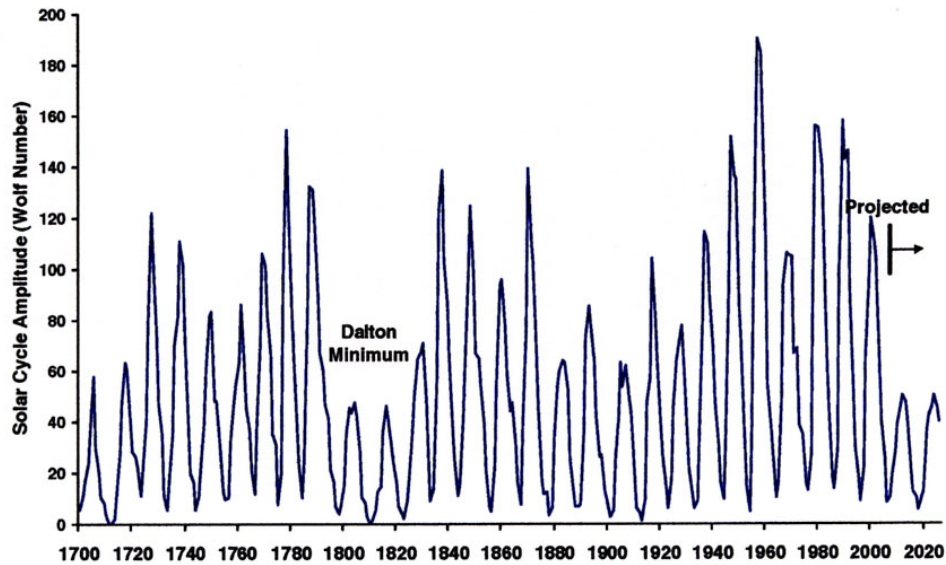


Figure 1: Past Solar Cycles with a Projection of Solar Cycles 24 and 25

Badalyan, Obridko and Sykora's projection of a solar cycle 24 maximum of approximately 50 is shown with the solar cycle activity back to the end of the Maunder Minimum. Solar cycle 25 is also expected to be weak. The rise in amplitudes prior to the Dalton Minimum mimics the rise in amplitude from the late nineteenth century to the end of the twentieth century.

Figure 20

To illustrate that, Figure 20 shows another prediction, by a Russian, again. Here they are showing the projection up to 2030 with much lower sunspots, much lower than when Dickens was around there were harvest failures, ice on the Thames, and so on. Finally, there is a Japanese-American researcher. There is a debate. She is not quite comfortable with the predictions for cycle 24. We are in cycle 23, as I mentioned. But everyone is in agreement that cycle 25 is going to be a very low sunspot number. Here we are, preparing for warming, but the scientific evidence is saying we are going for cooling. Of course, we are far better prepared for warming. We can adapt to warming much easier than adapt to cooling. For Canada, for example, a 1°C drop in global temperature means we are out of agriculture, period. We saw that in 1992. Pinatubo cooled the world down and we came within two weeks of not having a harvest in Canada. We know that, and yet all of the push is for warming.

“With the publication of the article in *Science* [in 1995], I gained significant credibility in the community of scientists working on climate change. They thought I was one of them, someone who would pervert science in the service of social and political causes. So one of them let his guard down. A major person working in the area of climate change and global warming sent me an astonishing email that said, “*We have to get rid of the Medieval Warm Period.*”

Source: Presentation by S. McIntyre at Conference in Stockholm
Sweden, September 9, 2006

This is another quote which illustrates the problem. Remember, I said at the beginning there have been warm periods in the past? This quote is by Professor David Demming. And they did get rid of the Medieval Warm Period with the “hockey stick.” They cooked the data on tree rings and that has been shown to be true. There were other periods warmer than today. The Holocene Optimum (9000 to 4000 BP) was much warmer than today and the Medieval Warm Period (900 to 1200 AD) was much warmer than today. The Vikings were sailing Arctic waters where there is now permanent pack ice. We have pyramids of stones that the Vikings put up in the Arctic for navigational markers in narrow channels. They were farming soil in Greenland that is now permafrost today. The 1930s were warmer than today. I want to tell you something that is very disturbing. James Hansen is in the process of changing the official record of the temperature for the 1930s to show that it was colder than it is today, because he wants to be able to show that today is warmer than it was in the 1930s. You can look up that data; the discussion of it is in Steve McIntyre’s blog ClimateAudit.

