April 24, 2011

Climate Change 2010: Science, Risks, Responses

Briefing paper for MCCC, Canberra, Nov. 10, 2010

Professor Will Steffen

Commentary

by

Carter, R.M., Evans, D., Franks, S., Kininmonth, W. & Moore, D.

On November 10, 2010, Professor Will Steffen provided a scientific briefing for the Multi-Party Committee on Climate Change (MPCC) in Canberra in which he underlined his belief in (i) a high risk of dangerous global warming caused by human carbon dioxide emissions, and (ii) the urgent need for discriminatory policy action against such emissions.

Having considered Professor Steffen's presentation and references carefully, we have come to precisely the opposite conclusion. Which is (i) that there is no proven threat of dangerous warming of human origin, (ii) that costly attempts to cut Australian carbon dioxide emissions will cause no change in future climate, and (iii) that to the considerable degree that the science of climate change remains uncertain, the appropriate policy setting should be one of preparation for and adaptation to all climate events and hazards as they occur.

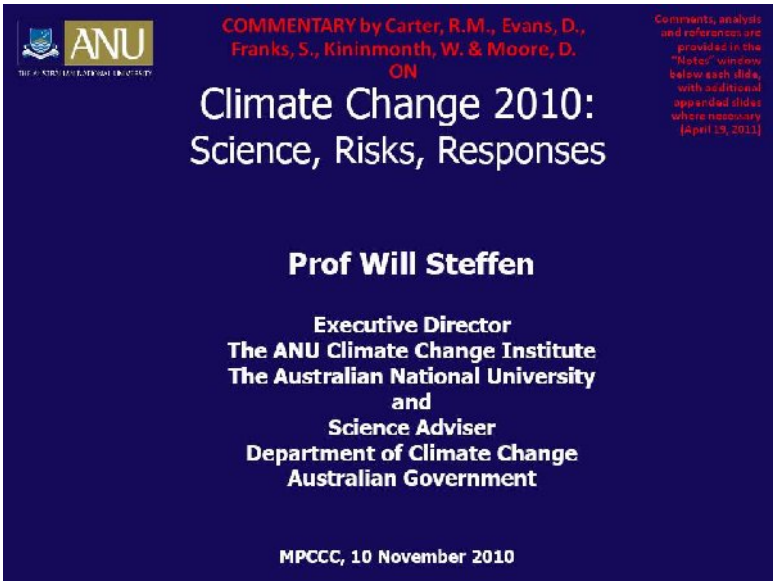
We provide comments, analysis and references regarding Professor Steffen's presentation below each slide (SLIDES 1-18). We have appended extra slides where they were needed to exemplify or underline particular points (SLIDES 19-35).

Finally, we note that the arguments for urgent action on a carbon dioxide tax (or ETS) put by Professor Steffen to the MCCC are, unfortunately, mostly derived from reports by the Intergovernmental Panel on Climate Change (IPCC). This United Nations body is made up of government officials, and its reports are authored by persons selected by the IPCC and supported by their respective governments. There has never been a comprehensive independent scientific review of any IPCC report by a member government or independent audit body. The main published comprehensive independent review has been "*Climate Change Reconsidered: The Report of the Nongovernmental International Panel on Climate Change*"*. This independent review, together with many shorter publications that are critical of IPCC procedures and results, does not support the IPCC's alarmist conclusions

These same IPCC arguments, which are now significantly out of date, were also used by Professor Steffen in July, 2009, when he provided advice to Minister Wong during her discussions on the emissions trading bill with Senator Fielding and his independent scientific advisors. Professor Steffen's paper was audited on that occasion also, and similarly found as wanting**.

Singer, S.F. & Idso, C., 2009. Climate Change Reconsidered. Nongovernmental International Panel on Climate Change, 880 pp. *http://www.nipccreport.org/*.

** Carter, R.M., Evans, D., Franks, S. & Kininmonth, W. 2009. Minister Wong's Reply to Senator Fielding's Three Questions on Climate Change – Due Diligence. Item 7 at *http://joannenova.com.au/global-warming/the-wong-fielding-meeting-on-global-warming-documents/#comments.*



SLIDE 1: TITLE SLIDE

SUMMARY COMMENTS ON THE WHOLE PRESENTATION

This presentation was delivered to the Multi-Party Climate Change Committee in Canberra on November 10, 2010 (see title slide, above).

The presentation:

(i) Contains no substantive new science, and fails to show that dangerous human-caused global warming is occurring;

(ii) Fails to cover recently published papers that provide evidence that dangerous warming is not occurring;

(iii) Comprises a rehash of many old and invalid IPCC arguments, the deficiencies of which have been pointed out many times by independent scientists (e.g., NIPCC - Singer & Idso, 2009); and

(iv) Contains similar arguments and graphics to a paper prepared by Professor Steffen as advice for Climate Minister Penny Wong in July, 2009, in response to questions she was asked by Senator Steve Fielding; that paper was rigorously audited by four independent scientists (Carter *et al*., 2009), who found:

> *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.

Minister Wong, and the government, subsequently chose not to implement any of this advice.

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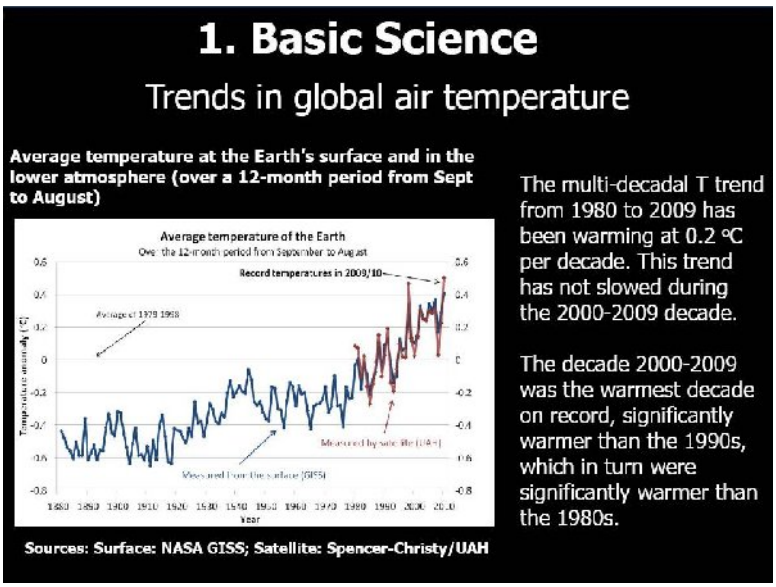
Singer, S.F. & Idso, C., 2009. Climate Change Reconsidered. Nongovernmental International Panel on Climate Change, 880 pp. *http://www.nipccreport.org/.*



SLIDE 2 - COMMENTS

This graphic is designed to convey a false impression that dangerous global warming is occurring. The precision suggested by the temperature scale belies the limited accuracy of the actual data estimates. Note that the length of record is only 130 years (4 climate data points) and that no error bars are shown. In reality, the alleged change over a century and a half is much less than the variation across any urban area on any day.

1. An independent analysis by Climatic Research Unit (CRU) staff of their temperature database for January 1969 (which is the one used by the IPCC) showed that for nearly all parts of the globe the sampling error on temperature estimates is more than 1° C, and in many places more than 3° C (Brohan *et al*., 2005; see SLIDE 19). This error implies that the HadCRUT3 temperature record has to attain a warming anomaly of $+0.9^{o}$ C before statistically valid warming since 1969 can be demonstrated.

The earlier parts of the graph, say pre-1950, are based on historic measurements where the limited number of measuring stations at the time means that there is an even greater sampling error than the estimates for 1969.

2. The later parts of the graph, especially post-1945, represent times of rapid population growth and urbanisation. The mainly urban sites that make up the global temperature record incorporate these local human warming effects into the record, and thereby bias the global statistic. (Christy *et al*., 2006, 2009; Pielke *et al*., 2009; Walters *et al*., 2007).

3. Unusually, and for reasons not explained, the graphic is based upon 12-month averages from September to August of the following year. Use of the standard calendar year would give different outcomes, because of the sensitive dependence of conclusions on the chosen interval.

The generally warmest years of recent times are 1998, 2005 and 2010. The GISS data set has 2005 and 2010 as equal warmest at 0.63^{o}C above the 1951-1980 Normal, with 1998 only 0.56^{o}C above.

IPCC has consistently used the global surface data set compiled by the UK Hadley Centre and University of East Anglia. This has 1998 as the warmest year, at 0.55^{o}C above a 1961-1990 Normal, followed by 2005 at 0.48^{o}C and 2010 at 0.46^{o}C. Supporting 1998 warmth, the MSU satellite data for the lower troposphere has 1998 as the warmest year at 0.43^{o}C above its Normal, followed by 2010 at 0.41^{o}C and 2005 at only 0.25^{o}C.

Thus the strong impression of continued recent warming conveyed by Professor Steffen's chosen graph is at odds with the pattern displayed by the two other, and most widely used, indicators of global temperature change. In reality,and as agreed by CRU's Professor Phil Jones in a BBC interview, "*from 1995 to the present there has been no statistically significant warming*".

4. When updated to March 2011, current global temperature graphs show a recent rapid fall in temperature: 0.5^{o} C cooling on the UAH satellite record (see SLIDE 20), and 0.45^{o} C cooling in the GISS temperature record. These falls take the temperature back towards and beyond the average for 1979–1998, and, when plotted, this destroys the impression of currently increasing warming. Furthermore, the state of the Southern Oscillation Index strongly suggests that global temperatures will fall even further in the next six months (cf., McLean *et al*., 2009).

Rather than still increasing, as implied by the graph, global average temperature is now falling, with data suggesting that 1998 was the warmest year of recent times (Liljegren, 2011a, b; see SLIDE 21). At the same time, atmospheric carbon dioxide concentration has increased by 5%.

The statement that a rate of 0.2^{o} C/decade warming has been maintained from 1980 to 2009 therefore cannot be sustained, and is at best misleading.

5. The statement that "the decade 2000-2009 was the warmest decade on record" is a deliberately misleading piece of scientific trivia. The "record" referred to is the instrumental record of the last 130 years only. This is an inadequate period of record over which to make meaningful statements about climate change. What is more, the magnitude of the warming referred to is also small, being less than a 1°C rise over 130 years, which is well within natural variation and has produced no known harmful effects.

Records of an adequate length, for example for the last 5,000 years of a Greenland ice core (Alley, 2004; see SLIDE 22), show that the late 20th century warm peak corresponds to a predictable temperature high on a well known millenial temperature cycle (Avery & Singer, 2007; Loehle & McCulloch, 2008; see also SLIDE 23). It is therefore no more surprising that temperatures were warm at the end of the 20th century than it is that, during the annual seasonal cycle, temperatures are warmest in late summer.

6. IN SUMMARY, Slide 2 is a misleading and inadequate basis on which to assess whether dangerous temperature change is occurring today.

In the proper context of recent climate data series, it is clear:

(i) That we currently live during the later stages of a NATURAL post-Little Ice Age warming that began about AD 1700 (SLIDE 23), and

(ii) That the two most accurate estimates of temperature change available for the last 50 years (satellite measurements, SLIDE 20; weather balloon radiosonde measurements, see SLIDE 24) indicate that the small amount of global warming recorded since 1958 was not unusual and can be associated with natural climatic steps (1977, Great Pacific Climate Shift – MacPhaden and Zhang; 1998, El Nino Shift) rather than manifesting a long-term dangerous trend forced by increasing carbon dioxide levels.

