The Garnaut Reviews' Omissions of Material Facts

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"It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts." Sherlock Holmes (aka Arthur Conan Doyle)

Preamble

In 1853-54 there was a serious outbreak of cholera in London's Soho district. The prevailing view of scientists at the time was that cholera - like climate change now - was caused by an invisible miasma in the air, and the Ross Garnauts of that time all deferred to various Royal Societies (e.g. the Royal College of Physicians) as the definitive authorities. John Snow, a doctor who had pioneered the use of chloroform, in 1849 published at his own expense the first book to challenge the conventional wisdom of the authorities of the day, and was duly put down by them.[2] However Snow persevered, and showed how the incidence of cholera in the 1854 outbreak was closely correlated with the nature of the drinking water supplied by the Southwark and Vauxhall water company on the one hand, and the Lambeth company on the other. He eventually won acceptance for his contention that cholera is a water-borne disease, having shown statistically how most cholera deaths occurred in premises taking their water from the first company, which had its water intakes adjacent to sewerage outlets to the Thames, while very few deaths occurred in premises whose water was supplied by the Lambeth company, which in 1849 had moved its uptake up river from the sewerage outlets.

Snow's pioneering counterfactual analysis has recently been cited in two econometrics textbooks (Angrist and Pischke 2009, Freedman 2010) that explain how multi-variate regression analysis can be used to evaluate competing theories of causation.[3][4] This paper shows how such analysis reveals that changes in atmospheric water vapour are a much more powerful explanation of climate change than changes in carbon dioxide levels, because like Snow it uses counterfactuals to show that although the atmospheric concentration of carbon dioxide is ubiquitous (the same everywhere), temperature changes are not, and that in most places changes in atmospheric water vapour have a very much larger – and much more statistically significant – association with changes in temperature . Were he alive now it seem

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[2] *On the mode of communication of cholera.* "Journals dismissed Snow's book - 'There is, in our view, an entire failure of proof that the occurrence of any one case could be clearly and unambiguously assigned to water'. However the reviewer later concludes, 'Notwithstanding our opinion that Dr Snow has failed in proving that cholera is communicated in the mode in which he supposes it to be, he deserves the thanks of the profession for endeavouring to solve the mystery. It is only by close analysis of facts and the publication of new views, that we can hope to arrive at the truth'". (London Medical Gazette, 1849).*Source:* www.johnsnowsociety.org

[3] Angrist, J.D. and J-S Pischke (2009). *Mostly harmless econometrics: an empiricist's companion*. Princeton UP, Princeton and Oxford.

[4] Freedman, David A. (2010). *Statistical Models and Causal Inference.* CUP, Cambridge (see Chapter two: "Statistical Models and Shoe Leather" for a full account of Snow's work).

more than likely John Snow would have been as sceptical of airborne carbon dioxide being the cause of changing climate everywhere as he was of miasmic air being guilty of spreading cholera.

Ross Garnaut's Update 5 *The Science of Climate Change* is notable for its avoidance of econometrics and counterfactuals, and concludes (in its section 4.2.2) by invoking the authority of the Royal Society, the National Academies of Sciences (USA), and the Australian Academy of Science with their support for the findings of the International Panel on Climate Change that global warming is caused by airborne carbon dioxide. In an uncanny repeat of the views of the peak authorities in 1850, the IPCC's *Climate Change 2007.The Physical Science Basis* goes out of its way (Solomon *et al.* 2007:28) to dismiss any role in climate change for the emissions of water vapour that are *simultaneous* with emissions of carbon dioxide whenever there is combustion of hydrocarbon fuels. Yet basic chemistry and physics show that while water vapour emissions are only in the range of 30-50 per cent of CO_2 emissions by weight, *in addition* to any moisture content of the fuel, their effect on surface temperature is much larger (see below). It follows that the tax on carbon to be proposed by Garnaut's next *Update* paper (17th March 2011) will also be a tax on water vapour and thereby, unavoidably, on rainfall. The political implications of that remain to be played out, but it is characteristic of all the Garnaut work on climate change that it dwells only on the supposed external costs of hydrocarbon combustion and never mentions the demonstrably larger benefits of elevated atmospheric carbon dioxide and rainfall on the world's primary production.

