Climate Change: Consensus or Controversy?

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Abstract: The hundreds of scientists comprising the Intergovernmental Panel on Climate Change (IPCC) maintain that there is a consensus that humans are changing the global climate. Yet many commentators in the media dispute this, and a reader of such commentaries would surely conclude that climate change is a controversy rather than a consensus. This is simply incorrect – the overwhelming majority of climate scientists accept the reality of the greenhouse effect and its impact on the current climate. The main arguments advanced by media commentators to dispute the IPCC position will be examined and rebutted.

Introduction

In 2001 the Intergovernmental Panel on Climate Change (IPCC), involving hundreds of climate scientists brought together to assess information on climate change, concluded that "There is new and stronger evidence that most of the [global] warming observed over the last 50 years is attributable to human activities" (*Climate Change 2001 Synthesis Report*, Cambridge Univ. Press, 2001). Yet readers of some newspaper columnists, or even of some thriller fiction (Michael Crichton's *State of Fear*), would likely conclude that there is no evidence of any global warming or any climate change that was out-of-the-ordinary, let alone evidence that such changes can be attributed to human activities such as the enhanced greenhouse effect. Thus, Andrew Bolt in the *Herald Sun* (25 March 2005), in an opinion piece entitled "Global dimwits" says "Time to panic, the world's getting hotter ... and colder. Doesn't make sense? Doesn't matter, it's another Green scare campaign." This followed a piece by the same writer entitled "Age of no reason" saying "Want to make a greenie boil? Just question their claims of global warming. It's not hard when so much of the evidence is paper thin." (*Herald Sun*, 18 February 2005). And Bolt is not alone. Neil Coulson, in an article entitled "Warming debate cooling" *(Herald Sun*, 1 July 2005), says "Not only is the scientific community not in agreement about the causes of global warming, but studies at the University of East Anglia show average global temperature has declined since 1998." Some commentators, even if they seem to accept that there has been warming, suggest alternative explanations. Thus Christopher Pearson (*The Australian,* 11 June 2005) believes that "One of the alternative explanations is that the main cause has been volcanic activity, much of it submarine and hard to detect." So how do these commentators regard the IPCC and its conclusions? Crichton (p. 245) says "That's the IPCC, as you know - a huge group of bureaucrats, and scientists under the thumb of bureaucrats." And according to Professor Robert Carter (*The Age*, 13 June 2005) "The United Nations Intergovernmental Panel on Climate Change has been the main scaremonger for the global warming lobby…Fatally, the IPCC is a political, not a scientific body."

So, what is the IPCC, and does it deserve such descriptions? Far from being "a huge group of bureaucrats" it is in fact almost entirely working scientists, and a large number at that, from universities and government research institutes in many countries. The handful of IPCC bureaucrats who work to ensure that these scientists can put together the massive assessments of climate every five years, are also generally scientists themselves. There is a bureaucratic structure, of course. Within the IPCC there are three working groups (addressing physical science, impacts, and mitigation/adaptation), each with its own Technical Support Unit (about 3-4 people). Working Group 1 (The Physical Science) has 140 scientists as Lead Authors currently working on the Fourth Assessment (to be released in January 2007), with an additional several hundred Contributing Authors who supply perhaps only a short paragraph on their area of specialty to the Lead Authors. The IPCC does NOT undertake research. Rather, the scientists involved in the IPCC process produce an assessment of the research on climate change. There is an open and transparent review process to ensure that the assessment is balanced. This process is very different to the review process a scientific (and, presumably,

an economics) paper undergoes at a journal prior to publication. A typical journal will use 2-3 anonymous reviewers and a single editor will decide whether authors have adequately addressed reviewer comments. An IPCC assessment undergoes four separate reviews (one for each of four drafts). For the First Draft of the Working Group 1 report for the Fourth Assessment, 547 reviewers provided more than 17,000 comments. Each of the 11 chapters of the report has two or three review/editors who collectively determine whether the Lead Authors have adequately addressed the comments from the reviewers. The reviewers are identified, and the Lead Author responses to the review comments are filed and become part of the public record of the IPCC. Reviewers volunteer themselves as "experts" (self-defined). The process of preparing such a thorough, and openly reviewed, assessment is time-consuming and exhausting. In the end, the assessment is "approved", word-by-word, by government representatives (many of whom are scientists) at plenary meetings, with many Lead Authors present. The government representatives can, and do, request changes. But no changes can be made without the agreement of the scientists. Nor can changes alter the thrust and conclusions of the assessment. There may be a better way to prepare an assessment of a complex scientific topic, but surely not to provide a balanced, scientific assessment.

