Minister Wong's Reply to Senator Fielding's Three Questions on Climate Change – Due Diligence[1]

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A. Preamble

Emissions trading legislation, such as the "Carbon Pollution Reduction Scheme" (CPRS) bill that is currently before parliament, rests upon the assumption that human greenhouse emissions, especially carbon dioxide, (i) are pollutants, and (ii) are causing dangerous global warming. Neither of these assumptions is supported by empirical evidence, and both have been under scientific challenge for many years by a large body of qualified and independent scientists.

Cognisant of these facts, Senator Steve Fielding has posed three direct questions to the Minister for Climate Change, Senator Penny Wong, in order to clarify whether or not evidence exists that human carbon dioxide emissions are causing dangerous global warming, as alleged by the UN's Intergovernmental Panel on Climate Change (IPCC).

The Minister's replies to the Fielding questions drew heavily on IPCC arguments and advice. Parliament, in preparing to implement policy based upon the advice of an international political agency, has not hitherto had available to it a due diligence scientific assessment of the adequacy of the IPCC recommendations (Professor Garnaut's extensive report being an economic and not a scientific analysis). As independent scientists, and at the request of Senator Fielding, we provide preliminary scientific due diligence in this document.

Our conclusions are (i) that whilst recent increases in greenhouse gases play a minor radiative role in global climate, no strong evidence exists that human carbon dioxide emissions are causing, or are likely to cause, dangerous global warming; (ii) that it is unwise for government environmental policy to be set based upon monopoly advice, and especially so when that monopoly is represented by an international political (not scientific) agency; and (iii) that the results of implementing emissions trading legislation will be so costly, troublingly regressive, socially divisive and environmentally ineffective that Parliament should defer consideration of the CPRS bill and institute a fully independent Royal Commission of enquiry into the evidence for and against a dangerous human influence on climate. We add, with respect to (iii), that the scientific community is now so polarised on the controversial issue of dangerous global warming that proper due diligence on the matter can only be achieved where competent scientific witnesses are cross-examined under oath and under strict rules of evidence.

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[1] This is a second edition of the Due Diligence Report, containing a new appendix H in review of a July 7 report from the Department of Climate Change by Professor Will Steffen.

[2] Author biographies are provided in Appendix I.

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B. Introduction

On June 15th, 2009, Senator Fielding provided Climate Change Minister Wong with three written questions on climate change.

Minister Wong agreed to address these questions, first, through discussion at a meeting held between the Senators, ourselves and ministerial science advisers Professor Penny Sackett (Chief Scientist) and Professor Will Steffen (Director, ANU Climate Change Institute). There were also Departmental and staff from each Senator's office present. At this meeting, an 11-page background paper was presented and discussed by Drs. Sackett and Steffen. Second, the Minister also provided a written reply to Senator Fielding on June 18th.

This paper provides a response to both the background presentation paper and to Minister Wong's written reply, and was released by Senator Fielding's office on June 26th.

C. The background presentation of June 15th - Commentary

The handout, and its presentation by Drs. Sackett and Steffen, summarized several important aspects of climate change science based upon standard IPCC arguments and graphics. Topics covered included the importance of solar irradiance as a climatic forcing agent, historic changes in air temperature, ocean heat and greenhouse gas concentrations, and the use of General Circulation Models (GCM) to hindcast and forecast global temperature patterns.

The arguments traversed in the briefing were mostly those contained in the IPCC's 4th Assessment Report (4AR; 2007), which, sometimes updated, have already been extensively presented at public meetings throughout the world. Many of the 4AR assumptions and conclusions have been criticized by independent scientists, in our view justifiably, and complex scientific disputes exist about, on the one hand, the adequacy of the historic climate databases available to the IPCC, and, on the other, about the interpretation of those databases in terms of a dangerous human warming signal.

Whilst we acknowledge the force of the logic and the advanced research investigations that underlie the conclusions of 4AR, that work does not provide empirical *evidence* for IPCC's claimed link between increasing greenhouse gas emissions (primarily carbon dioxide) and dangerous global warming.

In particular, the global temperature rises calculated by GCMs from the assumed forcings they are fed are proportional to an overall feedback factor of the climate, and climate feedbacks are not well understood. The IPCC assumes the feedback is predominately due to clouds and water vapour, but there is little evidence for this. First, a tropical hotspot is predicted by all models, yet radiosonde observations fail to identify it. Second, more recent studies (Paltridge et al., 2009; Lindzen, 2009) have shown using observations of upper tropospheric water vapour that the long-term water vapor feedback is largely negative, i.e. will act to reduce rather than amplify the response of climate to forcing from increasing atmospheric carbon dioxide.

We provide as appendices commentaries on issues of particular importance that were raised by Drs. Sackett and Steffen in their presentation, namely solar forcing agents (Appendix A), the adequacy of the historic air temperature and ocean heat records (Appendix B), and the adequacy of the IPCC as a "sole arbiter" of climate change policy (Appendix C). We also provide a critical analysis of two diagrams that were of particular interest to Minister Wong; first, one that represents computer GCM hindcasts as "evidence" for human-caused warming (Appendix D), and a second that represents the relative warmth of recent years as "unusual" (Appendix E). Finally, we provide appendices that critically discuss the application of the precautionary principle to climate change policy (Appendix F), and analyse the greenhouse effect (Appendix G).

D. Written responses to Senator Fielding's three questions
The June 18th covering letter - Commentary

D1. Murray-Darling River flow

D1.1. The Minister says in her covering letter that "*River flow in the Murray-Darling Basin*[MDB] *may decline by 10 to 25 percent by 2050 and by 2100 irrigated agriculture may decline by 92%*".

D1.2. Estimates for future flows in the MDB use linear correlations between global temperature and seasonal rainfall in the MDB, based on the incorrect assumption that global temperature dictates local Australian rainfall (Cai & Cowan, 2008). This runs counter to well-established principles of environmental physics, and is therefore neither robust nor sound science.

D1.3. It is well known that the MDB is subject to extreme hydro-climatic variability. This has previously been related to known modes of climate variability such as the El Nino-Southern Oscillation (Verdon et al., 2004) and the Indian Ocean Dipole (Verdon & Franks, 2005), and there is no empirical evidence to suggest that carbon dioxide has had any significant impact on the hydro-climatology of the MDB.

Recent analysis of multi-proxy reconstructions demonstrates that a natural switching between El Nino dominance and La Nina dominance is evident in records extending back to 1600 (Verdon & Franks, 2006).

As El Nino Southern Oscillation (ENSO) and Pacfic Decadal Oscillation (PDO) climate modes are quasi-global in their impact, in addition to their relevance to the MDB, they are key drivers of global climatic variability and have previously been linked to variability in European rainfalls (Zanchettin et al., 2008)

D1.4. Also, it is known that the computer climate GCMs, such as those that have been used to project future climate regimes in the MDB, have an intrinsic flaw that leads them to overestimate the recurrence of drought conditions (Wentz et al., 2007). Empirical testing of the models shows also that the rate of increase of evaporation from the oceans with rising temperature that they project is only one-third of the known value. (Held & Soden, 2006).

Inland Australia was dry during the cold glacial periods, and it was then that the great sand dunes were mobilised (Mithen, 2003). Inland precipitation increased as Earth warmed during the interglacials and vegetation in places has stabilised the dunes. The computer model

projections are the opposite of what history records as far as temperature, rainfall and aridity is concerned

D1.5. Australian government scientists, including from CSIRO and the Bureau of Meteorology (BOM), are well aware of the unreliability of GCM modelling as a means of predicting future climate, which is why their modelling studies (e.g., Walsh et al., 2002) carry disclaimers such as:

> *"This report relates to climate change scenarios based on computer modelling. Models involve simplifications of the real processes that are not fully understood. Accordingly, no responsibility will be accepted by CSIRO or the QLD government for the accuracy of forecasts or predictions inferred from this report or for any person's interpretations, deductions, conclusions or actions in reliance on this report".*

Similar statements are routinely issued by other science agencies that provide projections of future climate-related matters. For example, the Colorado Centre for Astrodynamics, which issues forecasts of Arctic ice cover, uses the following disclaimer:

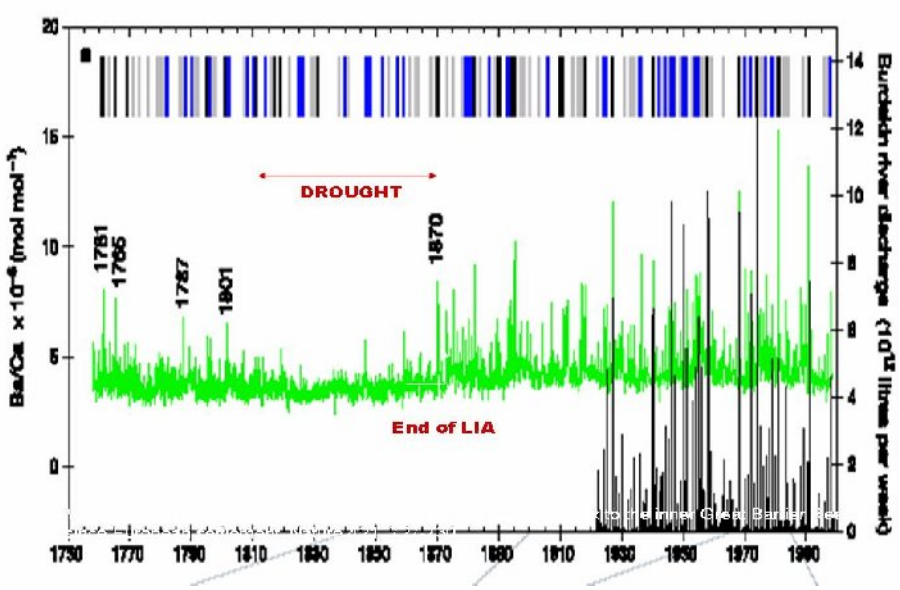
> *"The user assumes the entire risk related to use of this data. CCAR is providing this data "as is," and CCAR, the authors, or the University of Colorado disclaim any and all warranties, whether express or implied, including (without limitation) any implied warranties of merchantability or fitness for a particular purpose. In no event will CCAR, the authors, or the University of Colorado be liable to you or to any third party for any direct, indirect, incidental, consequential, special or exemplary damages or lost profit resulting from any use or misuse of this data."*

D2. BOM drought statement

D2.1. The Minister reports in her letter that the Bureau of Meteorology has stated that "*the combination of record heat and widespread drought during the past five to ten years over large parts of southern and eastern Australia is without historical precedent and is, at least partly, a result of climate change*" (BOM Drought Statement, July 3, 2008) .

D2.2. This statement is ambiguous, depending on what is meant by the terms "*historical*" and "*climate change*".

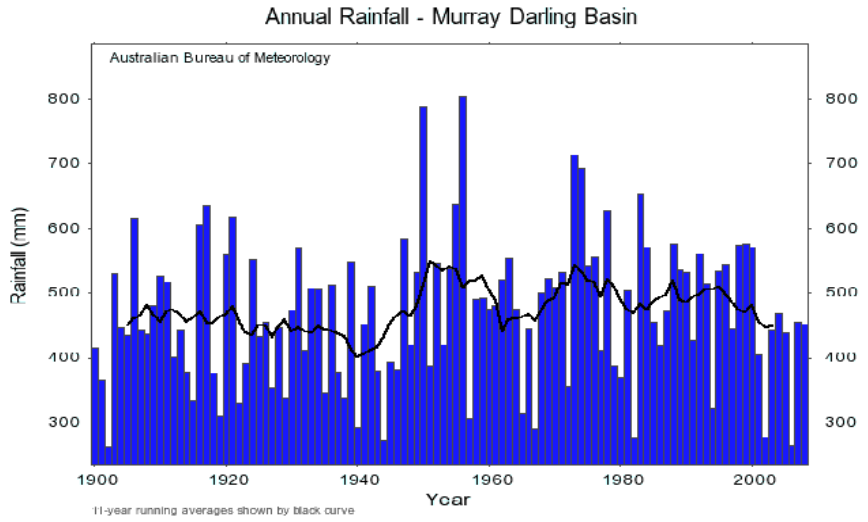
Interpreted at face value, the sentence states an obvious, and innocuous, result, which is that 5-10-yr long regional droughts are a normal part of Australia's climate. If, however, "*climate change*" actually means "*climate change caused by human carbon dioxide emissions*", as seems likely, then to the best of our knowledge the statement is without foundation – for no empirical evidence exists to support the contention that increased emissions have played any meaningful role in causing the recent drought.



D2.3. Besides which, a drought of 5-10 years length is by no means unusual as judged against records of Australia's climatic history. For example, the large Burdekin catchment in North Queensland was subjected to an almost 70-yr long natural drought between 1801 and 1870 (McCulloch et al., 2003) (Fig. 1, left).

Fig. 1. *River flow record for the Burdekin River, 1750-1998, based on the Ba-record of a coral core from the GBR shelf downdrift of the river mouth (after McCulloch et al., 2003).*

D2.4 The Bureau's statement remains controversial, if not wrong, even if we interpret the word "historical" to mean "last 100 years" (i.e., broadly, the period of instrumental record), as shown by Fig. 2 below.



The annual rainfall for the Murray Darling Basin since 1900 shows that the first half of the 20th century was drier than the second, indicating (if anything) a negative correlation between rainfall and the measured temperature rise.

Fig. 2. *Murray-Darling rainfall record, 1900-2008. (http://www.bom.gov.au/cgibin/climate/change/timeseries.cgi?graph=rain&area=mdb&season=0112&ave_yr=11).*

It is also notable that the period of the late 1930s and early 1940s was as dry as the current period, and that the data presented in Fig. 2 do not fully cover the 'Federation Drought' of the period 1895-1905 that is so etched in the Australian cultural psyche.

D2.5. The BOM's generalisation also fails to take account of the natural relationship that exists between rainfall and temperature.

Periods of above average rainfall have reduced temperature because of the local additional cloudiness, reduced solar radiation and the cooling effect of evaporation from moist soil

surfaces; periods of below average rainfall, especially drought, are hotter because of the generally clear skies, higher solar radiation and limited evaporation from dry soils.

E. Written responses to Senator Fielding's three questions
The June 18th written answers - Commentary

QUESTION 1

Is it the case that CO_2 increased by 5% since 1998 whilst global temperature cooled over the same period (see Fig. 1)?

If so, why did the temperature not increase; and how can human emissions be to blame for dangerous levels of warming?

The Department of Climate Change's (hereafter, "the Department") response to this question queried whether global average temperature is an appropriate indicator of global climate, and listed circumstantial evidence for regional planetary warming.

E1. What is the most appropriate measure of planetary climate?

E1.1. The Department's reply says "*When climate change scientists talk about global warming they mean warming of the climate system as a whole, which includes the atmosphere, the oceans, and the cryosphere*", and then adds "*in terms of a single indicator of global warming, change in ocean heat content is most appropriate"*.

E1.2. We agree that in an ideal academic discussion, and were accurate historical data available, ocean heat content might be a better criterion by which to judge global warming than would be atmospheric temperature. Use of this indicator was first pressed strongly by Pielke (2007, 2009) as a test of the dangerous warming hypothesis, but it has not been widely publicized by the IPCC.

E1.3. In any case, however, Senator Fielding's question was predicated upon IPCC's public advice, which has consistently used the UK Hadley Centre near-surface air temperature record since 1850 as a measure of global warming. This temperature record is the one that dominates in IPCC and government policy papers and discussion, and is the criterion of judgement that both politicians and the public are familiar with.

E1. 4. As illustrated in Fielding (June 15, Fig. 1; reproduced below as Fig. 3), the Hadley temperature record does not exhibit warming after 1998.

E2. Natural variability in air temperatures

E2.1. The Department asserts that "*at time scales of around a decade, natural variability can mask the atmospheric warming trend caused by the increasing concentration of greenhouse gases*".

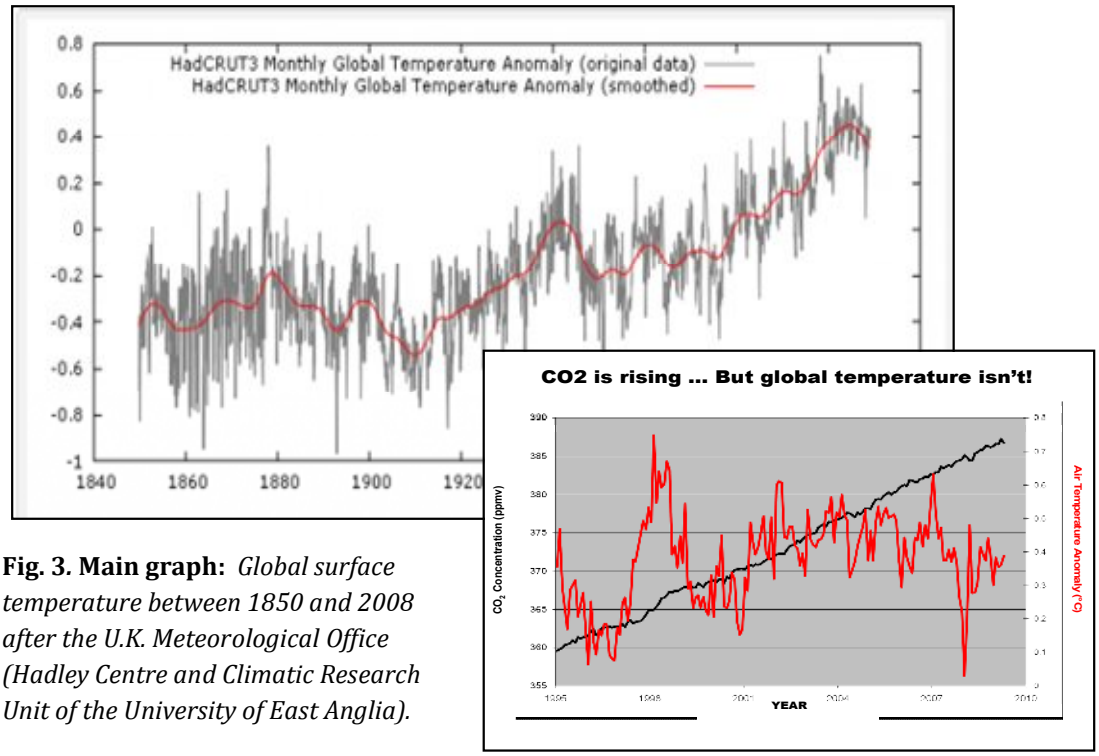


Fig. 3. Main graph: *Global surface temperature between 1850 and 2008 after the U.K. Meteorological Office (Hadley Centre and Climatic Research Unit of the University of East Anglia).*

Inset graph:
Carbon dioxide measurements taken at Mauna Loa Observatory in Hawaii (in black, rising) plotted against the Hadley temperature record since 1995 (in red, falling). These two sets of statistics are used by the IPCC in its reports. The IPCC considers them to be gold standards of our ability to measure atmospheric concentration of carbon dioxide and global temperature, respectively.