Statistics and the Garnaut Reviews

Garnaut's *The Science of Climate Change* is the fifth in his series of 8 papers updating *The Garnaut Climate Change Review* (2008), but like its predecessors is notable as much for what it leaves out as for what it thereby tendentiously includes. The list begins with Garnaut's first "key point":

> 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. ..The statistically significant [sic] 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 [sic].

However, the paper *Global Temperature Trends* by Breusch and Vahid (2011) commissioned by Garnaut for his 2008 Review, and updated for his new review, does not provide a great deal of support for that "statistically significant warming trend" being attributable to miasmic carbon dioxide.[5]

[5] Garnaut No5 (2011) states "I asked two leading econometricians (Trevor Breusch and Farshid Vahid), respected authorities on the analysis of time series, to examine the temperature record from the three (sic) authoritative global sources", failing even to mention the existence of the more comprehensive satellite data sets (UAH and RSS). Breusch and Vahid also failed in their primary duty of due diligence by remedying Garnaut's refusal to admit the existence of satellite records by checking them anyway.

> We conclude that there is sufficient statistical evidence in the temperature data of the past 130-160 years to conclude that global average temperatures have been on a warming trend. The evidence of a warming trend is present in all three of the temperature series. Although we have used unit roots and linear trends as a coordinate system to approximate the high persistence and the drift in the data in order to answer the questions, we do not claim that we have uncovered the nature of the trend in the temperature data. There are many mechanisms that can generate trends and linear trends are only a first order approximation… It is impossible to uncover detailed trend patterns from such temperature records without corroborating data from other sources and close knowledge of the underlying climate system.

Their first statement depends heavily on the absence of the tropics from global temperature sets for the period between 1850 and 1910 (see my Fig.2), as it was not until the 1950s that global temperature becomes a valid statistic, for only then did global surface temperature coverage reach 80 per cent, and it is now below that level again. This makes it very strange that Breusch and Vahid (2011) never assess the trends in the more truly global satellite temperature data sets, which surely should "corroborate" their data even though they do not go further back than 1978. The truth is shown in Fig.3: the linear trend in the UAH satellites' global data from December 1978 to February 2011 has an R^2 of 0.345, which is well below the minimum for statistical significance of 0.5, and indicates a rise of 0.0012 ^{o}C per month since 1978, or 0.0144 p.a., 0.144 per decade, and 1.44^{o}C per century, well below the 3^{oC} predicted by the IPCC, let alone the 5^{o}C predicted for 2100 by Garnaut (2008:Fig.4.5) if there is no "mitigation" (i.e. reduction of projected Business as Usual emissions, BAU). The UAH data do *not* in fact "corroborate" the NASA-Gistemp temperature data for the period when they overlap, as the latter shows a very large and apparently statistically significant trend since 1978 (see my Fig.4), with the annual change in the Gistemp series (1979-2010) at 0.0196^{o}C, which is 36 per cent higher than the UAH trend of 0.0144 ^{o}C.

Ross Garnaut like myself worked on the very successful float of Lihir Gold on the Australian Stock Exchange (ASX) in 1995 (in his case for Rio Tinto and in mine for the Government of Papua New Guinea). As he and I both know well, a prospectus like that for Lihir is required by the ASX rules for "Initial Public Offerings" not to leave out any material information with respect to the company being floated. In particular, "a prospectus is required to contain **all the information** that investors and their advisers would require and expect to make an informed assessment of the offer being made", ASX, 2011, my emphasis).

Garnaut's 8 *Update Reports* and 2008 *Review* are both in the nature of a Prospectus, inviting the Government and people of Australia to invest in a Carbon Tax (and eventual Emissions Trading Scheme, ETS) that will save them the costs of "dangerous climate change". That means Garnaut's 2008 and 2011 reviews should have disclosed the UAH satellite data as well as the Gistemp/NCDS/HadleyCRU surface data, even if using the former would have diluted the all too evident advocacy that characterises the Garnaut reviews.

Not even to mention the satellite data, and instead relying on surface measurements that perforce did not include the tropics before 1910, is again to omit "all the information that investors and their advisors would require and expect" to find in a company's IPO prospectus. The prospectus of a company that mentions only its profitable years and leaves out years of losses is very like the Hadley CRU, NCDC, and NASA-GISS data for "global" temperatures for 1850 to 1910 which omit the globe's hottest places, like Khartoum, Kampala, and Kinshasa (see my Fig.2), but are relied on by Garnaut's Breusch and Vahid for the baseline they need to show "unprecedented warming" since 1850 or 1880, see their Fig.1.