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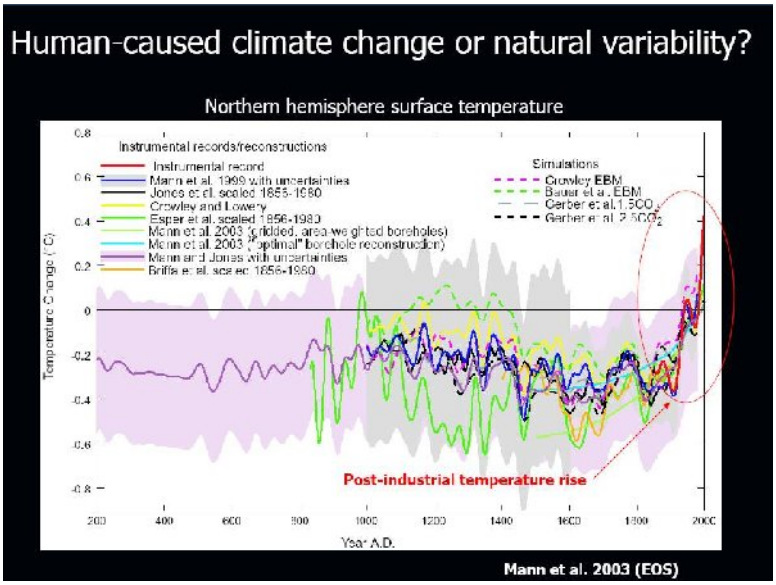

SLIDE 3 - COMMENTS

This is another misleading graphic which purports to show unusual global warming after the industrial revolution, and especially in the late 20th century. Termed a "spaghetti diagram", it displays a number of different reconstructions of temperatures over the last 1,000 years based largely upon the statistical analysis of tree ring data series. Such data are not a reliable basis for calculating historical estimates of temperature, and the best available reconstructed temperature record provides an entirely different perspective (SLIDE 23).

In addition to changing with prevailing temperature, tree growth varies with rainfall, cloudiness and carbon dioxide concentration. For this reason, varying growth rates cannot be associated unequivocally with temperature variations. In addition, the sensitivity of tree growth to temperature variation is much less than that of routine meteorological instruments.

Ways in which this graph is misleading or incorrect include the following:

1. The graph is for the northern hemisphere only, not global.

2. The junction on one graph of various proxy estimates of temperature (prior to 1900) together with instrumental measurements (post-1900) is unacceptable statistical practice in general.

In this particular case, it is scientifically unsound to append a relatively high precision temperature record to the end of a proxy palaeo-temperature record of dubious quality, in order to make comparative claims about the recent (instrumental) warming trend.

3. The various proxy records shown include the famous "hockey stick" graph of Mann *et al.* (1998, 1999), which has been discredited by other scientific papers and by a US congressional investigation (McIntyre & McKitrick, 2003, 2005; Wegman, 2007).

4. For the period that they overlap, some proxy records show a decline in temperature in the late 20th century (not plotted) which directly conflicts with the instrumental measurement of rising temperature (which is plotted).

That the proxy technique is unreliable when tested against actual temperature data is well known, and is referred to in the scientific literature as the convergence problem (e.g., D'Arrigo *et al*., 2008). The technique of deliberate truncation of the proxy measures at a point prior to their conflict with measurements was revealed by the Climategate emails. Accomplished by the tightly networked Mann *et al*. group of authors, this deceipt was known to its practitioners as the "hide the decline"

trick. A recent example of the gross misrepresentation that results has been provided by McIntyre (2011) (see SLIDE 25).

5. We only have a reliable record of GLOBAL temperature since 1979 (satellite measurements; SLIDE 20), a period which represents but 1 climate data point. That period can perhaps be extended to 2 points by consideration of the next most accurate temperature record, that from weather balloon radiosondes (available since 1958; SLIDE 24). For the weather balloon data, however, calibration differences between manufacturers can lead to inaccuracies, and, as for the thermometer datasets, the observation network covers only land and a few isolated islands.

However, and irrespective of whether you consider the radiosonde data or not, the accurate instrumental record of global climate is one of weather rather than climate. Little can be said about climate change on the basis of only these, and other slightly longer (thermometer) instrumental records.

6. Estimates of past local temperature over climatically meaningful time periods (at least many thousands of years) are based upon the relative variation of proxy records that represent paleoclimate at individual locations. Many such records indicate that within the last 2,000 years the Mediaeval Warm Period was warmer than the temperature of the late 20th century, including the El Nino-driven peak of 1998 (SLIDE 23). In support of this, frozen wastelands in Greenland (one of the most climatically sensitive regions on Earth) today occupy the locations of formerly productive Viking farming settlements, and such relative warmth ~1,000 years ago is supported by temperature estimates from Greenland ice cores (SLIDE 22).

The Late 20th Century Warm Period, and before it the Mediaeval, Roman, Minoan and Egyptian Old Kingom warm periods, are the manifestation of a well documented climate cyclicity at millenial time scale (Avery & Singer, 2008).

7. IN SUMMARY, the mild late 20th century warming was neither alarming nor unusual, because both in magnitude and rate it falls well within the bounds of known earlier natural climatic variation.

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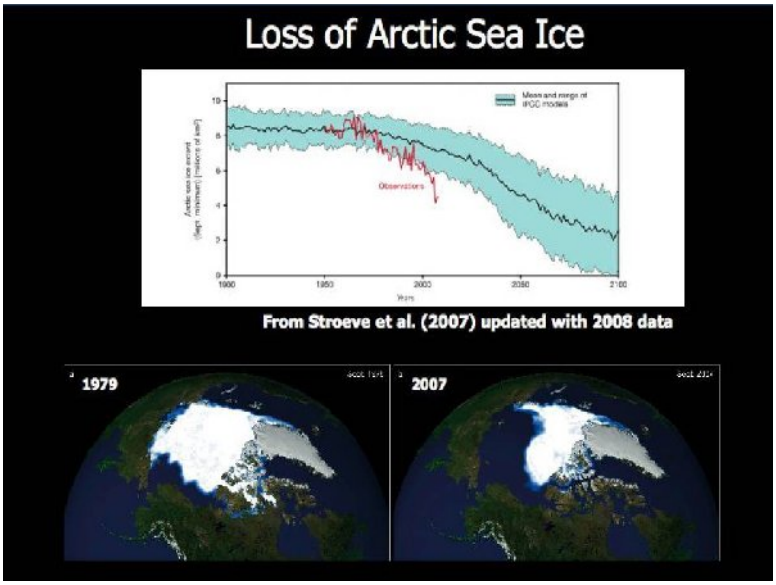

SLIDE 4 - COMMENTS

The information represented in this slide is both partial and incomplete.

1. Sea-ice area and thickness are not controlled by air temperature alone, but are also strongly affected by wind and ocean currents and temperatures.

2. Instrumental measurements of Arctic sea ice extent are only available from satellite observations since 1979. These measurements display an annual cycle of variation over a range of about 10 million km^2 (13-15 million km^2 maximum area, to 3-5 million km^2 minimum). Since 1979, there has been an overall decline in Arctic sea ice area, though not in the range of variation (see SLIDE 26).

At the same time that the Arctic sea-ice was declining, the area of ice around Antarctica has in some recent years expanded beyond the long term average, and in 2011 remains near the average (SLIDE 26). That the net global area of sea-ice shows a slight decline therefore exclusively reflects Arctic change.

Global warming theory predicts that BOTH polar regions should be getting warmer, hence these data conflict with that theory, and suggest that the change in area of Arctic sea-ice may be caused by factors other than global temperature.

3. Prior to satellite observations, historical records document large natural variations in Arctic sea ice over multi-decadal timescales. In particular, significant warming commenced about 1918 and persisted into the 1940s, as follows:

- Major warming commenced around Spitzbergen about 1918 (Ifft, 1922);
- In the 1930s, a fleet of 160 Soviet freighters operated a summer schedule in the eastern Arctic Sea; and
- The Canadian schooner *St Roch*, a sail-powered wooden schooner, was the first vessel to navigate the North West Passage, making from Halifax to Vancouver within a single season (86 days) in 1944.

The recent Arctic sea-ice decline must be considered in the context of these and other longer term natural variations. For example, in the early Holocene (10,000 years ago) the Arctic Ocean was largely ice free (Fisher *et al*., 2006; see SLIDE 27). Perhaps we should add, too, that none of these changes in sea-ice area resulted in changes in sea-level.

4. The upper figure in Slide 4 shows that the actual ice trajectory in the Arctic Ocean now lies well outside the projections of the IPCC's climate GCMs. In other words, and as for their atmospheric equivalents, the model projections are wrong.

5. Finally, and disturbingly, though this slide presentation was made in 2011, the red line of "observations" of sea-ice area is truncated about 2007, a year of particularly reduced area which has recovered since. As for Slide 2, this manipulation of the graphic is clearly an attempt to "guide the eye" to an alarming conclusion that is not justified by the latest facts.

6. IN SUMMARY, though there is an established gentle melting trend for Arctic sea-ice since around 1990, the trend is not global and falls well within earlier natural changes in sea-ice cover, and there is no evidence that the ice retreat has been caused by human carbon dioxide emissions.

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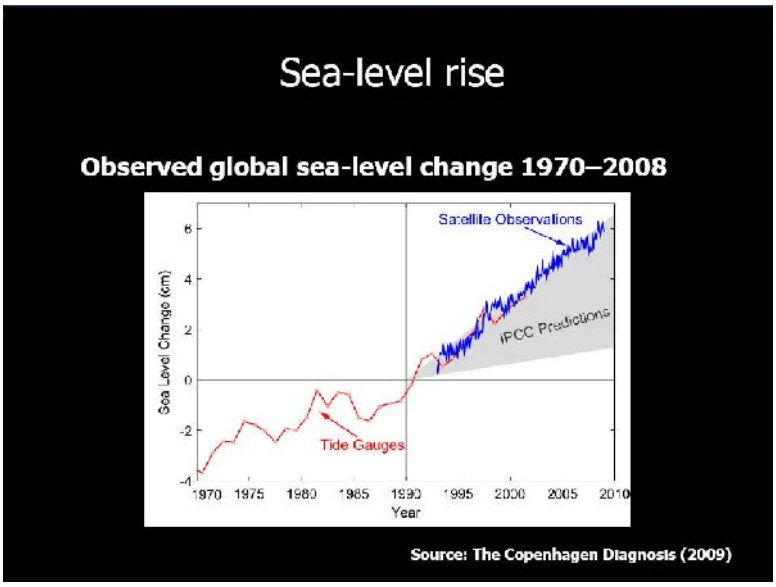

SLIDE 5 - COMMENTS

This graphic provides a poor representation of the record of historic sea-level change as measured by tide gauges, and contravenes good statistical practice by combining it with measurements made by the entirely different technique of satellite radar altimetry after 1993.

1. Tide gauges measure local relative sea-level change, which is change with respect to the local shoreline. An estimate of absolute sea-level rise from such records requires that they are corrected for vertical motion of the substrate, which may be either up or down and is caused by geologic processes like compaction subsidence, isostatic sinking or rebound and episodic tectonic movement. These processes are difficult to measure accurately, and poor knowledge of them can confound the interpretation of sea-level change measured with tide gauges.

Despite such problems, the corrected records from some of the world's best and longest maintained tide gauges indicate an average rise in global sea-level over the last 100 years of ~1.7 mm/yr (17 cm/century; see SLIDE 28).

2. In contrast to tide gauge measurements, satellite radar-ranging measurements of sea-level yield very precise results, including the ability to track short-term regional variations such as those caused by El Niño and La Niña events in the Pacific Ocean. However, the satellite measurements require calibration to a reference surface, which is accomplished using tide gauge data and correcting for glacio-isostatic rebound using a mathematical model of the earth's shape. Correction for other regional tectonic movements is not yet incorporated into the satellite sea-level estimates.

Satellite sea-level data is available only since 1993. It records a rate of rise of ~2.5-3.5 mm/yr (see SLIDE 29), i.e., a higher rate than that indicated by the tide gauges, and exhibits deceleration. The trend rate of rise between 1993 and 2000 is 3.14 mm/yr, whereas since 2001 the rate is 2.34 mm/yr; this represents a 25% reduction in the rate of recent sea-level rise.

3. The reason for the differences between the tide gauge and satellite records (see SLIDE 30; Houston & Dean, 2011a) is not fully understood, but may relate to some combination of inadequate calibration of the satellite records, dynamic oceanographic factors and inadequate correction of the tide gauge records for vertical substrate movement.

4. Today's sea-level is 1-2 metres lower than that reached during the last interglacial about 125,000 years ago, so modern variations in level of a few tens of cm should not be considered as either unusual or problematic.

