An Almanac of the Atmosphere
or
The State of the Climate 2011

being

a walk through observations, calculations and estimations of changes to the climate.

(and a view through the looking glass)

Compiled by Tom Quirk for Des Moore 22 March 2011

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TEMPERATURES MEASUREMENTS

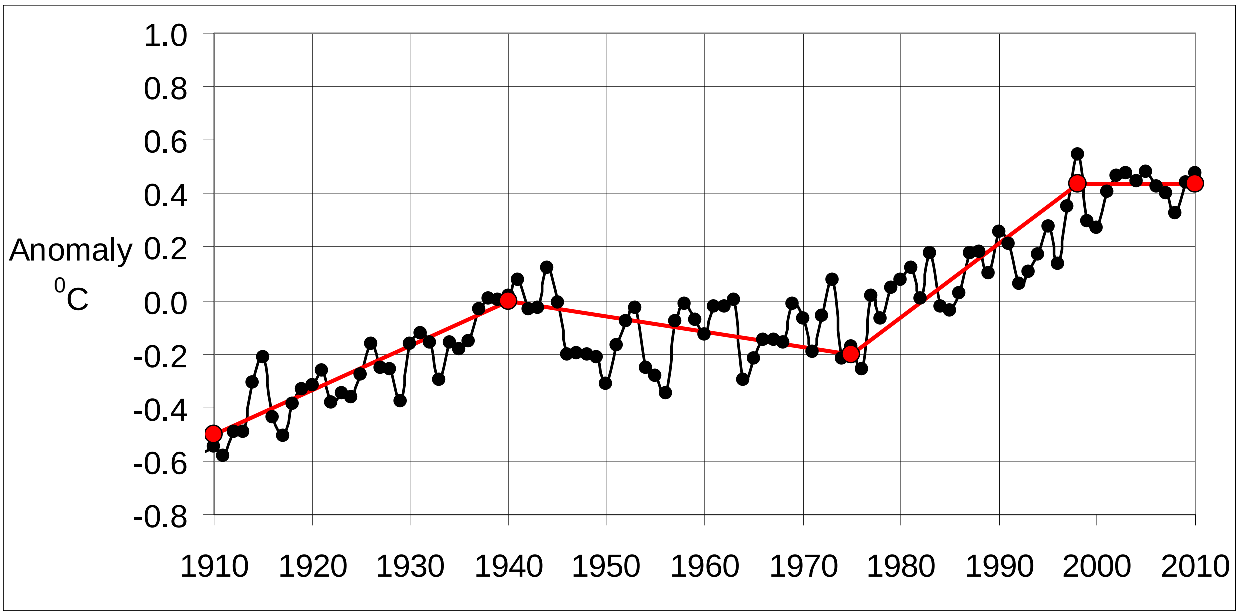


***Figure 1:** Annual global temperatures. Ten year averages, on their own, as used by Hadley Centre, IPCC and Garnaut, miss out on important change points. Here solid lines show warming and cooling periods. The Great Pacific Climate Shift occurs in the late 1970s when cooling turns to warming. Source Hadley-CRU*

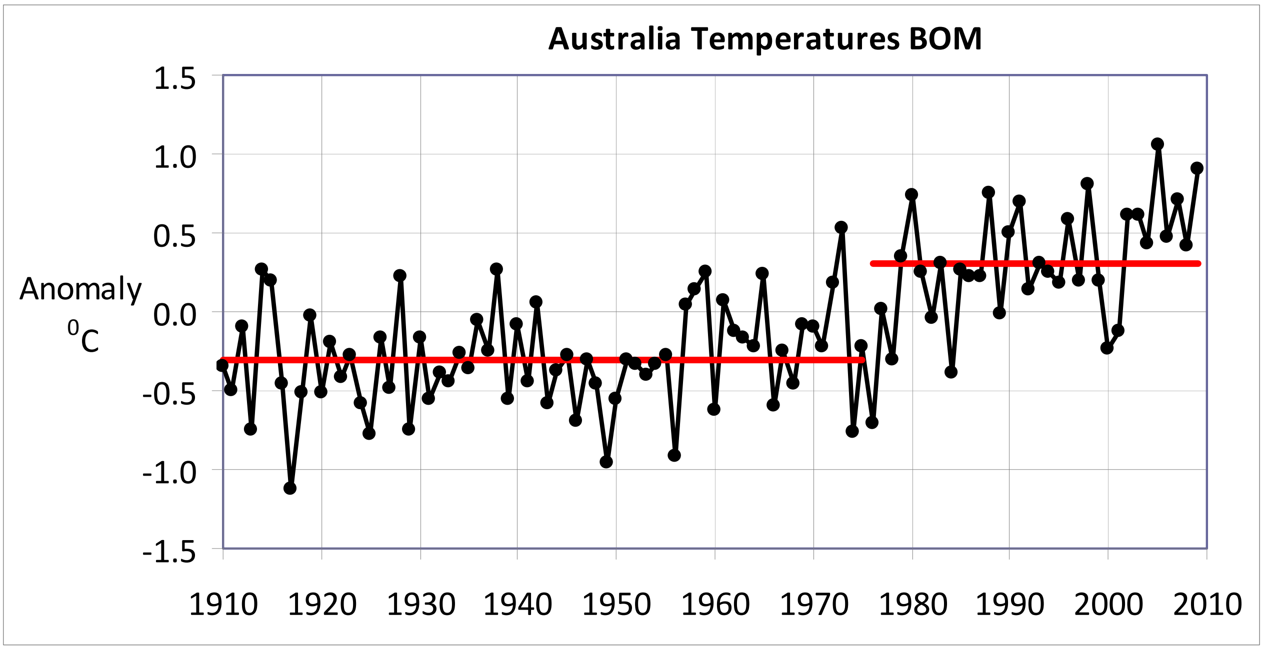


***Figure 2:** Annual Australian temperatures from the Bureau of Meteorology (BOM) high quality data series. The jump in the solid lines of 0.6^{0}C is a consequence of the Great Pacific Climate Shift of 1976-78 that is also reflected in the global temperature. Although this is due to natural changes, climate modelling assumes it reflects the effect of emissions of CO_2. This naturally suggests a relationship but not a causative one.*

Back in 1977, the Pacific Ocean underwent a major transformation in sea surface temperature patterns that was called the Great Pacific Climate Shift. Suddenly warm water replaced cold water that had dominated for most of the prior three decades near the west coast of North America and along the equatorial eastern Pacific. In 1997, researchers reported that a multidecadal oscillation in Pacific sea surface temperature and pressure had been discovered. They called it the Pacific Decadal Oscillation.

TEMPERATURE MEASUREMENTS AND ADJUSTMENTS

This illustrates the effect of adjustments that can be made by official bodies such as BOM to actual recorded temperatures

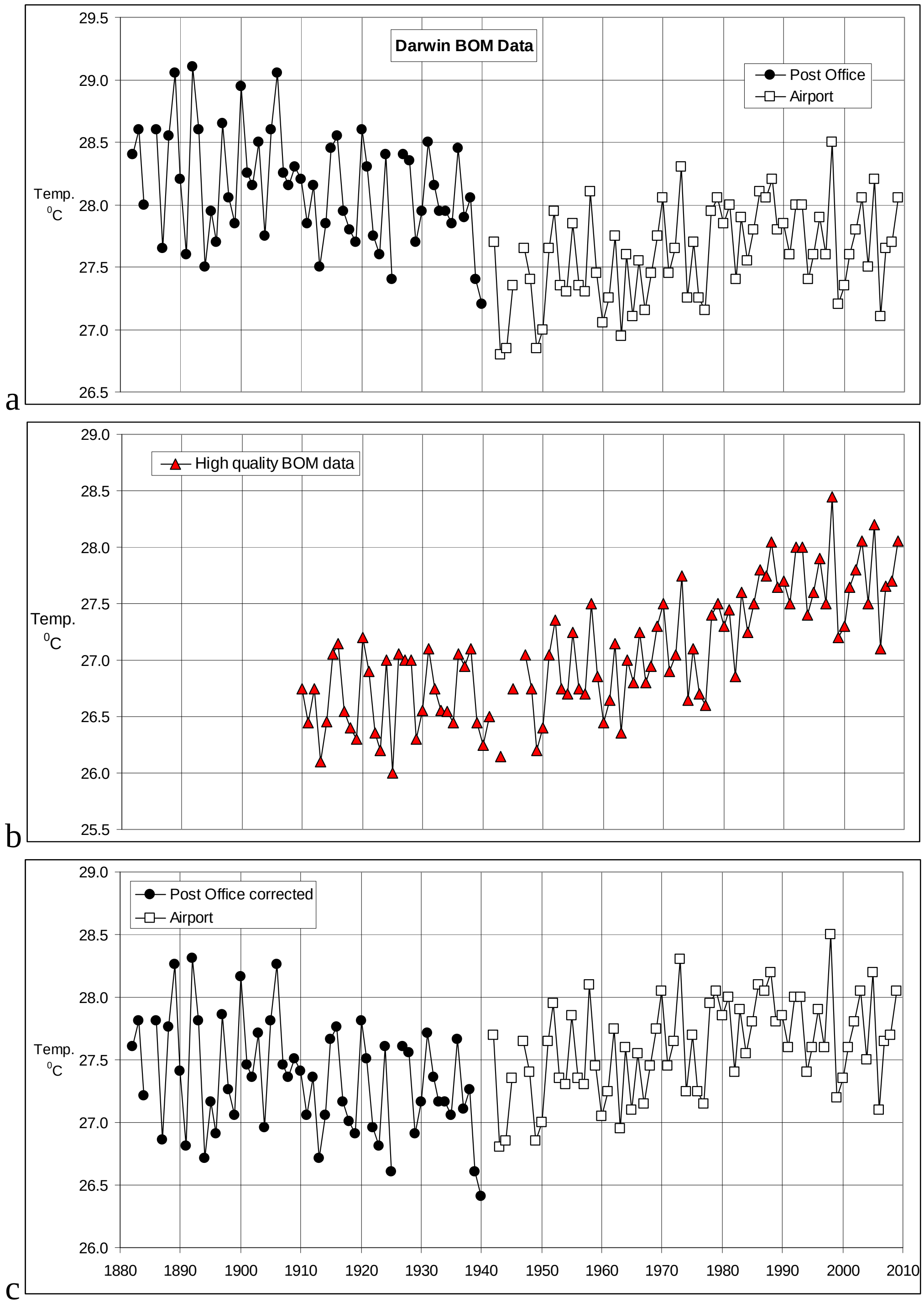


Figure 3: *BOM measurements at Darwin.* ***a)*** *Initially at the Post Office and from 1941 also at the airport. Measurements ceased at the Post Office when it was bombed in 1942.* ***b)*** *shows the result of the BOM "high quality" adjustments. The BOM reduced all measurements before 1940 by* 1.4^0*C and by* 0.6^0*C from 1940 to 1980 thus adding to the upward temperature trend.* ***c)*** *shows the simple reduction of Post Office temperatures by* 0.8^0*C for the change of location. This should be the preferred series unless faced with compelling evidence of the need for further adjustments. The international temperature databases (CRU, NCDC and GISS) use the raw uncorrected data shown in* ***a***.

