INTERIM DRAFT - 14 July 2007

(Should be replaced with final version sometime soon)

The Current Uncertainties in Climate Science

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12 July 2007

Summary:

We are often told that the average global temperature has risen 0.6°C since 1975, that this is due to the carbon dioxide that human's release into the atmosphere and that according to IPCC predictions the Earth will be 5.8°C warmer by year 2100. Not one of these claims can be proven to be true beyond doubt, not even the temperature increase since 1975.

Climate science is loaded with uncertainties, opinions and estimates, rather than solid incontrovertible evidence. Even if the theoretical amount of warming caused by increasing concentrations of carbon is known - and it decreases as the concentration increases - the likely reactions to this by other climate factors are unknown.

Until these uncertainties are resolved it would seem foolish to act in the belief that the popular hypothesis is correct, and equally foolish to be seen to be endorsing that hypothesis.

Introduction:

The increasing stridency of claims of a human influence on climate contrasts sharply with the number of critical uncertainties in climate science. Here I list some of the key uncertainties in this important field.

1. **An increase of 0.6 degrees in average global temperatures - UNCERTAIN**
2. **Carbon Dioxide has caused warming - UNCERTAIN**
3. **Historical carbon dioxide and temperature data - UNCERTAIN**
4. **Credibility of computer models - UNCERTAIN (but likely to be poor)**
5. **The credibility of IPCC reports - UNCERTAIN (but probably poor in places)**
6. **Is climate change due to natural causes - UNCERTAIN (but possibly true)**

Details:

1. An increase of 0.6 degrees in average global temperatures - UNCERTAIN

- That's according to near-ground thermometer readings but ...

... On land the "mean temperature" is the average of the maximum and minimum, not the average of all readings over 24 hours. A few hours sunshine on an otherwise cloudy day can produce more than 3 degrees difference in the mean temperatures calculated by the two methods, so the published mean temperature is, at best, only an approximation.

.. Temperatures at sea were taken once per day by sampling water up to 5 metres below sea level. No minimum and maximum temperatures were recorded, but they would be meaningless anyway if the ship was moving or the currents and tides around a stationary ship changed.

... The "urban heat island" is a major problem for temperature readings in and near cities and town. The population of urban areas has increased and so has the amount of heat released by traffic, industry and dwellings. Studies of temperatures in rural parts of Australia show very little warming, unlike temperatures near towns and cities.

... Temperatures are frequently recorded at airports but the measurements are now distorted by increased aircraft traffic and different heat output from aircraft engines, as well of course being subjected to the heat from any nearby urban area when the wind is from that direction.

... Many land-based observation sites have been relocated over time and experience shows that even a small move of a few hundred metres can alter the recorded temperature by more than 1 degree.

... Weather observation stations are not uniformly spread around the Earth and different methods of estimating the temperatures are used where no observations are made. Parts of the Earth are so far from observation stations that no estimates are possible. At the present time about 20% of Earth is beyond the reach of estimates but back in 1950 the temperatures for one-third of the globe could not be estimated and even more before that. The northern hemisphere has better coverage than the southern hemisphere. In the mid 1940s only 1/3rd of the southern hemisphere had observational or estimated data.

... The 3 agencies that supply the average global temperatures use different methods of estimation, don't agree on the actual figure and at least two can't (or won't) tell researchers which observation stations supplied the data for calculations in any year. Those researchers suspect that "urban heat island" effects have distorted the raw data and then have been carried into the estimation process but have been unable to confirm this.

No-one has verified the published temperatures but there are good reasons to doubt their accuracy.

But wait, there's more...

- Temperature measurements also made by instruments on satellites. These measurements are subject to a variety of adjustments (e.g. satellite orbit drift, instruments on different satellites) and there is no certainty that these temperatures are correct.

