JSCOT Submission, Section 2

Report on Models, CO_2 Growth, Millenial Climate

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Super-Models

"A key advantage of climate models is that they are quantitative and grounded in scientific measurements. They are based on fundamental laws of physics and chemistry."
- (US National Assessment Overview, p.12)

There are currently about two dozen major climate models in the world. Some of them are of the latest generation of coupled Atmosphere-Ocean General Circulation Models (AOGCMs). Being so large and expensive, only wealthy countries can afford them, such as the USA, Canada, UK, Germany, and here in Australia.

It is the results from these AOGCMs which form the basis for predictions by the Intergovernmental Panel on Climate Change (IPCC) in their reports. However, the models do not all agree with each other. They differ not only in their overall prediction of global temperature rise consequent upon a doubling of CO2 (or equivalent gases), but they also display great differences in their regional and rainfall predictions. To claim they are `based on fundamental laws of physics and chemistry' hides the fact that the outcome of a dynamic interplay between competing physical laws is highly unpredictable and even chaotic. That the models all produce different results both globally and regionally attests to this fundamental weakness of climate modelling.

In the case of climate, we must apply laws of radiation (the Stefan-Boltzmann Law) which work at the speed of light, laws relating to absorption and re-emission of infra red energy on molecules (eg. Dominant Wavelength Rule), laws governing kinetic energy transfer between gas molecules (involving laws of thermodynamics), laws governing evaporation and condensation of water, laws governing heat flows between air masses, laws governing ocean currents, the Coriolis Effect, the behavior of water under varying density regimes, reflectivity of light from a variety of surfaces, radiation absorption and emission from sea water, etc. etc. What prospects are there for successful climate modelling when the laws being modelled are not only so numerous, but are also dynamically interactive, and each operating over different time scales from the speed of light , to the crawling speed of thermohaline ocean circulation?

This not only explains why each model produces quite different outcomes at every level, but also explains the models' failure to predict anything successfully prior to an event. This is best illustrated by reference to a recent study, the so-called “National Assessment”, in the United States, where two models, the Canadian and Hadley (British) models, were used to give a detailed projection of future climate trends for the U.S.A.

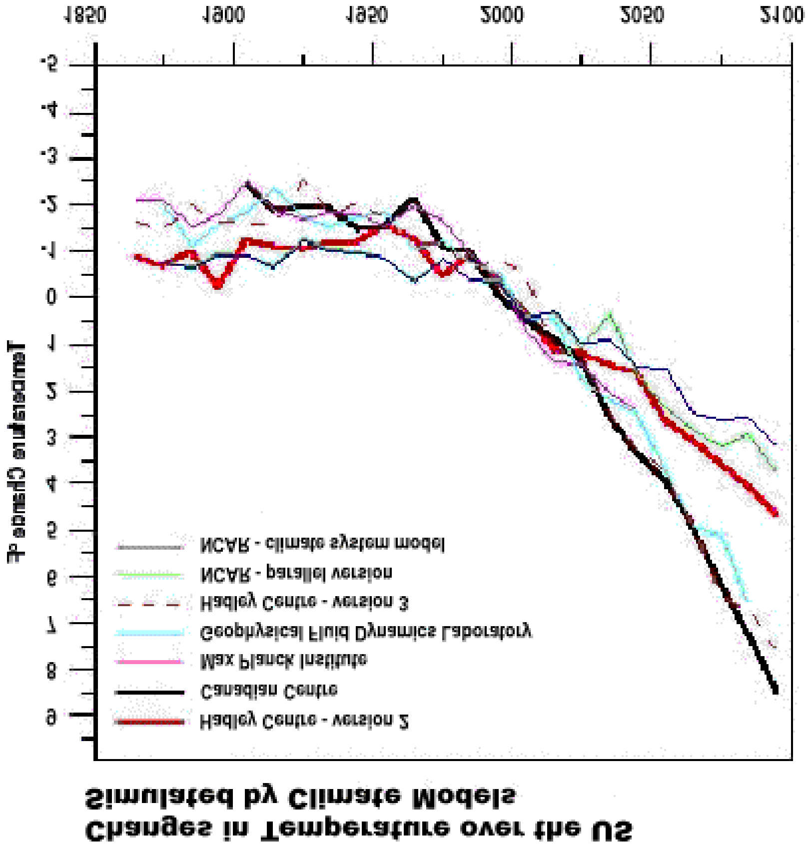

Fig.1 - U.S. Temperature by AD 2100 as predicted by various models

As Fig.1 above shows, the Canadian model is in a class of its own when it comes to alarmist temperature predictions, being more than double the predicted values of the most of the other models.

Here is how the Canadian and Hadley models simulated the current (1961-1990) climate of the U.S. (Fig.2)