Clearly, however, there are still many media commentators who dispute the IPCC conclusions. What scientific arguments are advanced to support the denial of global warming and the IPCC findings? Some frequently heard arguments are:

- The greenhouse effect is just a "theory".
- In the 1970s scientists were predicting an ice age.
- The warming is just due to urban heating.
- Satellites (and some stations) show no warming.
- We can't predict the weather a week in advance, so how can we do it 100 years in advance?
- The climate changed before humans were around, so the current changes are probably natural also.
- The warming is pretty small or unimportant anyway.

"The greenhouse effect is just a theory"

Many commentators, and many in the public, probably only heard about global warming in the late 1980s, when it became a political interest. So to many, it may appear that global warming is a relatively new "theory" still in contention. However, the physics of the greenhouse was established and understood many decades ago. Joseph Gentilli of the University of Western Australia, wrote about the greenhouse effect more than 50 years ago (*A Geography of Climate*, The Univ. of Western Australia, 1952): "It follows that the atmosphere lets incoming (solar) radiation through much more easily than outgoing (terrestrial) radiation. This is called the selective or "greenhouse" effect of the atmosphere." But Gentilli was certainly not the first to discuss this. Scientists realized in the 19th century that gases in the atmosphere cause a "greenhouse effect" which affects the earth's temperature. At that time they were interested in the possibility that a lower level of carbon dioxide gas might explain the ice ages of the distant past. For instance, Nobel Laureate Svante Arrhenius, in 1896, calculated that emissions from human industry might eventually lead to global warming (Arrhenius 1896). In 1939, G.S. Callendar argued that the level of both carbon dioxide and temperature had been rising, and that humans were affecting global temperature (Weart, 2003). There is a widespread scientific consensus on this, based on well-understood physics. Thus "First let it be said that even "back-of-the-envelope" calculations (much more believable in many ways than large computer models) suggest that there will indeed be some degree of global warming because of increasing greenhouse gases in the atmosphere. So there is not much argument from scientists about the actual existence of the phenomenon." (Garth Paltridge, "The politicised science of climate change", Quadrant, October 2004).

"In the 1970s scientists were predicting an ice age"
This argument appears to have arisen because one or two climate scientists did suggest that we were heading for an ice age, but this was never widely accepted in the climate community. But these claims did get wide wide distribution through the media, so it is not surprising that some people now think the scientific community, as a whole, simply changed its mind about the direction of temperature change since then. In fact, during the 1970s (and even before) there were many published papers warning of the warming likely to result from the enhanced greenhouse effect. Thus, "For global mean conditions, a surface temperature rise of about 2K was obtained for a doubling of the carbon dioxide amount…" (Hunt & Wells, *J. Geophysical Res*., 1979). "…our best estimate of the temperature rise which might be expected with a doubling of the atmospheric CO2 concentration is about 2-3°C…" (G.I.Pearman, in *Climatic change and variability. A southern perspective,* CUP, 1978). "If man-made dust is unimportant as a major cause of climate change, then a strong case can be made that the present cooling trend will, within a decade or so, give way to a pronounced warming induced by carbon dioxide." (W. S. Broecker, *Science,* 189, p 460, 1975). Even earlier than this there were predictions of the likely effect of the increased carbon dioxide on global temperatures: "A projected 18 percent increase [in CO2] resulting from fossil fuel combustion to the year 2000 (from 320 ppm to 379 ppm) might increase the surface temperature of the earth 0.5°C; a doubling of the CO2 might increase mean annual surface temperatures 2ºC." (*Man's Impact on the Global Environment,* MIT Press, 1970). This was a remarkably accurate 30-year forecast as global temperature increased about 0.45°C between 1970 and 2000.