E2.2. It is widely agreed that there is considerable natural variability in air temperature on decadal timescales and longer. It is the IPCC that have previously denied the importance of such natural climate variability.

For example, the 2001 Summary for Policymakers claimed, based on computer model simulations, that the climate system has only a limited internal variability. In turn, this claim was, and is, used to underpin the argument that carbon dioxide forcing is the only plausible explanation for the late 20th century warming trend.

For the Department to now invoke natural variability as an explanation for the elapsed temperature curve is to destroy the credibility of their previous arguments for carbon dioxide forcing.

E2.3. The Department also claims that "*in terms of the climate system as a whole, only about 5 percent of the warming since 1960 has taken place in the air*".

E2.4. Using the Hadley CRU temperature record, the rise in air temperature since 1960 has been about 0.5°C. Translating the 15×10^{22} J of additional heat in the upper 700 m of ocean since 1960 into a temperature rise, we find that this corresponds to an increase in upper ocean temperature of only 0.15°C.

Thus, using these metrics, air temperature increase since 1960 has been more than three times greater than ocean temperature increase.

E3. Ocean heat content

E3.1. The Department alleges that "*in terms of a single indicator of global warming, change in ocean heat content is most appropriate*".

E3.2. In reality, given present instrumental networks, ocean heat content is an unrealistic metric to use to judge climate change. It is also well understood that the oceans are the inertial and thermal "fly wheels" of the climate system, another reason why ocean surface layer heat content is a poorly quantified metric.

Sackett & Steffen (June 15th briefing paper) presented an unsourced ocean heat graphic that we presume was derived from Domingues et al. (2008). The pattern of increasing heat depicted by Domingues et al., and further adopted by Richardson et al. (2009), conflicts with several other recent research interpretations, and especially so for the more recent data, which is derived from the ARGO network (see Appendix B). Papers by Dickey et al. (2008), Willis et al. (2009), Levitus et al. (2009) have all concluded that the trend in ocean heat over the last few years is either flat or decreasing; thus the Domingues et al. interpretation is an outlier.

E.3.3. But in any case, the 0.15°C suggested increase in average ocean temperature since 1960 (see E2.4) is not statistically significant when viewed against the known limited precision of expendable bathythermograph (XBT) instruments for measuring temperature, and the temporal and spatial paucity of observations before the deployment of ARGOS buoys over recent years. And there remains controversy about the calibration of the ARGOS buoys, which we discuss further in Appendix B.

E4. Ice, snow and frozen ground

E4.1. The Department describes a number of regional changes in ice and snow distribution, and comments, without citation, that "*overall the amount* [global implied] *of ice, snow and frozen ground has declined*".

E4.2. So far as we are aware, no accurate inventory exists of the worldwide volume of modern ice and snow, let alone over the millennial history that is required in order to judge whether observed modern changes are unusual. As Idso & Singer (2009, p. 136) note, "*global data on glaciers do not support claims made by the IPCC that most glaciers are retreating or melting*".

In the absence of such historical records, descriptions of melting ice in particular areas are indicative only of a negative precipitation:melt mass balance in those areas, and circumstantial so far as global change or the cause of melting are concerned. In attributing areas of melting to a human greenhouse effect, the Department is making the common error of failing to distinguish between the occurrence of melting and the identification of its cause.

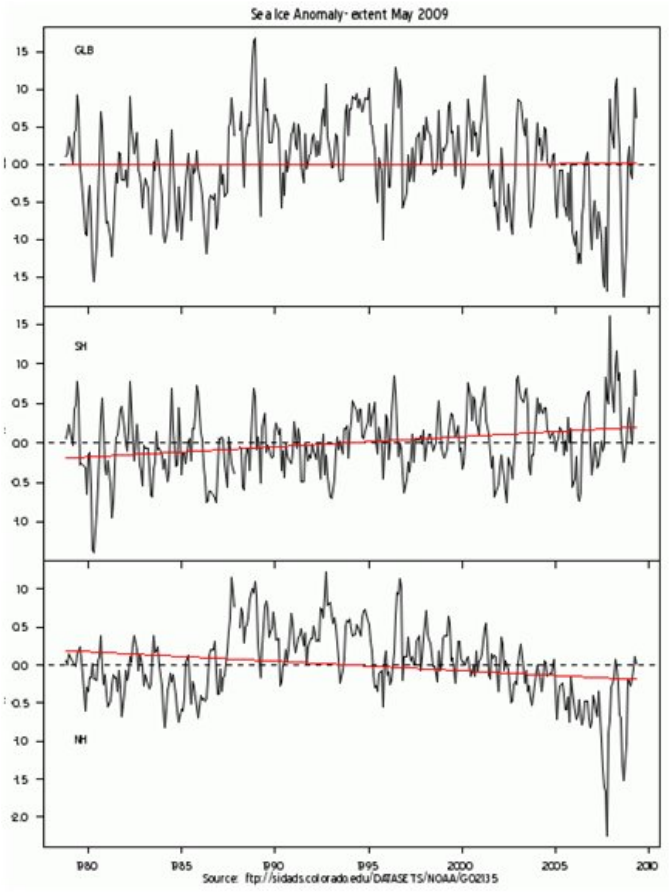


Fig. 4. *Sea ice anomalies since 1979 globally (top) and for southern hemisphere (middle) and northern hemisphere (bottom).*

E4.3. Anyway, and as the Department notes, different trends occur in different areas. For example a post-2000 retreat of Arctic sea-ice parallels a similar melting that occurred in the 1930s, whereas at the same time sea-ice around Antarctica has increased to an all time high of >1 million km^2 above the long-term average. Apart from the small region of the Antarctic Peninsula there is no evidence of warming over Antarctica and the Southern Ocean.

E4.4. The latest available data indicate - in the context of the large annual cycle of variation, and the observed decline during 2007 and 2008 - no global trend in sea-ice cover (Fig. 4, left). Arctic sea ice extent today is similar to that in 1979, when satellite observations commenced, and at the same time sea-ice cover around Antarctica is currently enhanced in area.

E4.5. Finally, there is no particular reason to view contemporary values of sea-ice cover as representing a climatic ideal.

Historical records point to much less sea ice over the Arctic Ocean during the 1920s and 1930s, and to several prior openings of the Northwest Passage. And, of course, Greenland was much warmer in the 10th and 11th centuries (see figure in Appendix E) when there were approximately 3,000 individual settlements and farmlets. As the cold of the Little Ice Age set in thereafter, none of these settlements survived beyond 1550 and some sites remain frozen today.

E5. The basis of the IPCC assessment

E5.1. The Department asserts that "*The argument presented in Q1 above is not new and has been thoroughly refuted by a very wide range of observations*".

E5.2. No argument is presented in Question 1. Rather a simple question and its supplementary are asked.

E5.3. The Department also points out that IPCC's 4AR (Summary for Policymakers, p. 5) concluded that: "*Warming of the climate system is unequivocal, as is now evident from observations of increases in average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea-level*".

E5.4. The IPCC passage that is quoted is an underwhelming conclusion which was apparent long before the IPCC even existed, and anyway says nothing about the cause of any warming. Scientists have known for more than one hundred years that earth's climate has warmed since the depth of the Little Ice Age during the 17th century. Indeed, the climate system had already undergone considerable warming before the establishment of a global network of observing stations in the late 19th century, which first allowed for the systematic monitoring of near-surface air temperature.

The key questions are not whether the climate system has warmed during the 20th century, but rather (i) whether the warming terminated in 1998 (Question 1); (ii) whether the warming was unusual in rate and magnitude (Question 2); and (iii) the degree to which the warming might have been caused by human carbon dioxide emissions (Questions 2 and 3). These questions are those that were posed by Senator Fielding, and they remain unanswered by the Department.

QUESTION 2

Is it the case that the rate and magnitude of warming between 1979 and 1998 (the late 20th century phase of global warming) were not unusual as compared with warmings that have occurred earlier in the Earth's history (Fig. 2a, 2b)?

If the warming was not unusual, why is it perceived to have been caused by human carbon dioxide emissions; and, in any event, why is warming a problem if the Earth has experienced similar warmings in the past?

The Department responded, citing ice-core data, that today's magnitude and rate of temperature change was unusual, that the last 2,000 years of climatic history is more relevant to humans than deep-time history, that strong evidence exists that post-1850 warming was caused primarily by human greenhouse emissions, and (after Garnaut) that the costs of adapting to climate change in Australia may be more expensive than attempting to abate it.

E6. Rate and magnitude of change

E6.1. Judgements about rate and magnitude of temperature change through deep time, i.e. prior to instrumental measurement, have to be made using proxy data from geological field observations for particular sites or regions (such as temperature-proxy oxygen isotope measurements on ice core or deep sea core samples).

Global warming between the last glacial maximum and the Holocene varied according to region. Ice cores from Vostok, Antarctica suggest a temperature rise of about 12°C (Petit et al., 2000); from Greenland the ice cores suggest warming of as much as 35°C (Alley, 2004). Isotopic analysis of sea bed cores from the warmest oceans around Indonesia suggests a temperature rise of only 3-4°C in tropical regions (Stott et al., 2004) (and note that a 1°C increase in tropical ocean surface temperatures is accompanied by a natural increase in of about 6% in global evaporation and precipitation; Wentz et al., 2007).

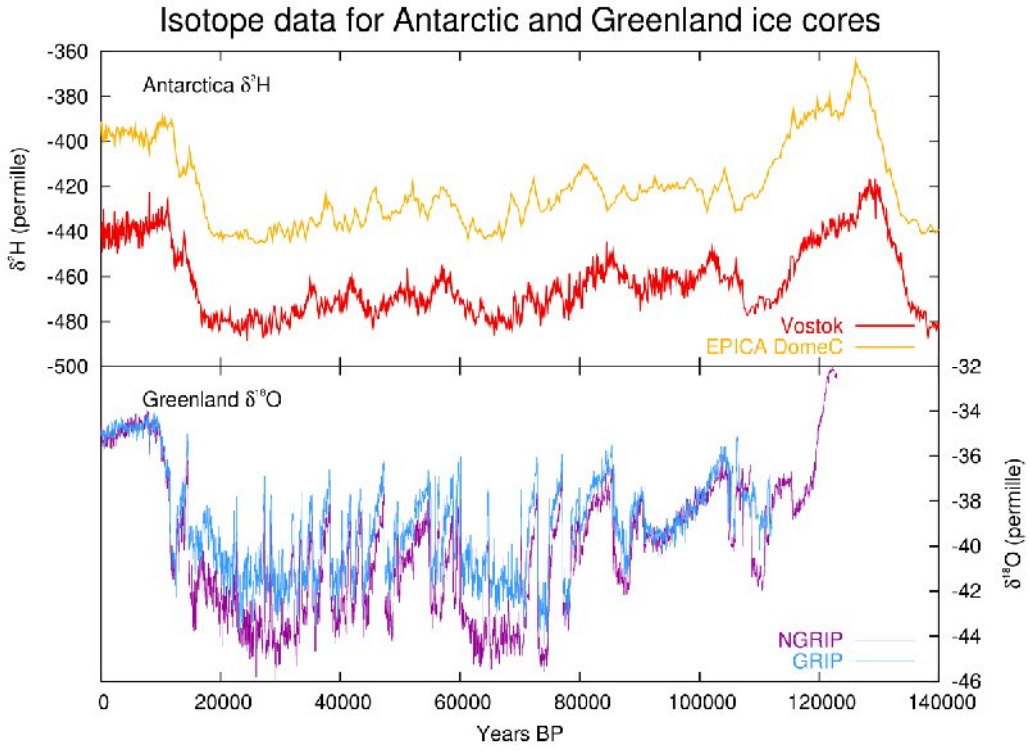


Fig. 5. *Variations in isotopic ratios of hydrogen and oxygen in ice cores are used as proxies for temperature over Antarctica (upper panel) and Greenland (lower panel).*

The short duration res Dansgaard/Oeschger warming and cooling events are conspicuous in Greenland, whereas short period variations are more muted in most Antarctic cores.

E6.2. Dansgaard/Oeschger (D/O) events – referred to by the Department in their answer - are sudden, step increases in the northern Atlantic and Greenland region temperature of more than 10°C over decades, followed within centuries by rapid cooling again (Fig. 5, above).

Irrespective of the debate (which continues) as to the degree to which such climatic events are worldwide or restricted to particular regions, they are dramatic climate oscillations that need to be allowed for in any planning scheme for dealing with future climatic contingencies.

E6.3. Figs. 2a, b of Fielding (June 15th; reproduced below as Figs. 6a, b) display data from two proxy deep-time temperature records. These records show that the rates (1-2°C/century) and magnitudes (about 0.8°C warming since the last cold phase of the Little Ice Age) of historical climate change fall well within prior natural limits.

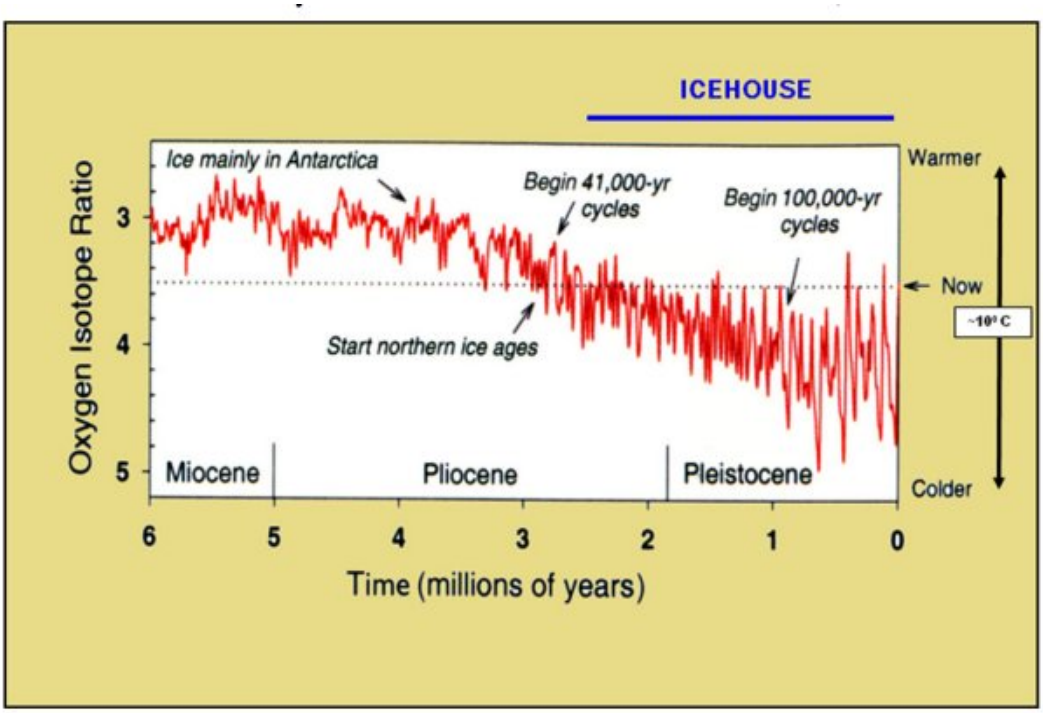


Fig. 6a. *Composite deep ocean temperature curve from DSDP Sites 846 and 849, North Pacific, over the last 6 million years (proxy: oxygen isotope ratios in marine cores). The approximate temperature scale relates to closely similar climatic fluctuations that occurred in oceanic surface waters, in a pattern that recurs worldwide, but varies in exact magnitude from place to place (after Mix et al, 1995).*

Note that temperatures were higher than today's at many times in recent earth history, and expressly so during the early Holocene (about 8,000 years ago), during previous warm interglacials during the last several hundred thousand years, and for an extended period between 6 and 3.5 million years ago.

The rate of temperature change, both in Greenland and globally, during the late 20th Century Warming was between 1 and 2 deg. C/century. Thus recent, modern rates of warming fall well within the natural rates of change of the last 10,000 years (Fig. 5b, below).

E6.4. The Arctic is a region where more infrared radiation is emitted to space than is absorbed from incoming solar radiation. This local radiation imbalance is corrected by the transport of energy from the tropics to sustain local temperatures. Sudden increases in local temperatures arise from changes in this equator to pole energy exchange, which is modulated by a combination of changes in wind pattern, changes in ocean currents and changes in atmospheric circulation. Such changes in poleward energy transport are similar in character to an El Nino event, and are at least hemispheric in scope. The resulting polar temperature changes represent a climatic anomaly that persists for centuries. Indeed, the Atlantic D/O climatic patterning is present in some Antarctic ice cores.