However, there is a much more serious omission of "all the information investors and their advisors would require and expect" in both the Garnaut Reviews when they make this statement:

> **No-mitigation case** – based on no action undertaken to mitigate climate change, and used as a 'reference' to assess the benefits of climate change action that accrue from the climate change impacts that are avoided. By the end of the century the concentration of long-lived greenhouse gases in the atmosphere is **1565** ppm carbon dioxide equivalent (Garnaut 2011:5 and Fig.1, my emphasis).

The present atmospheric concentration of CO_2 is 390 parts per million (ppm) of the atmosphere. To this Garnaut adds the atmospheric levels of other greenhouse gases, chiefly methane (CH_4) and nitrous oxide (N_2O), which are expressed in CO_2 "equivalent" amounts that bring the CO_{2e} concentration to between 455 and 465 ppm in 2010. To get from 460 ppm to 1565 ppm by 2100 requires that the rate of growth of CO_{2e} from now until 2100 has to be 1.0137 per cent p.a. The actual growth of atmospheric CO_2 from 1958 to 2010 was 0.295 per cent p.a., and projecting CO2e at that rate (the growth rates of CH_4 and N_2O are much lower than that of CO_2, see IPCC, Solomon et al. 2007:141)[6] to 2100 produces only 600 ppm of CO_{2e} by 2100, less than 38 per cent of (i.e. 62 per cent less than) Garnaut's 1565 ppm.

Garnaut offers no basis for predicting any *acceleration* in the rate of growth of the atmospheric concentration of CO2e above the actual rate from 1958 to 2010, and, failing that, this claim in his *Update 5* paper is equivalent to that of a company like Lihir Gold claiming in its IPO Prospectus in 1995 that it could borrow at say 1 per cent above LIBOR instead of the actual 2-3 per cent it did have to pay to its main bank lender, UBS. Had Lihir Gold made that claim, the ASX might well have rejected the Prospectus –and if not, shareholders would have been able to sue Lihir Gold when the truth became apparent.

The Real Science of Climate Change[7]

Real science involves very precise formulae, like Einstein's

$$E = MC\text{^}2 \ldots(1)$$

or the formula for combustion of a typical hydrocarbon fuel in the presence of air (using pure oxygen tends to raise the proportion of H2O in the outputs):

$$C_3H_8 + 5O_2 + 18.8N_2 \rightarrow Energy + 3CO_2 + 4H_2O + 18.8N_2 \ldots(2)$$

Climate science has never produced any such formulae, and as discussed below, always suppresses the second formula. If it could, we would be presented with something like

$$C + O_2 \rightarrow CO2 \text{ together with } \Delta H_j^o = -393.51\ kJ \text{ plus } xW/sq.m \ldots(3)$$

where *C* is solid carbon (graphite) and ΔH_j^o is the standard heat of formation, being the enthalpy change that occurs when one mole of a substance is formed from its component

[6] Growth of the methane concentration from 1998 to 2005 was NIL, despite Garnaut's claim (2010) that its growth rate is increasing, and of N_2O, 11 per cent over that period (in total, not p.a.), against 13 per cent in CO_2 (IPCC, Solomon *et al.* 2007:141).

[7] This section has benefited considerably from the insights of Anthony Kelly (2010). He notes that in the various applicable chapters in the IPCC's Solomon *et al.* (2007) no mention is ever made of the fact that most if not all anthropogenic water vapour is in the form of steam (p.630).

elements and *x* is the radiative forcing associated with the replacement of the O_2 in the atmosphere by CO_2.

Climate science has never been able to produce such a formula simply because it cannot, as there is no such precise relationship. The closest climate scientists get to producing a formula for the "radiative forcing" of greenhouse gases, namely the strength of their ability to radiate heat back to earth, is their equation 4. The subsequent change in equilibrium surface temperature (ΔT_s) arising from that radiative forcing is given by:[8]

$$\Delta T_s = \lambda \Delta F \quad ...(4)$$

where λ is the *assumed* (not proven) climate sensitivity, with units in K/(W/m^2), and Δ*F* is the *assumed* radiative forcing, given by

$$\Delta F = 5.35 \times \ln \frac{C}{C_0} \text{ W m}^{-2} \quad ...(5)$$

where C is the current or future level of atmospheric carbon dioxide and C_o is the pre-industrial level (280 ppm), and F is measured in Watts per square metre. A typical value of λ is said to be 0.8 K/(W/m^2), which gives a warming of 3 ^{o}C for a doubling of CO_2 (from 280 ppm to 560 ppm). The parameters λ and 5.35 are not data-based, e.g. by use of linear least squares regression, being fitted *ex post* at whatever level seems to match the observations (see Myhre 1998), so the *only* data in (4) and (5) are the base and projected levels of CO_2.[9]