5. IN SUMMARY, there are no convincing data from any source that indicate significant changes in the behaviour of global sea-level from that which characterised the 20th century pattern - which consisted of an oscillatory long-term rise at an average rate of 1.7 mm/yr (e.g., Holdgate, 2007; Houston & Dean, 2011b).

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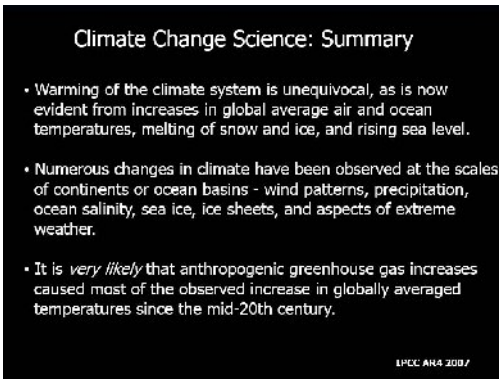

SLIDE 6 - ALTERNATIVE SUMMARY OF CLIMATE CHANGE SCIENCE

The Summary points in this slide are either misleading or untrue.

- The hypothesis of dangerous global warming caused by human-related carbon dioxide emissions rests on two wrong assumptions: (i) that prior to industrialisation Earth's climate was stable and equable; and 2) that changes have eventuated since industrialisation that are unprecedented. The pre-industrial information presented by Professor Steffen is selective, misleading and fails to detail the high degree of variability of climate in pre-industrial times.
- The chain of reasoning used by IPCC and government climate scientists is that the direct warming caused by doubling carbon dioxide (about 1° C, as easily calculated from non-controversial physics) is in nature amplified threefold by water vapour feedbacks associated with extra evaporation. The existence of such amplification was a speculative guess made around 1980, and has since been disproven by more modern observations made using radiosonde and satellite data (Linzen & Choi, 2009, 2011; Spencer & Braswell, 2010).

  Because one link in the chain used to make the claim that humans caused the warming is faulty, the conclusion is faulty. The IPCC claim that the observed warming is nearly all accounted for by carbon dioxide-forced warming and its amplification, but the non-existence of the envisaged amplification process indicates that other more powerful forces must be at work to account for the observed warming.
- In any case, and in their proper context, 20th century variations in climate were not unusual and fall well within the range of natural variability on longer timescales. Earth is now cooler than it was during the Holocene Climatic Optimum (~8,000 years ago), which itself was again significantly cooler and had lower sea-levels than the last interglacial (~125,000 years ago). Moreover, in the context of the pre-industrial "Little Ice Age" (14th-19th centuries), and the even more horrendous Last Glaciation (prior to 17,000 years ago), our current milder and wetter climate should be unequivocally welcome.

An alternative, and more accurate, summary of climate change science would read:

- During the 20th century, global average temperature exhibited multi-decadal oscillations of warming and cooling, which summed to a cumulative mild warming of about 0.7^{o} C. by 1998. Since 2001, global average temperature has declined (SLIDE 21) despite a 5% increase in carbon dioxide emissions.
- There is no convincing evidence that any modern changes in global air or ocean temperatures (including the cumulative 0.7^{o} C warming in the 20th century), melting snow and ice, floods or rising sea-level fall outside the range of natural variation, or are being forced directly by human factors (e.g., Bouziotas *et al.*, 2011).
- Use of the phrase "very likely" in the statement about hypothetical human-caused global warming follows the practice of the IPCC's 4th Assessment Report, and is asserted to indicate a greater than 90% probability. There is no scientific or statistical analysis that justifies such a conclusion.

IN SUMMARY, The idea of dangerous global warming caused by industrial carbon dioxide emissions is a testable hypothesis. It is tested by the facts related above, and fails.

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SLIDE 7 - COMMENTS

This slide is unrelated to the anthropogenic climate change issue, and appears designed solely to raise unnecessary alarm about coastal flooding.

1. Brisbane airport is knowingly constructed at the extreme edge of a flat coastal plain, indeed its seaward end is fringed by mangroves, as clearly visible on the photograph. Flood or king tide events such as that illustrated in the right hand photograph are therefore entirely to be expected. All coastal developments, including airports, must take account of potential storm surges that might occur at high spring tide or are caused by tsunamis. Scientists and emergency management personnel have been warning of this issue for many years, but with only limited recognition from planners and developers.

If Brisbane Airport management doesn't already have plans to deal with such events, then it needs to develop them urgently.

2. The significant issue in coastal development planning is the measured rate of change of local relative sea-level, as best indicated by adjusted tide gauge data. The National Tidal Centre of the Bureau of Meteorology (BoM) operates a baseline network of high quality tide gauges for Australia, and reports trends in sea-level that range from less than 1 mm/yr across the south and east of the country to more than 5 mm/yr along the coasts of the north and west. It is this quantitative data, not speculative IPCC computer projections, that must provide the benchmark for coastal planning in specific locations, taking into account at the same time the best estimates of local storm surge potential and tidal variation.

3. IN SUMMARY, projecting the BoM's summary of measurements of local relative sea-level rise at Brisbane during the 20th century (0.3 mm/yr; BoM, 2009) indicates a likely sea-level rise of 2.7 cm at this locality by 2100. This is a trivial change which does not require policy action at this time, beyond ensuring that the plans referred to under Point 1 are in place.

REFERENCE

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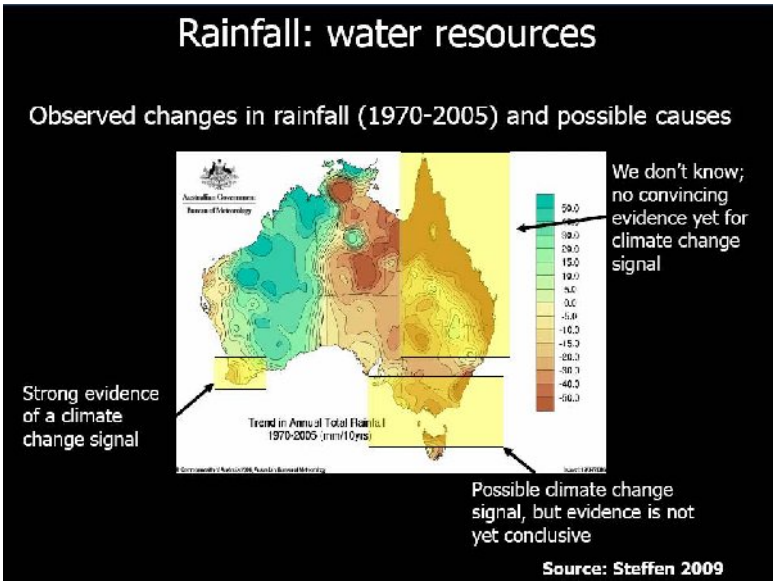

SLIDE 8 - COMMENTS

This graphic is poorly conceived, indeed misleading, because of the relatively short record length that it summarises (35 years). Trends over such a period are due to the disposition of randomly occurring wet spells and prolonged droughts on a multi-decadal scale, and do not signify an underlying change of climate. A similar graphic on a century timescale has much reduced trends that are of no statistical significance (see SLIDE 31).

1. By definition, any changes in long-term average rainfall are related to, or part of, climate change. Taken at face value, therefore, the text written on this graphic makes no point.

2. However, it is likely that use of the term "climate change" on the slide is meant to refer to HUMAN-CAUSED global warming. In which case we note that the annotation that strong evidence exists for such warming for a small area in SW Australia is not backed by any evidence given in the figure, nor in the cited publications (Steffen, 2009; Bates *et al.*, 2008).

In any case, the comments on this slide indicate that Professor Steffen is confident about low rainfall being due to human-caused climate change only for a small part of Western Australia. Even were that claim to be true, it would be a flimsy and inadequate basis on which to erect a sweeping national policy.

3. This is another slide that makes partial use of data. Aggregating net changes in rainfall between 1970 and 2005 means that the map corresponds to a strong but short-term drying trend during Australia's climatic history (Bureau of Meteorology; SLIDE 31), especially with respect to the wet 1950s. The below average rainfall shown for much of eastern Australia is therefore entirely to be expected.

4. More generally, global climate models consistently project an increase in rainfall of 1-3% for every degree C of temperature rise. Against this background, it is impossible to detect a statistically significant increase of global temperature over the 20th century (when the temperature rise was less than 1°C), for any changes potentially due to human-caused global warming cannot be distinguished from well-established and natural multi-decadal shifts in atmospheric circulation.

5. IN SUMMARY, inspection of annual rainfall graphs makes it apparent that over the longer term, rainfall data do not display a simple linear drying trend (Bureau of Meteorology; SLIDE 31), as greenhouse theory requires. Instead, eastern Australian climate falls under the dominant influence of oscillatory ENSO and longer multi-decadal climatic perturbations (such as the Pacfic Decadal Oscillation; PDO) (e.g., Verdon & Franks, 2006).

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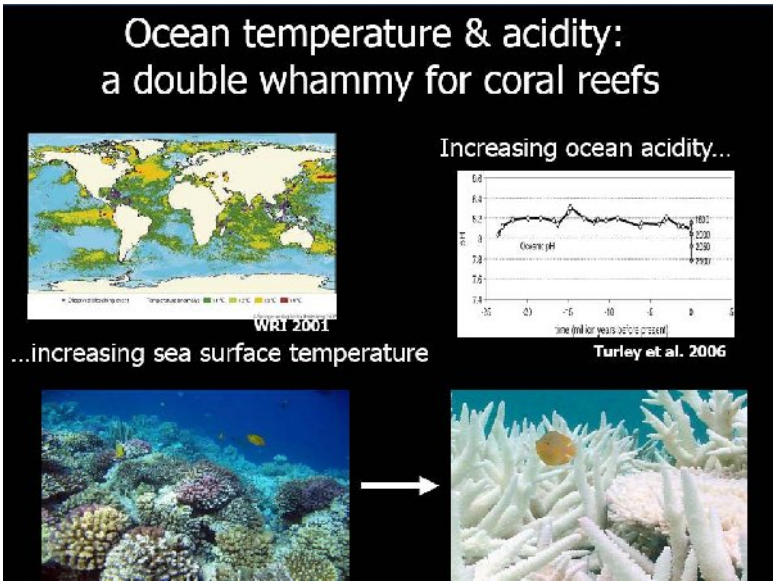

SLIDE 9 - COMMENTS

1. **pH.** The natural range of regional pH variation in the open surface waters of the Pacific ocean is 7.8-8.4 (Skirrow, 1965; see SLIDE 32), and not much less over time even at just one site (7.7-8.2; Monterey Bay Aquarium intake; see SLIDE 33). Variation between night time and day time pH on coral reefs has an even greater range of ~7.5-9.4. Natural coral reefs cope regularly with these variations without known adverse effect.

The minor fluctuations in pH shown in the Turley *et al.* (2006) reconstruction therefore greatly under-represent, and misrepresent, natural environmental variability.

2. The steep decline in pH plotted by Turley *et al.* (2006) between now and 2100 represents the output of unvalidated GCM computer models that are based on the IPCC's exaggerated economic scenarios and do not take into account reactions of long-term ocean buffering. The path of apparently alarming decline in alkalinity projected is therefore but one out of millions of equally plausible or implausible projections, and NOT a quantified and tested prediction.

Such computer projections may serve a valuable heuristic purpose, but until they are rigorously validated they have no part to play in policy formulation.

3. **Coral bleaching.** Over recent decades there have been many observations of episodes of coral bleaching (e.g., Glynn, 1996; Stark, 2006; Stone *et al*., 1999). The two key conclusions are:

- Bleaching episodes are related to regional oceanographic events, including El Niño events in the Pacific Ocean (warm water propagates eastward along the equator) and extended periods of calm (causing unusual warming of surface waters). During El Niños, sea-level fall up to 30 cm over the western Pacific Ocean exposes corals to direct sunlight and heat stress, and the warmer than usual water in the eastern Pacific also stresses the corals there.
- Universally, coral reefs recover from such events within a few years.

Corals have evolved over hundreds of millions of years, living through times when water temperatures were warmer and carbon dioxide concentrations were higher than now. The projected rises in human emissions, and ensuing hypothetical temperature rise, does not exceed these past conditions.