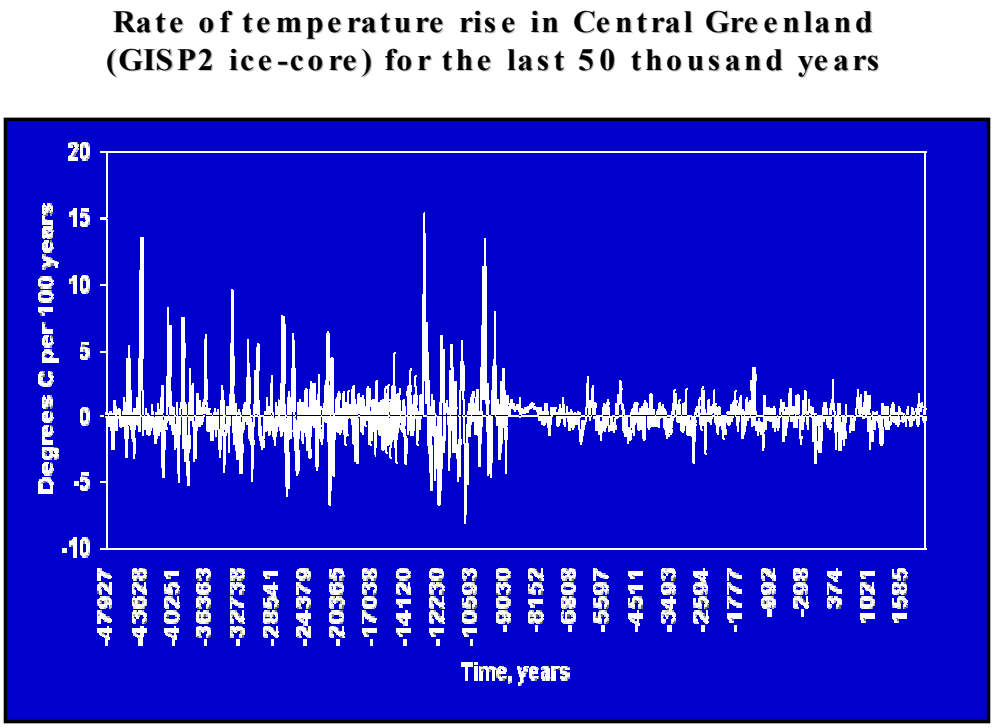


Fig. 6b. *Rate of temperature change for the last 48 000 years in °C/century, based on the analysis of oxygen isotope ratios from the GISP2 ice core in Greenland (after a slide by Andre Illarianov, 2004; data from Alley, R.B., 2004. GISP2 Ice Core Temperature and Accumulation Data. NOAA). Note that during the last 9,000 years of the Holocene, temperature change occurred regularly at rates between +2.5° and -2.5°C/century. Earlier, during the last glaciation, rates of change as high as 15°C/century are indicated.*

E7. Climate record of the last 2,000 years

E7.1. The Department writes that "*in terms of timescales of importance for humans, the last 2,000 years are most relevant, because this is the period over which our civilisations have developed*".

This statement reflects simple anthropomorphic bias, for there is nothing "typical" or "special" about the climate of the last 2,000 years. Understanding climate change in context, and a proper analysis of public risk, requires the study of climatic records that cover at least hundreds of thousands of years.

E7.2. The Department reproduces an IPCC figure of reconstructed Northern Hemisphere air temperatures over the last 1800 years. This figure represents a variety of proxy (mostly tree ring) temperature histories that are joined together with the (urban heat-influenced) 20th century temperature record and a speculative further " *'committed' additional temperature rise due to the thermal inertia of the ocean*".

E7.3. One of the proxy temperature series plotted is the infamous "hockey stick" reconstruction of Mann et al. (1999). This reconstruction, though strongly favoured in the 2001 IPCC 3rd Assessment Report (2001), is discredited (e.g., McIntyre & McKitrick, 2003, 2005, 2009) and was discarded for the 4th Asssessment Report (2007) without explanation.

Disturbingly, the Department continues to exhibit the "hockey stick" graph on its website at: *http://www.climatechange.gov.au/science/faq/question2.html*

E7.4. In general, the proxy reconstruction of ancient temperatures only provides a smoothed representation of the temperature record and that at a local or regional level. The interpretation of tree rings, etc., cannot discriminate the same detail as direct observations of temperature.

Thus it is poor practice to append a global instrumental record to the young end of a series of proxy geological records. Such a construction is misleading because it amplifies recent temperature trends without scientific foundation.

E7.5. Abundant historical and geological data shows that warming events associated with the Minoan, Greco-Roman and Medieval Warm Periods occur on a millennial, perhaps solar, climatic cycle (Bond et al., 2001; Singer & Avery, 2008; Moros et al., 2009), and were at least as warm as the late 20th century warming. These warmer periods were interrupted by the colder Dark Ages of the middle first millennium and the Little Ice Age of the second millennium, and such climatic rhythmicity must be controlled by major variations in equator to pole energy transport, i.e. is not primarily driven by carbon dioxide variations.

E8. The greenhouse effect

E8.1. The Department asserts that "*The greenhouse effect is a well-understood physical phenomenon, like gravity*".

E8.2. The greenhouse effect is indeed a real phenomenon that lends itself to measurement. The intrinsic nature of gravity, however, is not understood. In contrast, the intrinsic nature of the greenhouse effect is well understood; but it is often misrepresented, as it is in the Department's summary statement.

E8.3. A brief explanation and discussion on the greenhouse effect is provided in Appendix F.

E9. Empirical relationship between change in radiative forcing and global air temperature

E9.1. The Department reports that a general relationship between radiative forcing and temperature rise can be derived by an "*analysis of the climatic shift between the last ice age and the present warm period*", and that "*this relationship includes all feedbacks within the climate system in an empirical way that is derived without using models*".

E9.2. Analysis of the climate shift between the last ice age and the present warm period cannot give a quantitative relationship between the change in radiative forcing and the resulting change in global air temperature.

This is so because the influences of Earth's orbital changes versus the feedback effect as Earth warmed, and the oceans expelled more carbon dioxide, are not known. To use such a relationship is to explicity discount the unquantified influence of the changes in orbital geometry that are considered to regulate glacial-interglacial climate rhythms.

E9.3. Furthermore, if carbon dioxide forcing is as powerful as is being suggested, then the question has to be asked: "*Why did each of the interglacial warming events of the past ~500,000 years stabilise at about the same temperature?*" Several recent interglacials were significantly warmer than the Holocene interglacial (e.g., Watanabe et al., 2003), which would have required the Earth to have passed the so-called tipping point of irreversible warming on more than one previous occasion.

E9.4. As we understand it, the paper that first formalised the concept of a "CO_2 forcing parameter" in the fashion referred to by the Department was that by Hansen et al. (1988).

Hansen et al.'s forcing parameter has no physical basis in measurement. Rather, the assumption was made that the ~100 ppm post-industrial increase in carbon dioxide was directly responsible for the increase in global temperature of 0.6^0C that has been measured over the past century.

E9.5. Over the 20th century, both cooling and warming phases were concurrent with rising carbon dioxide levels, and the 1988 paper was published 13 years after a 33 year ***cooling*** trend that was paralleled by an ***increase*** in carbon dioxide concentration. Essentially, the 46 year period from 1942 to 1988, when the paper was published, saw 33 years of cooling and only 13 years of warming concurrent with increases in carbon dioxide, yet the models used a forcing parameter that directly related the warming only to concentration increases.

Also, in calculating the carbon dioxide forcing parameter full allowance was not made for the likely contribution that urbanization (the urban heat island effect - UHI) made to the (thermometer) measured warming.

E9.6. Therefore, (i) there is no valid basis for the assumed carbon dioxide forcing parameter, (ii) the parameter has a built in warming overestimate, and (iii) climate CGMs that apply the parameter are inaccurate.

E10. Costs of adaptation could be high: but not as high as those of unnecessary precaution

E10.1. The Department asserts that "*The Garnaut Review also found that the climate change impacts on infrastructure will have a significant effect on Australia's output and consumption of goods and services, and that the costs of adaptation could be high*".

E10.2. The Garnaut Report, like the heavily criticized Stern report that preceded it (Carter et al., 2006), contains no credible independent science assessment, but rather simply uncritically accepts IPCC science advice as a given. For that reason alone, the economic analysis in the report is of little value.

First, the report presumes that late 20th century warming will continue unabated throughout the 2ist century, which is already known to be wrong.

Second, the report adopts a precautionary approach in a situation where the potential hazard – future warming or cooling - is quite unknown.

The pitfalls of adopting a precautionary approach to an assumed hazard, rather than using a prudent approach to known hazards, are explained in Appendix G.

QUESTION 3.

Is it the case that all GCM computer models projected a steady increase in temperature for the period 1990-2008, whereas in fact only 8 years of warming were followed by 10 years of stasis and cooling. (Fig. 3)?

If so, why is it assumed that long-term climate projections by the same models are suitable as a basis for public policy making?

The Department pointed out that the model averages plotted in many IPCC diagrams (for example, the figure in Appendix D) result in a smoothing of the simulated natural variations that are present in individual GCM model runs. This has the effect of suppressing the episodic short periods of cooling that are simulated by most models.

E11. Natural climate variations again

E11.1. It is indeed clearly the case that individual GCM model runs simulate "natural" variability in a way which includes the depiction of periods of several years to a decade or so of cooling within a temperature projection that nonetheless progressively rises.

But in concluding that "*GCMs can and do simulate decade-long periods of warming or even slight cooling embedded in longer-term warming trends*" the Department is implying that the lack of warming since 1998 is caused by a natural cooling forcing of sufficient strength to temporarily overcome the assumed longer-term carbon dioxide-forced warming.

E11.2. Hitherto, the IPCC (e.g. 3AR, 2001) has argued that the climate system possesses only limited internal variability, which is why carbon dioxide forcing came to assume especial significance in their eyes.

E11.3. The climate system varies on a range of timescales from the interannual (El Nino-La Nina) through the decadal (e.g., Pacific Decadal Oscillation, North Atlantic Oscillation), the multi-centennial (eg, the Mediaeval Warm Period-Little Ice Age) to multi-millennial (glacial-interglacial). The shorter timescale oscillations are manifest as internal variability, and are not incorporated in the GCMs.

So even if the models do simulate some variability in global temperatures, they cannot be doing this for the correct reason, and any short-term variability that they happen to predict "right" must be either by chance or for the wrong reasons. And that individual GCMs may project periods of cooling as long as 10 years has no necessary bearing on the cause of the current cooling trend.

E11.4. We conclude that there is no reason to call upon carbon dioxide forcing to explain the recent limited warming that occurred between 1979 and 1998, and that the computer-based

projections that show progressive warming through the 21st century are highly misleading scenarios to provide to policymakers.

Alternative interpretations to carbon dioxide forcing include that of Stockwell & Cox (2009) who show that most of the warming exhibited by the Australian and global temperature graphs between 2010 and today represents a step change between 1976 and 1979, caused by a PDO regime shift. Second, McLean et al. (2009) show that at least 68% of the variance in the radiosonde and MSU temperature records, since 1958 and 1979 respectively, is accounted for by changes in the Southern Oscillation Index.

Also, the termination of the warming in 1998 is consistent with a known multi-decadal pattern of warming and cooling, in which the end of the century warming peak marks a turn around from a PDO warming to a cooling phase (Klyashtorin & Lyubushin, 2007) (Appendix B, paragraph 4 and figure). This same change was interpreted by Swanson & Tsonis (2009) as marking a climate dynamical modes synchronization that caused a natural shift in global temperatures in 2002-2003, after which temperatures have started to decline. Meanwhile, Yasuda (2009) has demonstrated a relationship between PDO cyclicity and the 18.6- year period lunar nodal tidal cycle.

To now acknowledge these and other similar studies, and accept that there is thus significant internal variability to the climate system, and plausible alternative multidecadal drivers for the climate changes observed in the 20th century, is to destroy the plausibility of the occurrence of dangerous human warming.

E12. It's not about the trend, but about testing the greenhouse hypothesis of dangerous warming

E12.1. The Department's discussion of both questions 1 and 3 raises the question of natural variability "masking" the warming trend caused by human carbon dioxide emissions. In essence, the Department claims that a trend of 10 years is too short a time to be recognized, and represents "weather variation" rather than long term "climate change".

E12.2. This, in turn, raises the question "how long a period of time IS required to represent a true climate trend?" Given that the IPCC clearly views the 1979-1998 warming trend as significant, the answer would seem to be "20 years". But this, too, is surely inadequate to recognize as a period of "climate change" when the meteorological definition of a climate normal involves a 30-year span of data. Indeed, using this criterion, the entire 150 yr-long instrumental record represents just 5 climate data points!

E12.3. In reality, climate data sets are those that represent at least thousands of years of record, and are drawn from geological, not instrumental, sources.

For example, the Holocene record through the GRIP ice core record from Greenland shows that temperature there has steadily declined by about 2^0C from its early Holocene climatic optimum, i.e. the present long term trend is one of cooling, short-term centennial warming in the late 20th century not withstanding.

E12.4. In any case, the Department's preoccupation with trend analysis reveals its lack of understanding of the meaning of Questions 1 and 3, for the questions are about testing the greenhouse hypothesis, not determining arbitrary trend lines over short periods.

The greenhouse hypothesis as understood by politicians and the public is that dangerous global warming will result from human carbon dioxide emissions. Given a mixing time for the atmosphere of about 1 year, that emissions rose at the same time that temperatures fell between 1940 and the late 1970s, and again between 1998 and 2008, represents two tests of that hypothesis – both of which it fails.

E12.5. Enhanced infrared absorption by greenhouse gases is an immediate atmospheric physical effect within the mixing time. It cannot be deferred or diverted, and if it is occurring at a measurable level the atmosphere must become warmer. The idea that atmospheric warming has ceased because the heat is somehow being taken up in the ocean while the atmosphere cools is simply unfeasible, and all the more so when the ocean itself is cooling too. There is simply nowhere for the heat to go (see discussion in DiPuccio, 2009).

E12.6. It is clear from this, therefore, that factors other than human emissions are exercising a controlling influence on the pattern of the global temperature curve. That does not mean that human activities have no effect on global climate, but it does mean that any effect must be small.

F. Three new reports – Copenhagen, United States, Department of Climate

F1.1. During the week of June 15-19, during which the discussions between Senators Fielding and Wong were in progress, two new reports on global warming were released overseas, and on July 9 a third was issued by the Australian Department of Climate Change.

Copenhagen synthesis report

F1.2. The first of these (Richardson et al., 2009) comprises an updating of the conclusions of IPCC 4AR by a group of IPCC researchers and advisers gathered in Copenhagen.

The Copenhagen Synthesis Report comprises six sections, of which only the first, "*Climatic Trends*", concerns science. The remaining five sections comprise sociological and political matters.

The graphs and discussion in "*Climatic Trends*" comprise an analysis and update of global climate trends since 1950. As is typical for IPCC-related publications, the report relies heavily on modern instrumental observations and the projections of unvalidated GCMs. In the absence of a proper scientific contextual setting for long-term climate change, the report contributes little to the debate.

In addition, in the section of the report entitled "*Social and Environmental Disruption*", a 2^0C "guardrail" is adopted, warming above which is alleged to be dangerous. This figure is derived from the models, whose overstated water vapor feedback leads to exaggerated temperature rises, and also exaggerates the instability of the Earth's climate system. Empirical evidence for this arbitrary 2^0C figure is also absent, so adopting it is premature in advance of a

comprehensive hazard:benefit analysis – which cannot be done meaningfully on a global basis, but requires customisation for all different parts of the globe.

U.S. climate change impacts report

F1.3. On June 6, White House science adviser John Holdren issued the first global warming report under President Barack Obama, entitled "*Global Climate Change Impacts in the United States"*. This is a climate status report required to be provided periodically to Congress.

The impacts report is strongly alarmist, and its release has already generated a storm of comment and protest. Joseph D'Aleo, former chairman of the American Meteorological Society's Weather Analysis and Forecasting Committee comments that the report is "*wrong on many of its claims*" and marks "*an embarrassing episode for the authors and NOAA*"

Noted social scientist Professor Roger Pielke of the University of Colorado says that the report misrepresents his own work, makes claims that are not supported by citations provided, relies heavily on analyses that were never peer reviewed, ignores peer-reviewed studies that reach opposite conclusions from those proclaimed by the report, and cites analyses that do not support conclusions rendered.

Department of Climate Change – Faster Change & More Serious Risks

F1.4. A third new global warming report was released by the Department of Climate Change on July 9, 2009, compiled by science adviser Professor Will Steffen.

Professor Steffen was one of the two scientists who accompanied Minister Wong to her first discussion meeting with Senator Fielding, and it transpires that several of the arguments he puts in his July 9 report were discussed as part of the earlier Fielding-Wong exchange. We have examined these arguments in the first version of this report (paragraph F1.2, above), but for completeness we now insert an extra appendix that contains an independent critical review of the latest report from the Department of Climate Change (Appendix H).

F1.5. In summary, the warming alarm signalled in the three recent climate reports discussed above depends almost entirely on the projections of unvalidated computer GCMs whose climate sensitivity is known to be too high. For example, the GCM's rely on a large water vapor feedback for most of their predicted warming, yet the radiosonde observations of the missing tropical hotspot prove that the water vapor feedback is small.

The reports do not contain new empirical evidence for dangerous human-caused warming, and nor do they contradict the fact that climate is no longer warming. Therefore, they do not necessitate the rephrasing of any of Senator Fielding's questions, and nor do they add significantly to the public debate.

G. Answers to Questions 1-3

In the absence of clearcut answers to Senator Fielding's questions by the Department of Climate Change, we now provide our own answers to questions 1-3.

1a. Is it the case that carbon dioxide increased by 5% since 1998 whilst global temperature cooled over the same period (see Fig. 1)?

Yes.

1b. If so, why did the temperature not increase; and how can human emissions be to blame for dangerous levels of warming?

That temperature did not increase measurably despite additional forcing from carbon dioxide emissions indicates (i) that human emissions are only one of a number of forcing factors governing climate, and (ii) that the effect on temperature of the human emission forcings is numerically small (i.e., the climate sensitivity is lower than the IPCC acknowledges).

2a. Is it the case that the rate and magnitude of warming between 1979 and 1998 (the late 20th century phase of global warming) were not unusual as compared with warmings that have occurred earlier in the Earth's history (Fig. 2a, 2b)?

Yes.

2b. If the warming was not unusual, why is it perceived to have been caused by human carbon dioxide emissions; and, in any event, why is warming a problem if the Earth has experienced similar warmings in the past?