The Bureau of Meteorology does not use the Darwin measurements in their composite Australian high quality time series but adjustments have been made to many sites included in the composite series.

100 YEARS OF ATMOSPHERIC MEASUREMENTS – 1910 TO 2010

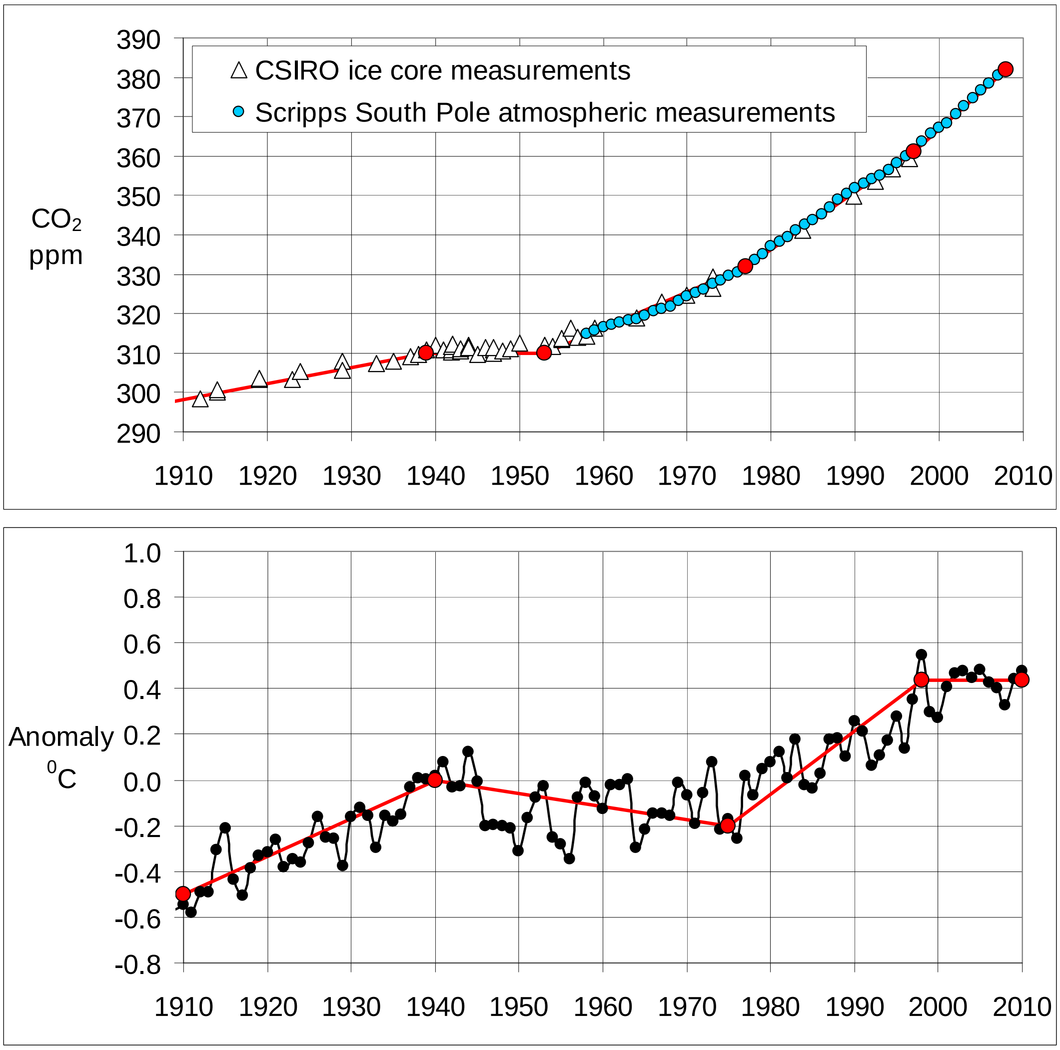


Figure 4: Top – *Ice core and atmospheric measurements of CO_2 concentration levels in Antarctica at the Law Dome for ice cores and at the South Pole for direct measurements. From 1940 to the early 1950s there was no increase in CO_2. Red dots indicate significant changes in annual increases.* ***Bottom –*** *Global temperatures estimated by the Hadley Centre of the UK Met Office. Solid lines indicate warming and cooling*

Period	CO_2 at the South Pole Annual increase in ppm	Period	Global Temperature ^{0}C Increase per 10 years
1910 - 1939	0.38 +/- 0.03	1910 - 1939	0.15 +/- 0.02
1939 - 1953	0.08 +/- 0.05	1939 - 1977	-0.02 +/- 0.03
1953 - 1977	0.77 +/- 0.03		
1977 - 1997	1.46 +/- 0.02	1977 - 1997	0.12 +/- 0.03
1997 - 2009	1.89 +/- 0.03	1997 - 2009	0.02 +/- 0.06

Temperature change does not appear to have a strong relationship with CO_2 change in the atmosphere

DIRECT ATMOSPHERIC MEASUREMENTS OF CO_2

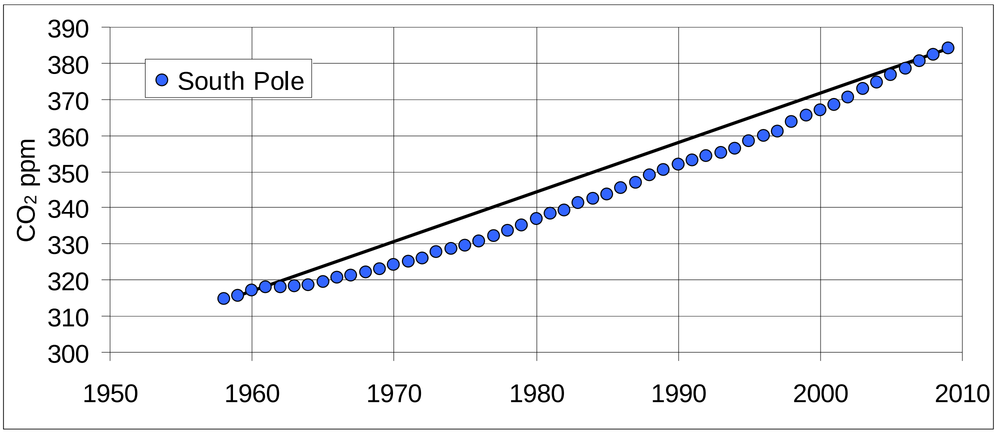


Figure 5: *Annual CO_2 measurements at the South Pole. The solid trend straight line is drawn from the first to last measurement of the time series. For each year the difference of the measurement from the trend line is shown in Figure 6. Source Scripps Institute.*

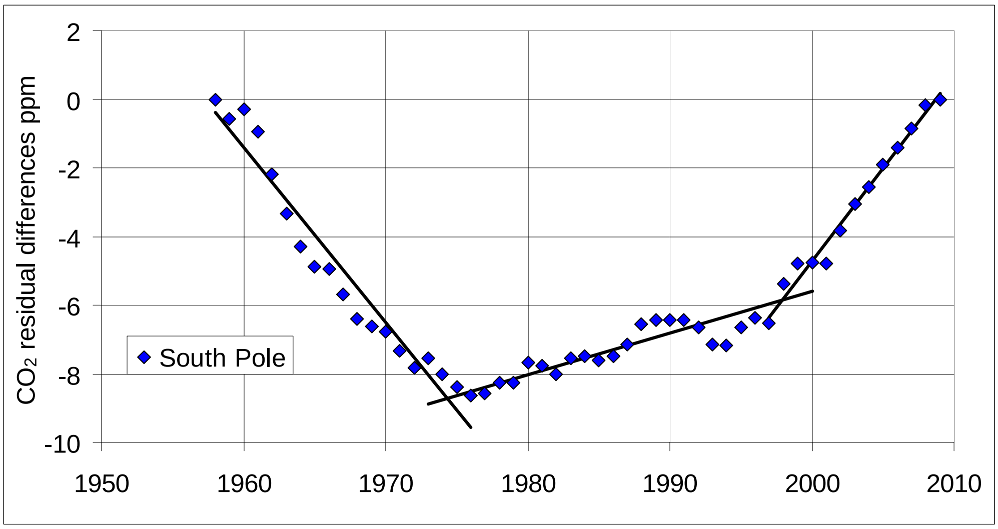


Figure 6: *Residual differences of CO_2 measurements from the trend line for each year. The three straight lines show periods of constant increase and their intersections in 1974 and 1998 mark years of significant change. The changes are coincident with the changes in temperature trends shown in Figure 7. The other 60 year CO_2 time series from Mauna Loa in Hawaii gives the same results.*