As a result, this model consistently overstates its forecast of global temperature from 1959 to 2010 by 0.0112oC p.a. (0.112^{o}C per decade), and 0.59^{o}C for 2010 compared with the Gistemp global temperature of 14.83^{o}C in that year (see my Fig.8). That is not a trivial difference, and it gets worse over time.

Thus the equations (4) and (5) may look impressive but they lack the precision of Einstein's (1) or the chemical formulae like (2) that govern the combustion of hydrocarbon fuels. Not only that, if climate scientists were capable of the basic linear least squares regression analysis in which Arrhenius (1896) was fully proficient, they would at least be able to do regressions in which they showed that

$$\Delta T_t = a + b(3CO_2)_t + c(4H_2O)_t + d(18.8N_2)_t + u_t \quad ...(6)$$

and then provided statistically significant values for the coefficients. But they never have provided such values for the *b* and *c* coefficients like those I show below.

Similarly while climate scientists are aware of the Clausius-Clapeyron relation which defines the maximum partial pressure of water vapour that can be present in a volume of atmosphere in thermodynamic equilibrium as a strongly increasing function of temperature, they have failed to

[8] This account is based on the article *Radiative Forcing* in Wikipedia, accessed 14th March 2011.

[9] Myhre, G, E.J. Highwood, K.P. Shine, F. Stordal (1998). New estimates of radiative forcing due to well mixed greenhouse gases. *Geophysical Research Letters*, 25.4, 2715-2718

quantify it accurately in the context of their predicted climate change. This maximum is known as the saturation vapour pressure, e_s:

$$e_s(T) = e_s(T_o)exp^{-L/Rv(1/T_{-1}/T_0)} \quad \ldots.(7)$$

"where *L* is the latent heat of the appropriate phase transition (vapour to liquid at warm temperatures, vapour to solid at sufficiently cold temperatures), *Rv* is the gas constant for water vapour, and *To* is a reference temperature. At the freezing point, e_s is 614 Pa or 6.14 mb; *L/Rv* = 5419 K for condensation into liquid and 6148 K for condensation into ice" (Pierrehumbert *et al.* 2007:145).[10]

It is important to realise that while satellite observations indicate that the response of global evaporation to rising temperature is close to that implied by (7), with the cooling effect entailed by evaporation and associated precipitation, the GCM models deployed by climate scientists apparently *reduce* the evaporation implied by Clausius-Clapeyron, presumably because it increases potential global warming (Kininmonth 2010:61).

Pierrehumbert *et al.* (2007:180) also caution against what they term "wholly indefensible statements which simply invoke the Clausius-Clapeyron relation…[as being] at the root of the behaviour of water vapour, *but the proper use of the relation hinges on identifying the temperature to which the relation should be applied; it's not the surface temperature, and the effect of the relation on evaporation is of little relevance to water vapour feedback*" (my emphasis).

As a result of not acting on the advice of Pierrehumbert et al. (2007), Solomon *et al.* (2007) wrongly attribute increases in water vapour only to rising surface temperatures, although using those increases to raise the radiative forcing they ascribe to atmospheric carbon dioxide is enough to triple the temperature change due to that by 2100 from 1^oC to 3^oC. This artefact is termed the "feedback" effect whereby rising temperature raises evaporation whose own radiative forcing would be much stronger than that of atmospheric carbon dioxide alone, were it not for precipitation rising *pari passu* with evaporation. But Randall and Wood *et al.* 2007 in Solomon *et al.* (2007:633) and Garnaut (2008:81 and 2011:26-27) downplay the role of precipitation in cancelling out rising evaporation, indeed they predict increasing drought despite the rising water vapour they rely on for their infinitely spiralling further temperature increases that deliver their desired "runaway" greenhouse effect.