Dangerous human warming is perceived because of relentless repetition by political lobby groups and the mass media of the IPCC's judgement that such is the case. In reality, any human-forced warming that might emerge in future is unlikely to be a problem, and can anyway be dealt with by the same technique of preparation and adaptation that we use to deal with natural climatic hazards – be they warmings, coolings or extreme events.

3a. Is it the case that all GCM computer models projected a steady increase in temperature for the period 1990-2008, whereas in fact only 8 years of warming was followed by 10 years of stasis and cooling. (Fig. 3)?

Yes.

But in a smoothed sense, that acknowledges that predictions of individual models do not monotonically increase but show warming and cooling variability on a small time scale. However, IPCC does not discriminate between individual models, and argues that the average of an ensemble of models provides the best estimate of future temperature. This is the context of Senator Fielding's Question 3.

3b. If so, why is it assumed that long-term climate projections by the same models are suitable as a basis for public policy making?

It is well understood by climate modellers themselves, and stressed by the IPCC, that model outputs serve as projections of possible climatic futures, not predictions of probable futures (see

D1.4, above). The models quantify processes for which there is a low understanding, such as in the feedbacks, and this makes their outputs very uncertain. In such circumstances, it is simply incorrect to frame public policy around the assumption that GCMs provide firm climatic predictions.

H. Conclusions

Senator Fielding posed three questions to Climate Minister Wong. These questions have not been answered simply or directly, though parts of the response by the Department of Climate Change were concerned with relevant issues. We have therefore in turn responded to the issues raised by the Department in our discussion in this paper.

Meanwhile, we have also provided a succinct answer to Senator Fielding's three questions, such as the Department might have provided, in the immediately preceding section of the paper.

We draw the following general conclusions:

- At the moment the planet is no longer warming; only time will tell whether the stasis and minor cooling trend will deepen significantly or will instead be succeeded by resumed warming. Both possibilities are plausible, based upon the well known pattern of natural multi-decadal climate cycles.

- No strong evidence exists that human carbon dioxide emissions are causing, or are likely to cause, dangerous global warming on top of natural, cyclic trends.

- It is unwise for government environmental policy to be set based upon monopoly advice, and especially so when that monopoly is represented by an international political (not scientific) agency, viz. IPCC.

- Other authoritative, independent audits have recently reached similar conclusions to ours (Idso & Singer, 2009). As Carlin has recently concluded (2009; EPA internal document):

  "As of the best information I currently have, the GHG/CO2 hypothesis as to the cause of global warming, which this Draft TSD supports, is currently an invalid hypothesis from a scientific viewpoint because it fails a number of critical comparisons with available observable data. Any one of these failings should be enough to invalidate the hypothesis; the breadth of these failings leaves no other possible conclusion based on current data".

- Accordingly Parliament should defer consideration of the current CPRS bill and institute a fully independent Royal Commission of enquiry into the evidence for and against a dangerous human influence on climate.

  The scientific community is now so polarised on the controversial issue of dangerous global warming that proper due diligence on the matter can only be achieved where competent scientific witnesses are cross-examined under oath and under the strictest rules of evidence.

Appendix A - Solar forcing agents for Earth climate[3]

1. At the June 15th briefing, Dr Sackett explained that historic measurements of solar irradiance (the amount of light and heat coming from the sun) show a variation in intensity since the 17th century of ~2 W/m^2, or only 0.1%, which is inadequate to explain all the variation seen in global temperature, including during the 20th century. We agree with this conclusion, which is well established science.

2. The implication that the sun can affect Earth's climate only through variations in irradiance, which is also present in IPCC reports, is however incorrect, for other aspects of earth-sun energy interrelations are well known to play a role. Account has to be taken of variations in both the Sun's toroidal (latitudinal) and poloidal (longitudinal) magnetic fields, and relevant cyclicities include the Schwabe (11 year), Hale (22 year) and Gleissberg (80-100 year) cycles.

3. The sun also influences climate through the effect of its plasma and electromagnetic fields on rates of earth rotation, and therefore the length of day (LOD; e.g., Lambeck & Cazenave, 1976), and the effect of its gravitational field through the 18.6 yr-long Lunar Nodal Cycle - which causes variations in atmospheric pressure, temperature, rainfall and oceanic temperature, especially at high latitudes.

4. Strong evidence also exists of links between solar activity and both monsoonal activity (Agnihotri & Dutta, 2003) and multi-decadal climate oscillations such as the Atlantic Decadal Oscillation (Lim et al., 2006). In addition, magnetic fields associated with solar flares have an effect in modulating galactic cosmic ray input into the earth's atmosphere, which may in turn cause variations in the nucleation of low level clouds, causing cooling: and a 1% variation in low cloud cover produces a similar amount of forcing (~4 W/m^2) to the rise in greenhouse gases. As recognized by the IPCC, this hypothesis is controversial, and it remains under test in current CERN experiments led by Henrik Svensmark (e.g., Svensmark, 2007). But irrespective of the results of these experimental tests, and of the precise causal mechanism, empirical and correlative evidence exists for a link between varying cosmic radiation and climate (e.g., Neff et al., 2001).

5. We provide below a short list of papers that indicate how variable solar outputs are, or might be, connected to various earth climate-related indices. The research contained in these papers shows conclusively that several important empirical connections have either been missed, or are poorly represented, by the IPCC in their 4AR discussion and the related GCM climate modelling. As a result, the models underestimate the amplitude of variability and changes from solar-induced climate signals.

6. A related and important point is that most of the critiques of solar causes playing a significant role in temperature records after, say, 1985 are based on inadequate science.

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[3] The authors acknowledge the help of Dr. Willie Soon, Harvard-Smithsonian Center for Astrophysics, in the preparation of this Appendix

This is because the authors of such critiques, in general, fail to consider the fact that delays of 5 to 20 years (involving storage and redistribution of heat within the ocean circulatory system) are fully within reasonable expectations for solar effects.

Soon (2009) has provided a recent accounting of such effects. If one wants to start interpreting the peak solar radiation outputs in the 1980s and early 1990s, with weakening since then, then lagged solar effects can explain nicely what is observed in the climatic records to date.

In summary, the argument that the sun can only affect climate through irradiance, that irradiance changes are small, and so the sun does not play a role in global warming, is incorrect.

Peer-reviewed papers concerning known and possible mechanisms of solar forcing of Earth climate

Agnihotri, R. & Dutta, K. (2003) Centennial scale variations in rainfall (Indian, east equatorial and Chinese monsoons): Manifestations of solar variability. *Current Science*, vol. 85, 459-463

Higginson, M.J., Altabet, M.A., Wincze, L., Herbert, T.D. & Murray, D.W. (2004) A solar (irradiance) trigger for millennial-scale abrupt changes in the southwest monsoon? *Paleoceanography*, vol. 19, doi:10.1029/2004PA001031.

Jiang, H., Eiriksson, J., Schulz, M., Knudsen, K.-L. & Seidenkrantz, M.-S. (2005). Evidence for solar forcing of SST on the North Icelandic Shelf duing the late Holocene. *Geology*, vol. 33, 73-76.

Kodera, K. (2004) Solar influence on the Indian Ocean monso on through dynamical processes. *Geophysical Research Letters*, vol. 31, doi:10.1029/2004GL020928.

Kodera, K. & Shibata, K. (2006) Solar influence on the tropical stratosphere and troposphere in the northern summer. *Geophysical Research Letters*, vol. 33, doi:10.1029/2006GL026659.

Lambeck, K., & Cazenave, A. (1976) Long term variations in the length of day and climatic change. Geophys. J. R. Astr. Soc., vol. 46, 555.

Lim, G.-H., Suh, Y.-C. & Kim, B.-M. (2006) On the origin of the topical Atlantic decadal oscillation based on the analysis of the ICOADS. *Quart. J. Roy. Meteorol. Soc.*, vol. 132, 1139-1152.

Liu, J., Wang, B. et al. (2009) Centennial variations of the global monsoon precipitation in the last millennium: Results from ECHO-G model. *J. Climate*, vol. 22, 2356-2371.

Maasch, K.A., Mayewski, P.A., Rohling, E.J., Stager, J.C., Karlen, W., Meeker, L.D. & Meyerson, E.A. (2005) A 2000-year context for modern climate change. *Geografiska Annaler*, vol. 87A, 7-15.

Mackey, R. (2009) The sun's role in regulating the Earth's climate dynamics. *Energy & Environment,* vol. 20(1).

Mangini, A., Spotl, C. & Verdes, P. (2005) Reconstruction of temperature in the Central Alps during the past 2000 yr from a $\delta^{18}O$ stalagmite record. *Earth & Planet. Sci. Lett*, vol. 235, 741-751.

Neff, U. et al. (2001) Strong coherence between solar variability and the monsoon in Oman between 9 and 6 kyr ago. *Nature*, vol. 411, 290-293.

Poore, R.Z., Quinn, T.M. & Verardo, S. (2004) Century-scale movement of the Atlantic Intertropical Convergence Zone linked to solar variability. *Geophys. Res. Lett.*, vol. 31, doi:10.1029/2004GL019940.

Prieto, J.I., Martinez-Garcia, J.C. & Garcia, D. (2009) Correlation between global solar irradiation and air temperature in Asturias, Spain. *Solar Energy, in press.*

Soon, W. W.-H. (2005) Variable solar irradiance as a plausible agent for multidecadal variations in the Arctic-wide surface air temperature record of the past 130 years. *Geophysical Research Letters*, vol. 32, doi:10.1029/2005GL023429.

Soon, W. (2009) Solar Arctic-mediated climate variation on multidecadal to centennial timescales: Empirical evidence, mechanistic explanation, and testable consequences. *Physical Geography*, vol. 30, 144-184.

Svensmark, H., Jens Olaf Pepke Pedersen, Nigel Marsh, Martin Enghoff & Ulrik Uggerhøj, 2007. Experimental Evidence for the Role of Ions in Particle Nucleation under Atmospheric Conditions. Proc. Royal Soc. A, vol. 463, 385–96.

Tan, M., Hou, J. & Liu, T. (2004) Sun-coupled climate connection between eastern Asia and northern Atlantic. *Geophysical Research Letters*, vol. 31, doi:10.1029/2003GL019085.

van Loon, H. & Meehl, G.A. (2008) The response in the Pacific to the sun's decadal peaks and contrasts to cold events in the Southern Oscillation. *Journal of Atmospheric and Solar-Terrestrial Physics*, vol. 70, 1046-1055.

Wang Y.J. et al. (2005) The Holocene Asian monsoon: Links to solar changes and North Atlantic climate. *Science*, vol. 308, 854-857.

Weng, H. (2005) The influence of the 11 yr solar cycle on the interannual-centennial climate variability. *Journal of Atmospheric and Solar-Terrestrial Physics*, vol. 67, 793-805.

White, W.B. & Liu, Z. (2008) Resonant excitation of the quasi-decadal oscillation by the 11-yr signal in the Sun's irradiance. *Journal of Geophysical Research Letters*, vol. 113, doi:10.1029/2006JC004057.

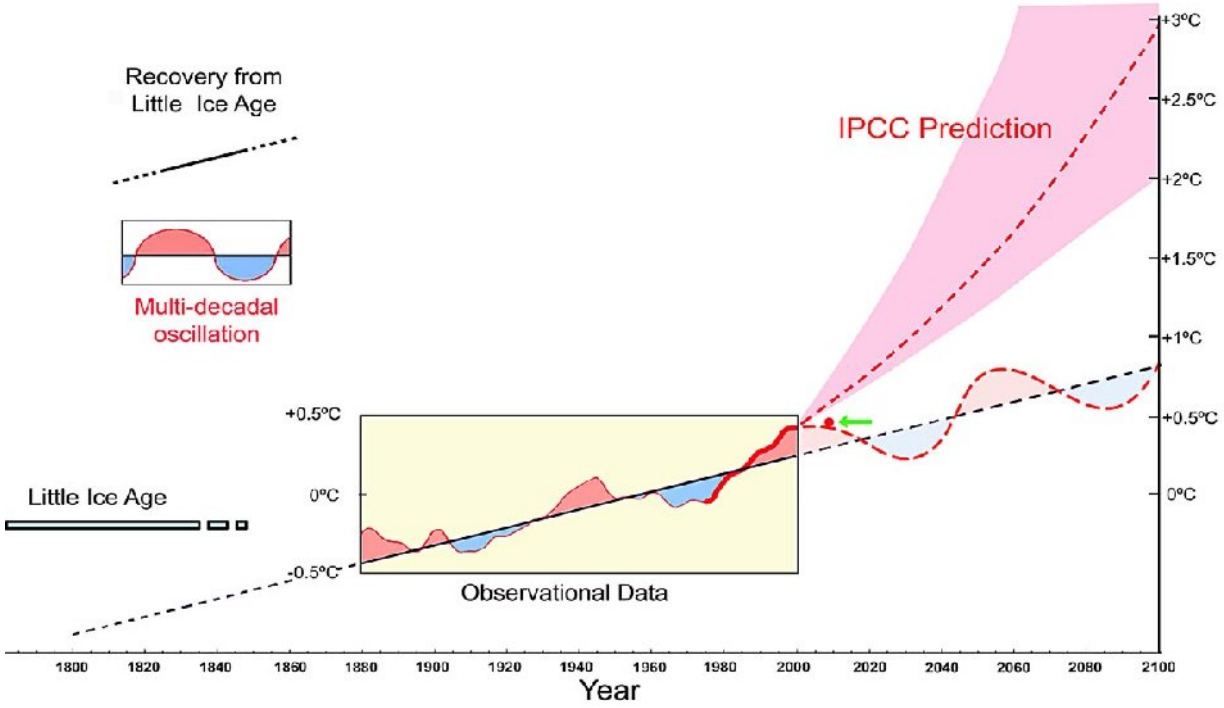
Wiles, G.C. et al. (2004) Century-scale solar variability and Alaskan temperature change over the past millennium. *Geophysical Research Letters*, vol. 31, doi:10.1029/2004GL020050.

Appendix B - Historic air temperature and ocean heat records

1. Since the IPCC's first report in 1990, the currency of the public debate about global warming has been the average global atmospheric temperature, as represented by the British Meteorological Office's temperature record since 1850 (Hadley Centre, Climate Research Unit).

2. At the same time, it is widely acknowledged that thermometer surface measurements such as those used by the Hadley centre are subject to the Urban Heat Island (UHI) warming artefact, especially since the second world war.

3. Satellite-borne measurements of atmospheric temperature, using microwave sensing units not subject to UHI distortion, commenced in 1979. These measurements comprise the highest quality data series of global temperature that are available, and show temperature in 2008 had returned to 1979 levels. Nonetheless, a gentle warming trend of around 1^0C/century can be argued from the MSU data using a simple linear regression. This is the maximum possible rate of modern warming, and it falls well within known earlier rates of natural warming (Fig. 2b in Fielding, June 15th – see E6.2).



Measured surface temperature from 1880 to 2000 (in yellow box) followed by IPCC model projections of future temperature made in 2001 (red dotted line plus pink envelope). Red dot (indicated with green arrow) represents the global temperature in 2008. Note that all IPCC projections now fall outside the error bounds of the trend based on the elapsed temperature record. Global average temperature appears to be following its usual 30 year oscillations, superposed upon the established upward trend of ~0.5^{0}C per century that has marked the recovery from the Little Ice Age (Akasofu,2009).

4. The temperature trends of the last 150 years are best seen in context against the temperature graph provided by Fielding (June 15th), after Akasofu. This graph shows a

steady warming trend since the mid-19th century, as the world warmed out of the Little Ice Age of the 1600s and 1700s. Superimposed on this warming are the characteristic multi-decadal oscillations associated with climatic features such as the Pacific Decadal Oscillation. The last warming 1975–2001 occurred at a similar rate and magnitude as the preceding warming 1910-1944. World average temperature is now falling, as would be expected in terms of the next natural multi-decadal oscillation.

5. Human emissions of carbon dioxide only reached appreciable magnitude after 1940. So warmings and coolings prior to 1940 cannot be other than largely natural. The superimposition of the long-term warming trend in place since before 1800 and the multi-decadal oscillation fully explains the observed course of the global temperature curve up until today. The principle of parsimony (Occam's Razor) militates against human carbon dioxide emissions causing a measurable influence on world temperature, until it can be shown that modern temperature change is proceeding in some way differently than in the past.

6. The Department of Climate Change now asserts that we should abandon use of these measures of global average temperature in favour of ocean heat content as a measure of climate change.