- The temperatures obtained from satellites show less warming and when the very obvious periods of El Nino events (warming) and volcanic eruptions (cooling) are removed from the record the temperature graph moves up and down with a certain average level, then steps up slightly in 2002 and then moves up and down with a centre-point at a new level. This is very different to the pattern of warming according to the near-surface temperatures mentioned above.

- One should be aware that average temperatures give us no indication of the distribution of hot spots and these might be important for determining the cause localised temperature change. Temperature maps, showing the variations around the world are of some help but most maps distort the high latitudes and places like Greenland appear far larger and significant than they really are.

It's hard to say if there's been much warming when the temperatures are so uncertain. Even if there is warming there is uncertainty about how much is global and how much is caused by local influences.

2. Carbon Dioxide has caused warming - UNCERTAIN

- Well, yes it does but the increase in amount of direct warming decreases as the concentration of carbon dioxide increases, so the warming caused by an increase of 50 ppm from today's figure will be less than the 50 ppm increase that brought it to today's levels.

- Carbon dioxide catches some but not all of the heat (long-wave radiation) being released from the earth as it cools down, which in particular happens at night. The carbon dioxide radiates this heat in all directions, which we can split into up and down, and down is obviously towards the Earth. Radiation is measured in watts and it will increase the temperature, but by how much? Some reliable sources say 1 watt/square metre means 0.1 degrees C warming but climate models assume anything from 0.5 degrees to 1.0 degrees (5 to 10 times that original amount). A good estimate is that a doubling of carbon dioxide will probably cause a temperature increase of about 0.4 degrees, which is less than the climate models assume.

- Carbon dioxide only absorbs radiation in certain wavelengths (something like listening to a radio) and there is a question of whether the current concentration of carbon dioxide is saturated and is unable to absorb any more radiation. This implies that additional carbon dioxide will have very little impact.

- The above paragraph says "probably" in that last sentence because no-one is sure of how things will work. Higher temperature might mean more cloud and that extra cloud will shade us from the sun and cause cooling. More carbon dioxide will encourage vegetation to grow and what is currently barren, hot ground may become greener and cooler.

- There's just one problem .... the mismatch with temperature change.

... Since 1958 the concentration of carbon dioxide has always increased but temperature has gone up and down. If the near-surface temperatures are correct (see 1), it looks like temperature didn't increase until 1978, some 20 years later. It was first claimed that the heat all went into the oceans but

the explanation later changed to sulphides in the atmosphere, but both explanations have little evidence to support them and the hypotheses are uncertain.

... On the other hand, if the satellite-based temperatures are correct - and they do seem to be the most accurate - then the pattern of warming shows no relationship to the continued increase in carbon dioxide.

... Carbon dioxide is reasonably well-mixed within each hemisphere but the maps which show temperature changes don't show even generally consistent increases and don't show the greatest increases where carbon dioxide emissions are highest. If carbon dioxide in the atmosphere causes heat to be radiated back to the earth then we should expect both of the above.

... Historical evidence indicates that carbon dioxide concentrations increase as a consequence of higher temperatures, not as a cause. (This assumes that the data for temperature and carbon dioxide are correct but these assumptions are uncertain.)

... If carbon dioxide causes warming then how can we account for concentrations of carbon dioxide that were much higher than today but temperatures not only did not go into a runaway situation but were much lower than today?

- And ...

... There's a question mark hanging over the claim that in pre-industrial times the carbon dioxide concentration was about 270 ppm and that it's increased steadily since then. Maybe that figure is correct but one researcher has examined old measurements and claims to have found measurements in the late 1800s that are closer to today's 385 ppm and found an increase in the 1940s which decreased a few years later. Maybe the commonly published figures are not so accurate after all, and that might change scientists' beliefs about the influence of carbon dioxide on temperature.

The impact of an increase in carbon dioxide on global temperatures is very uncertain but appears to be so minor even at much higher concentrations that it is easily overwhelmed by other climate forces.