Tolstoy said, “I know that most men, including those at ease with problems of the greatest complexity, can seldom accept even the simplest and most obvious truth if it be such as would oblige them to admit the falsity of conclusions which they delighted in explaining to colleagues, which they have proudly taught to others, and which they have woven, thread by thread, into the fabric of their lives.” So they not only created

the global warming industry, but they believe their own industry now. One of the things that I said on an interview this morning, I hope I have the intestinal fortitude that if I am wrong, I will be the first one out there saying I was wrong. But, as I said, if you put your whole life into it, you have to do that.

I will leave you with this. It has pushed the political boundaries and pushed science into the politics. We simply can't afford it any more. We need to get all the facts on the table and we need to get the hysteria out of it; we need to get the emotion out of it. Because the minute you start saying, "You don't care about the planet and children are going to die," then it plays the emotion card. You may have seen that horrendous ad with the man standing on the train track when the train is coming; he says, "It won't bother me," then he steps aside and there is a child standing there. I personally think that is obscene. I think that playing that kind of emotion does not help make good decisions. You don't make good decisions in an emotionally charged atmosphere. You have to look at the matter logically and objectively and put all the data on the table. I thank you for your time this afternoon.

Questions and answers.

Question: What do you think of Svensmark's work on cosmic radiation?

Ball: One of the problems that we have had with precipitation – I mentioned how difficult that is – is that formation of rain or snow is an extremely complex process. Only about 1 percent of all the clouds today on the earth actually provide precipitation; in the tropics it is a higher percentage. So the problem was, why doesn't more precipitation occur and why does precipitation vary over time? One of the limitations is what are called condensation nuclei. For water vapor to change to water droplets, it needs nuclei. Svensmark argues that cosmic radiation is creating ionization in the atmosphere that provides cores around which the water can condense. He shows the correlation between variations in the cosmic radiation and cloud formation. More cloud cover blocks the sunlight and the globe is cooler. So as the cloud cover varies, the temperature varies, just like with a screen on your window. The problem with Svensmark is that it only applies to low clouds, not to high and middle clouds. Clouds function differently at different altitudes. I am not discarding Svensmark; the correlations of the low clouds are very, very high. But I think it needs a little bit more testing. It should have been included in the IPCC report, but they have written a rule that said, "Cut out the papers after a certain date." But people like Michael Mann and James Hansen have included papers that are in press; they are not even published yet, but because they submitted them, they got them in before the deadline date and therefore that allowed them to be included. The Beck paper and the Svensmark paper didn't make those deadlines, so it was purely a political deadline that was set up.

Question: Could you reference the Beck paper?

Ball: The Beck paper is “180 Years accurate CO₂ – Gasanalysis of Air by Chemical Methods,” *Energy and Environment* Vol. 18, No. 2, 2007. By the way, *Energy & Environment* is run by Sonja Boehmer-Christiansen, who is a socialist. She is the one who published the hockey stick when *Nature* and *Science* refused it. Her argument is we have to get both sides out there. Like when I talk to audiences, I just say, “Make up your own mind whether it is good or bad. Who am I to tell you?”

Question: You had one graph on the ice core data and the CO₂ levels. People like Dr. Zbigniew Jaworowski question ice core data in general. Do you believe that ice cores are a proper method of measuring CO₂? With all the obvious spin that has been done on the science for the past thirty years, what is the actual agenda behind the green and environmental movement?