However, Pierrehumbert *et al.* (2007) also assume that increases in atmospheric water vapour (hereafter denoted by $[H_2O]$) stem only from rises in temperature, and are independent of processes like combustion of hydrocarbons that directly release water vapour into the atmosphere. Such releases *must* be more than as potent *pro rata*– in terms of generating radiative forcing by reducing outgoing long wave radiation (OLR) - as increases in $[H_2O]$ resulting from rising temperature. Moreover, like those increases in $[H_2O]$, the increases produced by combustion must also be "approximately logarithmic in specific humidity once the [total] concentration is sufficiently large to saturate the principal absorption bands". Moreover, "one finds that each doubling of water vapour reduces OLR by about $6W/m^2$ (Pierrehumbert 1999). This is about 50% greater than the sensitivity of OLR to CO_2.

[10] Raymond T. Pierrehumbert, Hélène Brogniez, and Rémy Roca (2007). On the Relative Humidity of the Atmosphere, chapter 6 in *The Global Circulation of the Atmosphere*, T Schneider and A Sobel, eds. Princeton University Press. (2007).

The idea that small quantities of water vapour can have a lot of leverage in climate change has a fairly long history, and is now widely recognized. Water vapour feedback was included in the very first quantitative calculations of CO_2-induced warming by Arrhenius [1896], and the importance of water vapour aloft was implicit in such calculations…" (Pierrehumbert *et al.* 2007:146).

For example, we know that in 2008-2009 combustion of hydrocarbon fuels generated emissions of about 8.6 billion tonnes (8.6 GtC) of carbon (or 31.4 billion tonnes of CO_2, i.e. 31.4 $GtCO_2$) (le Quere *et al*., 2010) – and from data in Gaffen and Ross (1999) that implies direct water vapour emissions (just from the combustion process of burning a hydrocarbon fuel using oxygen) of 17.5 GtH_2O.[11] But using the Pierrehumbert *et al*. figure above, the radiative forcing (RF) from this addition to [H_2O] is 50 per cent higher than that of increased atmospheric CO_2. According to the IPCC (Forster and Ramaswamy 2007: 141), the radiative forcing per $GtCO_2$ is 0.0019 Watts/sq.metre, so that from changes in [H_2O] is 0.0028 W/sq.metre. That means hydrocarbon combustion generated RF of 0.108 W/sq.m. in 2008-09, of which 0.059 W/sq.m. was due to carbon dioxide emissions, and 0.049 W/sq.m. to water vapour emissions. Yet Garnaut's **The** Science of Climate Change never notices this effect, and it is dismissed as of no consequence by the IPCC's Forster and Ramaswamy *et al.* (2007).

The implications are very profound, because if the IPCC and Garnaut are right that increasing water vapour does not lead to increased precipitation, then the RF and resulting global warming from hydrocarbon fuel combustion have been seriously underestimated. However Lim and Roderick (2009) have shown that in reality, while there is evidence for increasing evaporation between 1970 and 1999, it has been matched by increased rainfall, *pace* Garnaut and the IPCC.[12] Thus just as the IPCC and Garnaut generally ignore uptakes of CO_2 emissions by the biospheres, they also ignore that rising [H_2O] is matched by rainfall. This explains why they always ignore the positive social benefits of the output of hydrocarbon combustion, and explicitly treat increases in agricultural productivity and rainfall as social "bads".

Regression analysis of climate science counterfactuals

Using the Mauna Loa data set on addition to atmospheric CO2 from 1958 to 2009, and regressing Gistemp temperature anomalies against it , we have the results shown in Table1.

[11] "Based on carbon emissions data (Marland et al. 1994), we estimate global water vapor emission from fossil fuel consumption to be of order 10^{12} (in 1960) to 10^{13} (in 1990) kg yr^{-1}", Gaffen and Ross, 1999. Carbon emissions were 5.57 GtC in 1990, yielding a factor of 5.57/10 for the ratio between emissions of water vapour and carbon, in Giga tonnes, from hydrocarbon combustion, namely 1.795, say 1.8 (or 0.49 Gt H_2O to 1 Gt of CO_2).

[12] Lim, Wee Ho and M.L. Roderick 1999. ***An Atlas of the Global Water Cycle*** *Based on the IPCC AR4 Climate Models*. ANU E-Press, Canberra.