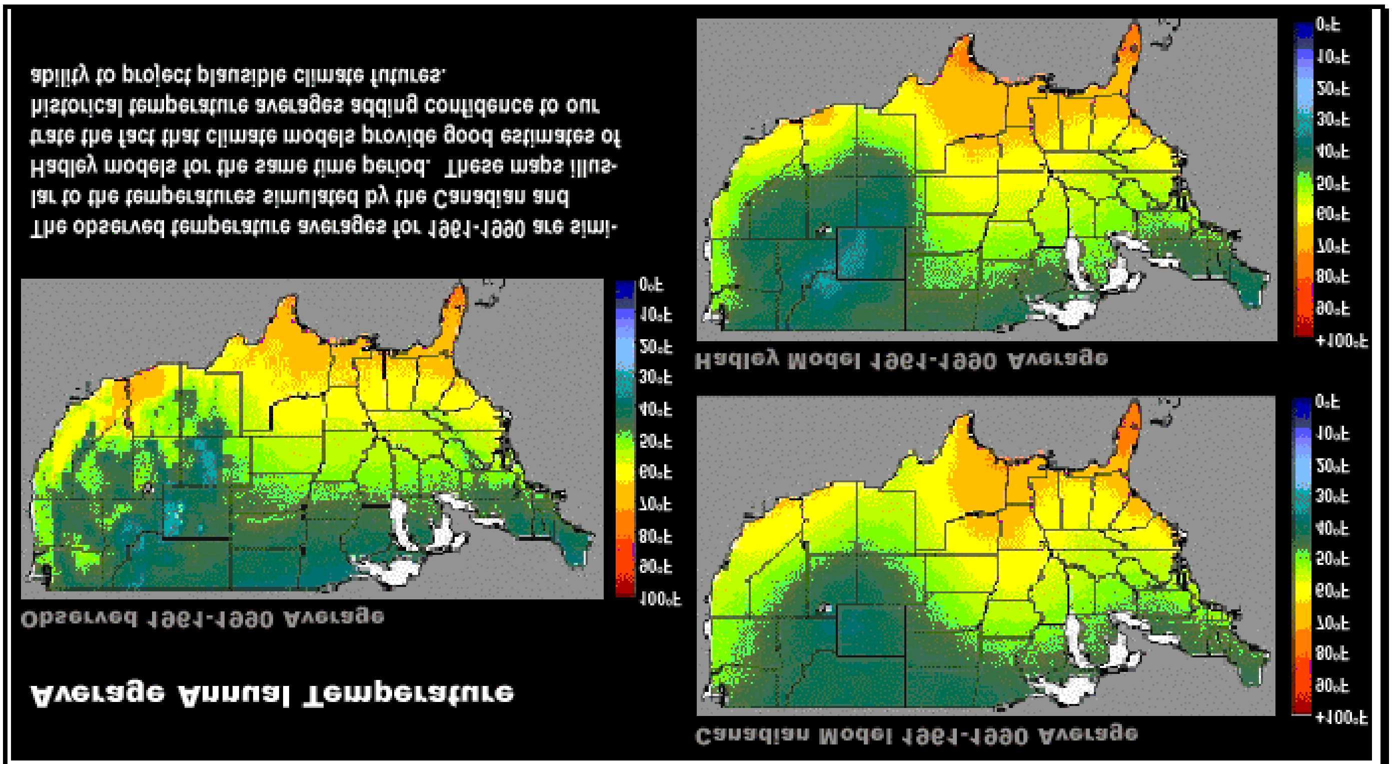

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Fig.2 - Control runs of two modelscomparing their outputs with the present climate

The two models show a present climate pattern across the USA almost identical to the observed pattern. The implication is that since the two models are able to reproduce the 1961-1990 climate average almost exactly, they can therefore be trusted to accurately model future trends. Note their claim to this effect in the map legend on Fig.2 above:

That claim is completely false reasoning, since models can be endlessly `tweaked' until the output reproduces the desired observed climate. This is hardly different to training a parrot to say "Pretty Polly" - human speech is imitated, but ask the parrot to recite a poem, or respond to a question, and the mimicry is exposed for what it really is. Such is the situation with climate models - their mathematical parameters can easily be adjusted with `parameterizations' and `flux adjustments' to give a desired output, such as the one shown above. It is no great feat of modelling to reproduce the present.

Predicting the present, or even the past, is not `predicting' at all - rather it is **retro**dicting. Successful retrodiction in a climate model (or indeed any model) is hardly different to 20-20 hindsight, and does not of itself suggest any predictive capability. The real test is their ability to model and **pre**dict the future.

If we accept these models as predictive tools and not electronic parrots, we should at least expect them to predict similar future outcomes, given they are almost identical to each other when modelling the current 1961-1990 base period, and also given that they are claimed to be `based on fundamental laws of physics and chemistry'.

However, this does not happen. When predicting the future for the US, they immediately reveal their true colors as electronic mimics, not models of the real climate (Fig.3 below).

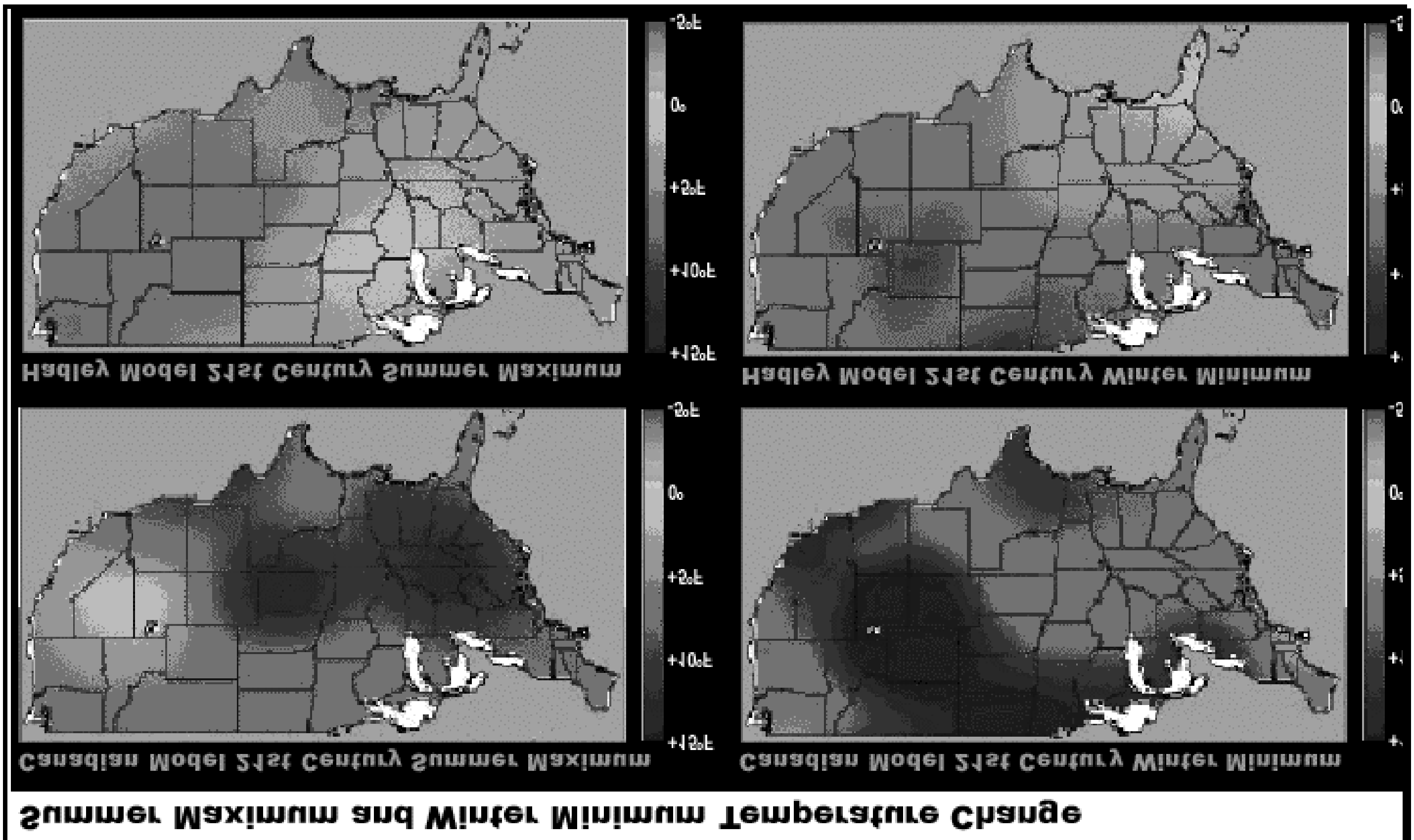

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Fig.3 - 21st century Maximum/Minimum temperatures as predicted by the same models

Looking into the future, and starting from the same base, the two models could not be more different. Both predict warming, but that's where any similarity ends. The size of the warming and its regional distribution are completely different in both, as we can see from Fig.3 above.