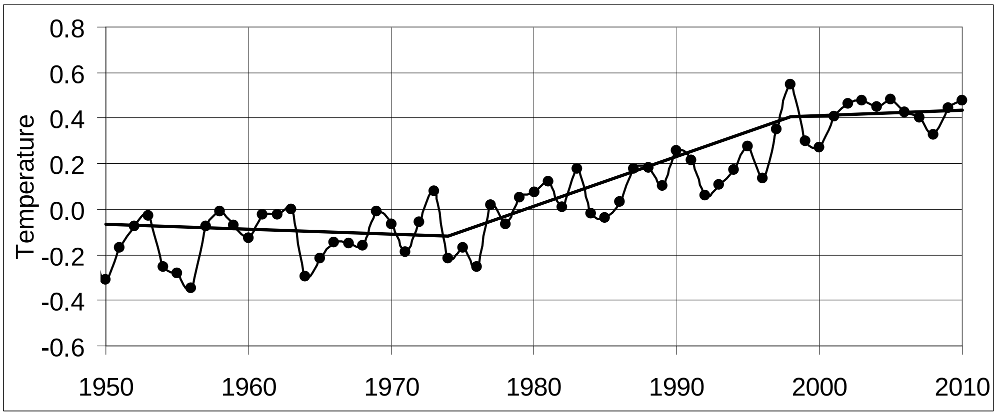


Figure 7: *Global temperatures estimated by Hadley CRU. Solid lines indicate warming and cooling*

The coincidence of the mid 1970s breaks in the temperature and CO_2 time series, at the time of Great Pacific Climate Shift, illustrates the strong interaction of the oceans with the atmosphere. Likewise the timing of the change in the global temperature in 1998 coincides with a change in the annual rate of CO_2 increase. The mid 1970s and late 1990s breaks may be indicators of the start and end of a phase of the Pacific Decadel Oscillation that has a powerful influence on CO_2 in the atmosphere.

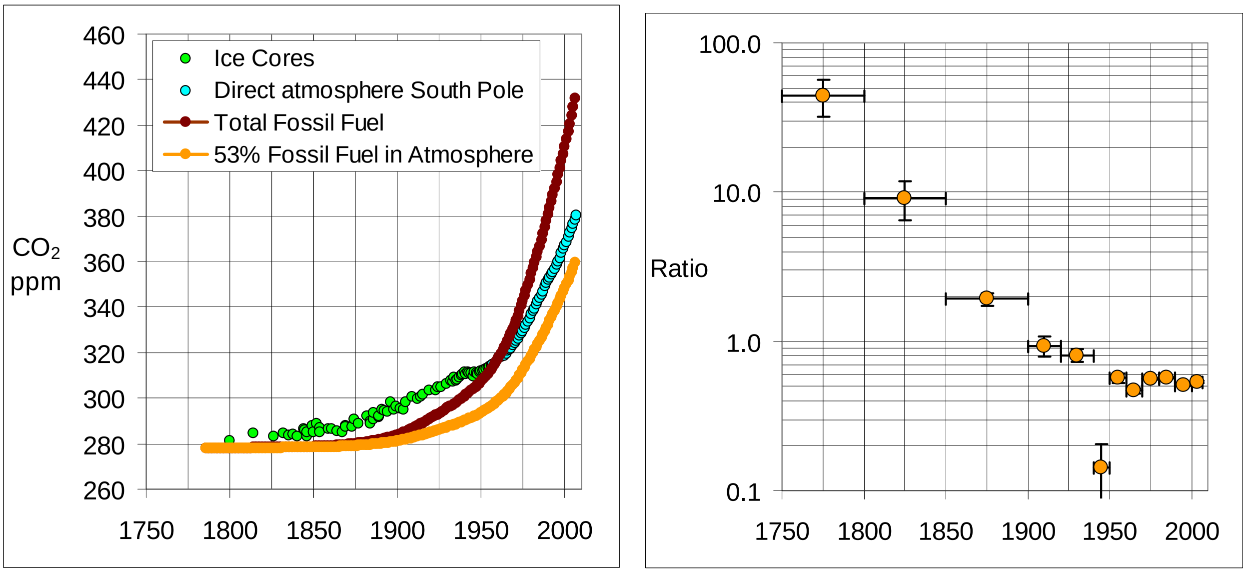


Figure 8 Left: *Law Dome ice core CO_2 measurements combined with direct measurements of CO_2 at the South Pole, total fossil fuel emissions added to a starting point of 278 ppm in 1750 (2009 CDIAC). Also the 53% estimated fossil fuel emissions remaining in the atmosphere.* ***Right:*** *Ratio of increase of atmospheric CO_2 to fossil fuel emissions in the same period. CO_2 measurements up to 1957 are from Law Dome ice cores (CSIRO 2006) while 1958 to 2007 are South Pole atmospheric measurements (Scripps 2009). The estimates of emissions are from CDIAC (2009).*

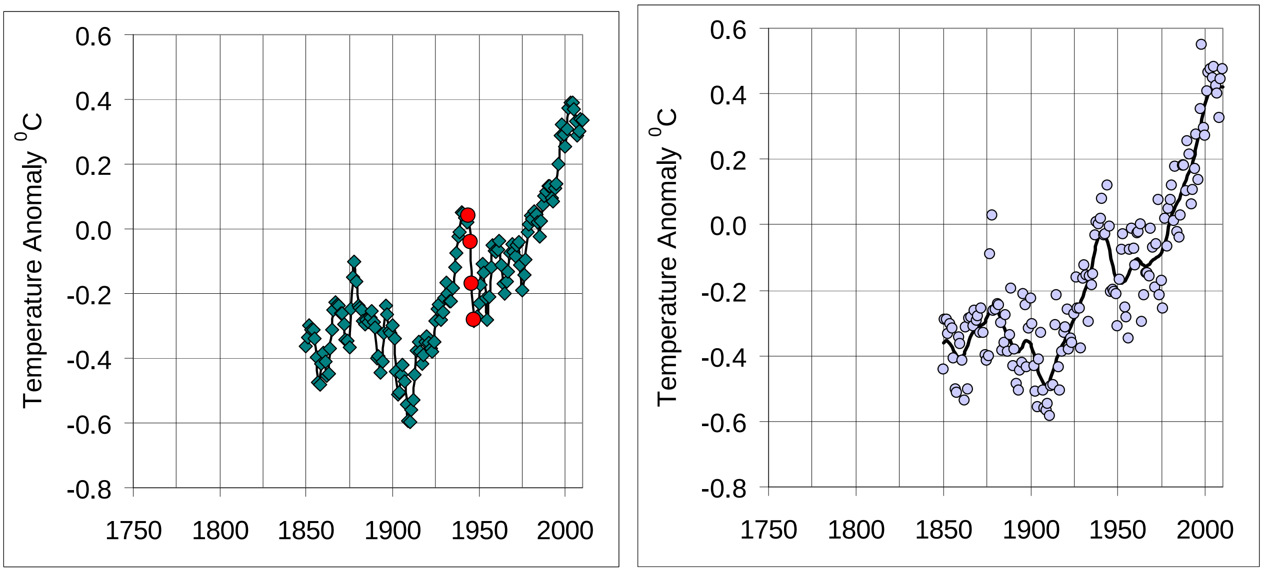


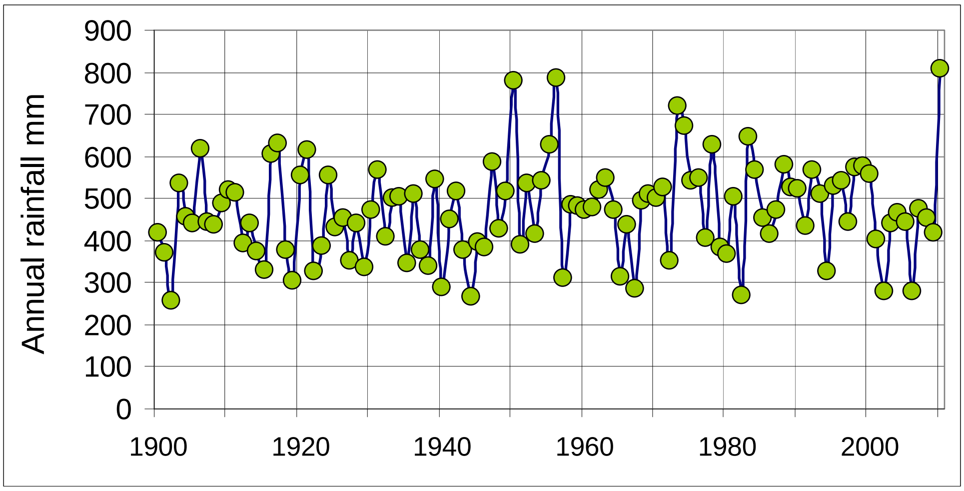
Figure 9 Left: *Global sea surface temperature anomaly calculated by Hadley-CRU. There is a rapid fall in sea surface temperature through 1944 to 1948.* ***Right:*** *Global surface temperature calculated by Hadley-CRU. Continuous curve is Hadley-CRU smoothed data.*

The ratio of annual increases of atmospheric CO_2 to fossil fuel emissions (Figure 8) dips to near zero in the period 1940 to 1950. This is a time when emissions were increasing but with a constant level of CO_2 (see Figure 4 and 8). This coincides with a remarkable fall in sea surface temperatures from 1944 to 1947 (Figure 10) that marks the beginning of a phase of the Pacific Decadel Oscillation. This again shows the importance of the oceans influence on the level of atmospheric CO_2.

An important comparison is the change in temperature with the change in atmospheric CO_2. The result raises a question about the processes involved in temperature change being driven by CO_2.