Table 1 Regression of Absolute Values of GMT anomalies (as reported by Gistemp) against [CO_2] data (absolute ppm), 1959-2009.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.899[a]	.808	.804	9.80892	.808	206.186	1	49	.000	1.666

a. Predictors: (Constant), CO2MLO

b. Dependent Variable: Tanomaly

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-296.097	22.021		-13.446	.000	-340.349	-251.844		
	CO2MLO	.912	.063	.899	14.359	.000	.784	1.039	1.000	1.000

a. Dependent Variable: Tanomaly

These results look impressive, with a high R^2 of 0.8 and a statistically significant coefficient on the CO2MLO variable (i.e. atmospheric CO_2 as measured at the Mauna Loa Observatory). But as von Storch and Zwiers note in their textbook (1999), comparison of time series using least squares regression has a high risk of serial or spurious correlation, and the Durbin-Watson statistic at 1.666 shows that to be potentially the case in this instance.

This problem is usually addressed by taking year-on-year differences in the data, with the results shown in Table 2:

Table 2 Regression of changes in surface-measured GMT on changes in [CO_2]

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.575[a]	.331	.317	.13403	.331	23.721	1	48	.000	2.521

a. Predictors: (Constant), dCO2195909

b. Dependent Variable: dGistemp

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-.212	.050		-4.240	.000	-.313	-.112		
	dCO2195909	.157	.032	.575	4.870	.000	.092	.222	1.000	1.000

a. Dependent Variable: dGistemp

Table 2 probably explains why the IPCC (Solomon *et al.* 2007) and Garnaut (2008 and 2011) never report regression results, for while the Durbin-Watson statistic at 2.5 rules out serial correlation, the R^2 falls to .317, indicating that the CO_2 variable, although statistically significant, does not account for "most" (i.e. more than 50 per cent) of observed temperature change since 1958, as claimed by Garnaut (2011), Hegerl and Zwiers *et al.* (2007:670) and Solomon *et al.* (2007:10).

The truth evaded by Garnaut is that Hegerl and Zwiers as lead authors of the crucial Chapter 9 ("Understanding and Attributing Climate Change") in IPCC's AR4 (Solomon *et al.* 2007) were well aware that standard multivariate regression analysis of changes in temperature as a function of changes in atmospheric CO2 and natural influences (e.g. water vapour) does not

yield their desired outcomes, hence their refusal to report such analysis. Instead they have resorted to developing a new method of analysis that they have named "detection and attribution of fingerprints (sic)". But this system does not appear in standard textbooks, as it twists the raw data into their desired shapes by use of modelled parameters rather than using only raw data. Thus although their model has the form y = Xa + u where *y* is the "filtered" climate variable and X is a matrix of independent variables that could determine y, while *a* is a vector of scaling factors. But in their hands X, the matrix for the independent variables, contains only "signals that are estimated" by climate models, rather than real world data (Hegerl and Zwiers *et al.* 2007: 744).

Thus their model is tautologous, as by avoiding use of data it always delivers the pre-determined results generated by its climate models. Nevertheless, Francis Zwiers was invited to give testimony to the United States' House of Representatives Committee on Energy and Commerce, Subcommittee on Energy and Power hearing entitled "Climate Science and EPA's Greenhouse Gas Regulations" on 8th March 2011. Here is a direct quote from Zwiers' Testimony: "Figure 2 also shows the prediction that was made by the IPCC in 2001 that the decade of the 2000s would be 0.1-0.2°C warmer than the 1990s, primarily because of the influence of rising greenhouse gases" – but fails to provide *any* statistical evidence linking that 0.1-0.2°C to rising atmospheric CO_2. It is telling that his Figure 2 does not include the linear regression trend lines for the temperature data used there, as they are of course derisory, even though naturally he uses 2000, a La Nina year as his start year:

$$y = 0.0015x + 0.151$$
$$R^2 = 0.1073$$

(UAH Global temperature anomalies January 2000 to October 2010; I left out the very cold La Nina-affected November and December 2010 just to be helpful to Zwiers).

Zwiers similarly chose not to show the trends in increases in the atmospheric concentration of CO_2 for 2000 to 2010, perhaps because the trend is actually slightly negative (albeit not significantly so) for that period:

$$y = -0.0035x + 1.998$$
$$R^2 = 0.0009$$

Comparison of these two trends may explain why Zwiers like Garnaut does not perform regressions on his data. Here are the results:

(1) Constant = 0: UAH anomalies = f(increases in CO2)

Adj R^2: 0.014; Coeff. on CO_2= 0.035; t = 1.68; p = 0.096

(2) Constant not zero:

Adj R^2: 0.0004; Coeff. on CO_2= 0.0116; t = 0.97; p = 0.33

Setting the constant (y-intercept) at zero gives Zwiers his best chance, but it does not help. In both cases there is NO statistically significant correlation at all between the increases in CO_2

and the UAH anomalies (for that the *t* statistics should be >2, the $p < 0.15$, and the R^2 should be at least 0.5). However if Zwiers had regressed sales of mobile phones against atmospheric carbon dioxide data he would doubtless have found a stunning correlation.