3. Historical carbon dioxide and temperature data - UNCERTAIN

- Data from ice cores is unreliable and uncertain

... The temperatures derived from the ice cores in Greenland and Antarctica don't show a reasonable match at the same points in time, nor is the pattern very similar. This mismatch makes it impossible to determine an average global temperature which has any real value.

... Gas data from ice cores might be distorted by the drilling and extraction process. The weight of the slow accumulation of snow will eventually force the compacted snow to become ice but only after most of the gas has been forced upwards, so any gas concentration at a particular point in time ends up being dispersed from that point in the ice to some indeterminant point above there. The recorded levels of gas are therefore the averages over some unknown period of time, not a value at a specific time.

... Some researchers claim that chemical variations in the ice don't represent temperature but just the level of precipitation (in this case, snowfall). This would explain the variation at the two poles but means that the temperatures are not known.

- Carbon dioxide levels from leaf stomata are better but even these are limited. On the underside of leaves are stomata which change in size according to the concentration of carbon dioxide. Ancient leaves can therefore indicate the carbon dioxide concentration when the leaf died. Above certain concentrations of carbon dioxide the stomata no longer change (385 ppm for many plants) and any levels above that point are uncertain.

- Temperature data from proxy measurements needs to also be treated with caution. The "hockey stick" temperature graph that featured in the IPCC TAR of 2001 relied on a small group of bristlecone pine trees in the western USA for the northern hemisphere temperature data in the early part of the last thousand years. Not only should we question if a group of trees in one location was representative of the entire hemisphere but it is widely recognised that tree growth depends on sunshine, temperature, rainfall and soil nutrients.

Historical climate data always need to be viewed with some scepticism, particularly when findings from one location are extrapolated over a much wider area..

4. Credibility of computer models - UNCERTAIN (but likely to be poor)

- Computer models encapsulate information for which the confidence ranges from certainty through to speculation, and then the models are tweaked so they calibrate as closely as possible with historical weather observations. This deliberate manual alignment means that no model can be proven to be correct.

- It is very difficult (or impossible?) to independently "peer-review" a model because the models are complex and the modelling community appears to exchange ideas and even models or parts of models. If we apply conventional thinking and empirical experience about computer software in general we can expect a number of errors, some of which may be dormant for years, and that is despite the probability that corrections have already been made.

- These models do not (and at this time *cannot*) incorporate variations in solar activity (e.g. sunspots, solar winds) or El Nino (or La Nina) events but these show a very strong correlation to variations in temperature some days, weeks or months later.

- Models are very poor at determining the influence of changing cloud cover and there is uncertainty over whether clouds have a warming or cooling effect.

- The output of models are *projections*, not predictions. The difference is that climate is too complex to predict because too many climate factors could change. The models use "scenarios" to describe how a very small set of climate factors might change and the output *assumes that all other factors are unchanged*. Too much faith is placed on the output of these scenarios because historical evidence shows that climate is always changing under a variety of influences.

- Experts say that the models are not initialised to existing values (which come from meteorological observations) so how can they predict the future if they don't start from a known and accepted point.

- Despite the promises of their operators, no computer models of climate have been shown to be accurate.

- Even if the models produced results which matched the observations there would be no guarantee that the models were correct. It might be that the combination of factors gave us the "correct" result, with some produce estimates that are too high and others that are too low. It might also be that a major factor in the model is based on something that the temperatures changed rather than something that forces a change in temperature.

- A consensus of models proves absolutely nothing because all the models might be wrong, especially if they make incorrect assumptions about one or more key factors.

There is no reason to believe the output from computer models of climate.

5. The credibility of IPCC reports - UNCERTAIN

- The IPCC is a small administrative organisation that relies on governments to appoint people to a task-force which investigates of recent climate research. It performs no research for itself but draws on papers published in peer-reviewed journals.

- The peer-review is a flawed process which is easily manipulated by journal editors or by reviewers who have been known to reject papers which contradict their own research. On top of this the IPCC selects only certain papers and rejects or pays scant regard to others.