Period	Change in sea surface temperature ^{0}C	Change in global temperature ^{0}C	Change in CO_2 ppm	**Sensitivity ^{0}C per ppm of CO_2**
1910-1940	0.636	0.465	11	**0.05**
1950-2000	0.492	0.543	55	**0.01**

MURRAY-DARLING BASIN YEARLY RAINFALL 1900 TO 2008



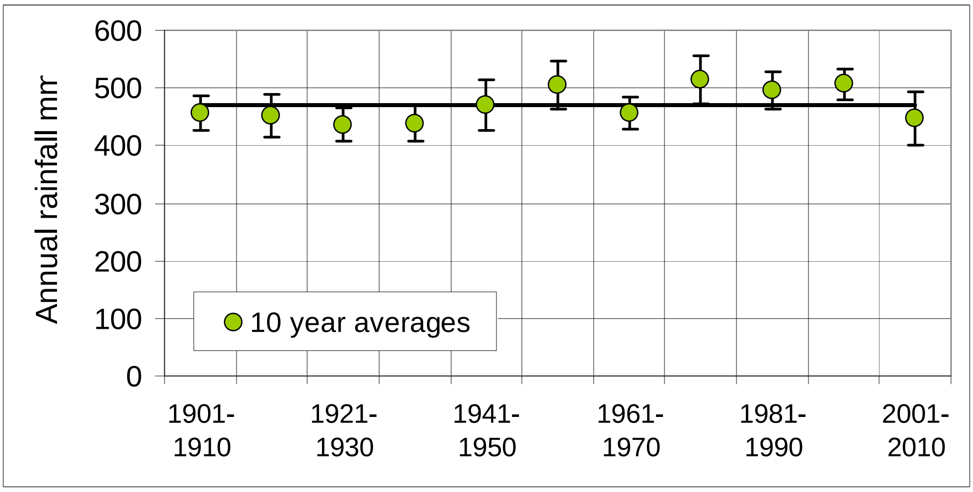


***Figure 10: Upper**: Yearly and **Lower** 10 year average rainfall in the Murray-Darling Basin. Mean value of 471 mm (solid line) and median 472 mm. There is no significant trend in rainfall through this period but with large variability- standard deviation of 112 mm with rainfall extremes of a minimum 257 mm and a maximum of 808 mm in 2010*

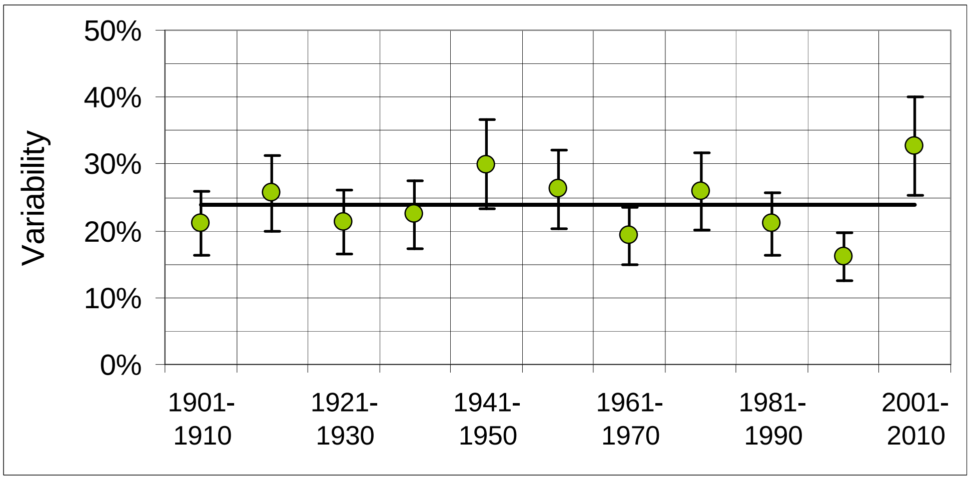


***Figure 11:** Murray Darling Basin variability. Variability is the rainfall standard deviation divided by mean rainfall for 10 year periods.*

There results do not provide any support for the climate model projections of less rainfall and more variability.

The 1963 study by Sir Samuel Wadham of Australian climate over 75 years compared with overseas concluded that “nowhere in the world is there such a huge area of pastoral land of such erratic rainfall”.

LONG TERM BEHAVIOUR OF ATMOSPHERIC METHANE

The CSIRO-BOM report ‘State of the Climate’ published in 2010 has the following: “methane, which is another greenhouse gas, has shown similar increases [to carbon dioxide].”

CSIRO measurements and analysis of methane extracted from ice cores at the Law Dome in Antarctica. Direct measurements in the atmosphere come from CSIRO station at Cape Grim on the northwest corner of Tasmania. The data for these two figures comes from the CSIRO. This includes the smoothing of the data. All the methane data can be found on the Carbon Dioxide Information Analysis Center http://cdiac.ornl.gov/by_new/bysubjec.html#atmospheric . The only additional data handling has been to calculate the annual increase in methane concentrations.

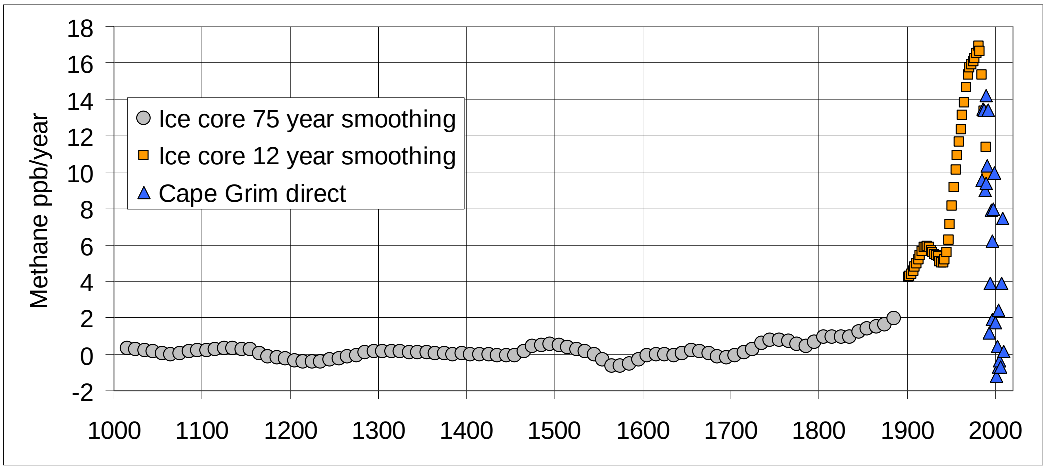


Figure 12: *Ice core and direct measurements of atmospheric methane. Data source CSIRO*

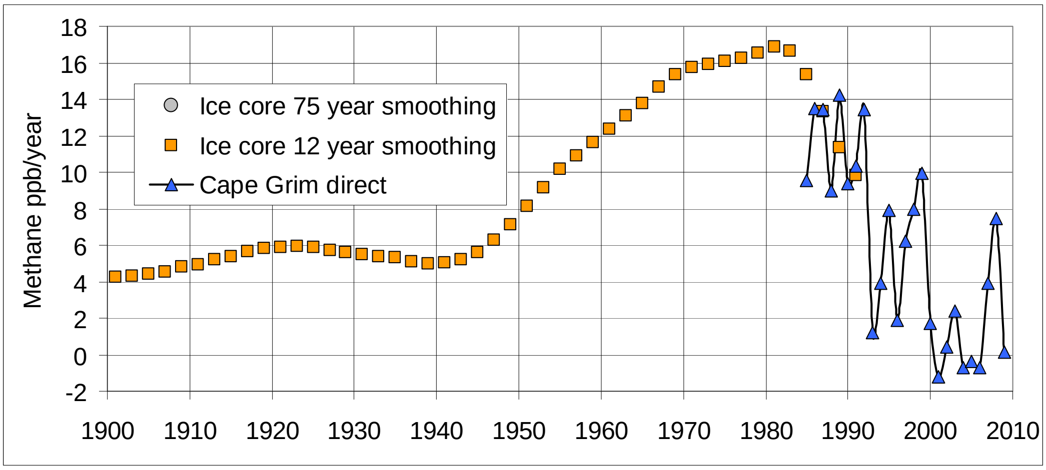


Figure 13: *Ice core and direct measurements of atmospheric methane from 1900. The peaks in the direct measurements correspond to El Ninos with the exception of 1992 which is an indirect result of the Mt Pinatubo eruption. Data source CSIRO.*

Annual increase in atmospheric methane

From year **To year**	1000 1750	1750 1800	1800 1850	1850 1900	1900 1950	1950 1960	1960 1970	1970 1980	1980 1990	1990 2000	2000 2009
Methane ppb/year	0.05	0.63	1.00	1.63	5.36	10.00	13.85	16.11	15.76	7.22	1.27

The annual increase in atmospheric methane is at about the rate of the early part of the nineteenth century. An explanation for the rise in methane from the 1940s to the 1980s is the expanding consumption of natural gas and its leakage from pipelines, particularly in the old Soviet Union. The steep fall at the end of the 1980s and early 1990s occurred as the leakage was greatly reduced and since that time variations follow a natural pattern showing El Ninos.