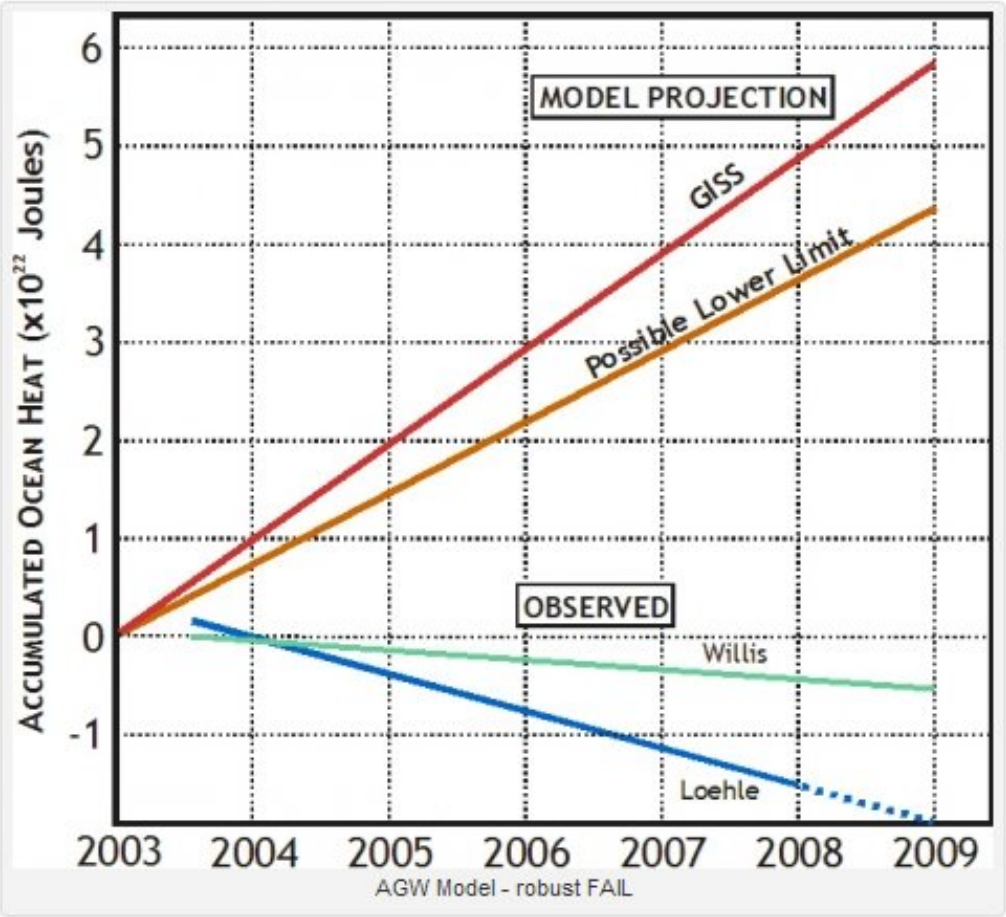
7. Ocean temperatures have only been measured adequately since the beginning of 2004, using the Argo network of buoys: *http://en.wikipedia.org/wiki/Argo_(oceanography)*, *http://www.argo.ucsd.edu/Marine_Atlas.html*. Earlier measurements, made during the 20th century on ships of opportunity, were not collected under controlled conditions and are therefore of dubious quality (cf. Thompson et al., 2008).

   The Argo data currently show slight cooling since the beginning of 2004 (Loehle, 2009; *http://www-argo.ucsd.edu/rey_line_atlas.gif*, *http://www-argo.ucsd.edu/nino34_atlas.gif*). Note that regularly updated global Argo data are not yet posted routinely on the Internet, i.e. there is no website that provides the latest ocean temperature and the data analysed in Loehle's paper were provided directly by Josh Willis.

8. This cooling trend is also reflected in upper ocean heat content, as estimated by Loehle (2009) and DiPuccio, W. (2009), and summarised in the figure below (next page).

9. As discussed in more detail by DiPuccio (2009), ocean temperatures need to be rising above a certain rate to be consistent with the IPCC greenhouse warming hypothesis. They aren't. Ocean heat content is falling, and there is nowhere for the heat alleged to be accumulating to be hiding.

10. Finally, enthusiasm for the use of ocean heat content as an arbiter of climate change should be tempered by the IPCC's considered view that "*Limitations in ocean sampling imply that decadal variability in global heat content, salinity and sea level changes can only be evaluated with moderate confidence*" (IPCC Technical Summary, p. 84).



Accumulated ocean heat as projected by GCM models, and as observed. Loehle and Willis represent two different interpretations of the available measurements.

The observations indicate an increasing heat deficit in the upper ocean from 2003. Estimates for this deficit to 2008 vary between 5.88 x 1022 J and 7.92 x 1022 J. This shows there to have been no positive radiative imbalance produced by carbon dioxide forcing since 2003, as has been predicted by the GISS and other models.

Appendix C – IPCC advice

1. The IPCC was established in 1988 by the United Nations under the co-sponsorship of the World Meteorological Organization (WMO) and the United Nations Environmental Program (UNEP).

2. Based on the participation of many professional advisers, including government appointed scientists, the IPCC produces comprehensive assessment reports of the human greenhouse influence on modern climate change.

3. The IPCC does not follow the conventional peer-review process used for scientific research publications. Though outside reviewers are sought, the editing of IPCC technical volumes is accomplished under the control of lead authors; these authors have a demonstrated record of seeking advice from within a narrow coterie of like-minded scientists, and ignoring criticism from truly independent reviewers.

The tight IPCC editing group selectively favour the citation of papers that claim man-made warming.

4. The highly technical IPCC reports are accompanied by a brief Summary for Policymakers, a considered statement shaped to be suitable for use by government policymakers.

The final Summary for Policymakers is approved line-by-line by government appointed representatives. Though based on scientific advice, it is a political document. Indeed, after intergovernmental agreement of the SPM, the Techical Reports are edited to harmonise with its finding.

Because governments accept the SPM as the basis for setting their climate policy, the IPCC in effect acts as a monopoly provider of advice which, in general, is not subjected to further due diligence auditing.

5. The critical Chapter 9 (attribution of the cause of climate change) of IPCC's most recent 4th Assessment Report (2007) was written and reviewed by a small, interlinked group of authors, many of whom are employed at only three climate change institutions from amongst hundreds of qualified persons and organisations worldwide.

The claim of dangerous human influence on climate made in IPCC's 4AR is not based on empirical data, but on the projections of unvalidated computer models that are known to have serious deficiences that lead to exaggerated climatic responses.

6. Criticism of IPCC methodologies is not restricted to scientists who have left the organisation in protest against their working methods, or to so-called "sceptical" scientists. For example, the authoritative U.K. House of Lords Select Committee on Economic Affairs wrote in 2005 about the IPCC's reviewing procedures that:

"*We can see no justification for this procedure. Indeed, it strikes us as opening the way for climate science and economics to be determined, at least in part, by political requirements rather than by the evidence. Sound science cannot emerge from an unsound process".*

References

Note - McLean's auditing reports on IPCC methodology, listed below, were made using data released by the IPCC. McLean explains fully the way in which he has processed the data to reach the conclusions that he draws. All these reports were available for access on the web as of June 11th, 2009.

McLean, J, 2007, August/September. An Analysis of the Review of the IPCC 4AR WG I Report. *Science & Public Policy Institute.*
http://mclean.ch/climate/docs/IPCC_review_updated_analysis.pdf

McLean, J, 2007, November. Why the IPCC Should be Disbanded.
http://scienceandpublicpolicy.org/originals/whytheipccshouldbedisbanded.html

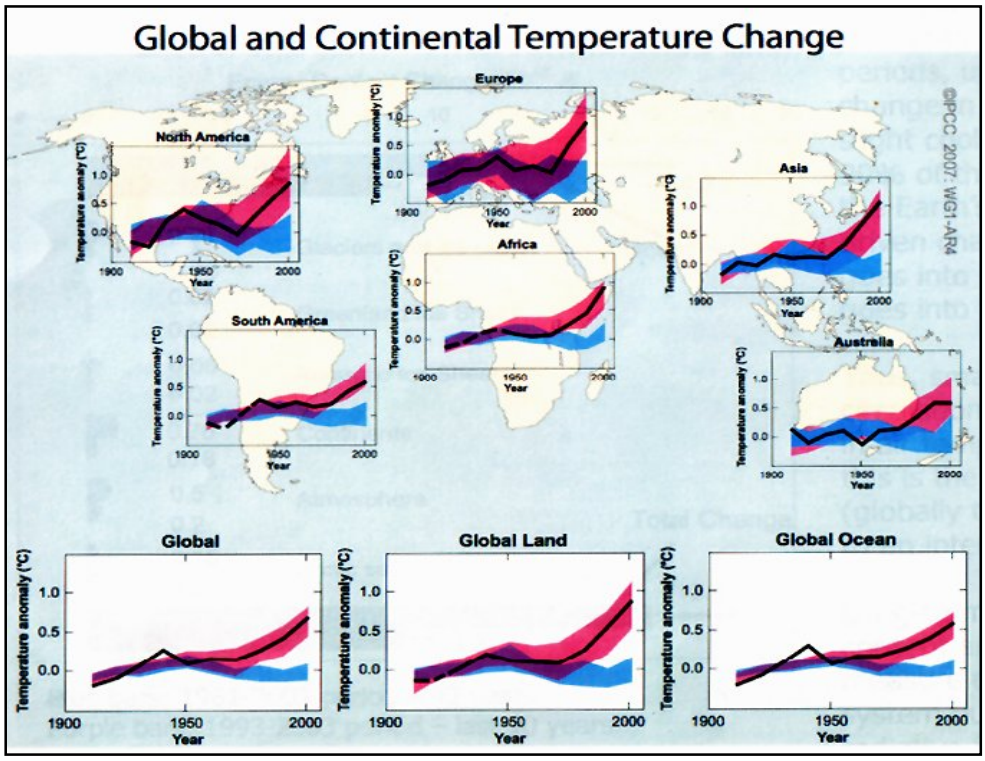
McLean, J, 2009. The IPCC Can't Count its "Expert Scientists" - Author and Reviewer Numbers are Wrong, International Climate and Environmental Change Assessment Project.
http://mclean.ch/climate/docs/IPCC_numbers.pdf

McLean, J, 2008. Prejudiced Authors, Prejudiced Findings. Analysis of IPCC data on chapter authors and reviewers published through the Science and Public Policy Institute. Particularly pages 16-17.
http://www.heartland.org/policybot/results/23573/Prejudiced_Authors_Prejudiced_Findings.html

Appendix D - GCM global temperature hindcasts are NOT evidence, and GCM temperature projections are NOT predictions

There is a widespread misapprehension that the climate projections of computer GCMs provide "predictions of future climate" or, when hindcast and compared with the historical record, "evidence for global warming". Neither is the case.

Models are not, and cannot be, evidence, and nor do they provide predictions.



Global air temperature has changed consistently over each continent and over the ocean through the past century. The black lines are observations. The blue bands are model simulations using natural radiative forcings only (changes in solar radiation and aerosols from volcanoes). The pink bands are model simulations using both natural and human changes to radiative forcing. The observed change in air temperature since 1950 is thus dominated by the human changes to radiative forcing.

1. GCM forward-looking outputs - which are projections and not predictions - provide selected realizations of selected future climate paths out of numerous equally probable alternatives. The models have no demonstrated statistical skill, and a GCM scenario is therefore a virtual reality future.

2. Conversely, GCM hindcasts – which attempt to simulate the elapsed temperature curve of the last 150 years – are exercises in curve-fitting in which various program parameters are selectively adjusted within apparently plausible ranges until a target curve (the historical record) is matched more or less successfully.

3. The *Global and Continental Temperature Change* graphic (above, after the IPCC) represents an example of this second, hindcasting technique. The graphs represent model runs for air temperature change over the last century, regionally and globally, using as inputs (i) those natural forcings presumed to be important (blue bands), (ii) natural forcings plus an imputed forcing from human emissions (pink bands).

   Because the GCMs are trained with all the inputs turned on (pink bands), it is inevitable that they predict the training data (i.e. the observations). It is equally inevitable that if

some inputs are turned off (blue bands) then the outputs do not fit the observations.

In essence, the graphic only tells you that that the climate models require the human emissions forcing input to be turned on in order to correctly predict their training data.

4. That the pink bands always provide a better fit with the historical record (thick black line on each graph) than do the blue bands is therefore not "evidence" at all, let alone, as claimed, evidence that human forcing can be identified and must dominate "*the observed change in air temperature since 1850*". Rather, it is simply an inevitable result of the modelling techniques used, and essentially a curve-matching exercise.

5. GCMs suffer from a wide range of other deficiencies (cf. , Essex, 2007), including:

    - They are based upon the Kelvin-Cheney Fallacy, which presumes that the physics of the system is fully understood (i.e. there are no "unknown unknowns"). It is not. In particular, climate feedbacks are a well-known blind spot.

    - Climate models have millions of degrees of freedom; by adjusting them, any target curve can be matched (paras 3 and 4, above). Such a result is trivial, and certainly not "evidence" for human-caused warming.

    - The climate model projections are only meaningful to the extent that they accurately mimic reality. In fact, the models fail many empirical tests, including:

      (i) inability to simulate distribution of temperature across the troposphere (the upper troposphere "hotspot" that they predict is not present) (Douglass et al., 2007, Santer et al., 2008, MacIntyre et. al., 2009), which indicates that the alleged feedback processes are not as strong as assumed by the GCMs (e.g., Paltridge et al., 2009),

      (ii) overestimation of climate sensitivity as judged by ERBE satellite measurements of outgoing infrared radiation; the models assume a feedback factor of 3, the missing hotspot limits the feedback factor to no more than 1.2, and other empirical tests (e.g. ERBE satellite data, cloud observations) suggest a feedback factor of about 0.5 (e.g., Lindzen, 2009), which in turn implies that the actual temperature rises due to the forcings considered by the IPCC are no more than 20% of what the IPCC is predicting,

      (iii) underestimation by a factor of three of the rate of increase of surface latent energy exchange with temperature (thus exaggerating the surface temperature response to radiative forcing, particularly water vapour feedback amplification, and underspecifying global precipitation response) (Priestley, 1966; Wentz et al., 2007),

      (iv) inability to project the elapsed course of temperature (stasis and

cooling in both the atmosphere and ocean) over the last ten years, and

(v) incorrect projection of an increase in ocean heat content, where observations demonstrate no increase for the last 5 yr (see Appendix B).

- These mismatches with empirical reality are caused, *inter alia*, by the models' failure to simulate cloud processes accurately, and to incorporate known multi-decadal oscillations (e.g. the PDO) and solar forcings other than direct radiance variation.

- GCM calibration is also faulty. Although human emissions weren't large before 1940, the models assume that all the heat rise since 1850 is due to the currently considered forcings, principally human carbon dioxide. Since 1850, the earth has been recovering from the Little Ice Age; the calibration of the models assumes that this natural warming trend is almost entirely caused by carbon dioxide emissions, and that in full knowledge also that ice core data show that temperature changes *precede* carbon dioxide changes during natural climatic cycling.

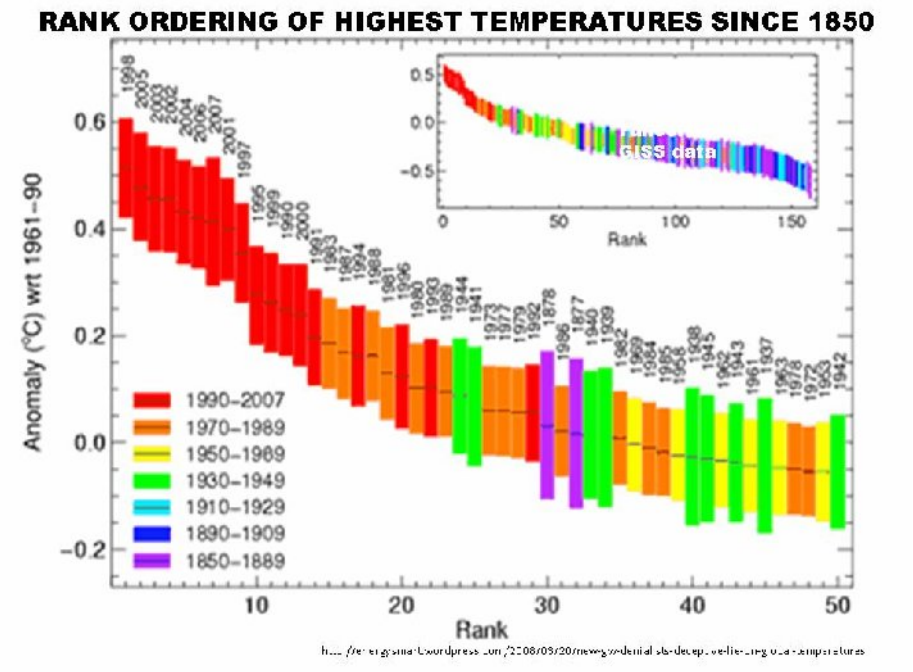
- GCM models have been developed under the assumption that the more comprehensive they are, the more useful will be their results. This may be incorrect, for simple models that deliberately use a limited number of variables to simulate complex natural processes are in at least some cases more accurate than more complex ones.

- Halide & Ridd (2008) have shown this for ENSO cycling, and Lawrence (2009) for the hydrological components of a Community Land Model used to provide information to the IPCC.

As Halide & Ridd conclude: "*If larger and more complex models do not perform significantly better than an almost trivially simple model, then perhaps future models that use even larger data sets, and much greater computer power may not lead to significant improvements in both dynamical and statistical models*".

Appendix E –The relative warmth of recent years is not unusual

*The diagram below provides a graphic presentation of widely repeated claims such as (e.g., June 18th response from the Department of Climate) that "*globally, 13 of the 14 warmest years on record have occurred since 1995*". As explained further below, that fact, which is undisputed, is scientifically misleading.*



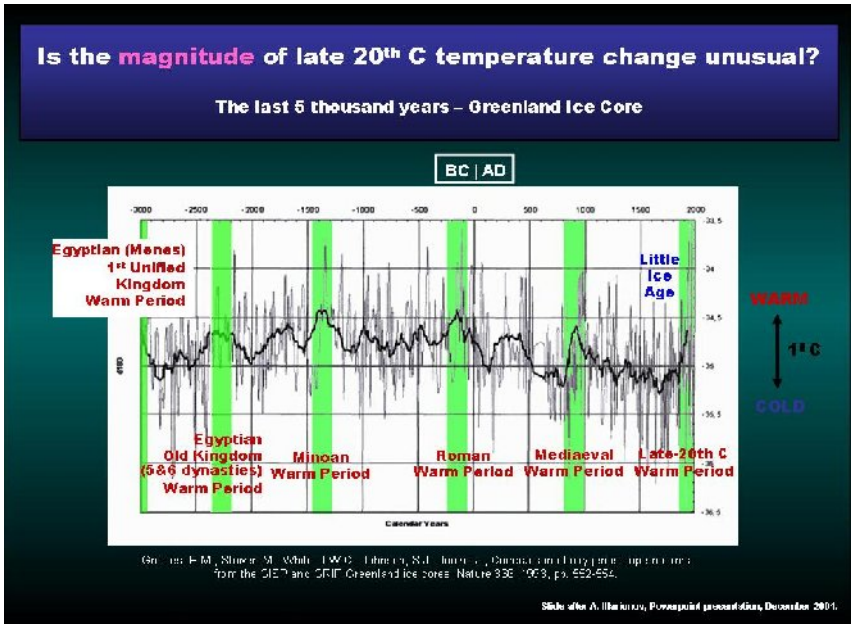
1. As written, the statement that "*globally, 13 of the 14 warmest years on record have occurred since 1995*" is true.