John Snow's Counterfactuals, Carbon Dioxide, and Climate Change

In the Preamble I gave a brief account of John Snow's counterfactual analysis of cholera by collecting statistics on the distribution of sources of water supply by households and of deaths from cholera. The problem with the bivariate regressions of global temperature change and atmospheric carbon dioxide reported in the previous section is that the only independent variable is changes in atmospheric CO_2. In that regard such regressions are like those implicitly relied on by the medical establishment in London in 1854, which could as easily have proved that the increasing incidence of cholera outbreaks was due to the equally well attested increase in use of horse-drawn vehicles, omnibuses, cabs, and the carriages of the rich, with horses' exhalation a plausible source of the miasma passionately believed by the Garnaut reviews of the day to be the cause of cholera.

The modern equivalent of John Snow's careful mapping of cholera deaths and water supply is climate data sets from over 1200 locations produced by the US Government's NOAA[13] that are deliberately ignored by the climate change establishment and its cheerleader, Ross Garnaut along with Breusch and Vahid, seemingly because they include time series of a wide range of climatic variables, not just temperature.

These location-specific and multivariate data sets provide counterfactuals simply because although atmospheric carbon dioxide is known to be a "well-mixed" greenhouse gas (i.e. WMGHG), like London's miasma in 1854, which means it is at much the same level everywhere, from Point Barrow in Alaska to Cape Grim in Tasmania to Mauna Loa in Hawaii, temperature *trends* are NOT the same everywhere, and are in general more closely associated with other climatic variables, such as the amount of sunlight reaching the surface, and, above all, the level of atmospheric water vapour, i.e. [H_2O]. In Fig.5 and Fig. 6 below the trends in annual mean maximum, minimum, average daytime, and mean temperatures are shown for both Point Barrow in Alaska and Hilo (near Mauna Loa) in Hawaii for the period 1960-2006. The respective trends differ considerably, although the R^2 correlation coefficients do not suggest high statistical significance. The *nil* trends in annual mean temperature at Honolulu and Mauna Loa itself from 1978-2006 (Fig.7) with R^2 of 0.01 and 0.1 respectively contrast with that for atmospheric carbon dioxide (R^2 0.99) (time series determined by data availability), and explain the poor correlations.

Regression analysis of the NOAA climate data for Pt Barrow for 1960 to 2006 (when this set terminates) provides a striking example of John Snow's counterfactual analysis. As shown in Table 3, changes in the level of atmospheric carbon dioxide play no role at all in explanation of the significant warming trend in minimum temperatures, while the role of atmospheric water vapour [H_2O] is strong and very highly significant (99%), along with opacity of the sky

[13] http://rredc.nrel.gov/solar/old-data/nsrdb/1961-90/dsf/data and http://rredc.nrel.gov/solar/old-data/nsrdb/1991-2005/statistics/data

at night (OPQ). Similar results are found for various locations in Hawaii, such as Hilo (Table 4), and New York City (Table 5), and many others, not reported here for reasons of length.

These counterfactuals all show no statistically significant correlations between atmospheric carbon dioxide levels (i.e.[CO_2]) and changes in temperature, and thereby fully support the conclusions of Paulo Cesar Soares (2010:111), that there is no causal relation between [CO_2] with global warming, given the absence of evidence for changes in [CO_2] preceding temperature either for global or local changes, and that the greenhouse effect of [CO_2] is very small compared with that of water vapour.[14]

Table 3 Regression of climate data, P Barrow 1960-2006

SUMMARY OUTPUT				
Dependent variable: Mean minimum annual temperatures,				
Pt Barrow 1960-2006				
Regression Statistics				
Multiple R	0.78			
R Square	0.60			
Adjusted R Square	0.57			
Standard Error	1.04			
Observations	46.00			
ANOVA				
	df	*SS*	*MS*	*F*
Regression	3	69.02	23.01	21.16
Residual	42	45.67	1.09	
Total	45	114.69		
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.05	0.40	-0.12	0.91
H2O	13.64	2.75	4.96	0.00
CO2 ML	0.02	0.26	0.06	0.95
OPQ	1.20	0.29	4.19	0.00
Independent variables				
H2O = atmospheric water vapour				
CO2 ML = atmospheric CO2				

Sources: http://rredc.nrel.gov/solar/old-data/nsrdb/1961-90/dsf/data and http://rredc.nrel.gov/solar/old-data/nsrdb/1991-2005/statistics/data

[14] P.C. Soares 2010, Warming Power of CO2 and H2O: Correlations with temperature changes. *International Journal of Geosciences*, 102-112.