GLOBAL SEA LEVEL CHANGES

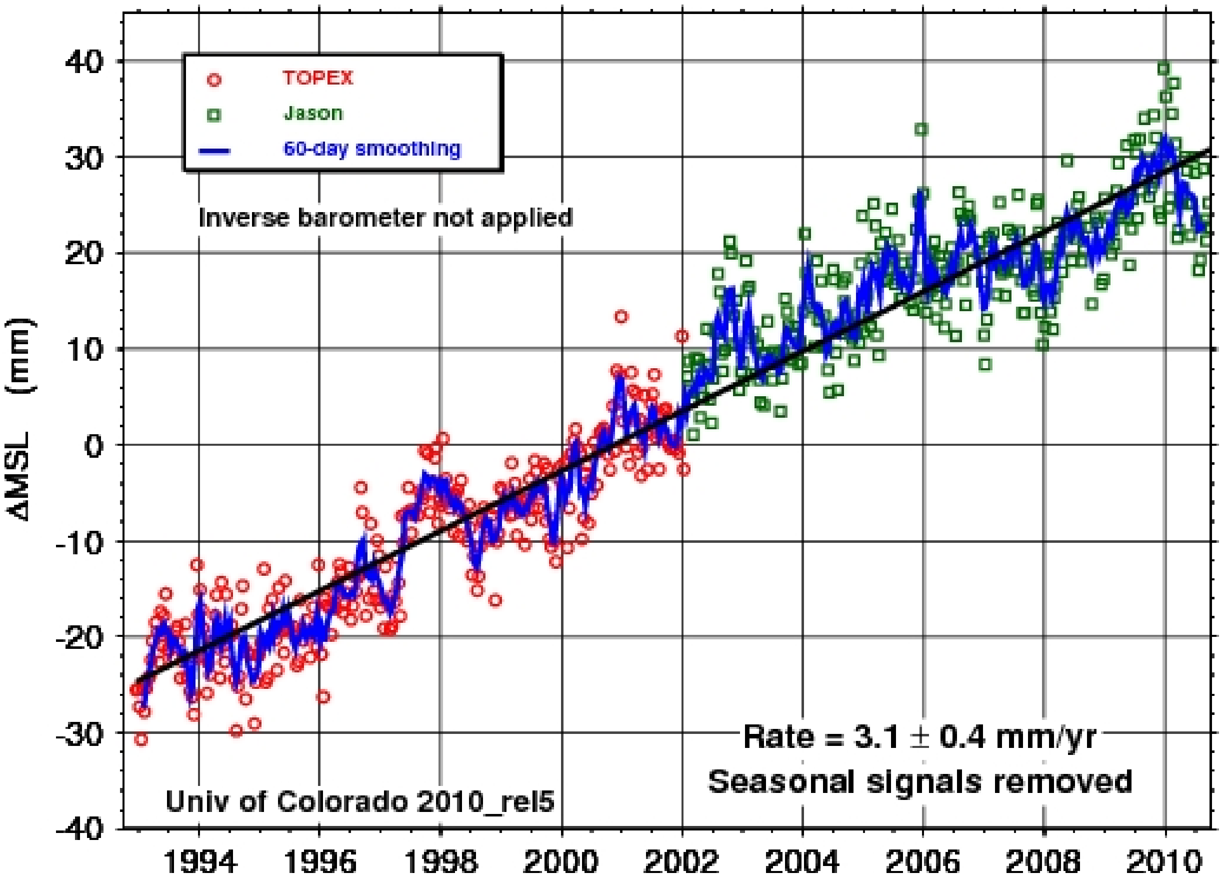


Figure 14: *The global mean sea level graph was made using satellite altimetry and processed by the University of Colorado at Boulder. Note that the rate of increase is 3.1 +/- 0.4 mm/year for1992 to 2010 but falls to 2.2+/- 0.3 mm/year for 2002-2010. If the rate of increase continues at about 3 mm a year, sea levels would reach about 30 cm in 2100. That is consistent with the IPCC's projection of 19-59 cm by 2100 and would not involve any significant inundations.*

Over the last century, global sea level changes were obtained from tide gauge measurements by long-term averaging. The increase over the period to 1990 was estimated at 2 mm per year.

Since August 1992 the satellite altimeters have been measuring sea level on a global basis with unprecedented accuracy using precisely known spacecraft orbits. The TOPEX/POSEIDON (T/P) satellite mission provided observations of sea level change from 1992 until 2005. Jason-1, launched in late 2001 as the successor to T/P, continues this record by providing an estimate of global mean sea level every 10 days with an uncertainty of 3-4 mm. The latest mean sea level time series can be found on this site.

There is some criticism of the processing of the satellite data with an analysis (N Morner 2011) showing that land uplift and subsidence corrections to tide gauges have increased the sea level rise by 1 to 2 mm per year.

THE GLOBAL OCEANS – detail showing sea level movements are complex.

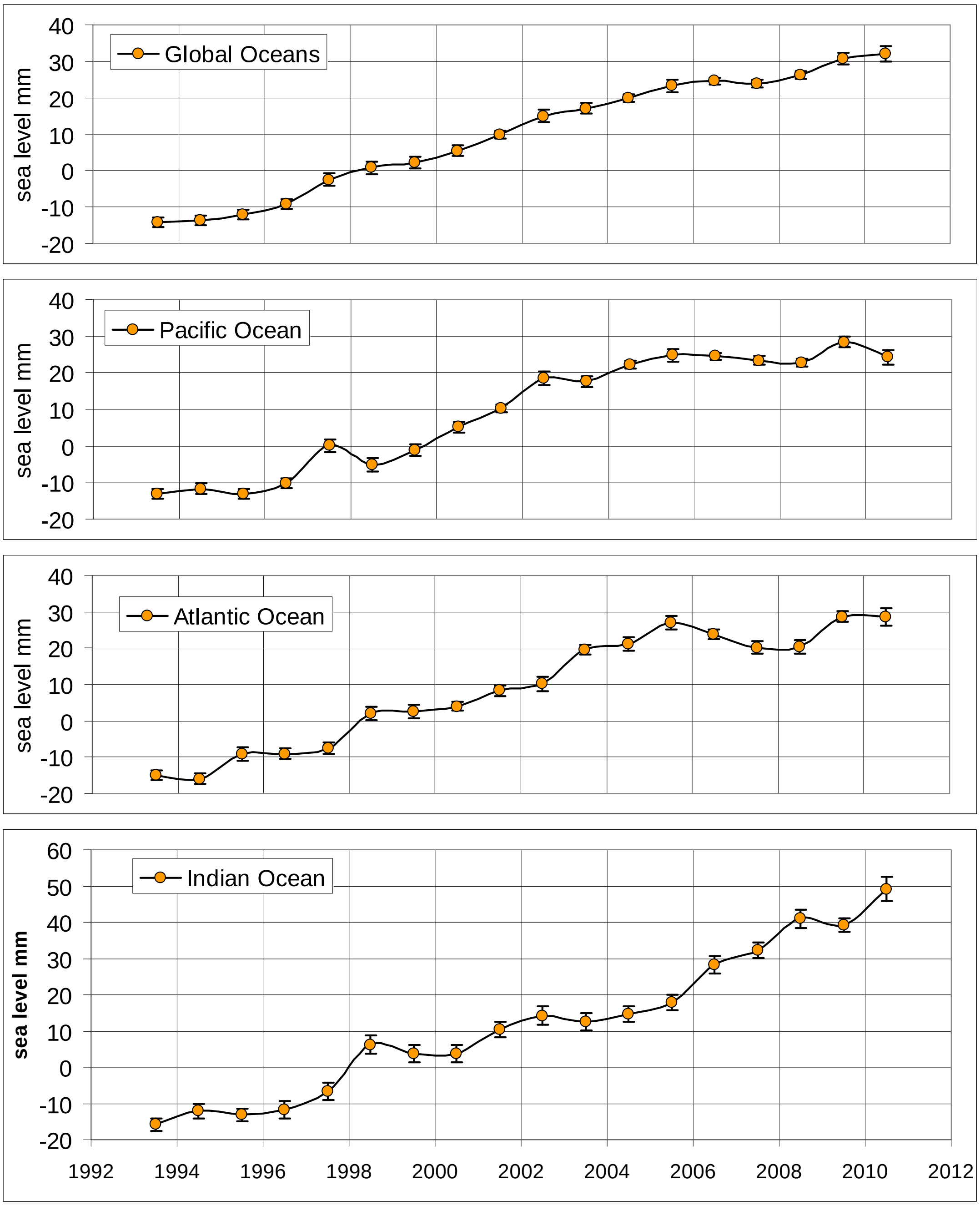


Figure 15: *Annual sea level anomalies derived from satellite measurements for the global oceans and separately the Pacific, Atlantic and Indian Oceans.*

Oceans	Annual sea level rise from 1993 to 2010 mm per year	Annual sea level rise from 2002 to 2010 mm per year
Globe - all	3.1 +/- 0.4	2,2 +/- 0.3
Pacific	2.8 +/- 0.2	0.9 +/- 0.3
Atlantic	2.8 +/- 0.2	1.6 +/- 0.6
Indian	3.7 +/- 0.2	4.8 +/- 0.5

The table shows the complexity of sea level rises. So in the Pacific Ocean a continuation of the present sea level rise for 100 years could be from 9 to 28 cm. This is at the low end of the IPCC global projections of 19 to 59 cm.

At the end of the last ice age, about 16,000 year ago, the sea level rose 120 m over a period of 7,500 years at a rate of 16 mm per year. The CSIRO projections for the Port Phillip Bay region are 10 mm per year.