2. In assessing how meaningful the statement is, the key phrase is "*on record*", which refers to the period of instrumental temperature records, i.e. about 160 years.

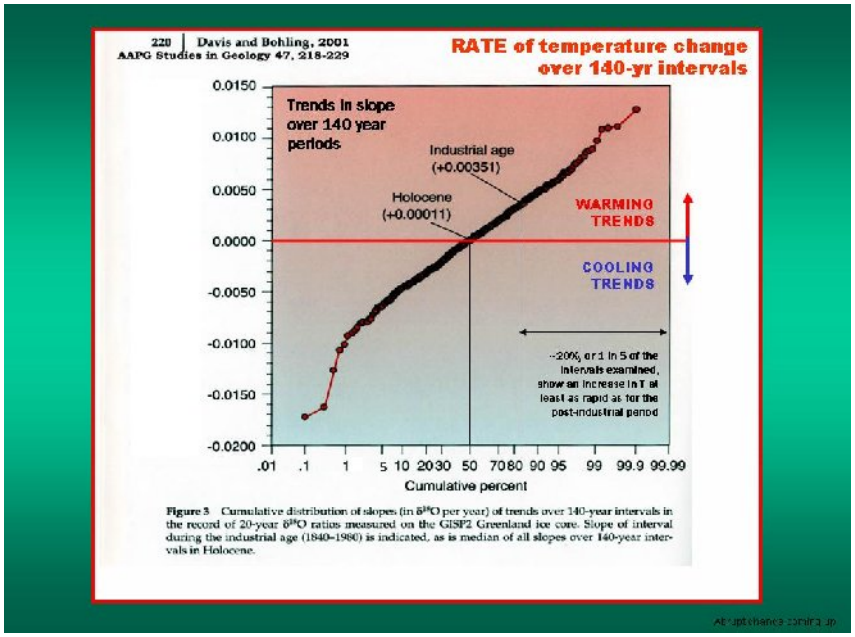
   This period represents only 5 climate data points, and is trivially short as a climatic time series. It is also a period of time over which natural warming occurred as a result of recovery from the Little Ice Age of the 1600s and 1700s.

3. To comprehend whether a climatic warming or cooling represents an unusual event the event must be viewed in the context of temperature time-series that represent at least several thousand years of climate history.

4. The temperature time series shown in the figure (below, next page) is drawn from the GRIP ice core in Greenland. It demonstrates that our planet is currently near the warm peak of a millennial climate cycle (cf. Singer & Avery, 2008).



5. It is therefore no more surprising that there has been a run of warm years around the turn of the 21st century than it is that most of the warmer days each year occur around and after mid-summer's day, or that the warmest part of each day occurs in the early afternoon.



6. In its appropriate climatic context, an alternative statement about the late 20th century warming is: "*over the Holocene (last 10,000 years), 20% of the set of contiguous 140-year-intervals have been warmer than was the post-industrial 140-year period"* (Fig. left; after Davis & Bohling, 2001).

Given the known periodicity of global temperature fluctuations over recent geological history, there is nothing unusual about post-industrial or late 20th century recent warmth.

Appendix F – The greenhouse effect

1. The greenhouse gases that are intrinsic to the greenhouse effect emit radiant heat independently of the radiant energy absorbed.

2. To suggest that greenhouse gases 'absorb and re-emit heat' (as expressed in IPCC explanations) unnecessarily constrains consideration of the breadth of the radiation processes operating in the climate system.

   In the form developed in the Department's response, the IPCC construct of radiation absorption and re-emission leads to faulty understandings of the intrinsic nature of the greenhouse effect and of radiation forcing.

3. The global energy budget of the IPCC shows clearly that greenhouse gases emit more infrared radiation than they absorb. The infrared radiation emitted to space largely emanates from the greenhouse gases and clouds of the atmosphere, and the net effect of the infrared interactions is a tendency to cool the atmosphere.

   There is a deep-seated misconception in the minds of the public that it is the absorption of infrared radiation by the greenhouse gases that warms the atmosphere and leads to the greenhouse effect; thus more greenhouse gases leads to more warming. This latter statement is true only indirectly.

4. The greenhouse effect arises because there is disconnect between the absorption of solar radiation at the Earth's surface (which tends to warm the surface) and the infrared radiation loss from the atmosphere (which tends to cool the atmosphere).

   The connection is made by the exchange of heat and latent energy (water vapour) between the surface and the atmospheric boundary layer, and by the distribution of this energy through the atmosphere by overturning - especially by buoyant convection in the tropics (Riehl & Malkus, 1958). Latent energy is released because the ascending air is saturated and the water vapour condenses; thermodynamic laws determine that the ascending air cools, which causes the atmospheric temperature to decrease at a rate varying from -6.5^{o}C/km near the surface to -10^{o}C/km in the upper troposphere around 10km altitude.

5. Overall the greenhouse effect arises because the thermodynamics of overturning of the atmosphere dictates that the surface is warmest and temperature decreases from there with altitude. The complex integration of energy exchange processes around the globe ensures that the emission of infrared radiation to space equates with the absorption of solar radiation, and thereby regulates a near "steady state" climate.

6. The effects of the so-called greenhouse gases are a significant part of this construct, and the quantification of their radiation properties is essential for a full understanding of climate processes. However, a range of other processes are equally or more important in evaluating the magnitude of the enhanced greenhouse effect, and unfortunately these are not well quantified.

7. The upper bound of Earth's natural temperature range envelope is stable because evaporation from the oceans increases almost exponentially with surface temperature. This is a powerful *negative* feedback that exerts an increasing constraint on surface temperature rise (Priestley, 1966).

   In contrast, the GCMs assume strong *positive* feedback from rising ocean surface

temperatures, their "water vapor feedback" (which the radiosondes failed to observe). A negative feedback (Paltridge et al., 2009) makes for a stable system; a positive feedback makes the system unstable and prone to tipping points.

The Earth's climate has been stable for a billion years, never going into runaway greenhouse warming. And over the last few hundred thousand years, as the Earth came out of each major glacial period the temperature approached a natural asymptotic upper bound at a value a little warmer than is currently experienced.

8. It should also be recognised that the influence of carbon dioxide on radiation forcing is logarithmically related to concentration, a point that is well acknowledged in each of the IPCC assessment reports. Thereby, each successive doubling of carbon dioxide concentration produces the same incremental increase in radiative forcing, i.e. the forcing decreases rapidly as carbon dioxide accrues.

9. Over the last half a million years or so, the Earth has remained firmly within a bipolar climate envelope the bounds of which are represented by the glacial minima and interglacial maxima.

   Atmospheric carbon dioxide, not least because of its logarithmically decreasing forcing effect during warmer times, has only a limited ability to shift the bounds of the envelope. Ecosystems that have developed within, and are adapted to this envelope will continue to survive, albeit that their range or diversity fluctuates with climate.

Appendix G – Giving Earth the benefit of the doubt: Shouldn't we apply the precautionary principle?

1. A common expression of human caution, often attributed to Rupert Murdoch, is that in matters of potential global warming we should "*give Earth the benefit of the doubt".*

   The statement reveals a profound misunderstanding of real climatic risk, not least because it assumes that global warming is more dangerous, or more to be feared, than is global cooling. In reality, precisely the converse is true.

2. "*Giving Earth the benefit of the doubt"* is often further expressed as a desire to implement the "*precautionary principle*", which is a sociological and not a scientific construct.

3. In order to take precautions, you have to know what you are taking them against.

   Some computer models (GCMs; deterministic) project that the global temperature in ten years time will be warmer than today's. Other computer models (statistical; based upon projection of past climate patterns) project that global temperature will be cooler ten years hence.

   The reality is, therefore, that no scientist can tell you with confidence whether the temperature in 2020, let alone 2100, will be warmer or cooler than today's.

4. The only precaution that you can take in such a situation is to plan for a continuation of the present climate trend and recognize reasonable bounds of variability. As the temperature trend for ten years now has been one of cooling, this requires an initial precautionary response to cooling rather than warming.

   In fact, it is not precaution that is required, but prudence.

5. Given the certainty that natural climate change will continue in the future as it has in the past – including warmings, coolings and step events - it is clearly most prudent to adopt a climate policy of adaptation to climate change as and when it occurs (Carter, 2009).

6. Adaptive planning should therefore be tailored to provide responses to the known rates, magnitudes and risks of natural change, which means that the same plans will cover human-caused global warming or cooling should either emerge in measurable quantity at some future date.

Appendix H – "Climate Change 2009: Faster Change & More Serious Risks"

Review of a commissioned report to the Department of Climate Change by Professor Will Steffen, Australian National University

1. Professor Steffen's July 9 report carries an express disclaimer by the Department that it "*does not represent a statement of the policy of the Commonwealth of Australia*", and another by Steffen that "*The views expressed in this document are my own, and do not necessarily represent the views of the Australian Government Department of Climate Change*". Nevertheless, the report has been commissioned by the Department to reflect the views of the Australian scientific community, and it is therefore expected to be a major input to government policy.

   Some of the report's arguments were advanced also by Senator Wong in her discussions with Senator Fielding, and clearly have already been incorporated into government policy development.

2. In the Preface, Steffen indicates that his document "*reviews and synthesises the science of climate change since the publication of the IPCC's AR4, with an emphasis on rapidly changing areas of science of direct policy relevance*", and that it focuses especially "*on issues of importance to Australia*". Apart from this Australian customization, the report has significant commonalities with that of Richardson et al. (2009), which has been discussed in section F of the main text.

3. The credibility of the July 9 report is damaged at the outset by the inclusion in the Executive Summary of a version of the Mann et al. "hockey-stick" graph of northern hemisphere temperature for the last 1,000 years, complete with a shaded envelope of "natural variability" (which under-represents the magnitude of known recent climate variability), and vivid, red colouration applied to a "burning embers diagram" that is intended to convey alarm. For further comments on the inappropriateness of using this diagram, see paragraph E7.3 (main text).

   The value of the report is also compromised by its heavy dependence upon unvalidated modelling studies and "grey" literature, such as the Richardson et al. (2009) report, and its failure to consider recent research results that conflict with the IPCC's findings. A field as well funded as climate science is in a ferment of research, much of which is only available in pre-print or *in press* papers and in discussion on websites, which is where the breaking research-fronts lie. We use and cite such work when appropriate, because our concern is with the relevance, up-to-datedness and correctness of any science that we discuss: who performed the analyses, or where they might be available from, is irrelevant.

4. Therefore, as part of this review and its accompanying report, we have provided a selection of more than 130 recent references that contain evidence that contradicts the IPCC's assertions (i) that human-caused carbon dioxide emissions were the primary cause of the mild planetary warming observed in the 20th century, and (ii) that continuing

human-caused emissions will cause dangerous future warming. The majority of these papers are published or *in press* in major peer-reviewed journals. In addition, tens of thousands of other high quality, refereed papers contain evidence that is consistent with the null hypothesis that the fluctuating 20th century temperatures were largely caused by natural processes.

Recent research that throws doubt on the IPCC's central claims includes work that covers the validity of the concept of global temperature as a measure of climate change (Essex et al., 2007a), the inadequacy of deterministic climate modelling (Essex et al., 2007a; Green et al., 2009; Koutsoyiannis et al., 2008; Kucharski et al., 2009; Kukla & Gavin, 2004), negative feedback effects due to clouds (Cotton, 2009), ocean-land temperature relations, phase changes in annual temperature cycling, the influence of El Nino on global temperature and the impact of land-cover on temperature trends (Comp & Sardeshmukh, 2009; Fall et al., 2009; McLean et al., 2009; Pielke et al., 2007; Stine et al., 2009), falling ocean temperatures in southern Australia over the last several thousand years (Calvo et al., 2007) and globally over the last few years (Loehle, 2009), the residence time of carbon dioxide in the atmosphere (Essenhigh, 2009), and the low sensitivity of climate to increases in greenhouse gases (Lindzen & Choi, 2009; Soon, 2009; Spencer & Braswell, 2008).

In presenting an updated account of the IPCC's central thesis of dangerous human-caused global warming, the Steffen July 9 report ignores these and other important recent papers, and its four main chapters present instead an account of climate change that is heavily dependent upon GCM computer modelling. We comment in more detail on each chapter of the report in turn, below.

5. ***Chapter 1.*** This chapter briefly summarizes the main conclusions of IPCC's Fourth Assessment Report, claims that some recent changes observed in ice sheets and natural carbon sinks are "c*onsistent with accelerating climate change*", and argues that incremental changes in temperature may cause deleterious climate "*tipping points*" to occur.

   In support of this, four graphs are provided of recent changes in carbon dioxide emissions, temperature change, sea-level change and Arctic ice extent to show that these claimed deleterious changes (warming, sea-level rise, ice shrinkage) are tracking in "*the upper range of the IPCC projections of climate change for this century*".

   First, and as covered in more detail in Appendix D, the GCM computer projections that two of these graphs represent have no demonstrated forecast skill.

   Second, even if the GCM-projected changes should eventuate, it is far from self-evident what the balance of environmental and socio-economic benefits and disbenefits will be.

   Third, the illustrative graphs provided have been chosen or prepared in a selective way. For example, the Arctic sea-ice record chosen for display (Fig. 2a) fails to record the

known earlier examples of Arctic ice-melt, such as the report in the Monthly Weather Review (Nov 1922) that warmer conditions in Arctic Norway had commenced in 1918, that by 1922 the waters around Spitzbergen no longer froze in winter, and that land ice had receded to be replaced by moraines as glaciers that had extended into the sea had disappeared; similarly Time (13/9/1937) reported the discovery of a new shorter navigable northwest passage, noting also that the northeast passage to China was first navigated in 1879 and that in 1937 Russia was operating a fleet of 160 freighters through the northeast Passage on summer schedules. In another example of selectivity, by terminating the ice record around 2006, Steffen's Fig. 2a also fails to record the rebound of sea-ice that has occurred in the last two years, with the result that the area of sea-ice is now similar to that in 1979 (cf. paragraph E4.4 and figure, main text).

6. Even more importantly, the projected global average temperature (Fig. 1b) and sea-level (Fig. 1c) projections cited as evidence that "*the climate system appears to be changing faster than earlier thought likely*" originate from Rahmstorf et al. (2007) and Rahmstorf (2009), and have been shown to be invalid by discussions amongst a number of different, independent scientists (e.g., Liljegren 2009; McIntyre 2009; Stockwell 2009a, 2009b).

   Rahmstorf (2009) used smoothing techniques that cause spurious correlations which affect significance testings and exaggerate the warming temperature and rising sea level trends, as follows:

   - the size of the smoothing filter was enlarged from previous smaller filter size used in original Rahmstorf et al. (2007), in order to display a continuing rising trend;
   - excessive data "smoothing" was undertaken, with 5 different types of smoothing method (Stockwell 2009b) and non-objective data padding procedures (Liljegren 2009; McIntyre 2009);
   - superceded confidence intervals were taken from the 2001 IPCC report rather than the latest 2007 report (Liljegren 2009).

   Figs. 1a and 1b must therefore be rejected, yet they are pivotal to the argument that current "evidence" is "c*onsistent with accelerating climate change".* A more objective, transparent and empirically-based discussion of the available scientific data must be insisted upon.

7. The second argument presented in Chapter 1 is that accelerated climate change will lead to the transgression of dangerous tipping points. Notwithstanding that no accelerated change has been demonstrated (4, above), we agree with Steffen's overall comment, which is that "*much more needs to be understood about these phenomena to assess the degree of risk they pose*", and "*much uncertainty surrounds the location of such tipping points and the probability that they will be crossed*". Indeed, we would go further to say that 'tipping points' are an emotive proposition with no basis in science. As Priestley (1966) has noted, surface temperatures are constrained by evaporation and 70 percent of

the Earth's surface is comprised of freely evaporating oceans.

It is established that sudden natural climate events are a real and present danger, and more research is certainly needed into the topic; but at present no evidence exists, nor is there good reason offered, that human activity is significantly increasing the likelihood of occurrence of dangerous natural climate events. In this regard, more research is necessary in particular into the causes and varying regional magnitudes of the historical multi-decadal to centennial events epitomised by the Greco-Roman Warm Period, the Dark Ages of the first millennium, the Medieval Warm Period, the Little Ice Age, and the current period of comparative warmth.

8. ***Chapter 2.***This chapter develops the themes raised in Chapter 1 by discussing in more detail several of the natural processes of climate change that are claimed to be operating at "*rates at or near the upper level of IPCC projections*". No reasons are given as to why this should necessarily be a problem, even were it to be true, and in no case is the hypothetical human climate signal that is claimed able to be identified as measurable, i.e. as discrete from natural rates of change.

   The processes discussed are melting ice and rising global sea-level, changes in the hydrological cycle in Australia, ocean acidification, and changes in storms and other extreme events. We have already dealt with some in these issues in the main text of this report. Space precludes our giving a detailed treatment here, but we provide a brief summary of the main topics in the next few paragraphs.

9. ***Melting ice and rising sea level (2.1).*** The IPCC approach to sea-level study, which Steffen summarizes, is heavily theoretical, is based upon deterministic computer modelling and is concerned solely with eustatic (i.e., global) sea-level as opposed to the site-specific local relative sea-level knowledge that is required for meaningful coastal management around the world. Calculation of theoretical eustatic sea-level requires an accurate knowledge of the cryosphere and its processes that does not yet exist, as is indeed acknowledged in Steffen's comment (p. 7) that "*estimates of the contributions [to sea level rise] from polar ice sheet dynamics …. cannot yet be modelled quantitatively with confidence*".

10. Steffen's Fig. 5 requires special comment because in the context of Greenland and Antarctic ice masses the explanation provided is misleading, and particularly alarmist.