Ball: The answer to the graph, which shows how Callendar, who got the Nobel Prize, cherry-picked the lower 20 percent. That is in the paper by Zbigniew Jaworowski. He has been studying ice cores for thirty-five years. In that article, which you can download from the worldwide web,² he had written it to present to the U.S. Senate but was not allowed to present it, so he just said, “I am going to put it on the web. This is the paper I planned to present.” As I said, he has been studying ice cores for thirty-five years. He identifies in that paper all the problems with the ice core data. Because from the time that the snow falls to the time that the atmosphere is trapped in that bubble, in a process called firnification, is a minimum of eighty years. As that ice bubble is being created, you have water trickling down which contaminates the gas bubble. You have no idea how much contamination is going on. I would say that the ice core record of CO₂ is adequate, as I showed it, as a relative trend line, but in terms of absolute, no, it is not a good read. Just to illustrate, if you crush the ice to extract the air, you get a totally different reading than if you melt the ice to extract the air; the difference is about 20 percent in the readings. So it is simply not a credible source of information. Your question about the motive: I am always leery about imputing motives to people. Lawyers always say that is a dangerous thing. I put the blame at the feet of a guy by the name of Maurice Strong, and I can do that because he is Canadian. Maurice Strong was the guy who organized the 1992 Earth Summit in Rio de Janeiro. He was instrumental in setting up the U.N. IPCC and the Kyoto plan. Strong is on record as saying that the problem with the planet is the industrialized nations and it is our duty to get rid of them. Strong made his money in industrialization and then put on the cloak of green, but he is still making money as an industrialist, because he is in a company which imports cars from China. He is also on the board of the Carbon and Credit Exchange in Chicago, for all of his personal connections. I would put Maurice Strong at the heart of the agenda. It is a political agenda. Kyoto was not about reducing CO₂ in the atmosphere. Even if every country in the planet participated and achieved their targets, no scientist would have been able to measure the difference in

² Statement written for the Hearing before the US Senate Committee on Commerce, Science, and Transportation, “Climate Change: Incorrect information on pre-industrial CO₂,” March 19, 2004 <http://www.warwickhughes.com/icecore/>

CO₂ in the atmosphere. Kyoto was all about a transfer of wealth to punish the developed nations and give money to the poor. Someone once said about foreign aid, "Foreign aid is when you take money from the poor people of the rich countries and give it to the rich people of the poor countries." That is very cynical, but I am afraid there is a lot of truth in that.

Question: Why does the forthcoming sunspot cycle 25 so much lower than the preceding ones?

Ball: It is part of the internal mechanism of convective cells within the sun. The sun is a nuclear device and within the plasma of the sun, there are convective currents. The sunspots are part of that; they only appear within 40 degrees of latitude of the equator and as the sun rotates, they move out and then fall back in. What you are looking at is the dynamics of the sun. The sun; for example, is tilted by 7 degrees from the whole planetary system. It goes through constant cycles. What is interesting is that climatologists assume the sun is constant, while solar physicists refer to as a variable star.

Question: When is that cycle supposed to begin? When do we head out of 24 and enter 25?

Ball: We are just going into cycle 24 now; it peaks, I think, around 2010 or 2011. That cycle varies from about nine to thirteen years. About 2011 we peak with cycle 24 and then 25 about 2030. You have to allow for the variability, but that is a pretty accurate forecast.

Question: There was an article in the *Scientific American* that plants produce methane and are responsible for a lot of it in the atmosphere.

Ball: What they found is that forests are a major source of methane. That has been known. That is another example of how they blame the farmers for methane causing global warming. The atmospheric level of methane has gone down for fourteen years, but there is no mention of that, no apologies to the farmers. That is a classic example of bad science. Do cows produce methane? Absolutely, when they chew their cud and pass their cud. Has the number of cows increased in North America? Absolutely, from 120,000 120 years ago to 86 million today. Nobody argues about that. But in that same 120 years, we went from 65 million to 120,000 buffalo. Regrettable? Absolutely. Are you telling me that the buffalo weren't producing methane? So you see the selectivity of the formulas. By the way, to show the political bias of that, 250 million cows in India are never mentioned. The biggest source of methane in the world from human activity is the rice paddies in Asia, and they are never mentioned. The methane from those has increased because they are using fertilizer to increase the yields. You can look at every single one of these variables and say, why is the attack on that, every time it comes back to a political issue.