The same divergence occurs with precipitation (Fig.4 below)

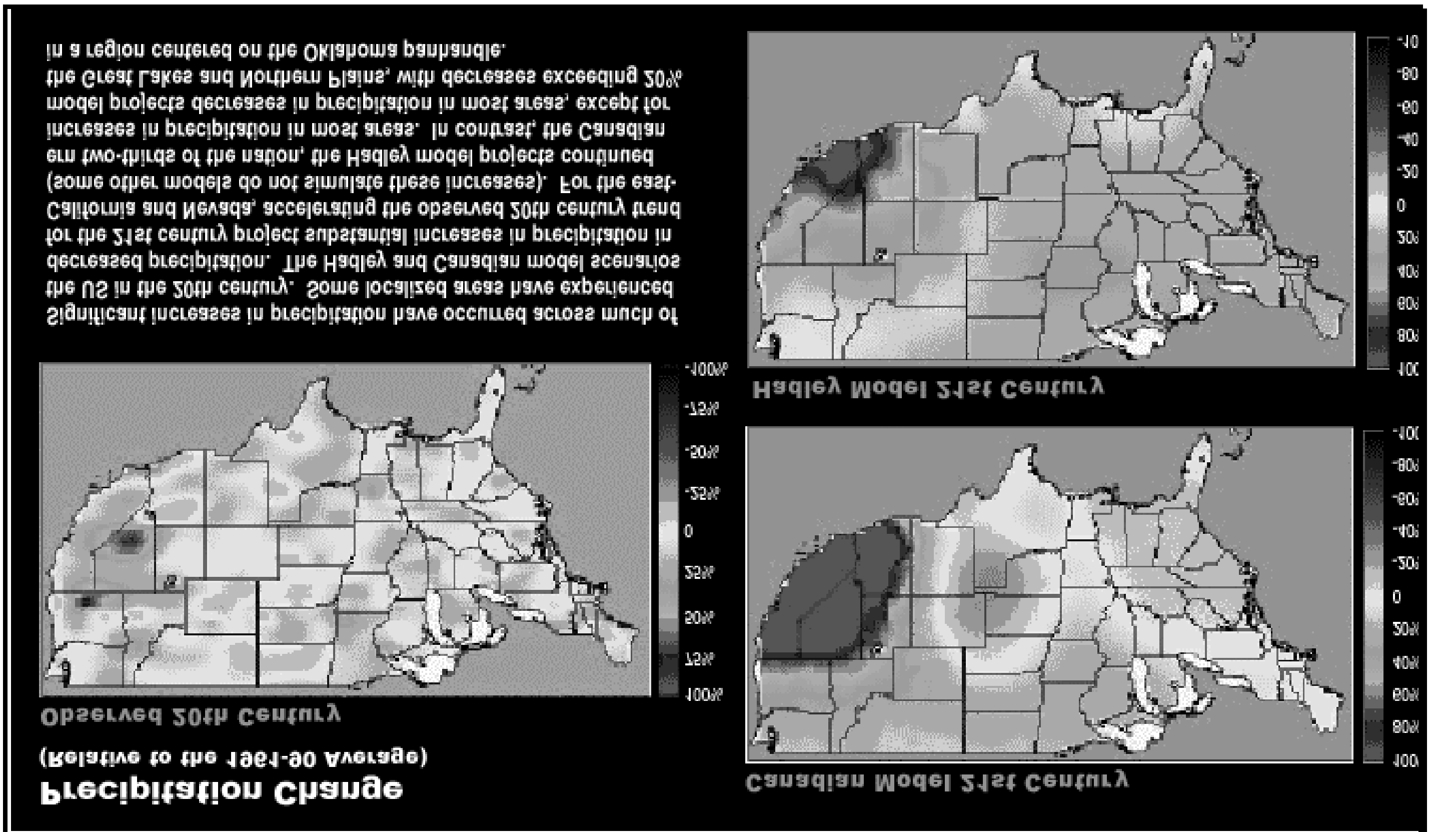

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Fig.4 - Predicted precipitation changes relative to present values

Again, we see that once the models are left to run into the future, using the same starting climate, and based on the same `fundamental laws of physics and chemistry', they go their separate ways. Indeed, the Canadian model presents an absurd future pattern of precipitation which could see rain forests spring up in the deserts of Nevada, Arizona and California!

On predictions of soil moisture, the differences are again striking (Fig.5 below).