    The cartoon suggests that surface meltwater finds its way from the surface through cracks and crevices of the ice sheet to bedrock, and contributes to ice sheet instability by lubricating the ice-bedrock interface. But such a process is confined to the lower elevations of the ice sheet periphery, where solar radiation is absorbed at the ice surface and causes melting. This meltwater may then be subject to re-freezing, as energy is lost to colder near-surface air and surrounding ice at sub-zero temperatures. In general, however, interior snow accumulation and ice sheet peripheral melting are co-existing

processes in a stable ice sheet, and changes in the precise position of the ice front occur constantly through time in line with regional variations in precipitation and temperature.

11. In addition to acknowledging inadequacies in modelling skill, Steffen also quotes papers that, contrary to many other studies, report empirical data in support of a recently enhanced rate of sea-level rise (Church & White, 2006; Domingues et al., 2006) and a warming of Antarctica (Steig et al., 2009). In reality, these papers are underpinned by complex data manipulations and computer modelling, and the outlier results that they produce contradict other similarly detailed studies that show a steady rate of long term sea level rise (albeit with decadal modulations which include the start of a recent fall; Jevrejeva et al. 2008; Cazenave et al. 2009; Woodworth et al. 2009) and a cooling Antarctic ice cap - which, like Greenland, appears to be close to mass-balance (Stenni et al. 2002; Goodwin et al. 2004; Masson-Delmotte et al. 2004; Schneider, et al. 2006; Monaghan, et al. 2008; Schneider & Steig, 2008; Chapman, 2009).

12. In summary, and as discussed in the main text (E4), no empirical evidence exists that a substantial global melting of ice is underway, and most sea-level studies show that a long-term natural rate of rise of ~1.6 mm/yr has characterised the last 200 years and remains unchanged.

13. ***Changes in the Australian hydrological cycle (2.2).*** This section of the report is concerned primarily with detailed analysis of various aspects of the Australian hydrological cycle, with especial reference to drought and the Murray-Darling Basin.

    We do not wish to discount the vital importance for Australia of the issues raised here. But all of them concern local, or at their widest regional, climatic patterning. As such, they are neither amenable to deterministic modelling and nor do they bear any necessary relationship to hypothetical human-caused global warming. We discuss several of issues more fully in Section D of the main text, where we conclude that no empirical evidence exists that human carbon dioxide emissions are affecting Murray-Darling Basin rainfall patterns or regional Australian droughts.

    The only meaningful graphic of the sequence in Fig. 10 is the first distribution chart (a). This shows the trend in annual total rainfall for the period 1900-2005 where, for most of Australia, the trend is positive. This is consistent with slightly warming sea surface temperatures, increasing ocean evaporation, and consequently increasing rainfall.

14. ***Changing alkalinity of the ocean (2.3).*** It is no coincidence that section 2.3 of Chapter 2 is entitled "*Ocean acidification*", for control of language is a powerful tool deployed by those who wish to convert others to a cause. Thus we hear about "carbon" when "carbon dioxide" is meant, "climate change" when "dangerous human-caused global warming" is meant, and now "ocean acidification" when "changing alkalinity of the ocean" is meant, because the oceans are consistently alkaline despite rainfall with its dissolved carbon dioxide being acidic.

15. The oceans have been alkaline since the late Precambrian, about 750 My ago, when the amount of carbon dioxide in the atmosphere was up to 20 times higher than now (e.g., Kump et al., 2000). Today, we live on a carbon dioxide starved planet as judged against geological history. In between, carbon dioxide was progressively removed from the atmosphere via inorganic and organic carbonate sediment deposition, some of which later became sequestered as onland limestone by tectonic processes of accretion of sea-floor to the continental margins.

    These geochemical, geological and biological processes continue today, in an ocean that is now heavily buffered by water-rock and water-sediment reactions (e.g., Walker et al. 1981), which means that it is difficult to permanently change the pH by adding acids (including dissolved carbon dioxide as $H_2CO_3^-$) or bases. At least as long ago as the Eocene, ~45 Ma, the pH range in shallow ocean water is estimated to have been similar to today, at 8.33-7.91 (Pearson & Palmer, 1999).

16. Ocean bio- and geochemical processes that involve carbon dioxide are controlled by the saturation level, which is the maximum amount of gas that can be dissolved in a given volume of sea water. The saturation level varies with temperature, pressure and the concentration of other dissolved materials; pH is consequential and of lesser importance. The carbon dioxide saturation level decreases with increasing temperature, and increases with increasing pressure. Saturation at the ocean surface is therefore controlled mainly by temperature, and at ocean depths near and below 3-4 km (at a level termed the lysocline, below which calcium carbonate dissolves) by pressure.

    Warm and shallow tropical ocean waters occasionally become supersaturated with carbon dioxide, causing the direct precipitation of inorganic calcium carbonate. More generally, and as a result of the biological processes of photosynthesis, respiration and decomposition, the oceans at large are undersaturated. Nonetheless, and despite the strong buffering, local, regional and depth variations in pH all exist; near the surface these are related to temperature changes and biological activity, and at depth to pressure and water-mass transport. The result is that seawater average pH is widely variable, typically from 7.5 at depth to around 8.5 in surface waters. Finally, pH varies not only with depth and geography, but also with time as a result of diurnal variations in temperature and biological activity. For example, Revelle & Fairbridge (1957) recorded a pH of 9.4 in isolated coral reef pools during the warmth of the day and 7.5 at night, the reduction being attributable to a lack of photosynthetic uptake but continued respiration; meanwhile, adjacent reef waters remained more or less steady at pH 8.2.

17. Against this long background history of ocean buffering and natural variability in carbon dioxide saturation, and the additional, self-evident fact that modern marine organisms thrive across a wide alkalinity range, it is asserted or implied, using deterministic computer modelling, that (i) a meaningful ocean average pH exists at which all, or most, marine organisms thrive; (ii) this average pH has become less alkaline by 0.1 pH units since pre-industrial time; and (iii) a doubling of atmospheric carbon dioxide will cause a

dangerous further change in ocean alkalinity that is beyond the range of adaptive response of many marine organisms (e.g., Guinotte et al., 2003).

18. The persistent, and determinedly alarmist model projections of "acidification" of the oceans suffer, from many inadequacies. These include:

    - inadequate density of historical and geographical data coverage;
    - uncertain accuracy of some historical pH measurements, including inadequate correction for the temperature-dependency of pH;
    - a failure to take into account Henry's Law, whereby any warming of the oceans results in the outgassing of carbon dioxide, concomitantly reducing the amount of dissolved gas and increasing the alkalinity;
    - the ignoring of experimental data which show that adding carbon dioxide or iron to the ocean can cause more photosynthesis (fertiliser effect) rather than pH change (Nielsdottir, M.C. et al., 2009) , a result consistent with the SeaWIFS satellite that has recorded an increase in oceanic chlorophyll-a levels over the last 15 years; new experimental results show that the common phytoplankton of the North Atlantic grow in size and volume with increasing carbon dioxide, in contradiction of earlier experiments that incorrectly reduced the pH of the ocean water used by the direct addition of hydrochloric acid instead of letting carbon dioxide bubble through the water;
    - the effect of weathering resulting from enhanced atmospheric carbon dioxide, which would slightly accentuate the acidity of rain, cause an acceleration in weathering and drive more calcium down the rivers to encourage the eventual formation of more oceanic limestone;
    - the assumption that any decline in pH should be attributed to increased atmospheric carbon dioxide, whereas some such changes are certain to be related to natural multidecadal cycling (e.g., the Pacific Decadal Oscillation) which is known to change oceanic temperature and biological productivity;
    - a lack of allowance for the proven adaptability of marine organisms; for example, ancient coral reefs first evolved at a time when the atmosphere contained many times the present concentration of carbon dioxide, in addition to which modern coral reefs thrive in carbon dioxide-rich environments; and
    - a failure to consider that the small changes in equilibrium ocean pH calculated by chemical modelling lie well within the current natural range of pH variability to which many marine organisms are already comfortably adapted.

19. Steffen also reports the recent claim that carbon dioxide-linked changes in temperature and alkalinity have caused a recent 14% decline in the rate of calcification in the coral *Porites* from the Great Barrier Reef (De'eath et al., 2009).

    Though De'eath et al.'s (2009) paper has been widely quoted as demonstrating a recent collapse of GBR coral growth rates, that conclusion conflicts with earlier research that showed a statistically significant increase of 4% in growth rates during the warmings of the 20th century (Lough & Barnes, 2000).

    Stimulated to enquire into this, Ridd et al. (2009) have attempted to replicate the results of De'eath et al., and concluded that their inference of slowed coral growth rate "*depended unduly on questionable end-of-time-series data from cores that ended in the years 2004/2005".* In addition, their analysis *"did not allow for the naturally occurring ontogenetic reduction in calcification rate that is evident in the data set "*. Thus it is evident that the dataset analysed by De'eath et al. does not support the hypothesis that coral calcification has slowed recently on the GBR, whether due to acidification of the ocean or for any other environmental reason.

20. *Conclusions regarding Section 2.3.* The concept of "ocean acidification" is based on computer modelling of the reaction of adding carbon dioxide to water, and projecting that a large increase in atmospheric carbon dioxide will cause a small reduction in ocean pH. In effect, the pH of surface water is expected to become slightly less alkaline, and move closer to the mean pH of the oceans, but at the same time it will remain well within the range of tolerance of most marine organisms. True "acidification" of the ocean would require average pH to be reduced to below 7, which is impossible given the ocean's effectively limitless buffering capacity.

    Carbon dioxide levels in the atmosphere are controlled partly by outgassing from the oceans, and in turn the alkalinity of the surface ocean is generally consistent with the carbon dioxide content of the atmosphere. But both the oceans and the atmosphere are in constant turbulent motion, with consequent variability in gas interchange at different locations, and modulated also by differing time constants up to millennia long. Ocean pH is therefore not just a function of atmospheric carbon dioxide alone, but rather depends just as much on complex biogeochemical processes and physical changes in temperature, salinity and nutrients – a major consequence of which is that ocean surface pH varies widely from one location to another, from about 7.9 in regions of upwelling deep water to about 8.2 in areas of surface sinking.

    The idea that a small shift in ocean average pH, should it occur, will cause catastrophic environmental damage is fundamentally implausible; and the more so because the alarm is yet again centred around the projections of unvalidated computer models rather than empirical evidence.

21. ***Changes in storms and extreme events (2.4).*** Steffen notes at the outset (p. 25) that *"it is difficult to determine whether, in fact, extreme events have been increasing over the past*

several decades, primarily due to the quality and length of the data sets needed to detect significant changes in infrequent events". This leads, yet again, to the inevitability that his discussion of extreme events is mostly predicated upon the projections of regional and global climate models, despite their established lack of statistical skill (cf. Appendix D).

A second problem with the Chapter 2 analysis of extreme events is the constant confusion of correlation and causation. To argue for environmental intervention to prevent or correct a human-induced change requires, first, demonstration of a change; second, demonstration that the change is on balance deleterious; and, third, demonstration that increasing human carbon dioxide emissions have caused the change, rather than happen to coincide with it. To our knowledge, these three conditions have not yet been met for any of the environmental issues that are commonly discussed in the global warming context, including those raised in Chapter 2.

Our preference is to utilise empirical data in any search to identify changes in the power or frequency of occurrence of damaging natural events. Extreme events are a major hazard for which preparation is required, for communities have to manage them irrespective of whether they are related to climate change or simply represent the variability of the natural system.

22. One of the few certainties in a warming world is the rapid increase in surface evaporation from the warmer temperatures of the ocean surface. Archaeological and geological evidence points to a wetter Earth during the Holocene Climatic Optimum 4,000-8,000 years ago. The great inland sand dunes of Australia formed during cold, arid glacial periods and not during the warmer interglacials. Although Australia is subject to periods of drought, these events are linked to changes in ocean surface temperature patterns rather than the absolute value of ocean temperature. Current GCMs are unable to resolve the causes of these changing patterns of ocean surface temperature, and it is only for the last few years that subsurface temperature data have been available as a resource to validate the ocean component of the GCM.

    Storms and extreme events are manifestations of the thermodynamics and hydrodynamics of the atmosphere's circulation. Steffen does not demonstrate any theoretical way in which the intensity and frequency of storms and extreme events might be linked to temperature. For example, wind strength is related to pressure gradient, which can be linked to the vertically integrated horizontal temperature gradient. Measurements suggest that as global temperature rises the equator to pole temperature difference actually decreases, potentially leading to reduced rather than increased storm intensity. Other empirical evidence (Chen et al, 2006) also suggests that warming leads to increased meridional overturning in the tropics and stronger vertical wind shear, a known inhibitor of tropical cyclone formation and intensification.

23. Notwithstanding these theoretical and empirical expectations, Steffen refers to papers whose authors use recent historical data to claim an increase in the intensity or number

of tropical cyclones. The topic is one of complex debate, but nevertheless the most recent studies indicate:

- that over the short term, 2009 represents a last-35 years lowpoint in the global energy index of tropical storm power (Maue, 2009 a, b);
- that over the longer term (6,000 years), the incidence of cyclones during the 20th century in tropical Queensland was less than the long term average rate of occurrence (Nott et al., 2009);
- that more landfalling cyclones occurred in tropical Queensland during the 15th, 17th and 19th centuries (Little Ice Age) than during the warmer 20th century (Nott et al., 2007); and
- that greater tropical decadal climate variability occurred in the 19th than in the warmer 20th century (Fig. 1) (Ault et al., 2009).

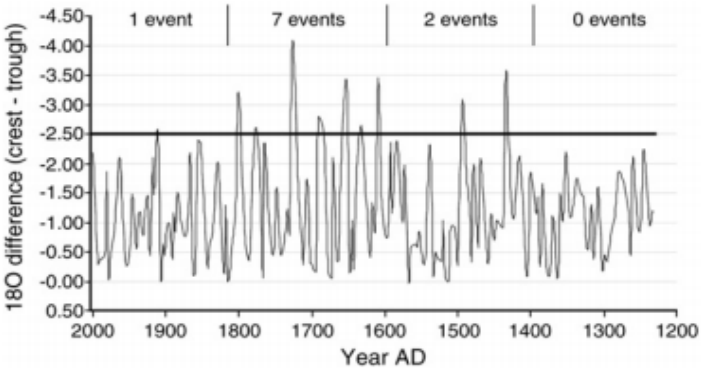


Fig. 1. Tropical storm history for the Chillagoe speleothem, North Queensland. Detrended $\delta^{18}0‰$ values in excess of –2.50‰ indicate landfalling severe cyclones. Note 7 events between AD 1600–1801 ("Little Ice Age") and only 1 event since AD 1801 (including late 19th and 20th century warming (after Nott et al, 2007).

24. ***Chapter 3.*** This chapter claims that the most important recent advances in climate science have stemmed from systems-level studies, illustrating that idea by presenting examples relevant to climate sensitivity, aerosol masking, carbon cycle feedbacks and palaeoclimate.

    What is conveniently ignored are the known examples that show GCMs to exaggerate the human perturbation of the climate system. For example, Wentz et al. (2007) identify that GCMs used in the 2007 IPCC fourth assessment underestimate the rate of increase of global evaporation with temperature by a factor of three or more. Consequently the models underestimate the increased global precipitation that global warming will bring. Similarly, Held & Soden (2006) identify that the Hadley Cell circulation of the same GCMs decreases in intensity with warming, contrary to empirical evidence over the past few decades of exactly the opposite response.

25. ***Climate sensitivity (3.1).*** "*Climate sensitivity is often defined today as the long-term temperature increase that would result from a doubling of atmospheric CO_2 concentration from pre-industrial, that is, to about 560 ppm*" (Steffen, p. 32).

It is relatively uncontroversial that a doubling carbon dioxide will in the first instance produce a warming of no more than 1^0 C (e.g., Lindzen, 1997). In nature, this figure will then be moderated up and down by various feedback loops, especially those involving evaporation, water vapour and low clouds.

The climate models used in the IPCC's 3rd and 4th Assessment Reports favour positive feedback loops due to water vapour and clouds, resulting in an estimated range of possible sensitivities between about 2.8 and 5.8^0 C for a doubling of atmospheric carbon dioxide. Steffen argues (p.34-35) that the IPCC models omit important slow feedback processes such as release of carbon dioxide from the deep ocean, and that when these are taken into account "*the eventual temperature rise in response to a doubling of CO_2 is at least 3°C and likely up to 6°C*". Such conjecture ignores the approximately 1,000 year overturning period of the thermohaline circulation, and the slow modification of carbon dioxide concentrations at the source regions (the polar seas) as the water mass slowly cycles through the deep oceans.

In contrast, independent scientists have argued that the IPCC's feedback calculations are overestimates, that clouds and water vapour exert negative feedback effects, and that a more likely climate sensitivity is between 0.3 and 1.5^0C (Idso, 2001; Schwartz, 2007; Idso & Singer, 2009, p.27; Spencer & Braswell, 2006; Spencer, 2009). Strong negative cloud feedbacks were demonstrated by Wyant et al. (2006), using superparameterization modelling techniques, and more recently, Lindzen & Choi (2009) have used empirical tests to show that the feedback from water vapour is negative, rather than positive as presumed by the IPCC.

It is clearly premature to raise global warming alarm with policymakers on the basis of presumed high climate sensitivities incorporated in climate computer models, the unvalidated projections of which are contradicted both by other modellings and above all by empirical evidence.

26. ***Aerosols (3.2).*** The tenor of Steffen's discussion underscores the many uncertainties surrounding our knowledge of aerosols on global climate. Empirical evidence clearly shows that aerosols injected into the stratosphere, for example by major volcanic eruptions, result in global cooling. The typical pattern is one of increased cooling as the volcanic aerosols disperse around the globe, followed by a return to the pre-volcanic trend as the aerosols sink to the troposphere under gravity and are washed out in rainfall. Even a major event becomes undetectable after a couple of years.

    The lower troposphere constantly receives aerosols injected into it by way of natural processes. Common sources include dust blowing over arid regions, smoke and ash from seasonal forest and grass fires, and salt and dimethyl sulfide from ocean evaporation. No accurate measurements are available regarding the relative contributions of human-caused and natural aerosol sources. To add to the uncertainty, the radiation absorbtion characteristics of atmospheric aerosols are poorly known, and even less is known about the quantification of their seasonal and regional distributions.