CHANGES IN SOUTHERN AND NORTHERN ICECAPS

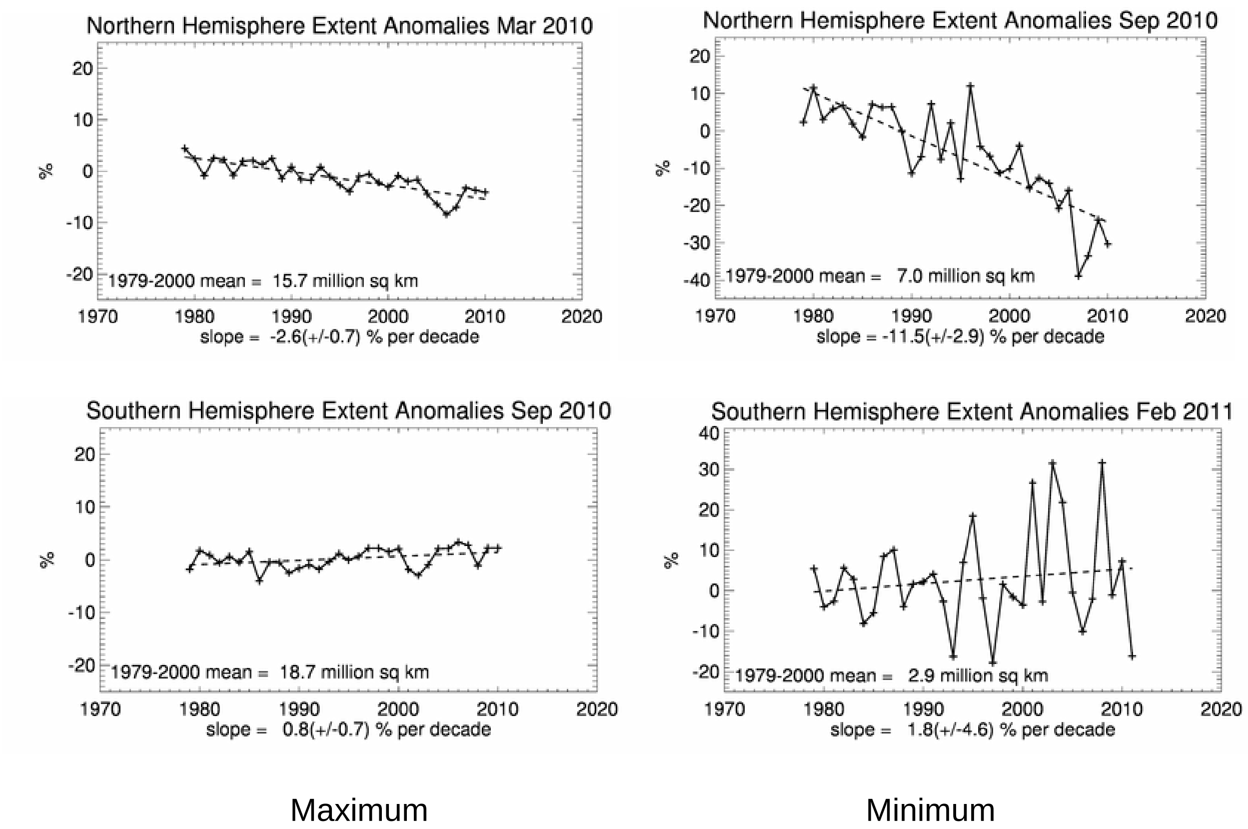


Figure 16: *Arctic and Antarctica ice extent. The maximum extent occurs in March in the Northern Hemisphere and in September in the Southern Hemisphere, summer minima occur in September and February. The Northern Hemisphere ice extent is decreasing with reducing maximum and minimum extent. Note that the slopes for the fitted straight lines give the change per decade.*

Data from National Snow and Ice Data Center: http://nsidc.org/data/seaice_index/

Receding ice is not a new phenomenon.

In 1903, Amundsen led the first expedition to successfully traverse Canada's Northwest Passage between the Atlantic and Pacific Oceans.

In 1922 the US Weather Bureau reported “The Arctic Ocean is warming up, icebergs are growing scarcer and in some places the seals are finding the water too hot. Reports all point to a radical change in climate conditions and hitherto unheard-of temperatures in the arctic zone. Expeditions report that scarcely any ice has been met with as far north as 81 degrees 29 minutes. Great masses of ice have been replaced by moraines of earth and stones, while at many points well known glaciers have entirely disappeared.”

MODELLING AND PROJECTING CLIMATE CHANGES

All the projections of future temperatures, sea levels, rainfall and disasters are the results of computer modelling. The critical inputs can grouped into four components:

1. **Present and past measurements of variables describing the behaviour of the atmosphere and oceans.**
   This is the primary driver of understanding and important in verifying model calculations. In general the measurements are 'state-of-the-art'. Proxy data can be problematic. An example is tree ring analysis and the arguments over the Medieval Warm Period.
2. **Estimating the variations of sources and sinks for green house gases**
   The problems of understanding the variations in methane (Figures 12 and 13) illustrate the uncertainties in understanding sources and sinks of green house gases. The structured increases in CO_2 (Figures 5, 6 and 7) point to the important role of the oceans in setting CO_2 levels in the atmosphere.
3. **Coupling the oceans to the atmosphere**
   The oceans are 70% of the surface of the earth and have as much mass in their top 10 metres as the entire atmosphere. The changes in ocean surface temperature are a key determinant of global temperature. The recent climate models couple the oceans to the atmosphere. However the consequences of decadel oscillations of ocean surface temperature (Figures 1, 2, 6 and 7) have largely been ignored since their occurrence and extent is not understood.
4. **Climate sensitivity**
   Climate sensitivity is how much warming is expected from a given change in CO_2. There is general agreement that more CO_2 in the atmosphere will increase the temperature at the surface of the earth. **A simple doubling of the CO_2 will give a temperature increase of less than 1^0C. The IPCC projections of greater increases from 2^0C to 4.5^0C are a consequence of positive feedback that follows the IPCC estimated radiative forcing.**

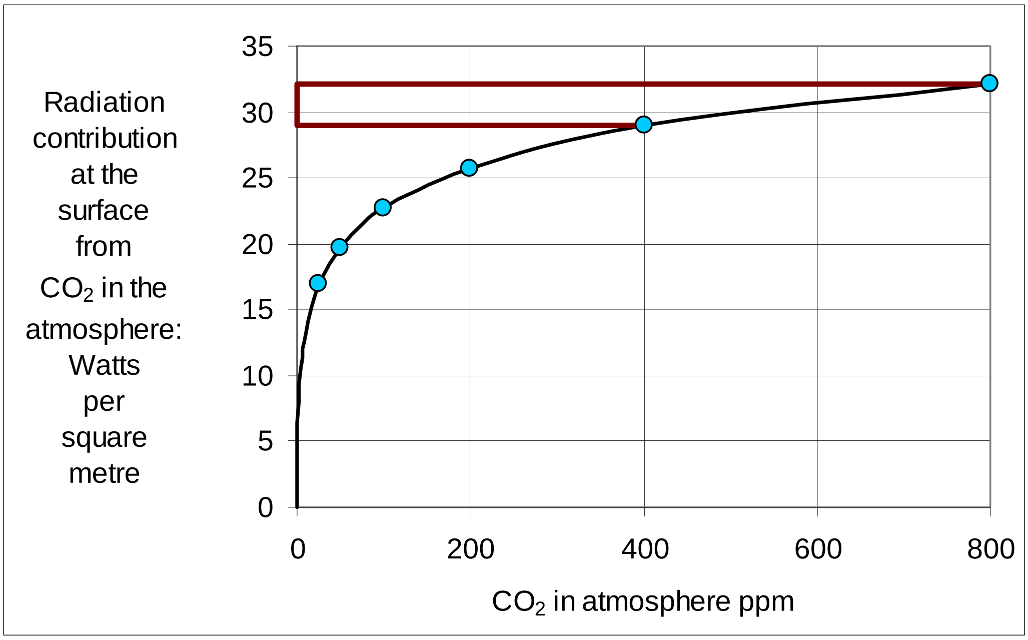


Figure 17 *As the concentration of CO_2 increases, there is increased radiation back to the surface of the earth (the greenhouse effect). This is measured in Watts per square metre (left axis). However the relationship is not linear. In fact doubling the concentration of CO_2 from 400 ppm to 800 ppm only increases the radiation from CO_2 at the surface by some 10% or 3.2 Watts per square metre. (Results derived for US standard atmosphere and cloudless sky from MODTRANS, a University of Chicago on-line calculator of energy in the atmosphere. MODTRANS is an international and IPCC accepted standard for atmospheric calculations).*

GLOBAL MEAN RADIATIVE FORCING

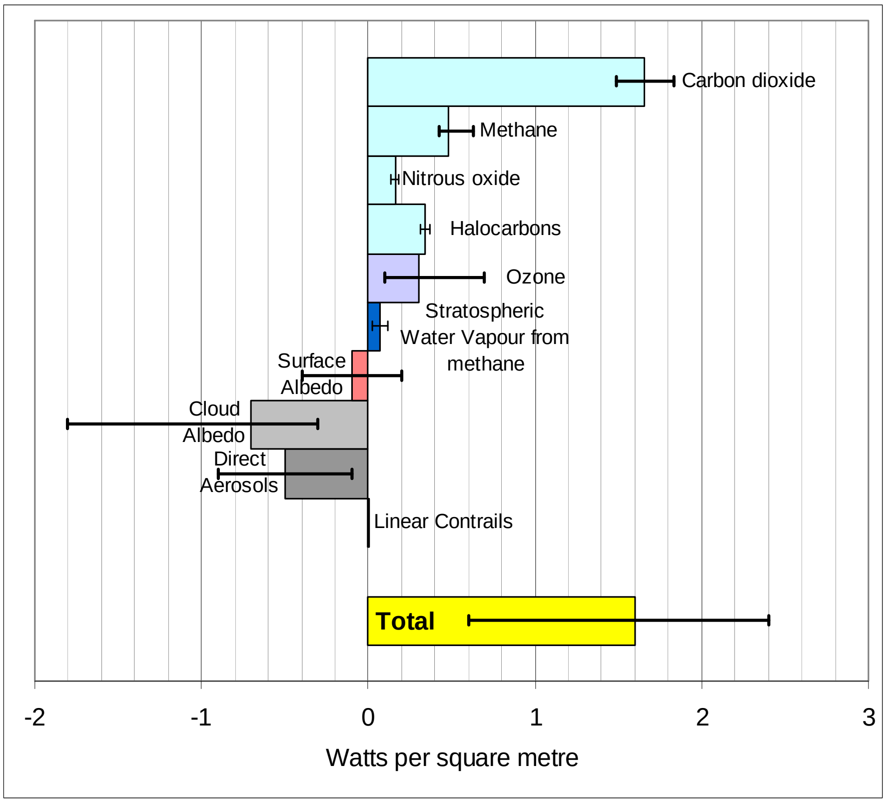


Figure 18: *Radiative forcing from various sources. The error bars show the uncertainty for each source. The total is described by the IPCC as "the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m^{-2} (see Figure SPM.2)". [IPCC-AR4 2007 WG1 Fig SPM.2]. Note the large uncertainties for aerosol and albedo forcing.*

The figure shows that the IPCC derived estimate of radiative forcing is 1.6 Watts per square metre from a range of sources which in many cases have considerable errors (some are estimates based on "expert" opinion not measurement). These large errors give the summed total radiative forcing itself an equally large error.

The radiative forcing value, in turn, leads the IPCC to claim in its last report that the resulting temperature increase of 0.8 (+0.4 to +1.1)^{0}C explains the temperature increase since 1750.

The temperature effects of the components of radiative forcing are often presented as feedback. It is generally agreed that there is a temperature increase due to increasing CO_2 and other greenhouse gases. Feedback is the result of other radiative forcing components that increase or decrease this temperature change. The feedback is represented by the formula: $\Delta T = \Delta T_0 / (1-f)$

where ΔT_0 is the initial calculated temperature increase, f the feedback factor and ΔT is the final temperature increase.