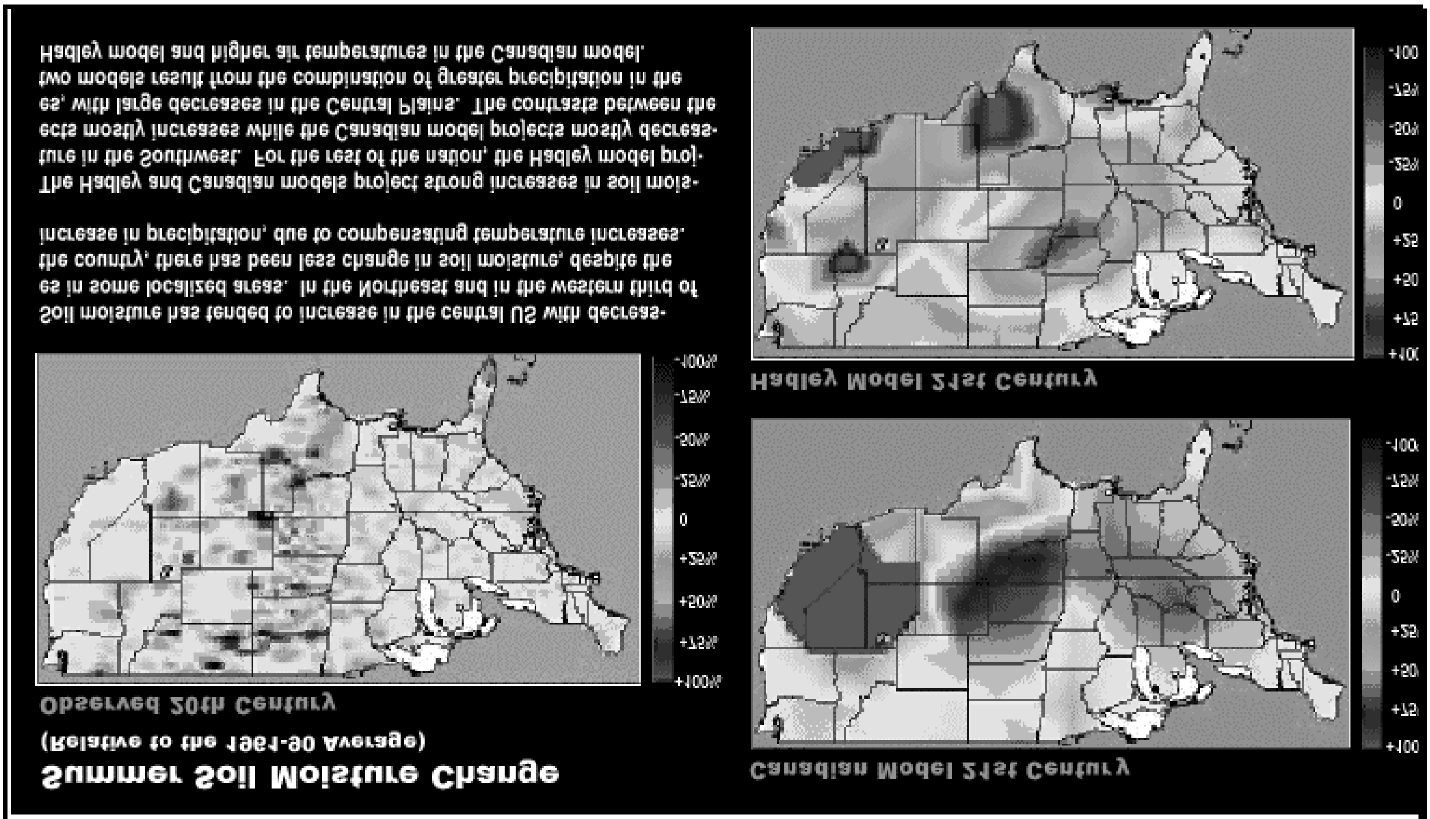

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Fig.5 - U.S. Summer soil moisture changes as predicted by the same models

The US National Assessment Overview used the 1961-1990 agreement with observed conditions as a means to convince the public and policymakers the models were fully validated. But the massive divergences into the future between the two illustrates better than anything else that their 1961-1990 agreement was the result of persistent adjustments of input parameters and flux adjustments until the desired outputs were achieved. That makes them mimics, not models.

But there is something else wrong with these attractive model map graphics.

Here is an example of the kind of predictions models typically make, the predicted global temperatures for the 21st century from the NASA-GISS model.

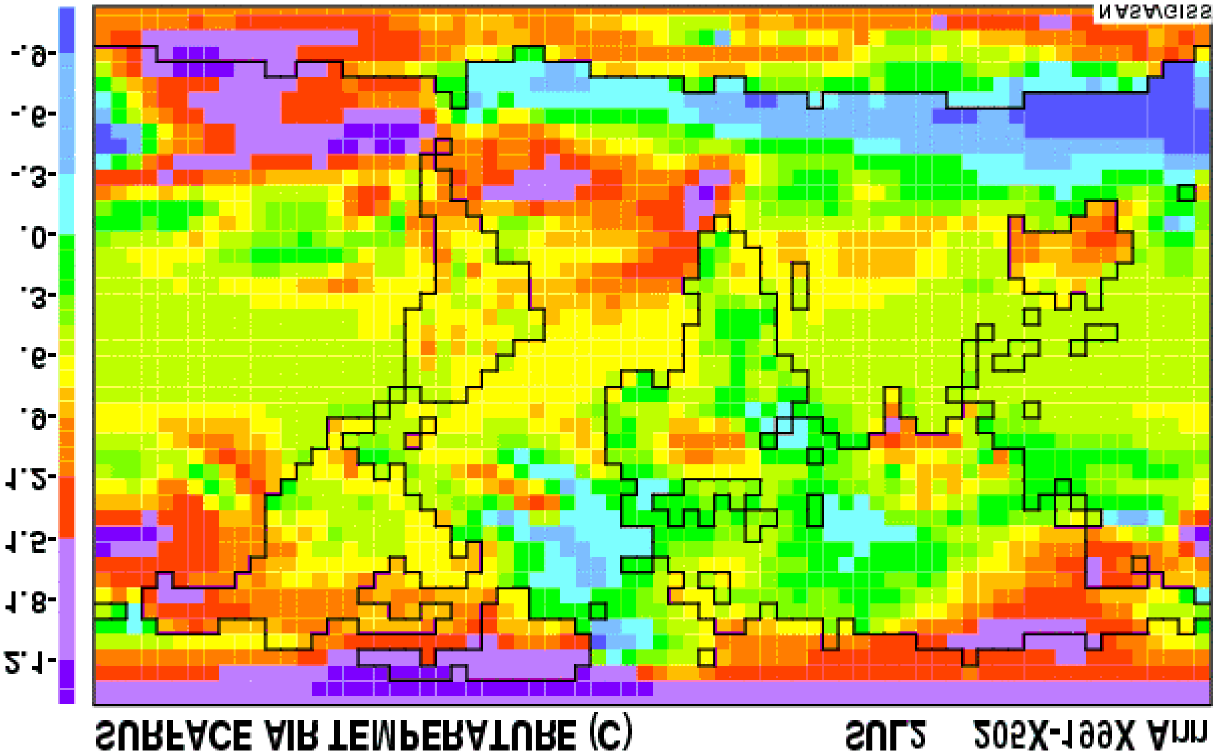

Fig.6 - Model output from the NASA-GISS model

This is very, very different to the Canadian and Hadley `models' as presented earlier. The first obvious difference is the very coarse resolution of the GISS model, the world being divided up into large `blocks' of uniform size, the blocks being so big that the British Isles are just two blocks, while Tasmania, does not even exist !

If we enlarge the Australian portion to double size, we get the following result (fig.7)

Fig.7 - Australia as depicted by the NASA-GISS model

This is what models actually look like, coarsely resolved, each block being a single point calculation for climatic variables, and each about half the size of Victoria.

This can be seen when we look at the model specifications [18]. The Canadian model uses blocks of 3.75° latitude by 3.75° longitude per block, with 10 atmospheric layers represented. The Hadley model uses 2.5° x 3.75° per block with 19 layers. (3.75° of latitude is about 255 miles).

The size of these blocks and the number of atmospheric layers is the `resolution' of the model. They represent a critical area of weakness because each block is actually a single point of calculation. All the mathematical expressions needed to calculate temperature, precipitation, radiation, reflectivity, greenhouse effects, evaporation, convection, ocean currents, biological effects etc. are all contained within the one calculation point. The results of those calculations are then applied to the whole volume of the block and then allowed to interact with calculated results from neighboring blocks.

Any climatic process which is smaller than a single block simply cannot be modelled.

Processes such as fronts, thunderstorms, cloud formations, tornadoes, floods, fogs, frosts etc. are all examples of climate or weather events which are smaller than a block. As Prof Patrick Michaels remarked, a thunderstorm would have to be bigger than Ohio to register its presence on a climate model. [15]

Yet these very local-scale processes are crucial to how climate works. Tropical thunderstorns are a key climatic influence in the tropics, but cannot be modelled because the blocks are too big. Reflectivity from cloud tops are an essential part of the radiative balance, but again cannot be modelled due to their being usually smaller than a single block.

To get around this problem, important climatic variables like clouds have to be `parameterized'. This means it has to be assigned an averaged value within the block, and the model allowed to work from there. This parameterization of variables allows the models to be closely adjusted so they can eventually mimic present climate, just as the Canadian and Hadley models have done. This is why they deserve to be described as `mimics' instead of models. These parameterizations are assigned by the modelers and thus reflect their state of understanding of the climate system.