- The "hockey stick" temperature graph which featured prominently in the IPCC TAR of 2001 was created by one of the lead authors of the report chapter in which it appeared. The peer review process for journal which first published that graph was poorly performed and for several years the creator of the graph refused to disclose the data and method to other researchers so that the graph could be verified. (It was discredited in 2006 when it was found that the method would produce hockey stick graphs from even random data and when expert statisticians discredited the technique.)

- Few scientists claim that the reports about recent climatic conditions are seriously flawed but they do question the interpretations and statements about future climatic conditions.

- The IPCC reports rely on historical temperature data (see earlier comments) and on climate models but these are unproven (ditto). The output of these models are known as *projections* but are treated as *predictions*.

- It is unclear how many IPCC editors and reviewers support the claim that humans are responsible for climate change. The critical chapter of the 4AR WG I report (released 2007), chapter 9, "Understanding and Attributing Climate Change" has 56 editors (co-ordinating, lead, contributing and review) but maybe not all fully endorsed the notion. Only 62 reviewers commented on this chapter and more than half (33) made fewer than 4 comments about the entire 84 pages, and at least some of the reviewers disagreed with parts of the chapter. Probably fewer than 100 people publicly endorsed the wording of that chapter before it was published.

- The IPCC has often said words to the effect "We don't know what else can be causing warming so it must be humans" on many occasions but at the same time the IPCC says that scientists have a low level of understanding of many climate factors. Logic says that if any natural climate factors are poorly understood then the cause cannot be attributed to humans.

The IPCC reports cannot be used to claim certainty of a human influence on climate.

6. Is climate change due to natural causes - UNCERTAIN (but possibly true)

- The Earth's temperature has risen and fallen, sometimes sharply, over billions of year before humans appeared. Scientists have speculated about different causes but the evidence is not easy to find. Moreover without very good knowledge of the climate system (see 4) there's no way to be certain if recent temperatures are natural or abnormal.

- We are never told about changes in winds but temperature variations can often be attributed to winds and ocean currents. Almost everywhere on earth experiences warm winds from certain directions and cool winds from others. Winds are produced by pressure differences and changes in

winds often indicate changes in the path of high and low pressure cells. We are rarely told about shifts in prevailing winds but these could easily be a cause of local temperature variations. At the top of the globe the Arctic ice is melting. It is easy to see that this occurs most where ocean current bring warm water from the south but hot air always moves towards cooler regions and the melting might in part simply be a transfer of warm air. (Winds don't somehow "balance out" around the world because the heat energy used for the melting of snow or ice will not cause a change in temperature. In other words the heat in warm winds can make little or no contribution to temperature change if the winds blow towards snow or ice, but it will cause melting.)

- Clouds have a big impact on temperature and since 1999 there's been a decrease in the amount of low-level (dense, cold, rain-bearing) cloud outside the tropics. Many places have also had an increase in high-level cloud, which is typically thin cloud that blocks a little sunlight but also blocks some of the natural cooling process of the Earth. Both of these changes causes warming.

- Research suggests that cosmic rays might have an influence on low-level cloud. The research is not convincing but the idea is interesting. Correlations between temperature and cosmic rays have been claimed and further investigation seems justified.

- Every day and every season it's obvious that the sun is a major force on Earth's temperature. The output from the sun is not merely radiation but also charged particles and magnetism, the latter linked to sunspots. The magnetic poles of the sun flip every 11 years and this pattern, especially the 22-year double flip, have been correlated to changing temperatures on earth.

- Global temperatures appear to rise and fall in association with El Nino conditions. These conditions have also been linked to droughts and higher temperatures in many parts of the world - but in other places greater rainfall and lower temperatures - and most effects appear to be related to the season. These conditions might account for local variations to temperature and, as we saw above (see 1), average global temperatures don't indicate exactly where the variations occurred. Some researchers claim a link between El Nino events and solar emissions (see previous paragraph).