4. **Ocean temperature.** Global average sea surface temperature has been cooling since 2003 (see SLIDE 34). More locally, since 1982 the water temperatures for the Great Barrier Reef have generally tracked the global pattern, with cooling since 2002 (McLean, 2010; see SLIDE 35).

5. IN SUMMARY, no substantive evidence exists that coral reefs are under dire threat from either increasing water temperature or decreasing ocean alkalinity.

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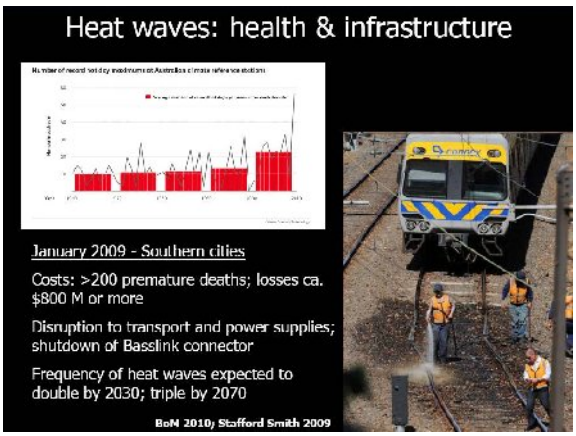


SLIDE 10 - COMMENTS

This slide represents yet more speculation that takes no account of natural variations in atmospheric circulation.

1. Regional heat waves almost universally occur because the weather becomes locked in a stationary pattern (known as a 'blocking situation'). In such blocking, a region comes under the influence of persisting warmer airflow from equatorwards, and the air is generally subsiding, dry and cloud free – conditions that lead to the sequence of very high temperatures that characterise a heat wave. At the same time, longitudinal flanking regions often receive persistent cooler winds from poleward locations.

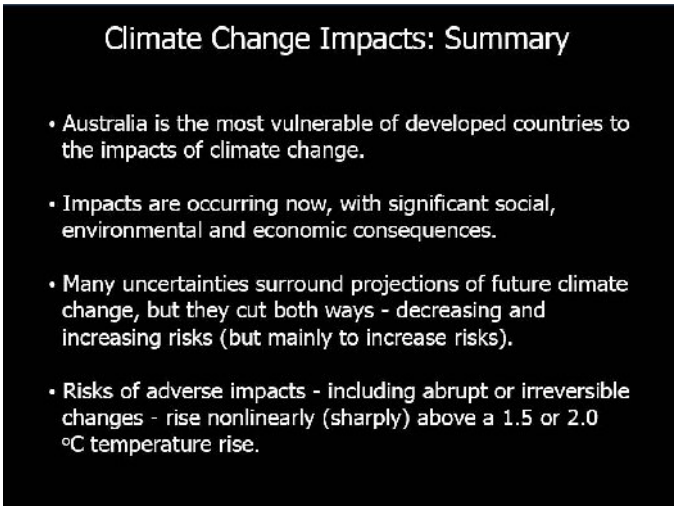
The 2003 heatwave of Western Europe was a typical blocking situation, but less attention was paid to the concurrent cooler than normal conditions over Central and Eastern Europe. Similarly Western Europe was cooler than normal during the summer of 2010, when the heatwave that affected Russia and the Ukraine was making headlines.

2. The graph of an increasing number of extremely hot days since 1950 is based upon an unspecified set of "climate reference stations". Choice of different groups of such stations will result in different outcomes, including the likelihood that in some places the number of hot days has DECREASED since 1950. Such partial statistics illustrate little that is useful. In addition, the use of trends in this naïve fashion is the wrong statistic for assessing the underlying frequency of extreme events, and likely leads to a false conclusion. Estimating the return frequency of extreme events is a complex matter, and the subject of a special branch of statistics.

3. The 2009 study of Southern cities rests on speculative computer models. As for Slide 9, the outcomes listed rely upon a particular set of presumptions, i.e., they are virtual reality projections and not predictions.

4. As with rainfall (cf. SLIDE 8, comments), given the natural year-to-year variations and the relatively small change in temperature across the 20th century, it is not possible to draw useful conclusions about such small changes in heat wave frequency as are indicated by Professor Steffen's graph. The overall message behind this slide is presumably that human-caused carbon dioxide emissions have caused the increase shown in the number of hot days. No evidence exists for any such supposition.

5. IN SUMMARY, any change in average temperature, or number of hot or cold days, has human health implications. Such changes occur naturally the whole time, and in general, health hazard has proved to be significantly greater for cold events rather than warm ones.



SLIDE 11 – ALTERNATIVE SUMMARY OF CLIMATE CHANGE IMPACTS

The Summary points in this slide are entirely misleading, if not untrue.

- The agricultural and urban parts of Australia are no more vulnerable to climatic hazards than are other developed economies.
- Climate impacts occurring now are not outside historical or palaeoclimatic experience, and in the absence of supporting evidence they should not be linked to dangerous human-related global warming ("climate change").
- Earth has been warmer and wetter in the recent past without human intervention. There are uncertainties about the sensitivity of future climate to increasing carbon dioxide levels, but there is no evidence that a warmer wetter world will be adverse overall.
- There is no sound scientific theory or evidence to suggest that increasing carbon dioxide levels will cause abrupt or irreversible climate change. None of the IPCC's computer models exhibit a 'tipping point' after 1.5-2.0^{o}C of warming.

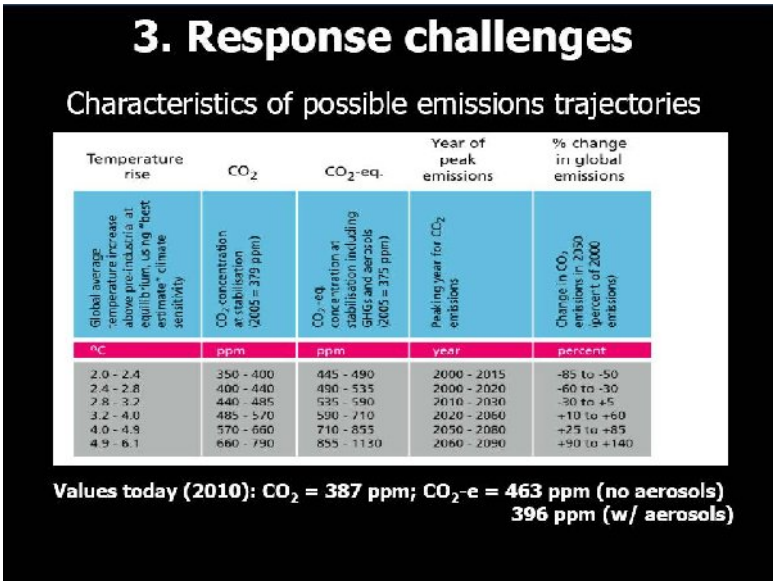
  Different models have different sensitivities to increasing carbon dioxide, but none show a tendency for 'runaway' global warming. Though some models with high sensitivity have been interpreted as showing 'runaway' tendencies, this simply reflects unrealistic model sensitivity and is not a characteristic of the climate system itself.

  Over the past million years, on each occasion that the Earth passed rapidly from glacial to interglacial conditions the global temperature stabilised at a value slightly warmer than now, which points to a degree of natural stability.

An alternative, and more accurate, summary of climate change impacts would read:

- Amongst the range of great natural hazards (earthquakes, volcanic eruptions, tsunamis, weather/climate events and change), it is climatic and climate-related hazards that are or most importance for Australia. The major Australian hazards therefore comprise storms, cyclones, floods, droughts and bushfires.
- No uncertainty at all attends the fact that all of these climate-related hazards have regularly occurred in the past, occur today and will continue to occur in the future. Therefore, there is a need for a national emergency management policy of preparing for such events (using the documented data from previous natural events as a guide), and responding and adapting to them effectively when they occur.

- Future climate change will include both warmings and coolings, of which the coolings are likely to be more economically hazardous and socially damaging than are warmings.
- No empirical evidence exists that 2 degrees of future warming would be dangerous, the figure is simply arbitrarily defined for political purposes. In actuality, the climate was about 2° C warmer than today both a few thousand years ago during the Holocene Climatic Optimum and also ~125,000 years ago during the peak warming of the Last Interglacial, and on neither occasion did an environmental crisis ensue. Indeed, the biosphere seems to have been more productive and diverse during these earlier warmer periods.



3. Response challenges

Characteristics of possible emissions trajectories

Temperature rise	CO_2	CO_2-eq.	Year of peak emissions	% change in global emissions
Global average temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity	CO_2 concentration at stabilisation (2005 = 379 ppm)	CO_2-eq. concentration at stabilisation including GHGs and aerosols (2005 = 375 ppm)	Peaking year for CO_2 emissions	Change in CO_2 emissions in 2350 (percent of 2000 emissions)
°C	ppm	ppm	year	percent
2.0 - 2.4	350 - 400	445 - 490	2000 - 2015	-85 to -50
2.4 - 2.8	400 - 440	490 - 535	2000 - 2020	-60 to -30
2.8 - 3.2	440 - 485	535 - 590	2010 - 2030	-30 to +5
3.2 - 4.0	485 - 570	590 - 710	2020 - 2060	+10 to +60
4.0 - 4.9	570 - 660	710 - 855	2050 - 2080	+25 to +85
4.9 - 6.1	660 - 790	855 - 1130	2060 - 2090	+90 to +140

Values today (2010): CO_2 = 387 ppm; CO_2-e = 463 ppm (no aerosols) 396 ppm (w/ aerosols)

SLIDE 12 – GENERAL COMMENTS ON SLIDES 12-15

1. The material presented in the next four slides is based upon the assumptions (i) that it is established that dangerous global warming will result from human carbon dioxide emissions; and (ii) that attempting to mitigate the risk of dangerous warming by punitive action against emissions is a superior policy option to that of preparation and adaptation to all climate change as it happens. Neither of these propositions has been shown to be true.

Global warming is not a problem requiring solution UNTIL a dangerous scientific hazard has been established. Our analysis of SLIDES 1-11 shows that the material in these slides fails to demonstrate that dangerous human-caused warming is occurring.

2. The material presented in SLIDES 12-15 is based upon the socio-economic scenarios of the IPCC's 3AR and 4AR, and on economic analyses contained in reports by Professors Stern and Garnaut. These scenarios and reports have been criticized as unrealistic by many independent economists, examples of which are listed below.

The economic modelling undertaken by Professor Garnaut and Treasury includes estimates which show that taking no action to reduce emissions would have only a very small adverse effect on economic growth between now and 2100. Given the many uncertainties about temperature predictions, and the potential for the further development of energy sources that are efficient alternatives to coal, little if any justification exists for taking early, urgent action to reduce emissions.

The IPCC's projected temperature and socio-economic scenarios are speculative, based on scientifically unsound assumptions, and they provide projected, not predicted, outcomes. They are

therefore not suitable for further application in economic modelling that is intended to be used as an Australian policy framework for political action.

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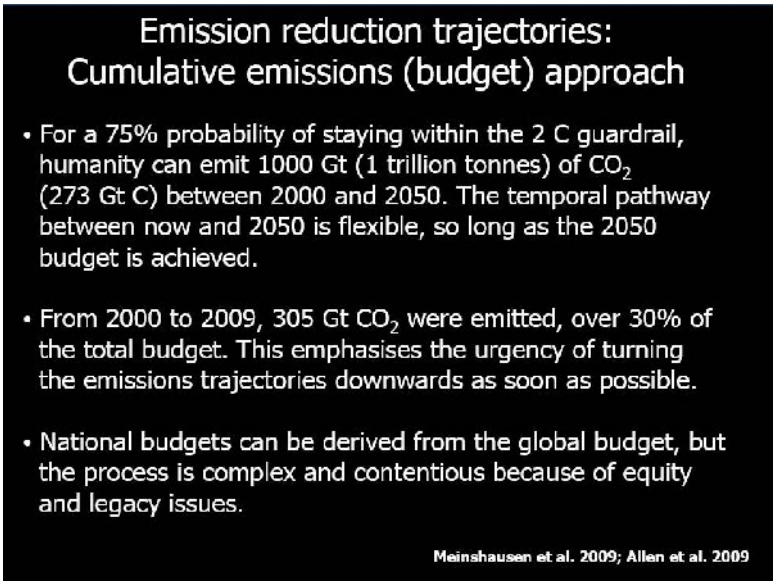


SLIDE 13 - COMMENTS

1. The probabilities and other figures presented on this slide are speculative and misleading. They represent projections of complex but unvalidated computer models which use as part of their input unrealistic socio-economic scenarios (see comments and references provided on previous slide).