The output of the models is thus dependent on the constraints applied by the modelers themselves, and are sensitive to any preconceptions, soundly based or not, they may have about how the real climate system works.

That said, how **did** the Canadian and Hadley models produce such highly resolved graphics for the US? The graphics were both impressive and alarming, particularly with the gratuitous use of red colouring. They did it by a technique known as `delta change' and `downscaling'.

> *The Delta Change method uses differences between simulated current and future climate conditions from the Hadley Centre for Climate Prediction and Research (HadCM2) General Circulation Model (GCM) added to observed time series of climate variables.* (Hay et al, 2000, Abstract **[8]**)
>
> *The "delta change" method is the primary future scenario generation technique suggested for use in the U.S. National Assessment*. (Hay et al, 2000 - Introduction **[8]**)

As shown by the above extracts, the technique involves using *existing* temperature and precipitation data from the surface records, a process which provides a highly resolved climate map of the US, as shown in Fig.2. To these are added the changes in temperature and precipitation predicted by the models for each large-area block, so that each and every temperature recorded within a 3.75° x 3.75° block (i.e. an area the size of an average US state) is raised by an amount predicted by the model for the entire block.

In this way, the model's coarse resolution is concealed. The resulting profile map predicting temperature and precipitation retains the high resolution inherited from the original surface data. This is not high-resolution modeling at all, but merely presents current conditions and `reddening' them graphically according to the predicted changes within each large-area block.

In a paper detailing the `Delta Change' and `Downscaling' methods (both of which were used for the US National Assessment), Hay et al. had this to say in their Abstract:

> *"Given the uncertainties in the GCM's ability to simulate current conditions based on either the delta change or downscaling approaches, future climate assessments based on either of these approaches must be treated with caution."*

In the main body of the paper, they are even a little more forthright:

> *"Given the uncertainties in the GCM's ability to simulate current conditions, future climate assessments based on either the downscaling or the delta change approach are questionable."*

There we have it from the modelers themselves. The Delta Change method used to create such highly resolved and emotive graphics was one that even the modelers admit is "questionable" and "should be treated with caution."

All the models have run the classic `CO2 doubling' experiment, the output being an `equilibrium temperature response of the model to CO2 doubling'. In the case of the NCAR model, this gives a projected global temperature increase of 2°C. However, the Hadley model, using inferior resolution to NCAR, gives a result of 2.6°C, while the Canadian model, which has the coarsest resolution of all the major models, gives a result of 3.5°C. If a similar exercise was done for Australia, it is likely that only the CSIRO model would be used, and both the public and Parliament would thus be denied the opportunity to critically compare the outputs of a number of models. It was this ability to compare models in the US case which revealed so much about the value of modelling generally.

CO_2 Growth - Past, Present and Future

The IPCC claims CO_2 will reach 2 to 3 times its preindustrial level by 2100 based on a long-standing assumption of a 1% annual growth of CO_2 in the atmosphere. However, for the last 20 years, the growth in CO_2 has not been exponential, as would be implied by a percentage growth function, but instead has been linear at around 1.5 ppm per year.

At 1% growth, CO_2 would grow to almost 1,000 ppm by 2100 (red line), thus reaffirming the claim that CO_2 would double or treble its pre-industrial level by 2100. However, at the current linear rate of 1.5 ppm, it will reach 500 ppm by 2100 (blue line), slightly less than the doubling claimed, and nowhere near the trebling.

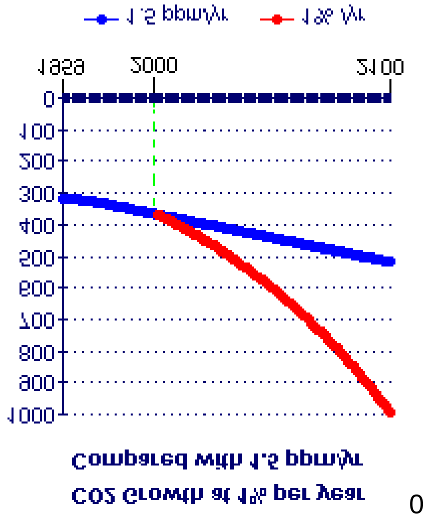

Fig.8 - CO_2 growth under different assumptions

This is a significant issue, because all the predictions made in the IPCC reports are based on this fiction of 1% CO_2 growth. Not only has CO_2 never grown by that much in a given year, but the use of a percentage function itself assures an upward-curving exponential graph as shown by the red line in Fig.8.

Based on a linear growth (the blue line), the model's temperature and precipitation predictions should be scaled back by about half at all levels, more in accord with the real pattern of CO_2 growth. The linear assumption of CO_2 growth is a realistic one given that one major fossil fuel - petroleum - has been subject to historical variability of both price and supply and will probably continue to do so.

The `Hockey Stick'

Evidence from places as far apart as Europe, North America, the Sargasso Sea, Peru, Kenya, Taiwan, and West Africa establishes that over the last 1,000 years, climate varied widely betweeen the warmth of the **`Medieval Warm Period' (MWP)** at the early part of the millenium, to the **`Little Ice Age' (LIA)** of the middle ages, to a position today roughly mid-way between these two extremes. Both events are well documented in Europe, Iceland and Greenland. In England, species of warm climate plants such as grape vines were grown commercially during the MWP, something which would not be possible today. During the LIA, `frost fairs' were common on the River Thames in London, where the river had frozen sufficiently to allow such events. This phenomenon was unique to that era. In Iceland and Greenland, both climatic events are also well recorded in Viking histories and ice core isotopes. Italy also has extensive historical and archaeological records of these climatic extremes.

The 1995 IPCC report summarised our understanding of these past events with this simple millenial diagram (fig.9) -

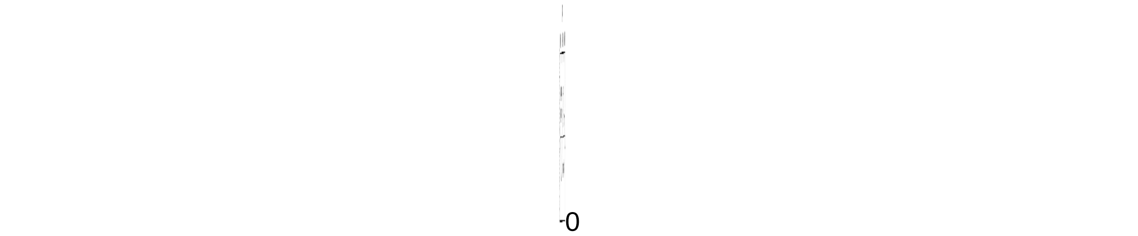

Fig.9 - The Last 1,000 Years according to the IPCC (1995) **[9]**

Evidence from isotopes and sunspot records since 1600 AD suggest the variable sun was largely responsible for these climatic shifts, particularly as the LIA coincided with an extended period of diminished solar activity known as the `Maunder Minimum'. Recent studies of the sun show that the sun is more radiant now than at any time since solar observations began in 1600 AD (fig.10). More importantly, the Maunder Minimum centred around 1675 coincided with the Little Ice Age, an event which was clearly solar-induced.