Feedback and temperature increase when atmospheric CO2 doubled

	f feedback	ΔT ^{0}C
Negative feedback (not found in any climate models but calculated by others)	-1.4 to -0.2	0.5 to 1.0
No feedback – ΔT_0 baseline from CO_2 and other greenhouse gases	0	1.2
Positive feedback (found in all climate models)	0.4 to 0.7	2.0 to 4.5
Measurement (this example is from precipitation)	**-0.5**	**0.8**

The IPCC estimates of forcing are not supported by a number of experimental analyses. An example of this is the climate models' prediction that global precipitation will increase at a rate of 1-3% per degree rise in temperature. A recent analysis of satellite observations (Wentz 2007) does not support this prediction. Rather, the observations show that precipitation has increased at about 6% per degree rise in temperature over the last two decades. This result indicates negative rather than positive feedback with increasing temperature.

Garnaut Climate Change Review **-Update 2011**

THE SCIENCE OF CLIMATE CHANGE

Before the 2011 Update Garnaut stated on April 16 2009 "there is uncertainty in the science ... the uncertainty adds to the case for strong and early mitigation" and on January 25 2010 "the science is not settled on all the dimensions of a complex natural system ...science is never settled ... the detail will be adjusted continuously".

Key points

• Observations and research outcomes since 2008 have confirmed and strengthened the position that the mainstream science then held with a high level of certainty, that the Earth is warming and that human emissions of greenhouse gases are the primary cause. - By mainstream science I mean the overwhelming weight of authoritative opinion in the relevant disciplines, as expressed in peer reviewed publications.

There are many distinguished mainstream scientists who disagree. As an example on 8 February 2011, 74 scientists sent a letter to the US Congress drawing attention to a report quoting 678 scientific studies to provide a point-by-point rebuttal of all the various claims by alarmist scientists, citing in every case peer-reviewed scientific research. Further the revelations through Climategate showed that considerable uncertainties were discussed even amongst those committed to the IPCC position.

• The statistically significant warming trend has been confirmed by observations over recent years:

- global temperatures continue to rise around the midpoints of the range of the projections of the Intergovernmental Panel on Climate Change (IPCC) and the presence of a warming trend has been confirmed;

Statistical analysis shows the temperature reached an apparent plateau but the change that occurred around 2000 is also to be found in other climate observables, in particular CO_2. This coincides with ocean surface temperature changes. There must be great uncertainty in temperature projections of present climate models if the interaction of the oceans with the atmosphere is not well understood.

- the rate of sea level rise has accelerated and is tracking above the range suggested by the IPCC;

The measured sea level rise on a global scale remains at 3 mm per year for the period 1993 to 2010. This is at the low end of the IPCC projections of 19 to 59 cm by 2100. However in the Pacific Ocean the rise from 2002 to 2010 is even less at 1 mm per year while the global rise is 2 mm per year.

The Royal Society: Climate change: a summary of the science *September 2010*
Paragraph 45: Because of the thermal expansion of the ocean, it is very likely that for many centuries the rate of global sea-level rise will be at least as large as the rate of 20 cm per century that has been observed over the past century. Paragraph 49; There is currently insufficient understanding of the enhanced melting and retreat of the ice sheets on Greenland and West Antarctica to predict exactly how much the rate of sea level rise will increase above that observed in the past century

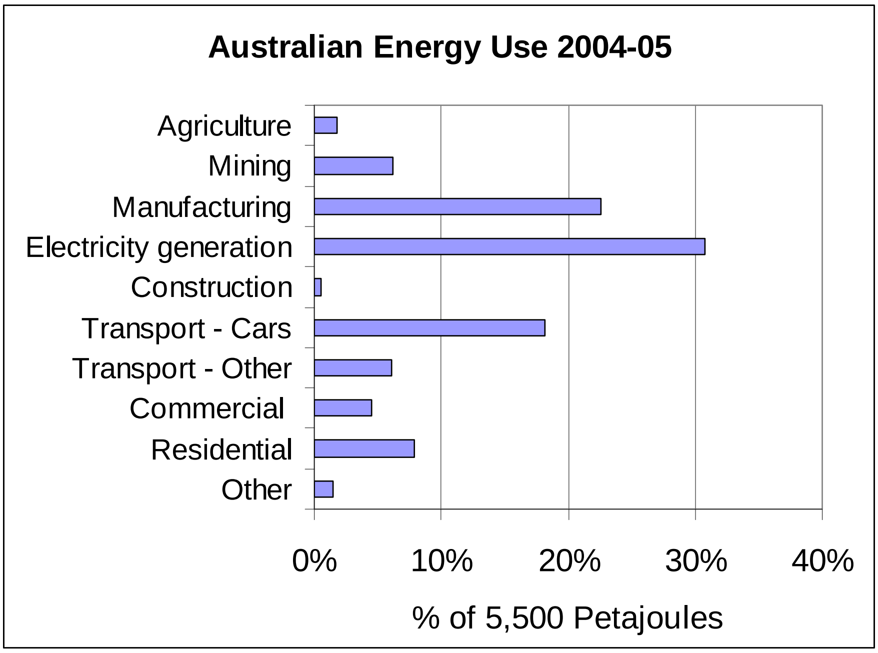
- rates of change in most observable responses of the physical and biological environment to global warming lie at or above expectations from the mainstream science.

As an example of observable responses consider methane There is no evidence for this statement and in fact what is happening is quite the contrary with the substantial reduction in annual increases of methane concentrations since 1980. Likewise statements about decreasing and more variable rainfall in the Murray-Darling Basin are not born out by measurement.

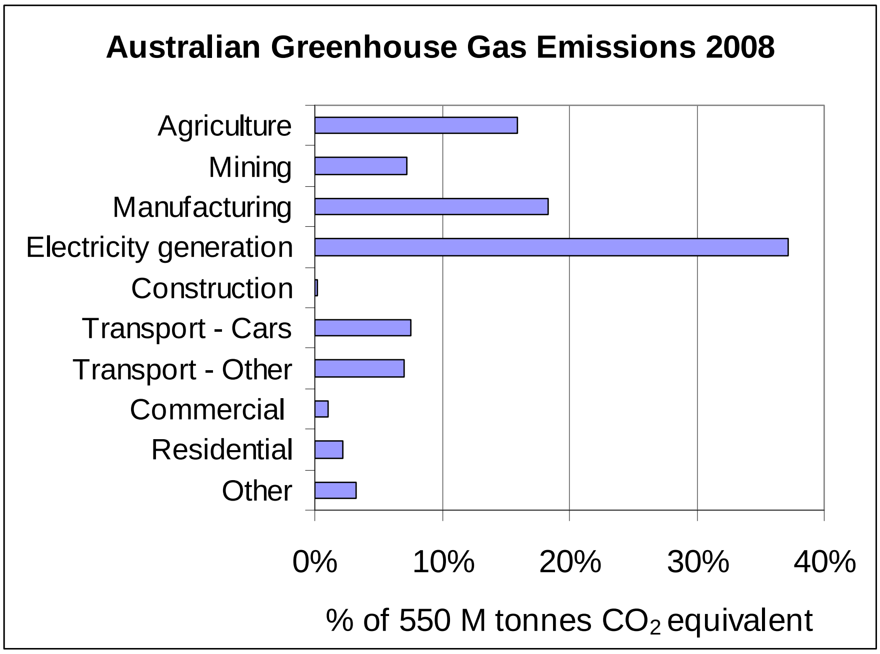
There is widespread agreement that recent severe weather events do not provide a basis for suggesting that rising temperatures will mean more frequent such events