2. The 2° C "guardrail" is a politically defined ambit claim based on the unsubstantiated assumption that a warming of such magnitude would be environmentally damaging. A reality check is provided by the fact that the Earth was 1-2° C warmer than today ~1,000 years ago (the Mediaeval Warm

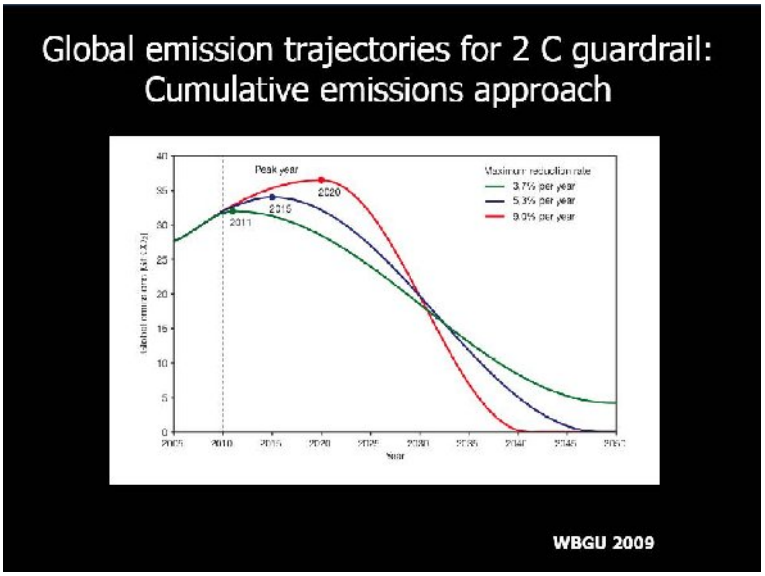
Period), ~8,000 years ago (the Holocene Climatic Optimum), and again during the Last Interglacial ~125,000 years ago; at none of these times was there an ensuing environmental crisis.

And in any case:

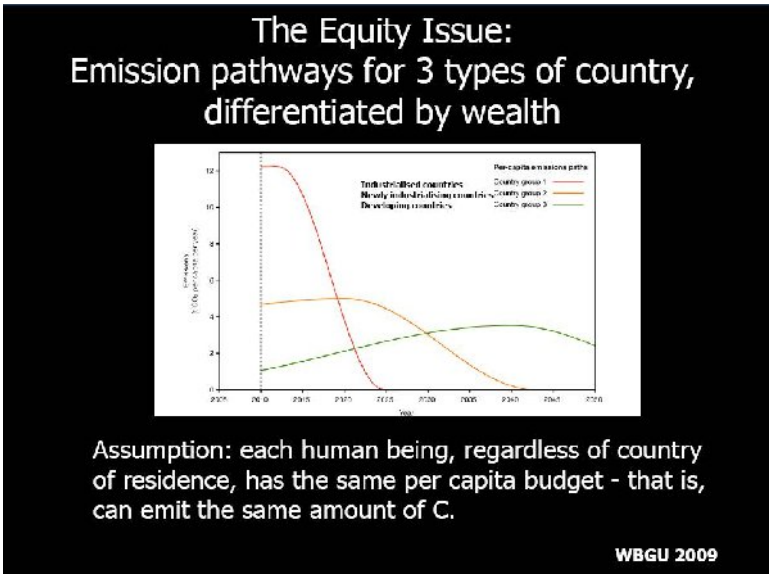
- At current rates of emission and atmospheric concentration increase (~2.5 ppm/yr), the accumulated concentration of carbon dioxide of about 600 ppm by 2100 will lie in the range of the IPCC's low marker B1 scenario. IPCC's best estimate for this scenario is 1.8^{o}C, and therefore its attainment lies within the imaginary "guardrail".
- The increase in carbon dioxide concentration from 2000 to 2009 was only 18 ppm. Therefore, no rapid increase in the rate of accumulation is occurring. We have adequate time to undertake a better evaluation of the real sensitivity of the climate system to carbon dioxide increase.

3. Australia derives much of its overseas income from the export of minerals, refined metals and agricultural products. Each of these is energy intensive, meaning that much of our per capita emissions of carbon dioxide are incurred by the production of goods consumed by other nations. If Australia is to continue to meet the needs of overseas customers for raw materials and food, our in-country emissions will continue to increase pro-rata. It therefore must be recognised that Australian emissions will continue to rise in support of the production of goods consumed by non-Australians (see also comments under SLIDE 15).

3. IN SUMMARY - no empirical evidence exists that 2 degrees of warming, should it occur, will result in environmental "damage". Indeed (and as the words "climatic optimum" imply), a warming of that magnitude is more likely to be beneficial for both the biosphere and for humanity's well-being.



SLIDE 14 - See comments made on the previous slide.



SLIDE 15 – COMMENTS

This graphic is based upon several presumptions, which include:

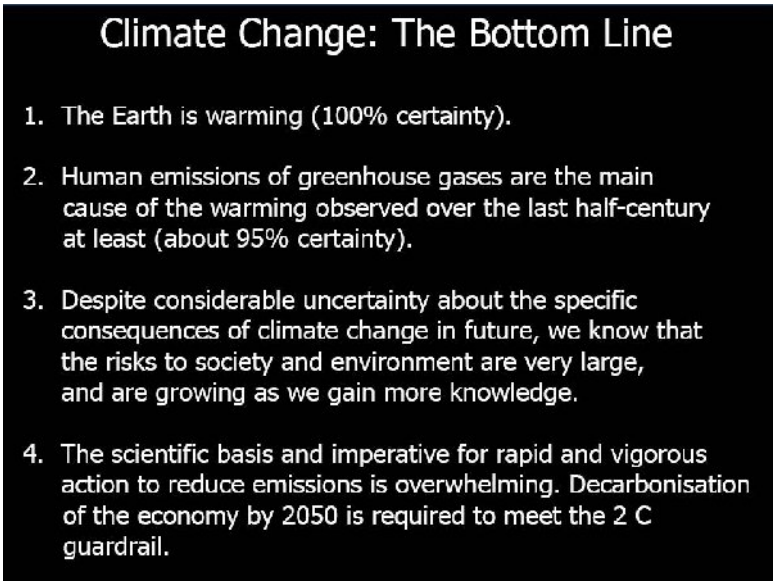
1. That existing populations in industrialised countries are to be held "responsible" for most of the human-derived carbon dioxide in the atmosphere, because their forebears burned most of the fossil fuels that produced these emissions.

2. That natural equity requires that all citizens (globally) should eventually be allowed the same per head emissions.

3. Therefore, the citizens of industrialised countries need to reduce emissions fastest, achieving a zero base by 2025, with "newly industrializing" countries to follow by 2040 and "developing countries" much later in the century. No indication is given of how these targets are calculated or of whether account is taken of the likely major adverse economic effects (through trade) on non-industrialised countries of significantly lowering the economic growth rate of industrialised countries between now and 2025.

These assertions are partly scientific and partly sociological, and all can be challenged. The morality of this type of equity is not obvious, it is very unlikely that newly industrialising countries will agree to cut their emissions by 2040, and the idea of equal per capita emissions is politically unrealistic. For example, past attempts, like the long drawn out *New International Economic Order* negotiations about 35 years ago, have failed to obtain industrialised countries' agreement to arrangements that would re-distribute wealth to non-industrialised countries.

4. See also the comments made on SLIDE 13 (above). Countries like Australia that export food and raw materials will necessarily have higher per capita emissions of carbon dioxide than those that are manufacturers and consumers. Wealth alone is therefore a misleading indicator of per capita personal consumption, and those countries that derive wealth from energy intensive industries will be disadvantaged by the application of such an indicator. Therefore, any simple, per capita emissions index is unfair to Australians, and must be rejected.



SLIDE 16 - COMMENTS

1. The first statement is meaningless. Whether the Earth is perceived to be warming or not depends entirely upon the length of time that is considered.

On a longer time scale, Earth has cooled over the last 60 million years apart from relatively short periods of recovery after glacial epochs (most recently, since 17,000 years ago) or less intense cold episodes (e.g., warming since the "Little Ice Age", 350 years ago).

Regarding the last 10,000 years, the following statements are all true:

- Earth has cooled since 10,000 years ago (Holocene cooling)
- Earth has cooled since 1,000 years ago (the Late 20th Century Warm Period being slightly cooler than the Mediaeval Warm Period)
- Earth has warmed since 350 years ago (post-Little Ice Warming)
- Earth warmed between 1979 and 1998 (Late 20th century warming)
- Earth has cooled slightly since 2001.

2. Despite statements made by the IPCC, no direct evidence exists that a measurable amount of the late 20th century warming was caused by human carbon dioxide emissions, even though in principle that might have been the case. Two other similar periods of warming have occurred in the last 150 years that were equivalent to the recent warming, and these could not have been due to human-related emissions of carbon dioxide, i.e., they had natural causes.

The statement of 95% certainty of human-caused warming (increased, without explanation, from the IPCC's 90%) is therefore wrong; no statistical analyses exist that can justify such a wild assertion.

3. There is no substantive evidence that the risks of climate change (be it warming, or cooling), or of hazardous climate-related events, are either increasing or decreasing because of human influence.

4. No scientific evidence shows that the politically defined 2° C of warming would be dangerous, or even damaging, and the term "guardrail" is therefore inappropriate. Indeed, the evidence from earlier periods warmer than now suggests that the biosphere is more productive and diverse under warmer and wetter conditions

5. THE REAL BOTTOM LINE - Were Australia to terminate all its industrial carbon dioxide emissions, the possible warming averted by AD 2100 would be ~0.01^{o} C; lesser cuts, say of 10% by 2050, will avert only ~0.001^{0} C of warming (Evans, 2011; Ferguson, 2011).

It is nonsensical to implement public policies (namely a carbon dioxide tax) that will cause damage to the economy, and especially to Australian battlers, in return for a hypothetical, unmeasurable decrease in temperature of less than one-hundredth of a degree in 90 years time.

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SLIDE 17 – The blue planet.

Climate Change 2010: Science, Risks, Responses
Will Steffen

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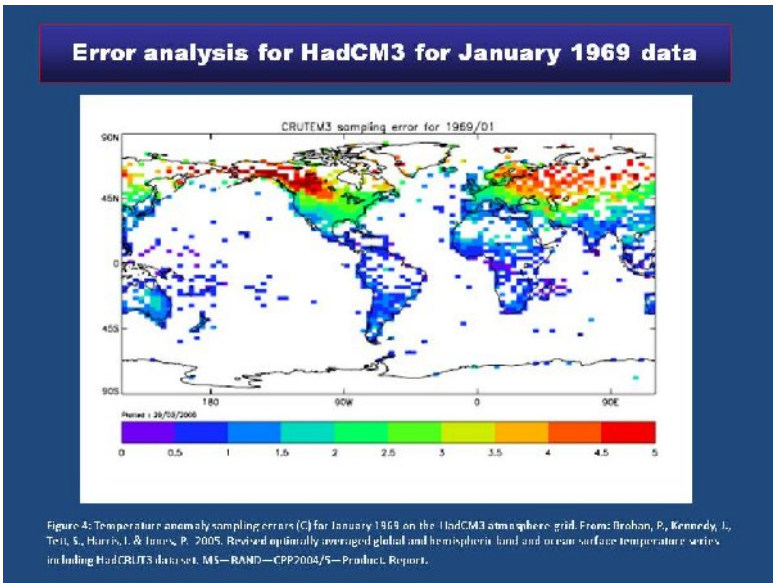
SLIDE 18 - References

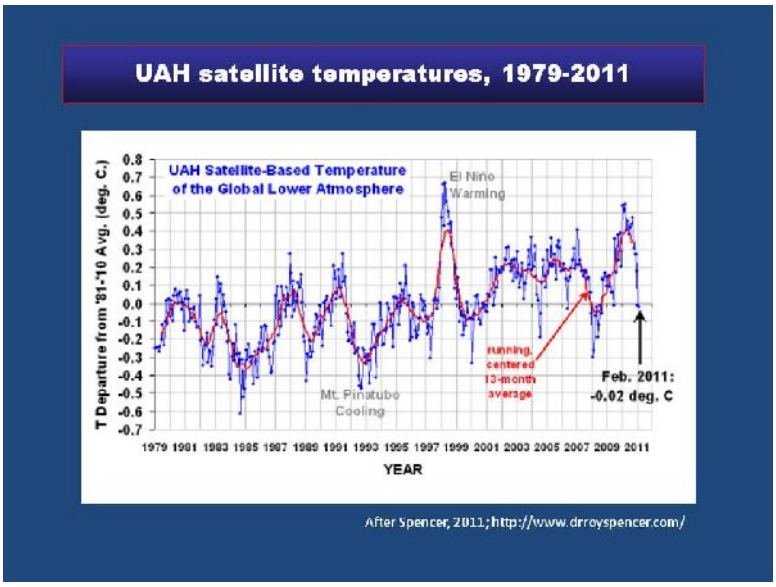
END OF SLIDES FROM STEFFEN, 2010

START OF EXTRA SLIDES



SLIDE 19 – Error analysis for HadCM3 for January 1969 data.