The MWP and LIA are well documented both historically and by proxy in Europe and the North Atlantic. Proxy evidence from elsewhere in the world confirms that these were truly global, not merely regional. events.

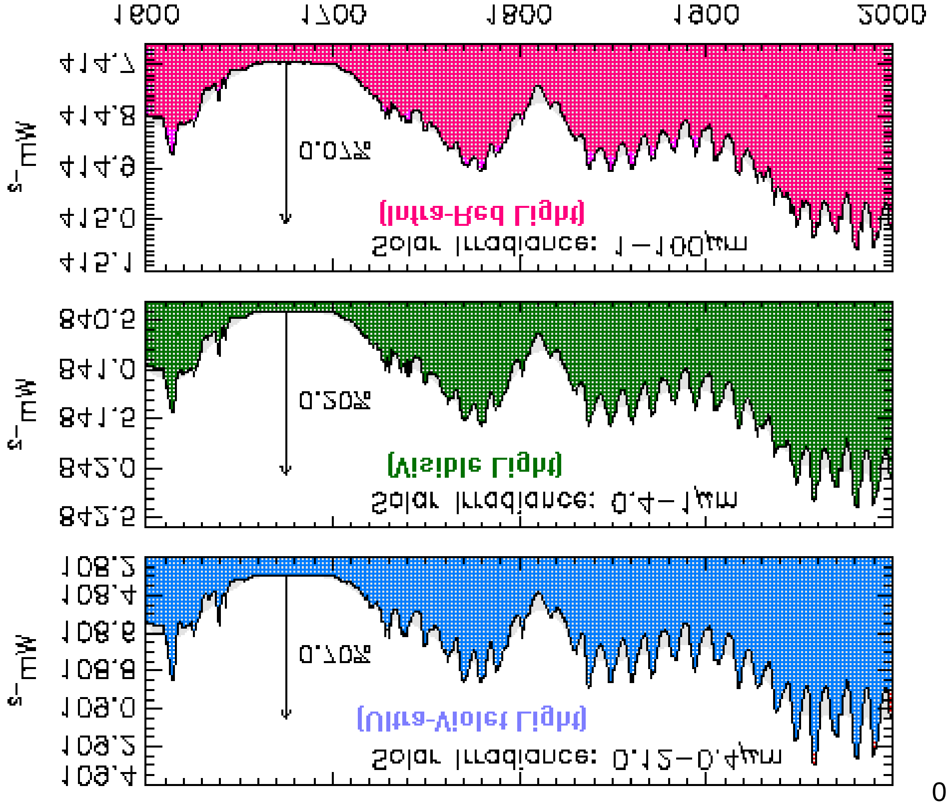

Fig.10 - Changes in 3 components of solar irradiance 1600-2000 **[1] [2]**

In the Sargasso Sea (an area sometimes known as the `Bermuda Triangle'), radiocarbon dating of marine organisms in sea bed sediments demonstrates that sea surface temperatures were around 1°C cooler than today around 400 years ago (the Little Ice Age), and around 1°C warmer than today 1,000 years ago (the Medieval Warm Period) **[12]**. See Fig.11 below

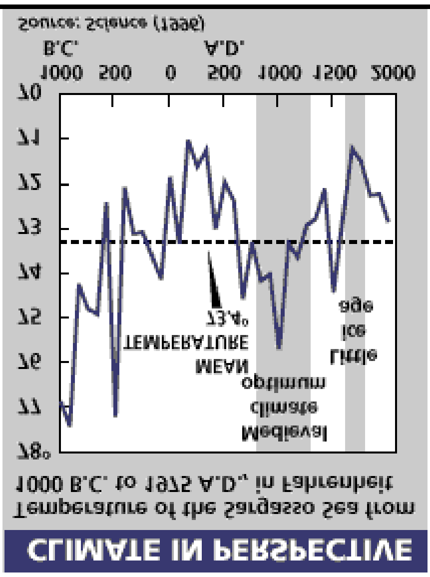

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Fig.11 - The Medieval Warm Epoch and Little Ice Age in the Sargasso Sea

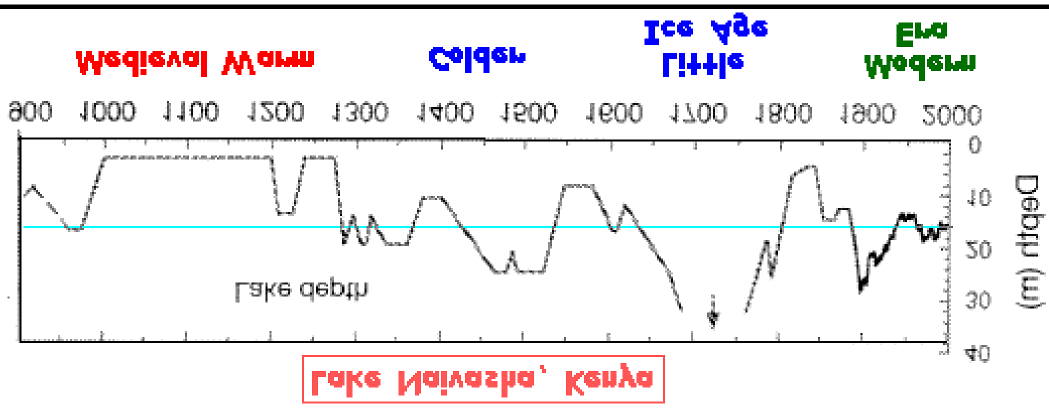

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Fig.12 - The Medieval Warm Epoch and Little Ice Age at Lake Naivasha, Kenya

At Lake Naivasha Kenya, lake sediments record the rise and fall of the level of the lake over the last 1,100 years, the lake level being a direct indicator of general climate change over that time. Not only is the lake level shown to be very low during the MWP, and very high during the LIA, but other events such as the Spörer Minimum around 1500 AD and the Wolf Minimum around 1350 also are evident. As for the 20th century, the lake level is at about the millenial average, higher than the MWP, and lower than during the LIA **[23]**. We can infer from this that the IPCC 1995 graph of the last 1,000 years is fully validated at this lake. See Fig.12 below.

In Peru, the Quelccaya Glacier (Fig.13) yields similar results using oxygen isotope ratos **[19]**. The LIA is very distinctive, whle the MWP (900-1200 AD) is generally above the `mean', comparable in amplitude with the present.