Question: The founder of the World Wide Fund for Nature Julian Huxley said that because of what the Nazis had done with eugenics, they made eugenics a dirty word. So what we are going to do with environmentalism is we are going to make that a clean eugenics. If you look at what Al Gore has been saying recently and different people in the environmentalist movement are saying we are going to reduce carbon emissions from the Third World, it's a genocidal policy. What do you think about that?

Ball: I have grappled with this question for a long time. I kept asking, what is the role of the extremists? I finally realized that the role of the extremist is to define the limits for the majority. I will give you an example: feminism was absolutely needed. Things still need changing. But the majority of women say, "Well, how far do we go with this? Now we are losing more than we are gaining." So the extremists define the limits. What Gore is doing is a blessing, because the public is saying, "Now hold on a minute. Hang tough, with your big carbon footprint stomping on all of us." So by the extremists defining the limits, as with Nazi Germany, I agree they went too far. But people are still concerned about genetic modification. I will give you an example: in the farming industry, the use of canola to produce medical products, such as a blood thinner. In order to do that, to produce canola, they would give the farmer \$120,000 for an acre of land. That is a huge return. But in order to do that, you have to cross the genes from bloodsuckers with plant genes. People get very uncomfortable when you are crossing plant and animal genes. There are some concerns about that. But I do tend to agree with you about genetics; this is a very touch issue. My concern with the environmental issue is there will be a tendency to say, "We don't believe anything you tell us," which is the point you are making. Don't throw the baby out with the bath water. How many people in this room know that seven years ago, the United Nations said the Number 1 environmental problem in the world is soil erosion? It wasn't then an urban issue, but it has become a world urban issue. Now the farmers have dealt with it; they have gone to zero-till and minimum-till. To illustrate with numbers, on the farm in North America, you normally lose about five tons per acre per year. With summer fallow, you are moving to about ten tons per acre per year. They have now reversed that with zero-till and minimum till. In China, they are losing 700 tons per acre per year in some of their farms. It is a huge problem. The Yellow River is yellow for a reason; it is all the soil in there. So there are dangers of throwing the baby out with the bath water; I think the credibility of science is in serious jeopardy with this, too.

Question: What do you think about the fact that Sir John Houghton is an evangelical Christian?

Ball: Sir John Houghton is a very interesting character. He was the head of the U.K. Met weather office and was then appointed by Margaret Thatcher to the IPCC. Sir John has published articles in religious journals, which he is perfectly entitled to do, writing that the production of CO₂ is a sin and industry is a sin. He was in charge of the U.N. climate change studies. As I said, you are entitled to your views, obviously, but you have to think that those are going to influence how you are looking at a situa-

tion and handling the job. I have the same problem, by the way, with entertainers, like Baldwin. You're given a platform to sing; shut up and sing. To use that platform then to push your own political agenda is, I think, unacceptable. In Canada, eight climate scientists tried to see the Prime Minister about climate change and we weren't even allowed near the Minister, let alone the Prime Minister. Bono and his crowd walk in and they are welcomed! What is going on here? Who is running the world? They are entitled to their views, but we are in this cult of celebrity and to me it is quite disturbing.

Question: Since 1998, the worldwide global temperature actually did not increase. According to satellite data, temperatures did not increase the last eight years. That is about, what, 20 percent of the hundred years? So why did they not increase the last eight years?

Ball: The question is about the global average temperature. I think it is a meaningless number, particularly when they start talking about .01, when you are only measuring to half a degree, or to 0.1. It is kind of meaningless. The surface temperature is contaminated by the urban heat island effect; some of you are familiar with. I did studies in Winnipeg in 1972 on the urban heat island effect, so I am very familiar with that problem. They are not allowing enough for that. The comment over here is the satellite data, when it came in, showed that the surface temperature clearly was seriously affected by that urban heat island effect, because it showed virtually no change. What goes on here is not only cherry picking in the data, but cherry picking in the source of the data we want to choose. So the IPCC still is dominated by the surface data, not by the satellite data.

Question: The beginning of the question was why did the temperatures not increase the last several years, since 1998? It didn't increase, so why don't you make more of that?