AUSTRALIAN ENERGY USE AND GREENHOUSE GAS EMISSIONS

Australian Energy Use for 2004-05. Source ABARE



National Greenhouse Gas Inventory 2008

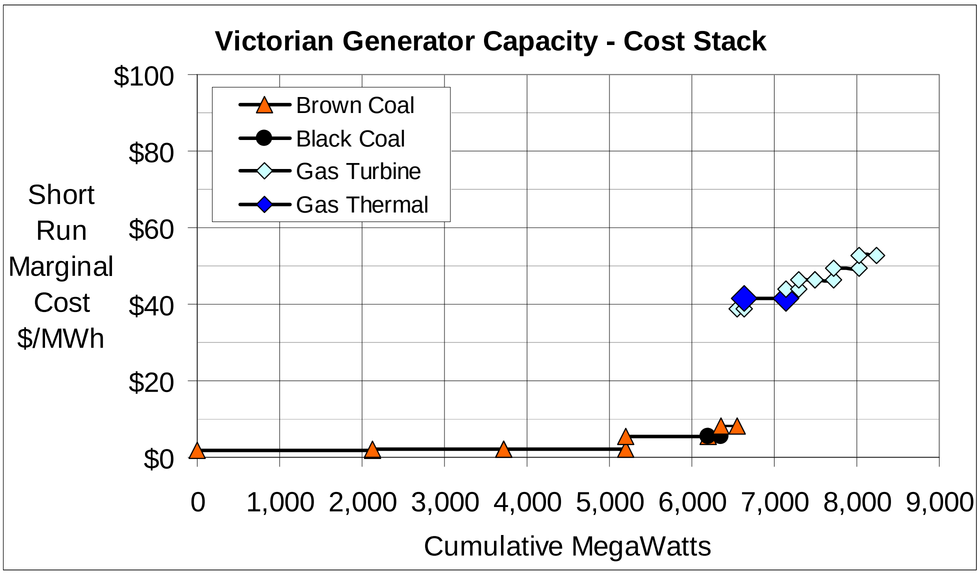


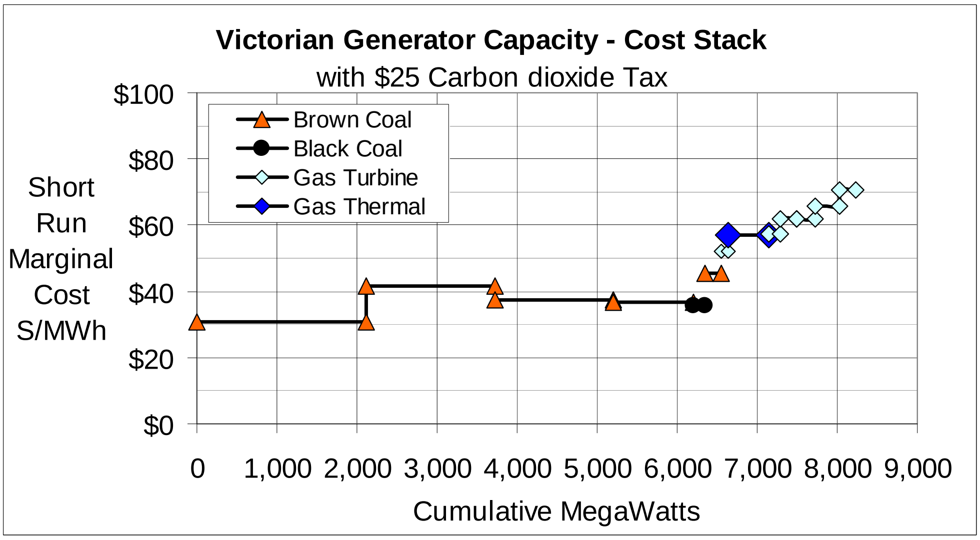
Note that

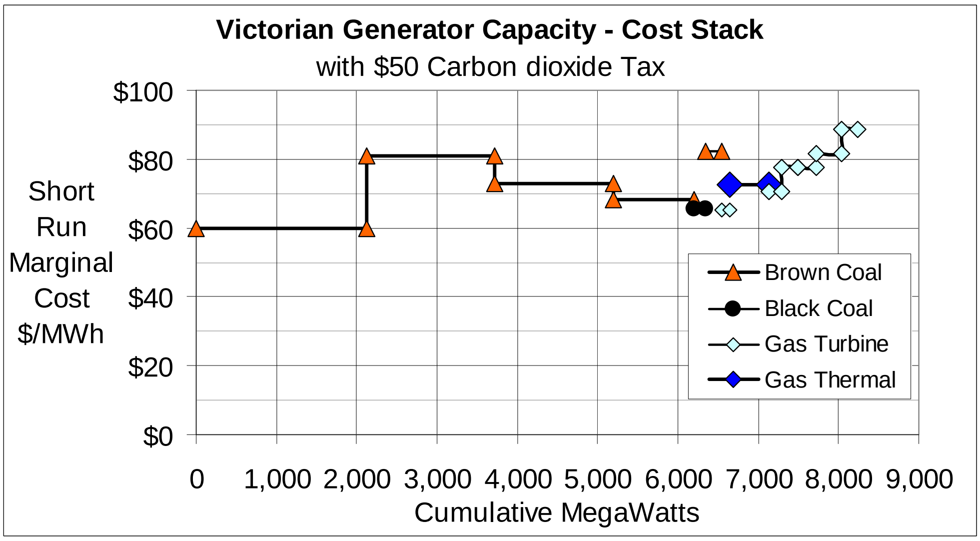
- Excluding agriculture, motorcars are the third largest emitters of greenhouse gases
- 64% of agricultural emissions are from enteric fermentation yielding methane.

ELECTRICITY GENERATION IN VICTORIA

Marginal costs in megawatt hours (MWh) for electricity generation calculated by ACIL-Tasman



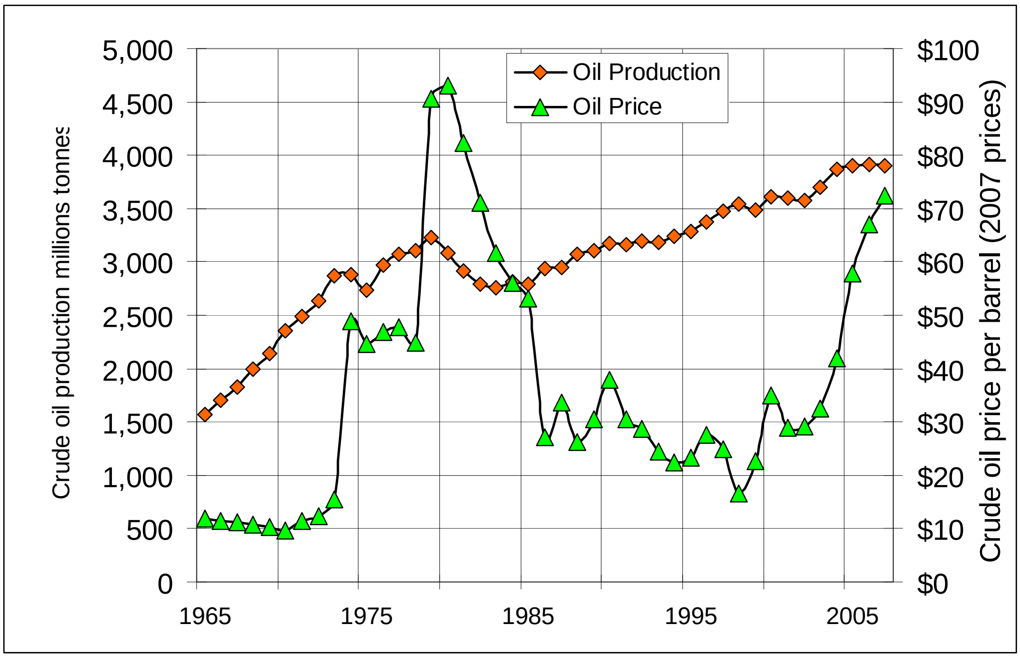


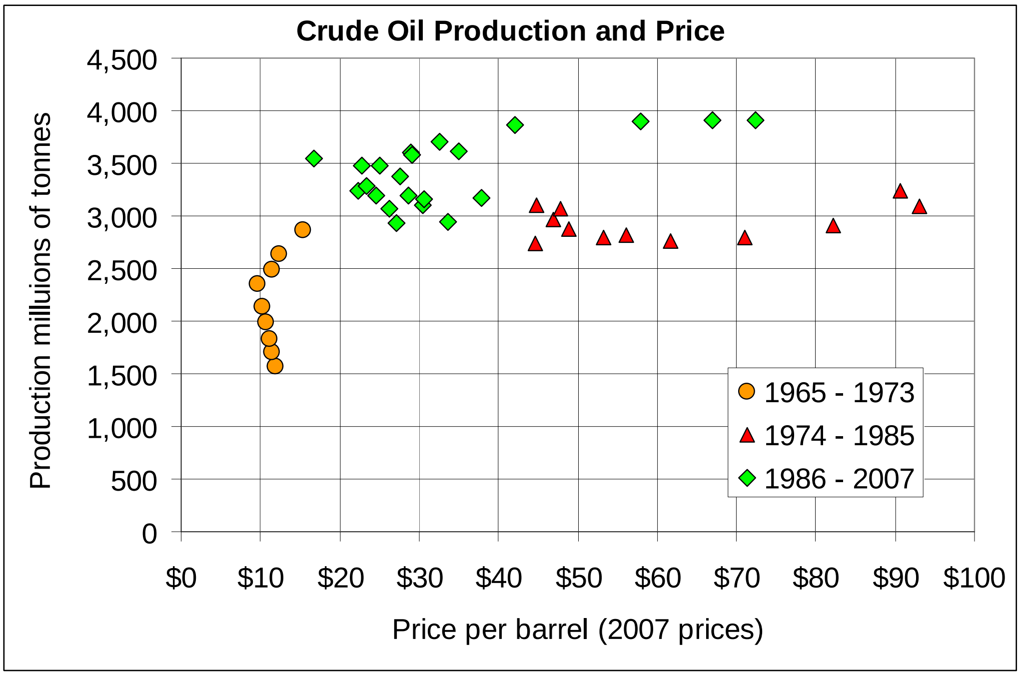


A tax on carbon dioxide emissions will have to reach $50 per tonne emitted before brown coal burning power stations lose a significant competitive advantage to gas use. The competitive example is Newport Power Station that burns natural gas and is some $40 per MWh above brown coal costs.

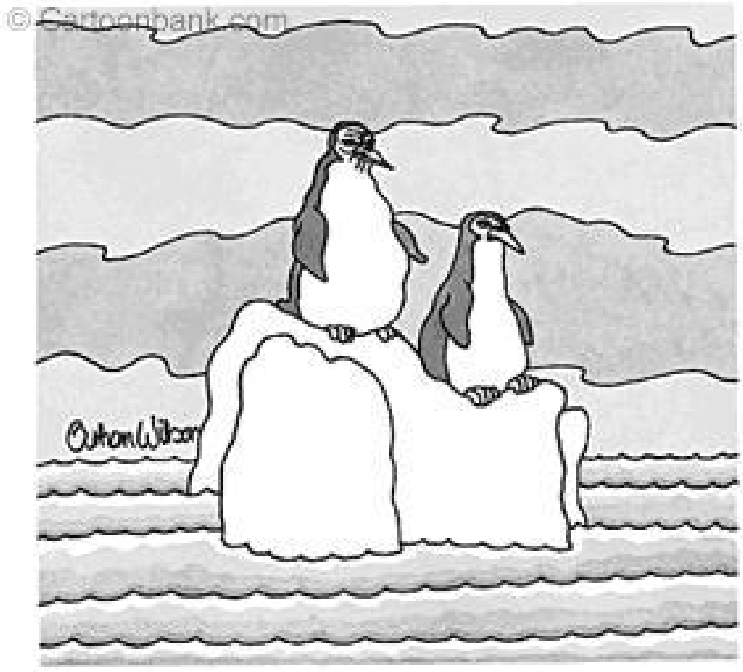
AN EXAMPLE OF A PRICE AND PRODUCTION RELATIONSHIP

The price and production of crude oil illustrates the complicated relationship when there are major price movements. Source BP Statistical Review 2008.





There are periods of falling prices from 1980 to 1985 and rising prices from 1986 to 2007 where there were no significant changes in production despite a factor of two change in prices.



"Call this an iceberg? When I was a kid we wouldn't have called this an iceberg!"

From the New Yorker