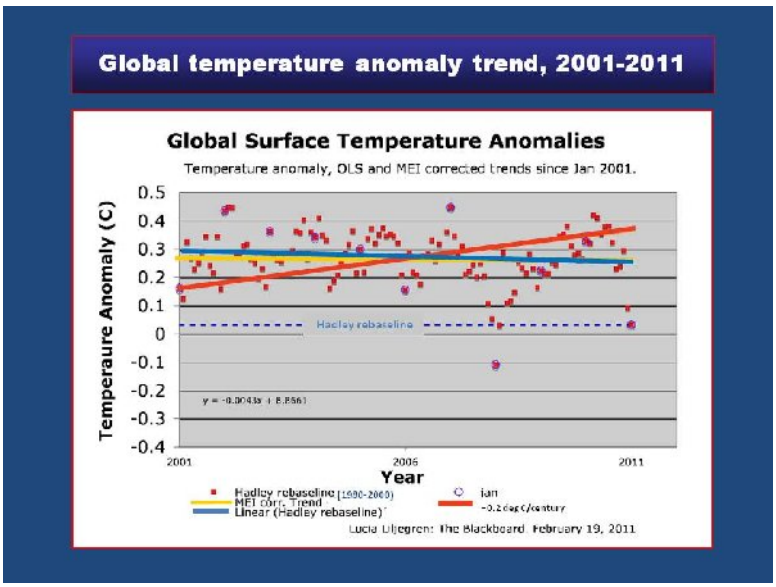
Source: Brohan, P., Kennedy, J., Tett, S., Harris, I. & Jones, P. 2005. Revised optimally averaged global and hemispheric land and ocean surface temperature series including HadCRUT3 data set. MS—RAND—CPP2004/5—Product. Report.



SLIDE 20 - The most accurate available record of global temperature from 1979 to 2011, measured by satellite-mounted microwave sensing units (MSU).

Note that (i) the temperature in early 2011 was the same as the temperature 31 years ago (in 1980); (ii) the presence of strong El Nino warming spikes (e.g., 1998) and a volcanic cooling episode (1993); and (iii) the lack of a strong overall warming trend, but nonetheless the presence of a ~0.2^{o} C warming step across the 1998 El Nino event.

Data: Spencer, R., University of Alabama, Huntsville, Atmospheric Science Department; *http://vortex.nsstc.uah.edu/data/msu/t2lt/uahncdc.lt*.



SLIDE 21 – Global surface temperature anomalies for 2001-2011 as recorded by the Hadley Centre.

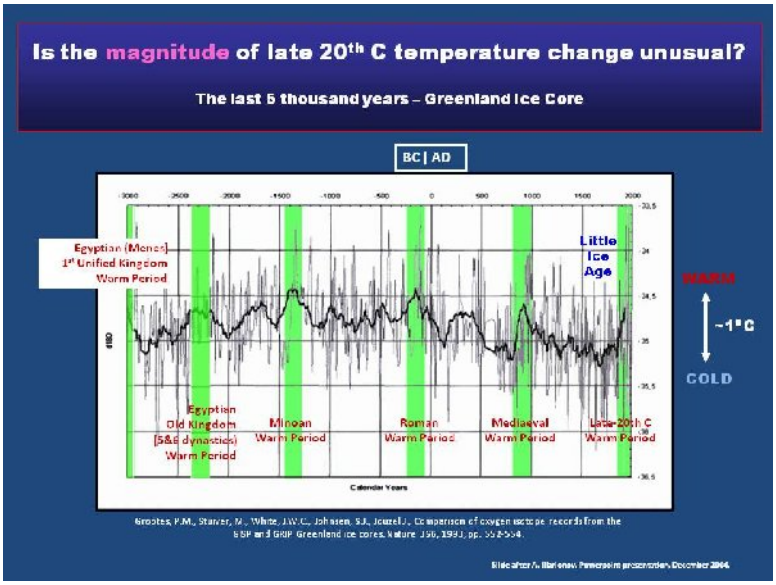
Note that global temperature has declined slightly over the last ten years, at a rate of -0.4^{o} C/century by ordinary least squares analysis (blue line, OLS) or -0.06^{o} C/century if temperature is corrected for ENSO variations (gold line; MEI = Multivariate ENSO Index-corrected). In comparison, IPCC's GCM models project a warming (red line) at a rate of +2.0^{o} C/century.

The HadCRUT3 dataset uses a 1961-1990 baseline for temperature anomaly calculation. As plotted here, the data has been adjusted to a 1980-1999 average temperature baseline.

IMPORTANT NOTE: The importance of this graph is not, *per se*, that it can be used to make the statement that *"temperature has cooled over the last 10 years"*. Though that statement is true, the criticism of it that 10 years is far too short a time over which to observe climate change is (in conventional weather/climate terms) also true. But beware then the critic who goes on to say that *"of course, if you look at temperature since 1979, it has undeniably warmed"*. Again, a true statement, and, again, 32 years is far too short a period to be of climatic significance - representing, as it does, just one climate data point.

Instead, the importance of the data shown in this slide is that, combined with our knowledge of increasing carbon dioxide levels, it comprises a test of the hypothesis that *"human carbon dioxide emissions are causing dangerous global warming"*. Given that carbon dioxide levels increased from 371 ppm in 2001 to ~390 ppm in 2011, an increase of ~5%, the hypothesis is clearly invalidated by this test. Equally, the test also invalidates the GCM models used by the IPCC of having predictive, as opposed to heuristic, value.

Graphic: Liljegren, Lucia, 2011 (Feb. 19). HadCrut January Anomaly: 0.194C. The Blackboard. *http://rankexploits.com/musings/2011/hadcrut-january-anomaly-0-194c/.*

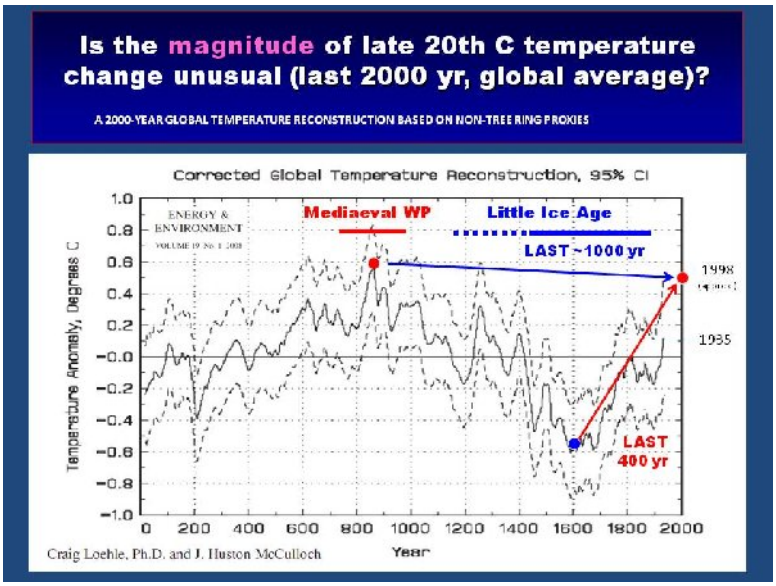


SLIDE 22 – Greenland ice core temperature record, last 5,000 years.

Note (i) the presence of warm phases (green bars) about every 1,000 years, which represent the millennial Bond solar cycle; (ii) that the Minoan, Roman and Mediaeval Warm Periods were all at least as warm as, or slightly warmer than, the Late 20th-century Warm Period; and (iii) that warm peaks are separated by cold periods, the last of which is called the Little Ice Age.

IMPORTANT NOTE – the temperatures shown are NOT global, but regional, in nature.

Data: Alley, R.B., 2004. GISP2 Ice Core Temperature and Accumulation Data, NOAA.



SLIDE 23 - Reconstructed global temperature history from AD 16 to AD 1935.

Plotted as a 29-yr moving average and derived from published climatic records based upon a variety of non-tree ring proxies (Loehle, 2007). This is the best available reconstructed record of likely global temperature over the last 2,000 years.

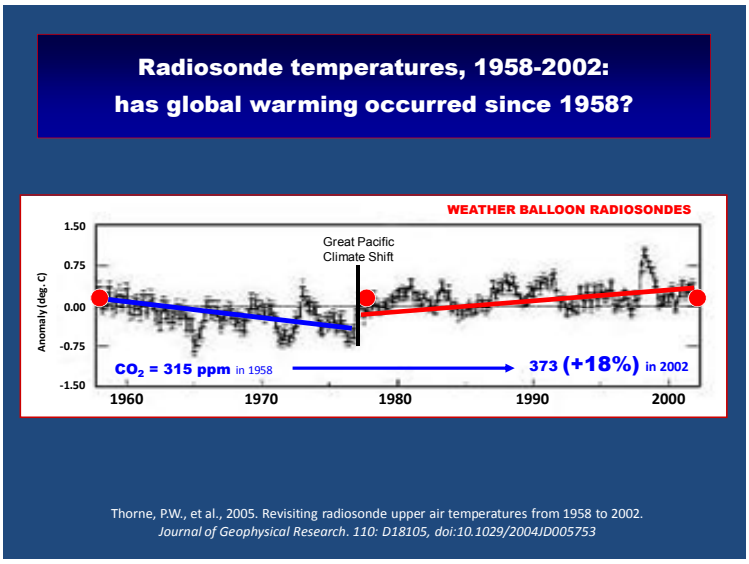
Note (i) the presence of both millenial and multi-decadal rhythmicity, (ii) that the Mediaeval Warm Period (MWP) was probably warmer than the Late 20th Century Warm period; and (iii) that warming

temperatures in the 20th century represent continuing recovery from the Little Ice Age,and have so far peaked (in 1998) at a level slightly cooler than the peak of the MWP, implying that there may still be a small amount of warming to come in the present Bond cycle.

After: Loehle, C. & McCulloch, J.H., 2008. Correction to: A 2000-Year Global Temperature Reconstruction Based on Non-Tree Ring Proxies. *Energy and Environment* 19, 93-100.