"The warming is just due to urban heating"
Many temperature records are derived from stations in cities, and the influence of the cities infrastructure on temperature (especially on calm, clear nights) is well known, so it is understandable that many query whether the warming we see simply represents the increase in size of cities and towns. To avoid this possibility, high-quality historical climate data sets avoid using urban stations or attempt to adjust temperature observations for such effects (adjustments are also needed for problems such as changes in exposure or instrumentation). The possibility that there is still a residual urban warming effect on temperatures over land cannot be completely dismissed (although several studies suggest it is small, eg., Parker, 2004). However, there is much other evidence that the earth is warming, not reliant on temperatures from urban areas. Thus, ocean temperatures have warmed similarly to temperatures on land, glaciers nearly everywhere have been melting (Oerlemans, 2005), springtime snow (and summer Arctic sea ice) extent has been receding (Mote et al., 2005; Comiso, 2002), and sea level has increased (Church and White, 2006). All of these trends are symptomatic of global warming and are, of course, unaffected by urban heating. Warming of the ocean temperature alone, or warming estimated from the observed glacier regression, both closely match the warming observed over land. Warming has even been detected in sub-surface ocean temperature in every ocean basin (Barnett et al., 2005). Clearly, urban heating cannot be the major cause of the observed warming. In Australia, minimum (night-time) temperatures, maximum (day-time) temperatures, and sea surface temperatures have all warmed substantially since the first half of the 20th century (Figure 1).

"Satellites (and some stations) show no warming"
A popular argument is that the lower atmosphere (as measured by satellites and from balloons) has not been warming since satellites started measurements in 1979, and that these observations contradicted the land based measurements. Until recently the available data did not show warming above the surface of the earth, despite expectations that such warming should occur with an enhanced greenhouse effect. Until recently only one research group had pieced together the observations from a number of successive satellites that measured global temperatures, and their record did not show warming. In the last couple of years, however, two other groups have independently developed ways of joining the different satellite records together, and in doing so have discovered flaws with the first group's record, which has since been corrected. As a result, all three groups have produced independent satellite records

exhibiting warming since 1979, although the amount of warming varies between groups. Furthermore, the values are now consistent with not only the ground based observations but also modelled projections.

Problems with the historical record of temperatures from balloons have also been uncovered (Sherwood et al., 2005). Some of the early instruments were not adequately insulated from direct heating from sunshine, so their daytime temperatures were biased warm relative to modern instruments (leading to an erroneous cooling trend). All of this recent work has meant that apparent lack of consistency between the warming at the surface and lack of warming, or even cooling, in the lower free atmosphere, has disappeared.

Not all land-based stations exhibit warming either. Michael Crichton, in his novel *State of Fear*, makes this point very strongly, using graphs to show the lack of trend in many locations. The one station he uses from Australia is Alice Springs. However, the exposure of the thermometers at Alice has changed in several ways during the period the station has been recording data (since the late 19th century). For example, a Stevenson Screen, which protects the thermometer from direct sunlight, was only installed about 1930 and before this, temperatures would have been warm biased, leading to an artificial cooling trend over the second half of the 20th century. The station was also moved to the airport outside the town in the middle of the 20th century, which would also have introduced an artificial cooling trend. If only data since the station was moved to the airport are used, Alice Springs shows a strong warming trend, similar to the warming observed across the Australian continent.

"We can't predict the weather a week in advance, so how can we do it 100 years in advance?"

This argument, although at first glance a perfectly reasonable question, confuses prediction of the details of the weather (say, Sydney's maximum temperature for tomorrow) with what climate models attempt to predict (there will be more cool days in Sydney next winter than during summer). You don't need to be weatherman to make the latter "prediction". Similarly, we can predict that the tropics are warmer than the poles, and that an El Nino will most likely be associated with below average rainfall in eastern Australia. Just as we can "predict" the seasons (and humans have been using this predictive ability for thousands of years in agriculture and many other activities) we can predict that changes in radiative forcing due to increasing greenhouse gases will lead to warmer temperatures (on average). This doesn't allow us to predict the maximum temperature for Sydney on 9 February, 2055, but it does allow us to say with that summer 2055 is likely to be warmer than summer 2005.

The difference between predicting weather and climate is similar to predicting what a die will show when it is rolled. If we roll the die a thousand times it is impossible to predict what each successive roll will be. But we do know that the average value of the thousand will be very close to 3.5. And if we weight the dice to slightly favour getting a 6 and roll a thousand again, we know that the average will be a higher value, even if we still cannot perfectly predict each roll.