Finally, a recent paper by Myhre (2009) uses satellite data to show that the assumed cooling effect of aerosols in the atmosphere is up to 40% less than that used by the IPCC in their climate models, i.e. the climate sensitivity set in the models is too high. As a result, the amount of warming credited to carbon dioxide by the models is overestimated

It is therefore heroic, at best, for Steffen to claim that "*The direct cooling effect of most aerosols in the atmosphere is becoming better understood, and their quantitative effect on radiative forcing are included in the IPCC AR4 (2007)*". Rather, his frequent use of the word 'estimates' in his discussion is a reflection that no valid quantification yet exists for the impact of aerosols. Therefore, the suggestion that removal of the aerosols would lead to the elimination of Arctic sea ice and Himalayan-Tibetan glaciers is untrammelled speculation.

27. ***Carbon cycle feedbacks (3.3).*** In section 3.3, Steffen provides a brief description of some aspects of the global carbon cycle, including comments on sources and sinks and the conclusion (p. 35) that global warming may cause a "*weakening in the efficiency of natural sinks*" within which to absorb human emissions.

    In reality, the effect of human emissions on global levels of carbon dioxide and methane in the atmosphere is not well understood. No one, including the IPCC, can satisfactorily account for the observed levels, even approximately. What we do know is that:

    - Humans currently add about 8 Gt of carbon per year to the atmosphere;
    - The atmosphere contains about 780 Gt., of which each year it exchanges ~90 Gt with the oceans and another ~100 Gt with plants;
    - Thus about 25% of the atmospheric carbon is turned over each year, and the observed decrease in carbon-14 after the cessation of atmospheric nuclear bomb tests in 1963 confirms that the half-life of carbon dioxide in the atmosphere is less than 10 years (Robinson et al., 2007);
    - The ocean has about 38,000 Gt of carbon dissolved in it, some of which is lost each year in the formation of limestone. The vapor pressure of CO_2 above the ocean rises with ocean temperature; the oceans eventually absorb any CO_2 above that vapor pressure;
    - The residence time of carbon dioxide in the atmosphere, at around 5 years, is much shorter than assumed by the IPCC, which suggests that only about 5% of the rise in carbon dioxide in the last hundred years is derived from human sources, the remainder being natural (Segalstad, 1998; Essenhigh, 2009).

    In light of these numbers and rates of carbon turnover, the small observed trends inabsorption of carbon dioxide attributed to humans are not significant. In the long run, when equilibrium is achieved, human emissions will have an insignificant effect on the amounts of carbon dioxide and methane in the atmosphere and oceans. Though we know

little about the transient effects of human emissions, there is little reason to suspect that they are dangerous; indeed, the effect of enhanced carbon dioxide on plant life is clearly beneficial.

28. Steffen also canvasses the dangers of a surge from melting permafrost should Arctic warming resume, yet historical and geological evidence clearly discounts this as a problem. In the medieval warm period, when global temperatures were a little higher than currently, people were buried in graves in what is now permafrost—so there were areas not permafrost then that are permafrost now. It is clear, therefore, that the warming associated with the Mediaeval Warm Period must have caused melting of permafrost, and release of methane, that did not lead to runaway warming.

29. ***Palaeoclimate studies (3.4).*** An essential part of understanding climate change is the study of the patterns of past, ancient climate change. The context for making adequate judgements about contemporary change is provided by the study of climate records that extend back for at least hundreds of thousands of years. Such records shows that there is nothing unusual at all about either the rate or magnitude of warming that occurred during the late 20th century (e.g., Carter, 2008).

30. Steffen commences his section on past climates unpropitiously by referring, first, to the results of a modelling study (Otto-Bleisner et al., 2009), followed by a commendation of the discredited Mann et al. (1999) "hockey stick" depiction of northern hemisphere temperatures (see main text, section E7) and a call for the development of a Southern Hemisphere equivalent. Steffen also uses information from the extended ENSO index record back to 1550 of Braganza et al. (2009), and a study of climate patterning in coral records from the eastern Indian Ocean since the mid-Holocene (6,500 ybp; Abram et al., 2007), to infer that "*the drought in south-east Australia is probably linked, at least partly, to climate change* ….".

Whilst the studies cited provide important information on the variability of ENSO and Indian Ocean Dipole activity over the more recent past, on their own they are inadequate as a context for Holocene (last 10,000 years) climate change, and they certainly do not sustain the conclusion that the current Australian drought is a result of human-caused global warming (cf. Lockart et al., 2009).

31. In many places around the world, the early Holocene, termed the "climatic optimum", was 1-2^0 C warmer than today, one major environmental consequence of which was the melting of the sea ice in the Arctic Ocean (Fisher et al., 2006). A recent study by Moros et al. (2009) shows that the southern Australian margin experienced reduced ENSO conditions at this time, as a result of a northward shift in oceanic frontal systems (Fig. 1). In addition, Moros et al.'s study shows the presence of a regular 1500 year climatic

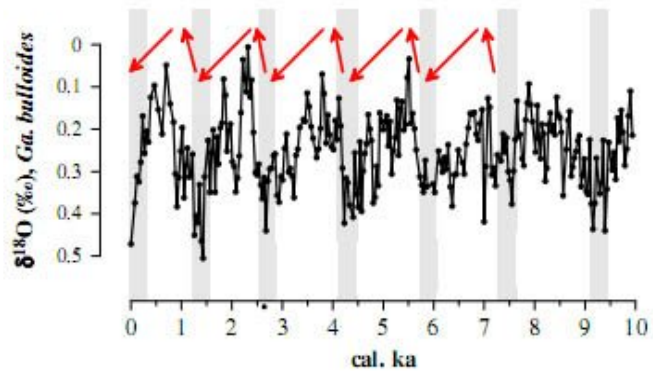


Fig. 2. Holocene climatic history represented by oxygen isotope analysis (a temperature proxy) of a marine core from Murray Canyon, southern Australia. Note the subdued record in the early Holocene, which relates to reduced ENSO variability, followed later by a marked ~1,550 yr cyclicity of climatic warming and cooling of possible solar origin (after Moros et al., 2009).

cycle of possible solar origin (cf. Singer & Avery, 2008) within which the warming at the end of the 20th century (not captured by the core) represents a regular sinusoidal warm peak, and is therefore entirely unfearsome. That unusual Southern Hemisphere warming did not occur at the end of the 20th century is also confirmed by the best extended tree-ring series available, three from Tasmania and South America (Cook et al., 1996) and one from western South Island, New Zealand (Cook et al., 2002) (Fig. 3).

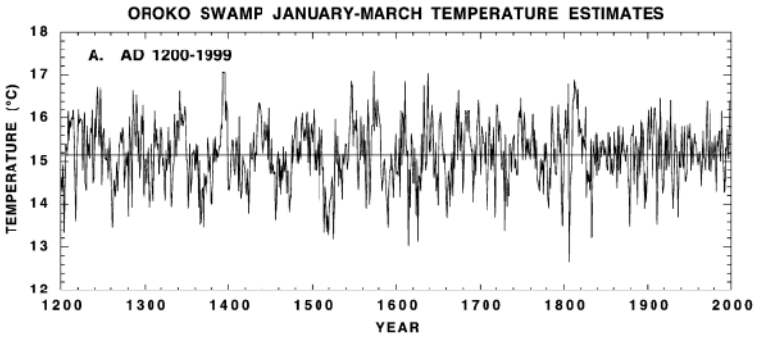


Fig. 3.800-year long tree ring reconstruction of summer temperatures for western South Island, New Zealand, using living and fossil specimens of silver pine. Note lack of unusual warming in the 20th century (after Cook et al., 2002).

Clearly, knowledge of such mid-range climatic cyclicities is vital for the correct interpretation of late 20th century warming, yet neither Steffen's July 9 report nor the IPCC's climate models take serious account of them.

32. Polar regions are sensitive indicators of climate change, and their ice-core records provide particularly important, extended proxy records of geologically recent climate change that are superior to tree-ring records.

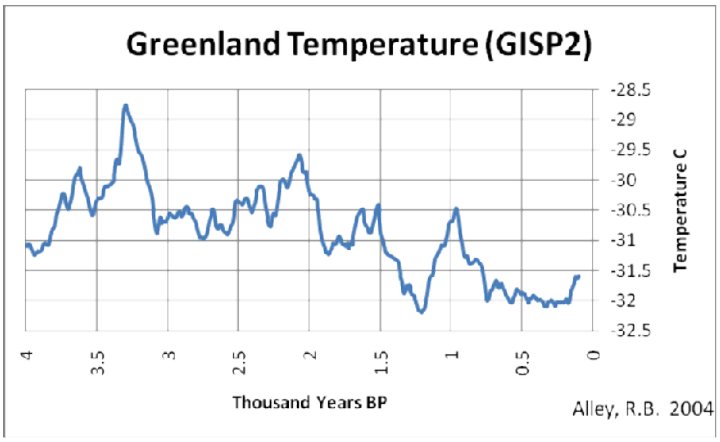


Fig. 4. Greenland temperature for the last 4,000 years, reconstructed from the GISP2 ice core. A millennial rhythm is apparent, with warmer temperature peaks at 3,700, 1,900 and 1,000 years ago.

More infrared radiation is emitted to space over polar regions than the local absorption of solar radiation. The local energy balance is maintained because the atmospheric circulation is continually transporting energy from the tropics to the polar regions. As a consequence, the temperatures over polar regions are warmer than they would be under purely local radiation balance. Therefore, variations in the intensity of the atmospheric circulation will lead to variations in temperature over polar regions: as the circulation increases and there is more rapid transport of energy then polar temperatures rise; if the atmospheric circulation diminishes there is a slowing of transport and polar temperatures cool.

The response of polar temperatures to atmospheric circulation helps explain why polar temperatures are much more variable than those of the tropics and middle latitudes. For example the magnitude of polar temperature variation over the glacial cycle is about 15^0C, whereas for the tropical oceans it is only about 3^0C. Other important conclusions from ice core data are discussed in section E6 of the main text.

33. ***Chapter 4.*** This chapter stresses the importance of studying climate change within the context of Earth Systems Science, including the effects of human activity. In this context, Steffen recommends that detailed attention be paid to developing a "*seamless prediction from weather to climate*", to studying the "*tipping points*" of the climate system, and stresses the importance of including human impacts in earth system models.

34. In discussing the first of these issues, Steffen claims (p. 41) that "*Global climate models can predict the state of the climate system a century into the future, given external forcing factors*", and that "*the missing scale in current modelling expertise is from a few years to a few decades*".

    It may be that writing "predict" rather than "project" represents an unconscious slip, but even with that word corrected the general tenor of these remarks is disturbing because it suggests that Steffen believes that GCMs are able to make valid climate predictions. This impression is reinforced by his independent statement on p. 34 that "*over shorter timeframes of less than a century or two, they* [global climate models] *are very reliable for projecting changes in global mean temperature*".

    On the contrary, Steffen's belief conflicts head-on with the realities of modern weather forecasting and climate modelling practice. A seamless prediction from weather to climate comes to an abrupt halt after a few days only, and "predictions" a week in advance are currently considered to be no better than early warnings. This is because computational rounding errors propagate rapidly through the simulation, and render predictions worthless. In addition, no ability currently exists to simulate the processes of internal climate variability such as ENSO, and a precise knowledge of the external forcing processes on climate remains lacking.

    The point cannot be overstressed that whilst weather forecast models are validated predictive tools on a scale of a few days, GCMs, for all their fine heuristic value, are not.

This was the precisely the reason that we concluded in paragraph E11.4 (main text) that GCM outputs "*are highly misleading scenarios to provide to policymakers"*, a point we now repeat.

35. This important matter apart, we agree with Steffen that the topics discussed in Chapter 4 are relevant to understanding climate change, and that the integrated systems approach is an important one. But, in studying matters at the system level, sight must not be lost of the importance of rigorous disciplinary studies of the component parts of the system.35. Finally, we should always remember the IPCC's adjuration (3rd Assessment Report, Section 14.2.2.2, p. 774) that "*In climate research and modelling, we should recognize that we are dealing with a coupled non-linear chaotic system, and therefore that long-term prediction of future climate states is not possible*".

    The solution to global environmental problems, therefore, is never going to be provided by the construction of ever more complex deterministic computer models (cf. Appendix D, last paragraph), however well integrated they might be, but by careful observational, statistical and theoretical studies using the time-honoured and sound techniques of empirical scientific investigation.

36. ***OVERALL CONCLUSION.*** The July 9 report by Professor Steffen draws on many of the same arguments for dangerous human-caused global warming that were advanced by Richardson et al. (2009) in their report from the *ad hoc* climate meeting in Copenhagen in March. These arguments are uncompelling.

    In essence, the July 9 report reveals:

    - an over-reliance on unvalidated computer model projections;
    - a failure to take full account of natural climate variability, and known short to mid-length climatic rhythms, to explain 20th century temperature changes;
    - an absence of any new empirical data in support of the concept of dangerous global warming caused by human carbon dioxide emissions; and
    - a failure to consider many recent papers and discussions containing evidence that conflicts with warming alarmism.

    In consequence, many of the conclusions of ***Climate Change 2009: Faster Change & More Serious Risks*** are misleading; and they are unsuitable, if not actually dangerous, as a basis for the development of public climate policy.

Appendix I – Brief biographies for the science advisers to Senator Fielding

Professor Robert (Bob) M. Carter – Geologist/Environmental Scientist

Bob Carter, Hon. FRSNZ, is an Adjunct Research Fellow at James Cook University (Queensland). He is a marine geologist and environmental scientist with more than 40 years professional experience, and holds degrees from the University of Otago (New Zealand) and the University of Cambridge (England). He has held tenured academic staff positions at the University of Otago (Dunedin) and James Cook University (Townsville), where he was Professor and Head of School of Earth Sciences between 1981 and 1999. Bob Carter's current research on climate change, sea-level change and stratigraphy is based on field studies of Cenozoic sediments (last 65 million years) from the Southwest Pacific region, especially the Great Barrier Reef and New Zealand, and includes the analysis of marine sediment cores collected during ODP Leg 181. Carter has wide experience in management and research administration, including service as Chair of the Earth Sciences Discipline Panel of the Australian Research Council, Chair of the national Marine Science and Technologies Committee, Director of the Australian Office of the Ocean Drilling Program and Co-Chief Scientist on ODP Leg 181 (Southwest Pacific Gateways). Bob has acted as an expert witness on climate change before the U.S. Senate Committee of Environment & Public Works, the Australian and N.Z. parliamentary Select Committees into emissions trading and in a climate change briefing in parliament house, Stockholm. Carter was also a primary science witness in the U.K. High Court case of Dimmock v. H.M.'s Secretary of State for Education, the 2007 judgement from which identified nine major scientific errors in Mr Al Gore's film "*An Inconvenient Truth*".

Dr David Evans - Carbon Modeller

David Evans worked for the Australian Greenhouse Office (now the Dept. of Climate Change) from 1999 to 2005, building FullCAM, a leading carbon accounting model that estimates carbon in plants, debris, mulch, soils, and forestry and agricultural products. (http://www.climatechange.gov.au/ncas/activities/modelling.html). FullCAM is used to calculate the land-use portion of Australia's Kyoto Protocol compliance, calculating carbon emissions and fixations from each 25 meter by 25 meter plot across Australia, using geographical maps of climate and soils data and maps of land cover changes derived from NASA satellite imagery. Evans is a mathematician and engineer, with six university degrees including a PhD from Stanford University in Electrical Engineering. The evidence supporting the idea that carbon dioxide emissions were the main cause of global warming dropped away from 1999 to 2003, and by 2007 had reversed itself. The evidence unequivocally shows that the IPCC's 1984 estimates of future temperature increases (which they hold almost unchanged in 2009) were exaggerated at least twofold or threefold (for example, http://sciencespeak.com/MissingSignature.pdf). During this period Evans moved from being an alarmist to a sceptic.

Associate Professor Stewart Franks – Hydro-climatologist

Stewart Franks is an Associate Professor of Environmental Engineering at the University of Newcastle. His PhD thesis addressed issues of uncertainty in modelling land surface – atmosphere interactions for atmospheric/climate models. Stewart's research interests primarily centre on the quantification and reduction of uncertainty in environmental modelling and hydro-climatic risk assessment. He is currently President-elect of the International Commission on the Coupled Land-Atmosphere System, a commission of the International Association of Hydrological Sciences.The remit of the commission is to organise symposia and workshops on dealing with hydrological variability and the interactions between the land surface and the atmosphere. A special focus is directed toward building knowledge and capacity in developing countries. Stewart has edited a number of books documenting examples of historic hydro-climatic variability across the globe. He is perhaps guilty of adopting a more philosophical approach to climate modelling than most. Stewart prefers to believe that if we don't understand the physics of climate, then we might be premature in building models of it and blindly believing their colourful output. He is also a firm believer that the politicization of climate science by politicians, scientist-advocates and environmental pressure groups is a particularly dangerous development in our modern technological society.

Mr William Kininmonth – Meteorologist/Climatologist

B.Sc (UWA), M.Sc (Colo State U), M.Admin (Monash U). William Kininmonth is a consulting climatologist with more than 45 years professional experience. He worked with the Australian Bureau of Meteorology for 38 years in weather forecaster, research and applied studies; for 12 years until 1998 was head of its National Climate Centre. He has worked closely with the World Meteorological Organization since 1982 as Australia's delegate to the Commission for Climatology, in expert working groups, lecturing at regional training seminars, and later as a consultant. He has been a member of Australian delegations to international conferences and intergovernmental negotiations relating to climate, including for the UN's Framework Convention on Climate Change (1991-92). William Kininmonth participated in the Australian Public Service Executive Development Scheme (1977) and was leader of an Australian Government project of assistance to the Meteorology and Environmental Protection Administration of the Kingdom of Saudi Arabia (1982-85). William Kininmonth is author of the book, *Climate Change: A Natural Hazard* (2004, Multi-Science Publishing Co, UK).

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