Ball: That is a good question. The global temperature has gone down since 1998 and that hasn't been advertised out there. Notice they are talking less and less about warming; they are talking about climate change. Because climate change allows them to talk the record down, wet or dry, more storms, less storms, it is all due to climate change, therefore humans. It is what Huxley called "the great bane of science" a lovely hypothesis destroyed by an ugly fact. I don't know when they are going to come around to dealing with it, but it appears to be due to the sunspot data.

Question: A lot of the argument on Capitol Hill is not taking place on the scientific level, on the level you are actually presenting. It seems like the more skeptical Democrats and the more skeptical Republicans are going along the global warming line out of fear of being attacked. They might argue, "Gore has a point," something very meek on that level. Is there any kind of push among the scientific community? I know you probably have a whole base of contacts who are on the level with this and on your side

on this. Is there going to be a conspiracy going the other way or any oppositional push?

Ball: One thing that bothers me is the large segments of the society that are bullied into science. It would have been easier for me to go with the prevailing wisdom and I would have made a lot more money. I would have got all those big government grants. People are believing the story out of fear of losing their jobs. I have sympathy for that. At EnvironmentCanada, people come up and say, "We agree with you, but we are afraid to say anything." That is not how to lead society. You have a vast majority of people who just say, "I am just trying to make a living. I don't care. Let them fight it out." And then they play on ignorance. The emotional thing that they play on, of course, is fear: "Your children are going to die." People are afraid of that. But also there is the ignorance. People don't want to appear stupid. You have all sat in a class where somebody asked a question and the class thought, "That is a stupid question." So he thinks, "In all my classes for the next three years, I will never open my mouth. I won't look stupid." People have to feel free to ask "stupid" questions. So it is the fear, which Crichton wrote about very well; it is the fear of losing the moral high ground. If you dare to question, you are immediately bullied into silence. Finally all this applies to science. The other thing is that if you want to get ahead, the research money is all on one side. I have watched it with the applications for grants. You start to see the key words showing up. It was unbelievable the kinds of things people were trying to connect to global warming to get that key word into their application. Just to see if I could test this, I wanted to submit a request for funding showing I was studying the connection between climate and AIDS. But you are looking at somebody who applied to the Canadian government for a grant of a million dollars because I said I wanted to study first-hand what it would be like to win the lottery!

Question: There is an article in the *Atlantic Monthly* this month about global warming which states there is a scientific consensus on human-caused global warming.

Ball: The numbers game, the consensus game as it is called, is just that. Consensus is not a scientific fact. In the 1970s, the consensus was we were heading for global cooling, and I was as opposed to that as I am opposed to global warming, because like when Bernard Baruch was asked what the stock market would do, he said, "fluctuate." If you ask me what the weather is going to do, it is going to fluctuate. The consensus argument goes, "Because this person is in the minority, he must be wrong." That is why that argument is used. It is simply not correct in terms of the absolute number of scientists that agree with me. Many of them are afraid to speak out. As I mentioned earlier about the UN IPCC, there are 22,000 scientists, but only about ten of them are climate experts or know anything about climate. All the rest are biologists who are studying the tree line or some aspect of the impact of climate change. So they are really not experts in that sense. When you look at the IPCC report, which is coming out on May 7 from the Technical Group of scientists, you will see that very, very few of them are in anything in other than those specialized areas. But change in society oc-

curs in a saw-tooth pattern. There is a prevailing wisdom, and then some people start to ask questions. If there is some validity to the questions, then it gains momentum, but it gains it very slowly. People resist change. We don't like change, we fear change. But at a certain point, even if people don't understand it, boom, dramatic change. That is the saw-tooth pattern. Look at tobacco. Struggling, struggling, and then suddenly overnight, you suddenly became a pariah if you smoked. It is a process of change, and as I said, the public doesn't necessarily have to understand. They have a huge well of common sense out there, and I rely on that. Forty percent of them are sitting and waiting; 20 percent are fanatical and they will never change. Twenty percent realize what's going on, and there's a huge wedge in the middle. Those are the ones who will gradually shift in that saw-tooth pattern.

Thank you all for coming and for your patience today.

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