"The climate changed before humans were around, so the current changes are probably natural also"

Climate has always changed. At least in Europe there is evidence of a Medieval Warm Period, and a (later) Little Ice Age, although how global these periods were is a topic of scientific debate. It seems unlikely that people could have caused these changes, or the larger changes seen in previous millennia. The argument that this means that the current warming is most likely natural is popular amongst geologists, presumably because they have a very long perspective on past climate changes. There are two problems with this argument. Firstly, many of these changes in the past were associated with changes in the position of continents, or changes in solar insolation due to planetary and orbital changes. In order to determine if the current warming seems likely to be due to natural variations, we need to look at the sort of

natural changes that take place under current orbital and continental distributions. In the last decade or so, there have been numerous attempts to reconstruct temperatures over the last millennium or two, to place the warming of the 20th century in context. These reconstructions suggest that the warming is very unusual compared with the climate variability in the past 1000 years or so. Even were this not so, however, this would still not lead, logically, to the conclusion that the recent warming must be natural. To make such a statement is analogous to accepting that the landscape of Manly has changed over millions of years because of natural factors, and then concluding that the recent changes in what we see from the window in this hotel must just be natural also.

The second problem with using geological timescale climate change as a comparison to today's observed changes is the rate at which temperatures are currently warming. In the past hundred years the Australian temperature has warmed around 1°C. This is much faster than the warming, for instance, as Australia came out of the last ice age maximum, and other natural climate variations.

"The warming is pretty small or unimportant anyway"

What we mean by "unimportant" to mankind is obviously more the province of economists than of atmospheric scientists, but to a mere meteorologist some recent changes are be worrying. At Spencers Creek, near Mt Kosciusko, snow depth at the start of October has declined by 40% in the past 40 years, due almost entirely to warming so less precipitation falls as snow and it melts sooner (Nicholls, 2005). Globally, the number of the most intense (Category 4 and 5) hurricanes has doubled over the past 30 years (Webster et al., 2005). The Atlantic 2005 hurricane season reset the record book for hurricane activity, at least partly due to the exceptionally warm ocean surface temperatures. A new global record for 24-hour rainfall was set in Mumbai. The mean annual number of warm nights (averaged globally) has increased by about 25 nights over the last 50 years, from a base of about 36 nights (Alexander et al, 2005). The frequency of extremes has also changed in Australia (Nicholls and Collins, 2006). There have been widespread increases in very heavy precipitation in may parts of the world (Groisman et al., 2005). Australian droughts, although not appearing to be any drier, are certainly setting new records for warmth (Nicholls, 2004). So, the question of whether or not climate change is important may depend on whether you are a farmer, a skier, a reinsurer or a policy maker, live on a hurricane coast, or are in an area where warmer nights lead to more mosquitoes and arboviruses.

And this is all assuming that "unimportant" is purely the domain of humans. In the natural world the unprecedented rates of change are already having an impact. A Stanford study (Root et al., 2003) reviewed over 1400 plant and animal studies, and found that around 80% of species have shown changes in behaviour or range, mainly in the direction expected from changes in the climate..

Concluding remarks

One valid concern about future climate change is the reliability (or perhaps lack of it) of the climate models used to predict *regional* climate change. There is general agreement amongst climatologists that regional climate predictions, especially of rainfall, can be problematic and require further refinement, so it may well be some time before we will be confident predicting all the details of, say, Manly's future climate. However, the prediction that the world will warm as greenhouse gas emissions rise is based on long-established physics, rather than any climate model. The results from the complex dynamical climate models do, however, confirm the expectations from our knowledge of the physics of the atmosphere. As well, both proxy indicators from the past 2000 years and directly measured observations of many variables over the past century add further confirmation that we are experiencing a climate change far beyond what could be expected from natural causes alone. Human induced global climate change is, unfortunately, our new reality, no matter what we would might be led to believe by media commentators.

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Figure 1. Annual mean maximum and minimum temperature anomalies averaged across Australia, and annual mean sea surface temperature anomalies averaged in the oceans around Australia (45-10S, 110-160E).