Proxies used: GRIP borehole temperature (Dahl-Jensen *et al.*, 1998); Conroy Lake pollen (Gajewski, 1988); Chesapeake Bay Mg/Ca (Cronin *et al.*, 2003); Sargasso Sea 18O (Keigwin, 1996); Caribbean Sea 18O (Nyberg *et al.*, 2002); Lake Tsuolbmajavri diatoms (Korhola *et al.*, 2000); Shihua Cave layer thickness (Tan *et al.*, 2003); China composite (Yang *et al.*, 2002) which does use tree ring width for two out of the eight series that are averaged to get the composite, or 1.4% of the total data input to the mean computed below; speleothem data from a South African cave (Holmgren *et al.*, 1999); SST variations (warm season) off West Africa (deMenocal *et al.*, 2000); SST from the southeast Atlantic (Farmer *et al.*, 2005); SST reconstruction in the Norwegian Sea (Calvo *et al.*, 2002); SST from two cores in the western tropical Pacific (Stott *et al.*, 2004); mean temperature for North America based on pollen profiles (Viau *et al.*, 2006); a phenology-based reconstruction from China (Ge *et al.*, 2003); annual mean SST for northern Pacific site SSDP-102 (Latitude 34.9530, Longitude 128.8810) from Kim *et al.* (2004); and Spannagel Cave (Central Alps) stalagmite oxygen isotope data (Mangini *et al.*, 2005). This provides a total of eighteen series, and wide geographic coverage (including tropical) and based on multiple proxies.

[For full reference citations, see original paper.]

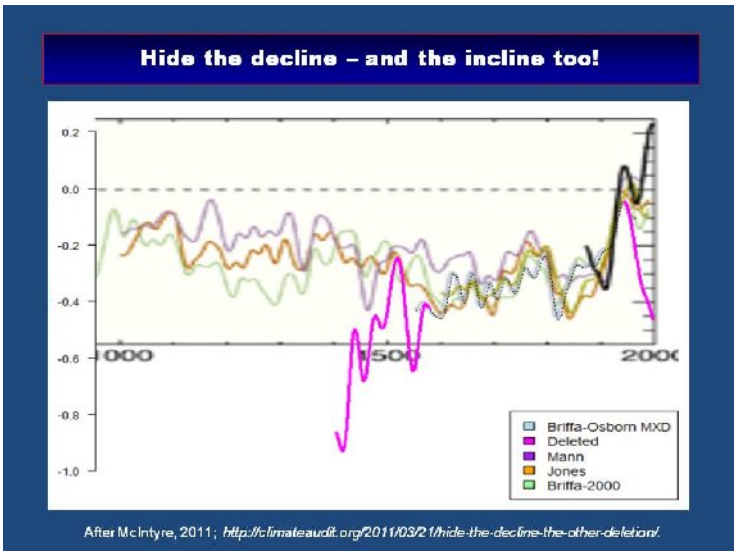


SLIDE 24 – Average lower atmosphere temperature anomaly measured between 1958 and 2002 by weather-balloon-mounted radiosondes.

Note that (i) the temperature in 2002 (and, now, in 2011) was the same as in 1978 and 1958 (red spots), i.e., no warming occurred for 52 years despite an increase in carbon dioxide of ~20%; (ii) a cooling of ~0.5° C occurred between 1958 and 1977 (blue line); (iii) a distinct warming step of ~0.75° C took place across the Great Pacific Climate Shift in 1977 (black line and label); and (iii) a warming trend of ~0.4° C occurred between 1978 and 2002 (red line).

After: Thorne, P.W., *et al.*, 2005. Revisiting radiosonde upper air temperatures from 1958 to 2002. *Journal of Geophysical Research.* 110: D18105, doi:10.1029/2004JD005753, and

Carbon Dioxide Information Analysis Center (CDIAC). http://cdiac.ornl.gov/trends/co2/.



SLIDE 25 – Hide the decline (and the incline too).

The earliest example of the "Hide the Decline" trick so far traced (McIntyre, 2011) appears in an MXD tree ring dataset plotted in spaghetti diagrams in papers by Briffa & Osborn (1999) and Jones *et al.* (1999).

Fig. 6 in Jones *et al.* (1999) (graphic above) presented proxy temperature reconstructions by Mann, Jones, Briffa and Briffa & Osborn. These reconstructions are also elements of later IPCC 3AR and 4AR spaghetti diagrams, including the one presented by Steffan as SLIDE 3.

McIntyre (2011) has recently shown that the MXD reconstruction plotted in Fig. 6 of Jones *et al.* (1999), after Briffa & Osborn (1999), was truncated at both ends. The omitted portions are shown in purple on the graphic above. They comprise a strong "warming" trend between 1402 and 1550, and a strong "cooling" trend between 1960 and 2000. Thus not only was the 20th century decline hidden, but also an equally significant 15th and 16th century incline.

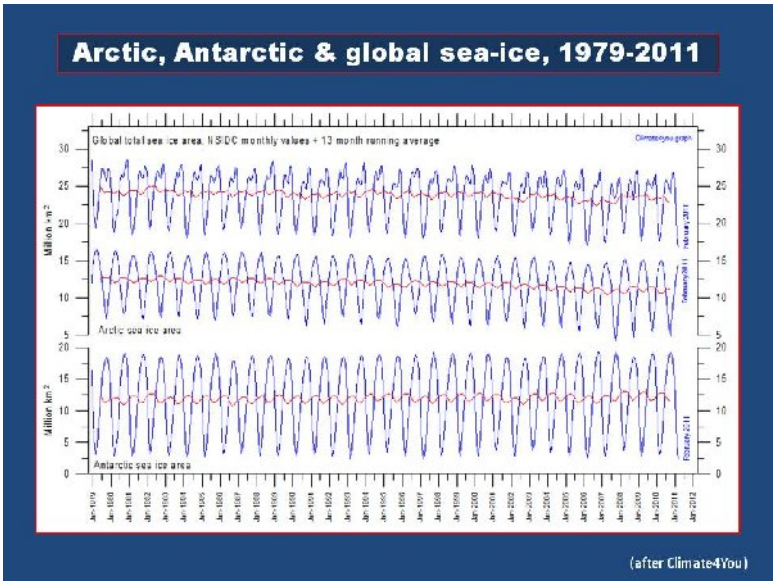
Statistical chicanery of this type has no place in science. Clearly, all IPCC-related spaghetti reconstructions that include manipulated data of this type should be discarded; and that includes SLIDE 3 (above) of Steffen.

REFERENCES

Briffa, K.R. & Osborn, T.J. 1999. Seeing the Wood from the Trees. *Science* 284, 926-927 ; DOI: 10.1126/science.284.5416.926.

Jones, P.D. *et al.*, 1999. Surface air temperature and its variations over the last 150 years. *Reviews of Geophysics* 37, 173–199.

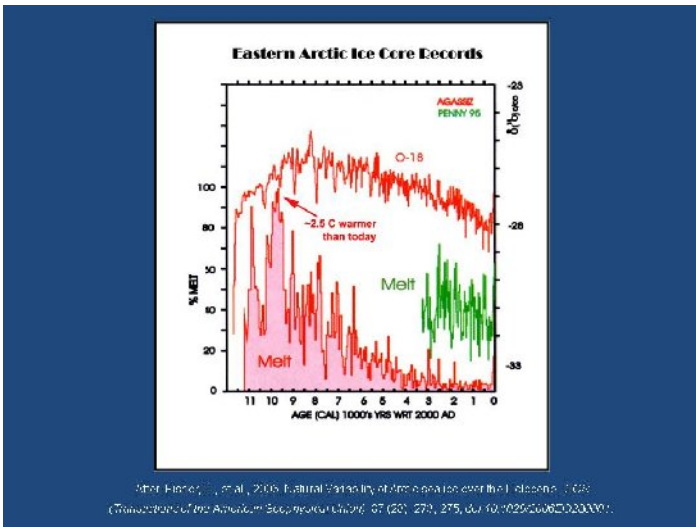
McIntyre, S. 2011. Hide the Decline – the Other Deletion; *http://climateaudit.org/2011/03/21/hide-the-decline-the-other-deletion/.*



SLIDE 26 – Summary of global sea-ice cover plotted as monthly data (blue curves) and as a running 13 month average (red lines).

Note the presence of a long-term, gentle decline in Arctic sea-ice cover (which carries through to the global average), but no significant change in Antarctic sea-ice over the period in question.

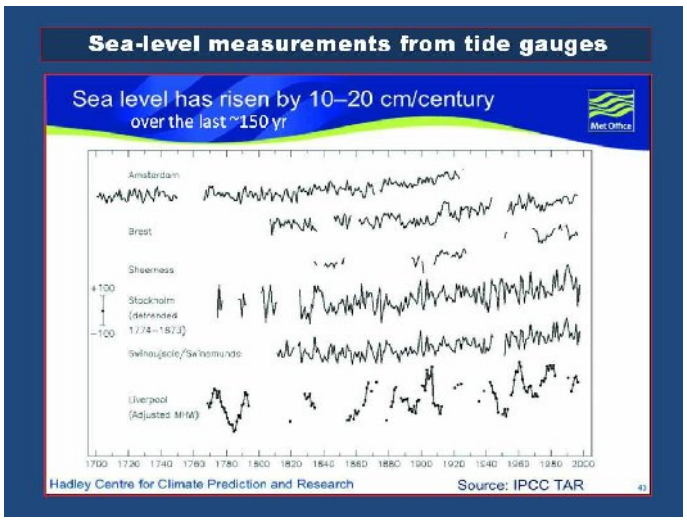
Graphic: http://www.climate4you.com/SeaIce.htm#Sea%20ice%20extension%20in%20a%20longer%20time%20perspective.



SLIDE 27 - Arctic sea-ice cover over the last 11,000 years.

Reconstructed sea-ice cover for the Eastern Arctic ocean from two ice core records (Agassiz and Penny). Note the virtual absence of sea-ice during the early Holocene climatic optimum, ~10,000 years BP, and the steady increase in ice cover since then - consistent with the long term cooling trend delineated by the oxygen isotope record (upper curve). Even during the recent 2007 melting episode, the amount of sea-ice in the Arctic Ocean remained much greater than the long-term Holocene average.

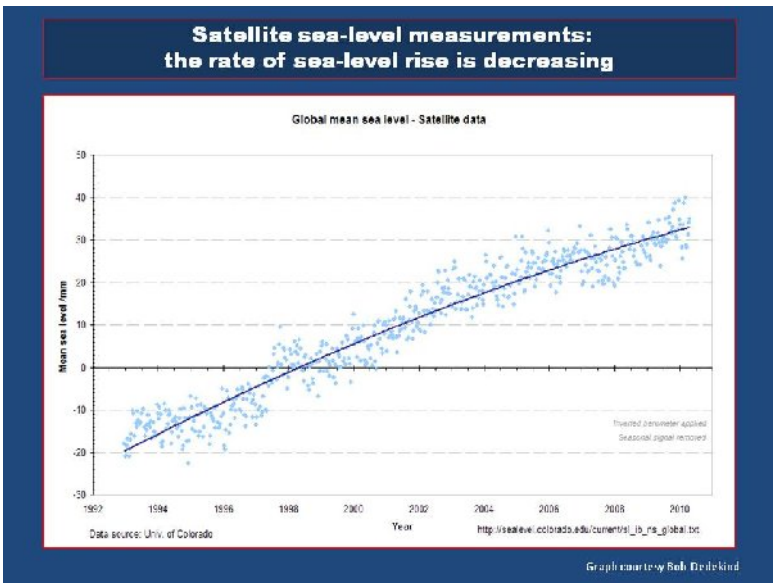
After: Fisher, D., *et al.*, 2006. Natural Variability of Arctic sea ice over the Holocene. *EOS (Transactions of the American Geophysical Union)* 87 (28), 273, 275, *doi:10.1029/2006EO280001.*



SLIDE 28 – Longest available tide gauge records from the northern hemisphere, which show an average rate of sea-level rise of ~1.7 mm/yr over the last 100 years.

Note there is no acceleration during the late twentieth century phase of warming.

Graphic: British Meteorological Office, after IPCC, 2001, Third Assessment Report.