There are many possible natural explanations of changes in temperature and research is continuing into these, so we can't be certain that they are not the cause of recent climate changes.

CONCLUSIONS

There are many uncertainties about a human influence on global temperatures, starting from whether the temperature is actually increasing. The magnitude of the influence of carbon dioxide on temperature is uncertain, computer models of climate have not been proven to be accurate, the level of scientific understanding of many climate factors is still very low and there are many natural factors that still need to be investigated.

In these circumstances it it very premature to blame humans for an increase in temperature which might not even exist.

ANNOTATED READING LIST

The emphasis on online articles in this list is for the ease of accessibility that such documents have.

General

Evans, D - "My Life at the AGO and Other Reflections" at http://ncwatch.typepad.com/media/files/D-Evans2007.pdf. David Evans talks about his time in the Australian Greenhouse Office, why he no longer believes that carbon dioxide is the cause global warming and how the science has been corrupted.

Section 1. An increase of 0.6 degrees in average global temperatures

Brohan, P., J.J. Kennedy, I. Haris, S.F.B. Tett and P.D. Jones, 2006: Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. *J. Geophysical Research* 111, D12106, available online as http://www.cru.uea.ac.uk/cru/data/temperature/HadCRUT3_accepted.pdf. (This paper might have been peer-reviewed but the accuracy of the methods discussed in it have never been proven.)

CRU temperature data at http://www.cru.uea.ac.uk/cru/data/temperature/ (v3GL - i.e. v3.0 global - recommended). The anomalies (i.e. variations from the average monthly values) are based on the average from 1961 to 1990.

"Global Surface Temperature Anomalies" (in particular the combined land and sea anomalies at the endof the page at http://www.ncdc.noaa.gov/oa/climate/research/anomalies/anomalies.html
but be careful because NCDC presents the anomalies from 1901-2000, which is different to those used by the CRU (see above).

"Climate Variability and Climate Change" at http://wwwghcc.msfc.nasa.gov/ghcc_cvcc.html. This discusses surface temperatures, based on thermometer readings, with satellite based measurements. Sadly the graphs have been withdrawn.

"Lower Tropospheric Temperatures" at http://mclean.ch/climate/Tropos_temps.htm

"How Not to Measure Temperature", series of 18 (or more) web blog entries mainly on page http://www.norcalblogs.com/watts/2007/06/ but with earlier entries on the previous page in that archive series and newer entries on the subsequent page. Some official US weather observation stations are clearly corrupted by their surroundings.

Section 2. Carbon Dioxide has caused warming

"The Manipulation of Reality - The Falsified History of Carbon Dioxide" at http://www.eike-klima-energie.eu/daten/berlin30507/berlin1e.htm (Claims that many high-quality measurements of carbon dioxide were ignored when determining concentrations prior to the monitoring which began in 1958)

Section 3. Historical carbon dioxide and temperature data

"Ice Cores" at http://mclean.ch/climate/Ice_cores.htm

Section 4. Credibility of computer models

Various comments from "Climate Audit" at http://www.climateaudit.org/?cat=25

Various comments from "Climate Science" at http://climatesci.colorado.edu/category/climate-models/

Section 5. The credibility of IPCC reports

see Evans (in "General" at the start of this section)

Section 6. Is climate change due to natural causes

"Antarctic Warming Investigated" at http://mclean.ch/climate/antarctic_temps.htm and be sure to compare the temperatures at Faraday Research Base with the cloud cover available at http://mclean.ch/climate/Cloud_Antarctic_Pen.htm. Which occurred first? The changes in low, mid and upper level cloud or the increase in temperatures? Could the cause of the local warming be simply an increase in warm northerly winds?

For cloud cover for various parts of the world see http://mclean.ch/climate/cloud_cover_main.htm but is the data accurate?