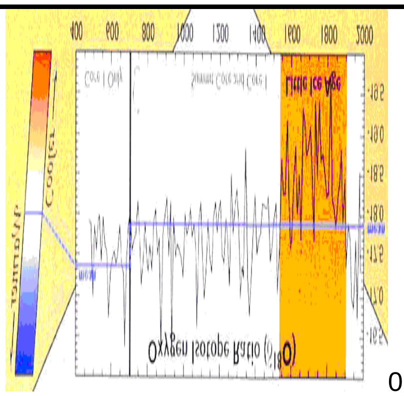

Fig.13 - The Medieval Warm Epoch and Little Ice Age at the Quelccaca Glacier, Peru

In Taiwan, lake sediment studies similar to those in Kenya, also reveal the clear imprint of the MWP and LIA **[13]**. In the seas off West Africa, sea surface temperature proxies indicate climatic shifts matching the Sargasso record. **[7]**.

The existence of these two climatic extremes at such widely separated locations during the last 1,000 years suggests that climate is subject to large natural changes of both warming and cooling.

But the notion that the MWP was warmer than today, or that climate could change in drastic ways all on its own (as with the LIA) without human intervention, proved intolerable to some sections of the greenhouse industry.

"New studies indicate that temperatures in recent decades are higher than at any time in at least the past 1,000 years." - (US National Assessment Overview p.11)

In 1999, a paper published by Thomas Mann et al finally provided the ammunition for the National Assessment Synthesis Team and the IPCC to deny the very existence of the MWP and LIA **[14]**.

The diagram on p.11 of the NACC Overview (Fig.14 below) sets out to deny the well-established record of climate history and instead shows a stable and benign pattern of `global' temperature falling slightly in a fairly continuous fashion from 1000 AD to 1900 AD, turning sharply upward during the 20th century. This is the notorious `Hockey Stick' diagram, meant to suggest that known climatic events of the last 1,000 years simply did not happen at a global level, and that the 20th century - the industrial century - saw global climate surge in a way never experienced in the last 1,000 years.

The political message of the Hockey Stick is clear - the climate was benign and stable for 900 years until industrial man arrived on the scene to change it.

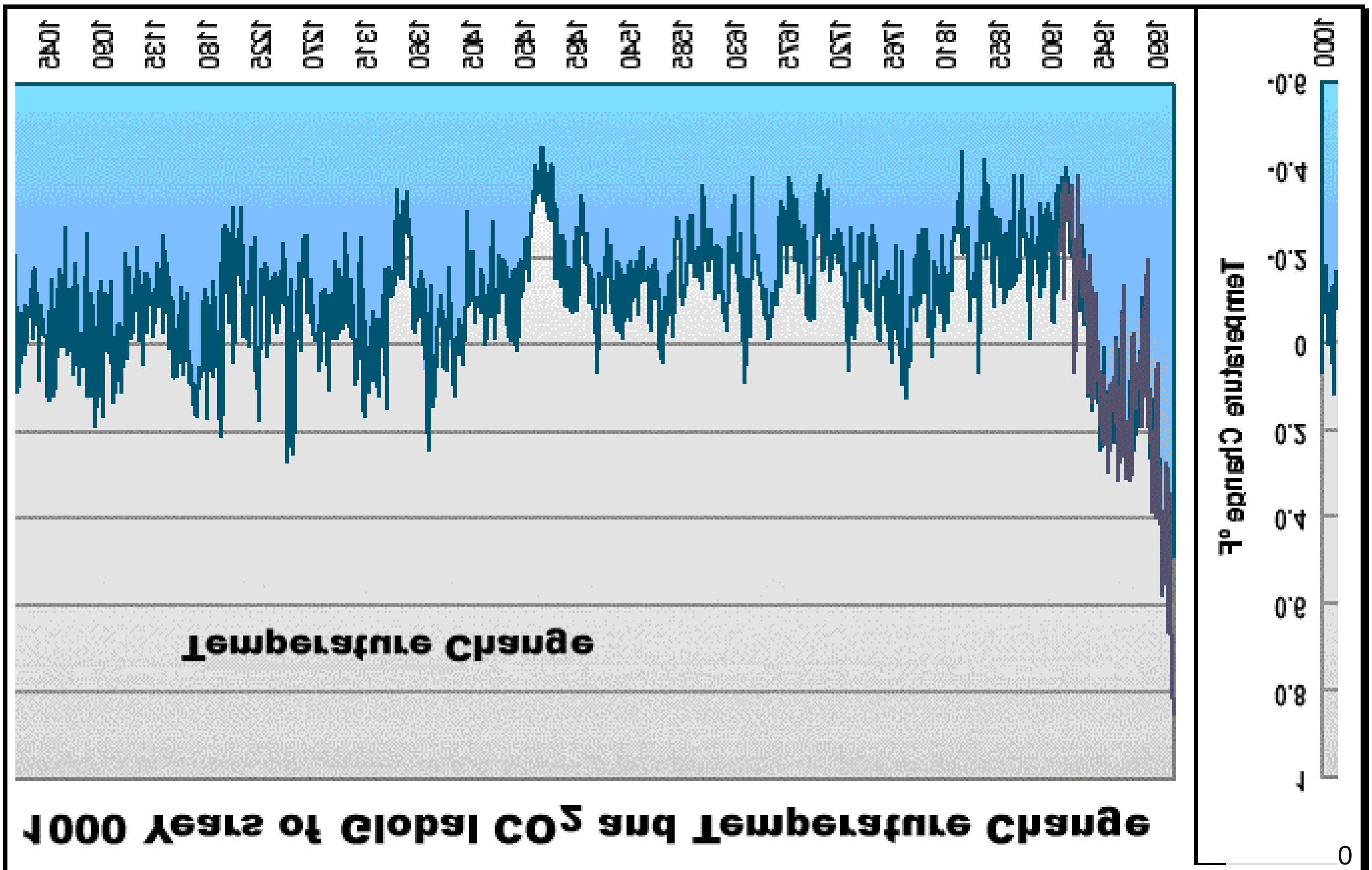

Fig.14 - `Global' Temperature based on Northern Hemisphere tree ring studies by Mann et al.

The National Assessment Overview incorrectly presented the Hockey Stick (above) as a `global' trend, when in fact it only applies to the Northern Hemisphere. The Overview even went a step further by omitting the error margins (shown in yellow, Fig.15 below) which were part of the original Hockey Stick diagram as presented in Mann's paper **[14]**. In that paper, the authors conceded that the reliability of the data pre-1400 was very poor, thus the need for the big error margins.