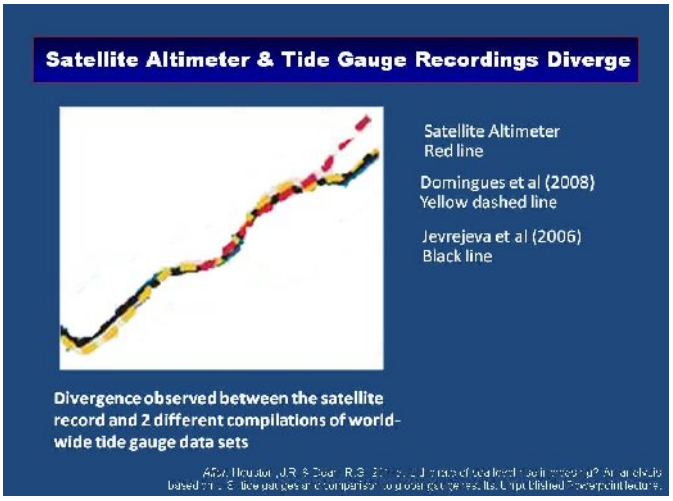
SLIDE 29 – Decreasing rate of sea-level rise recorded over the last 20 years from satellites.

Note that a full reconciliation has not been made between these figures (which show an average rise of ~2.5-3.5 mm/yr) and the tide gauge records (which show an average rise of ~1.7 mm/yr). The differences may relate to some combination of inadequate calibration of the satellite records, dynamic oceanographic factors and inadequate correction of the tide gauge records for vertical substrate movement.

However, ignoring for the moment the absolute accuracy of the satellite measurements, it is likely that their internal accuracy (i.e., the relative relationship between all the measurements in the set) is high. That noted, the measurements show beyond doubt that the rate of sea-level rise, far from accelerating, is currently decreasing. The trend rate of rise between 1993 and 2000 is 3.14 mm/yr, whereas since 2001 the rate is 2.34 mm/yr; this represents a 25% reduction in the rate of sea-level rise.

Data: University of Colorado, *http://sealevel.colorado.edu/current/sl_ib_ns_global.txt*.

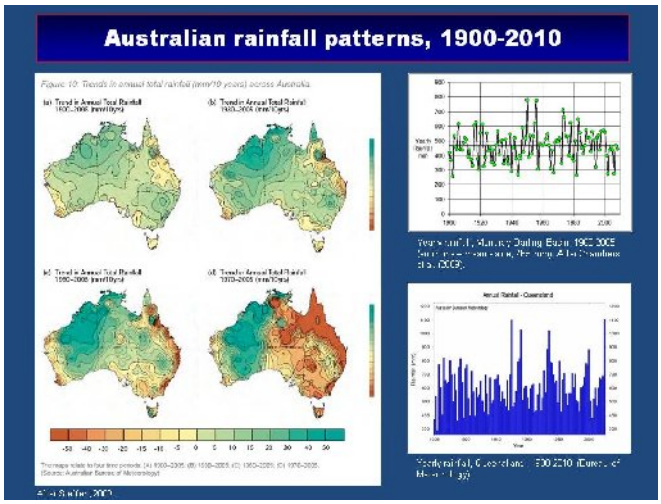
Graphic: Bob Dedekind.



SLIDE 30 – Comparison of tide gauge and satellite altimeter sea-level curves.

After: Houston, J.R. & Dean, R.G. 2011a. Is the rate of sea level rise increasing? An analysis based on U.S. tide gauges and comparison to global gauge results. Unpublished Powerpoint lecture.

See also: Houston, J.R. & Dean, R.G. 2011b. Sea-Level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. *Journal of Coastal Research*, in press. DOI: 10.2112/JCOASTRES-D-10-00157.1.



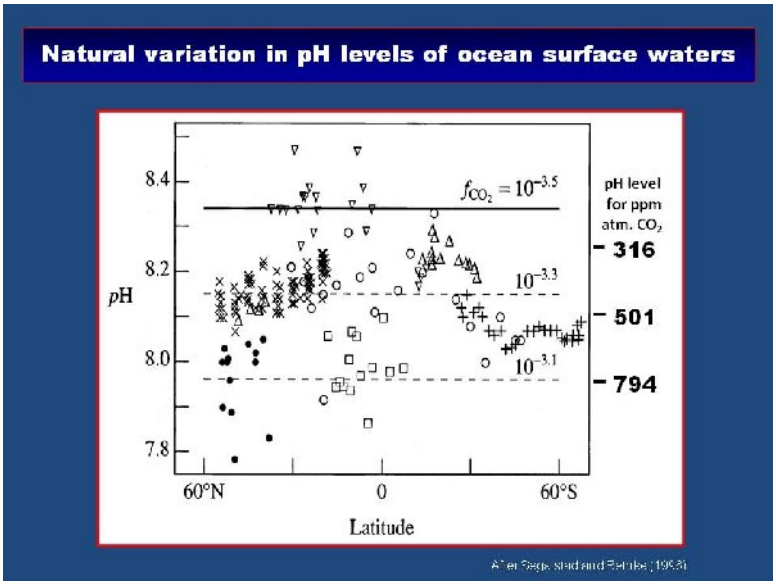
SLIDE 31 – Australian rainfall patterns, 1900-2010.

TOP RIGHT. Yearly rainfall in the Murray-Darling Basin. Mean value of 465 mm (solid line). There is no significant trend in rainfall through this period but with large variability of 106 mm (rainfall extremes of 257 mm and 777 mm). It is therefore difficult to relate this to any temperature changes or increases in atmospheric carbon dioxide levels.

REFERENCES

Chambers, J., Miller, A., Morgan, A., Officer, R., Rayner, M. & Quirk, T. 2010. Clearing the air on climate. *Energy & Environment* 21 (6).

Steffen, W.F. 2009. Climate Change 2009 Faster Change and More Serious Risks. Australian Government Department of Climate Change, 60 pp.



SLIDE 32 – Natural variation in pH levels of ocean surface waters.

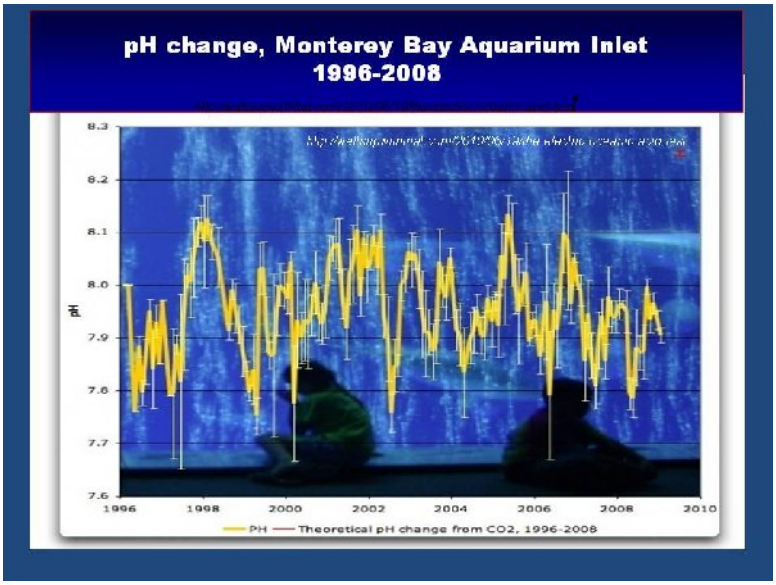
Measured pH levels for surface ocean waters between 60° N and 60° S in the western Pacific Ocean (after Skirrow, 1965). Note variability between 7.8 and 8.4, and compare that natural variability with the projections of hypothetical mean ocean pH level under atmospheric conditions with 318, 501 and 794 ppm carbon dioxide (calculated by Tom Segalstad after Bethke, 1996, for an idealised ocean model for carbon dioxide in equilibrium with seawater without considering the effects of solid mineral buffers such as $CaCO_3$).

Even with such unrealistic assumptions, the pH change is minor and remains well within modern natural variation.

REFERENCES

Bethke, C.M., 1996. *Geochemical Reaction Modeling.* Oxford University Press, New York, Fig. 6.1 (p. 84).

Skirrow, G. 1965: The dissolved gases - carbon dioxide. In: Riley, J.H. & Skirrow, G. (Eds.): *Chemical Oceanography*. Academic Press, London, pp. 227-322.

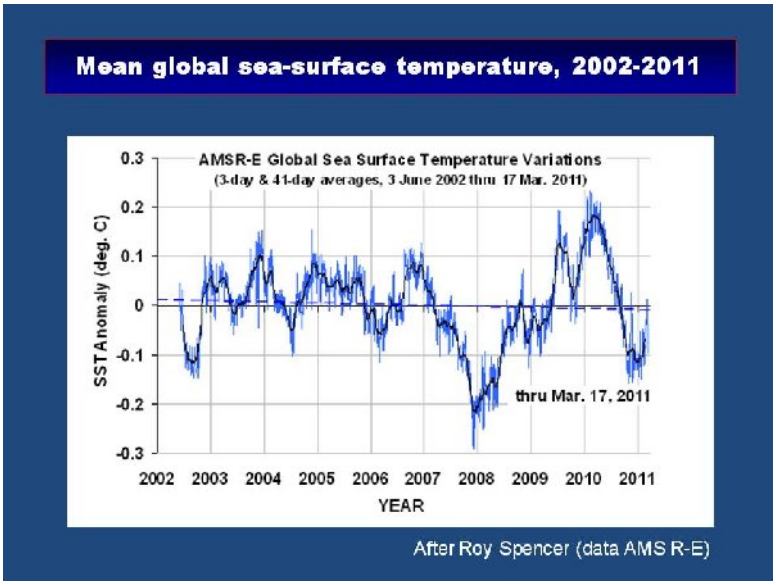


SLIDE 33 – pH change measured at the inlet of the Monterey Aquarium, 1996-2008.

pH measurements at the inlet pipe to the Monterey Bay Aquarium. Inlet is at 15 metres depth.

Light yellow lines show standard error of each month's measurements, indicating a wide spread of pH values in each month. Red interval at the top right shows the theoretical pH change which the Byrne *et al.* paper says might have occurred because of human carbon dioxide emissions over the 15 years 1991-2006.

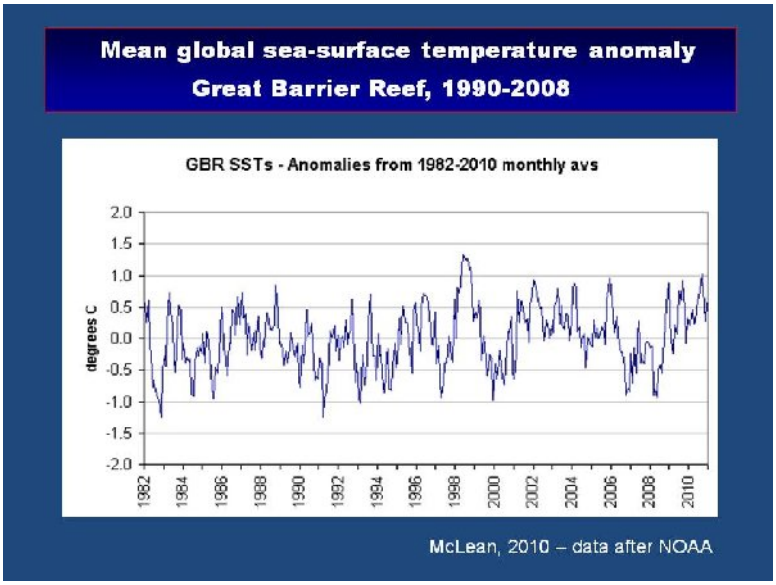
After: *http://wattsupwiththat.com/2010/06/19/the-electric-oceanic-acid-test*.



SLIDE 34 – Mean global sea-surface temperature, 2001-2011.

Global sea surface temperature anomaly, 2002-2011 (March). Note the absence of significant warming since 2002; the slight cooling trend is statistically indistinguishable from zero.

After: Spencer, R., 2011. *http://www.drroyspencer.com/.*



SLIDE 35 – Mean sea-surface temperature anomaly, Great Barrier Reef, 1990-2008.

Sea-surface temperature anomaly record for the Great Barrier Reef, showing no indication of a long term warming trend and a cooling since 2003.

Over the period of overlap, the GBR record shows similarities to the global SST record (SLIDE 34), with both records displaying no statistically significant warming and annual fluctuations in sympathy with ENSO cycling.

After: McLean, J. 2010. Sea-surface Temperatures along the Great Barrier Reef. *http://mclean.ch/climate/GBR_sea_temperature.htm*.

Authors:

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