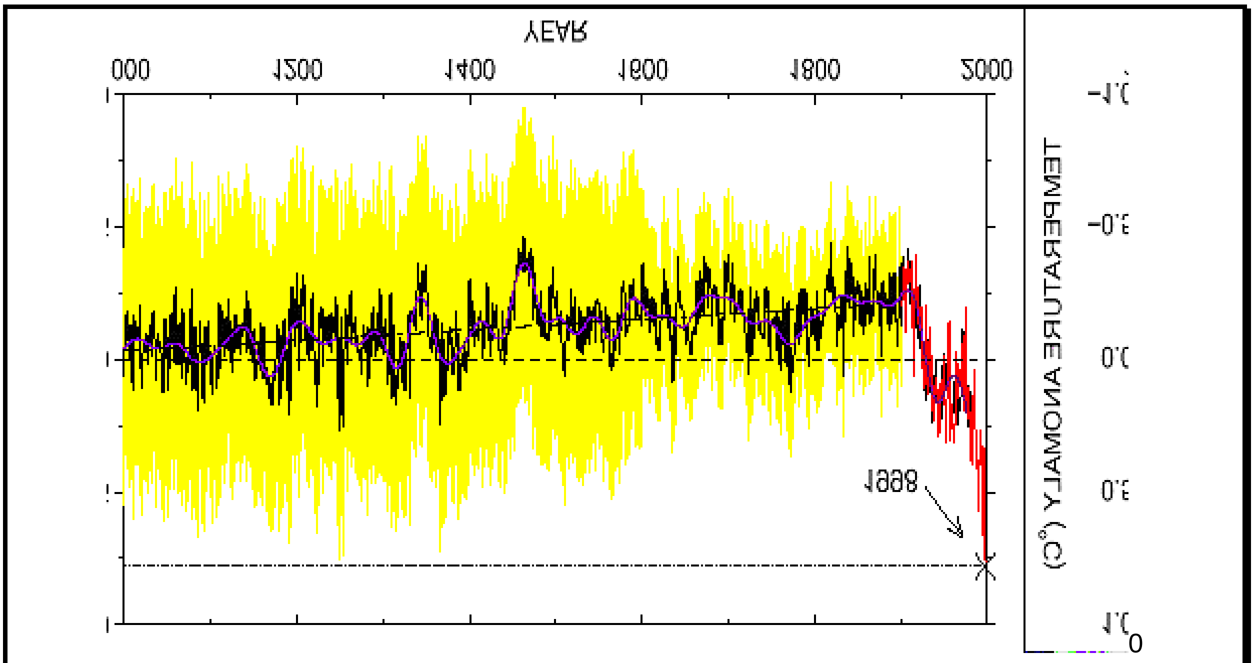

Fig.15 - The original `Hockey Stick', with error margins (yellow) included

The Medieval Warm Period (MWP) and Little Ice Age (LIA) are acknowledged only as regional events confined to Europe and the North Atlantic (where the historical and proxy evidence is too overwhelming to challenge). While the denial of the medieval warmth assists the claim about 1998 being the `warmest year of the millenium', denial of the LIA also assists in the claim that natural climate has been benign and unchanging for the last 1,000 years - until human intervention supposedly changed everything in the 20th century.

As to whether the `Hockey Stick' represents a genuine climate history, or is merely an attempt to wish away the MWP and LIA, can best be judged by the type of evidence which was used. Mann et al used what they called a `multi-proxy' study of tree rings and ice cores to derive their estimate of temperatures over the past 1,000 years. 12 proxies in all were employed, 9 of them being based on tree rings. The remaining three were from ice cores, one from Greenland, the other two from Peru..

Here is a list of the long-term proxies they used, as scanned from the paper itself -

SERIES	LOC	No	TYPE
ITRDB (PC #1)	N. Amer	1000	T. Ring width
ITRDB (PC #2)	N. Amer	1000	T. Ring width
ITRDB (PC #3)	N. Amer	1000	T. Ring width
Fennoscandia	68N 23E	500	T. Ring density
Polar Urals	67N 65E	914	T. Ring density
Tasmania	43S 148E	900	T. Ring width
N. Patagonia	38S 68W	869	T. Ring width
Morocco	33N 5W	984	T. Ring width
France	44N 7E	988	T. Ring width
Greenland stacked core	77N 60W	553	ice core $\delta^{18}O$
Quelccaya (2)	14S 71W	488	ice core $\delta^{18}O$
Quelccaya (2)	14S 71W	488	ice accum.

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Four of them are not even in the northern hemisphere, the primary focus of the study (one tree ring site is even in Tasmania [3], and another from Patagonia, both deep in the southern hemisphere). The proxies from Greenland, Fennoscandia, the Polar Urals, and France are within the region known from historical evidence to be profoundly affected by the MWP and LIA. It is worth noting that the Quelccaya ice core data listed in the table is only taken 488 years into the past, when Fig.17 above shows it can be taken back 1,600 years ! The Greenland core is similarly limited to 553 years. In other words, neither of the ice proxies are taken back far enough to even cover the MWP. Only the tree rings are taken back that far.

On the basis of such fragmentary data from only 8 northern hemisphere sites, the Mann et al paper announces that `1998 was the warmest year of the millenium', a poorly-evidenced conclusion which was hastily adopted in time for the US National Assessment. It has also been embraced enthusiastically by the IPCC in their latest draft report.

The 1,000-year `Hockey Stick' is thus a compilation of a few tree ring records, with the surface record of temperature (itself widely disputed) crudely grafted onto the end to create the `toe' of the hockey stick. The problems with using tree rings as a proxy for temperature are:

1) Tree rings only record climatic conditions during the growing season, not the whole year.
2) Tree rings are also influenced by the level of soil moisture and precipitation.
3) Presence or absence of snow packing around the trunks affects early spring growth.
4) In dense forests, varying access to light will also affect growth.
5) If cloudiness increases, as would be expected in warmer conditions, the reduced sunlight can make the tree ring narrower, not wider.
6) Tree growth is affected by variations in soil nutrients.
7) Tree rings in the 20th century are invalid due to the Fertilizer Effect of CO_2 enhancing ring growth.

In other words, treating tree ring widths and density as being directly proportional to annual temperature and unaffected by any other key variables is faulty science. Of all the proxies in common use, such as isotopes, lake and sea bed sediments, plant pollens, ice cores etc., tree rings are about the least reliable as indicators of past temperatures. It is regrettable that they did not take the ice core isotopes back to the medieval years early in the millenium.

But even with tree rings, there is a lot of selectivity going on. Tree ring data covering the last 300 years from alpine mountains in Taiwan (Taiwan Fir) confirmed the existence of the Little Ice Age **[13]**, but this does not appear in the `hockey stick' northern hemisphere scenario. Taiwan is in the northern hemisphere too.

Historical accounts and archaeological evidence are the strongest evidence of all, being the direct testimony of human witnesses who lived through these events. It was the existence of this historical evidence in respect of Europe and the Viking colonists which prevented the promoters of the `hockey stick' from challenging the existence of the MWP and LIA in northern Europe.

For the IPCC to regard a recent study of such records as now representing the only acceptable version of global climate history for the last 1,000 years, in spite of a mountain of contrary evidence, is more a political decision than a scientific one. It ignores important evidence of these events at locations far removed from Europe, such as Kenya, the Sargasso Sea, Taiwan, West Africa and Peru.

The `Hockey Stick' has been embraced by the IPCC mainly because it facilitates the claim that `the 1990's is the warmest decade of the millenium, and 1998 was the warmest year of that millenium'. Indeed, one could well ask if the `Hockey Stick' owes its very existence to the greenhouse industry's need to characterize 1998 in this way.

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