Table 4 Multivariate regression of climatic variables, Hilo 1960-2006

SUMMARY OUTPUT				
Dependent variable: Changes in Annual Maximum Temperature				
Hilo, Hawaii 1960-2006				
Regression Statistics				
Multiple R	0.59			
R Square	0.35			
Adjusted R Square	0.28			
Standard Error	0.59			
Observations	45			
ANOVA				
	df	*SS*	*MS*	*F*
Regression	4	7.46	1.87	5.38
Residual	40	13.86	0.35	
Total	44	21.32		
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.13	0.24	0.54	0.59
dCO2	-0.07	0.16	-0.47	0.64
dAVGLO	0.00	0.00	3.34	0.00
dAvWS	-0.09	0.34	-0.27	0.79
dH2O	2.35	0.58	4.08	0.00

Independent variables

dCO_2 = annual changes in atmospheric carbon dioxide at Mauna Loa Slope Observatory;

dAVGLO = Average daily total solar radiation, i.e. sum of direct and diffuse radiation less albedo (Wh/m^2);

dAvWS = Changes in annual average wind speed;

dH2O = changes in precipitable water vapour (cm).

Sources: http://rredc.nrel.gov/solar/old-data/nsrdb/1961-90/dsf/data and http://rredc.nrel.gov/solar/old-data/nsrdb/1991-2005/statistics/data

Table 5 Regression of climate data, New York City (JFK) 1960-2006

SUMMARY OUTPUT				
Dependent variable: mean annual minimum temperature				
New York 1960-2006				
Regression Statistics				
Multiple R	0.85			
R Square	0.72			
Adjusted R Square	0.69			
Standard Error	1.86			
Observations	46			
ANOVA				
	df	*SS*	*MS*	*F*
Regression	3	365.79	121.93	35.15
Residual	42	145.69	3.47	
Total	45	511.49		
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.26	0.67	-0.39	0.70
dCO2	0.06	0.43	0.14	0.89
dH2O	18.64	1.93	9.64	0.00
dOPQ	-0.53	0.35	-1.49	0.14

dOPQ = average annual opacity of sky cover.

Sources: http://rredc.nrel.gov/solar/old-data/nsrdb/1961-90/dsf/data and http://rredc.nrel.gov/solar/old-data/nsrdb/1991-2005/statistics/data

The Benefits of Hydrocarbon Fuel Emissions

Garnaut's first Update paper (2011) has the title "Weighing the costs and benefits of climate change action", and like the fifth is in breach of ASX disclosure rules, because at no point does it mention the undoubted benefits of hydrocarbon combustion in terms of (1) the fertilization effect of elevated atmospheric carbon dioxide on primary production, and (2) the benefits in terms of enhanced crop yields of higher global rainfall. For Garnaut (2008 and 2011), hydrocarbon combustions produce only costs, in the form of as yet unproven large rises in global mean temperatures (even though they would also have benefits in the form of

higher crop yields in all higher latitude zones), and the benefits of restricting use of hydrocarbons consist *only* of avoidance of the supposed costs of rising temperatures.[15]

Ironically, there is a huge contradiction between the basic Garnaut position that hydrocarbon emissions produce only costs, while in both his 2008 and 2011 reviews, he devotes space to the role of expanding agro-forestry in order to reduce atmospheric carbon dioxide concentrations through their absorption of substantial volumes of those emissions. In the 2008 *Review* Garnaut was able to raise the historic growth rate of the concentration of CO2e at 0.29 per cent p.a. (1958-2010) to his projection of 1.0137 per cent p.a. from 2010 to 2100 by suppressing the known take-up of more than half of carbon dioxide emissions by the globe's biospheres (Knorr 2009). He justifies that in his Update 5's section 2.3.2 on the carbon cycle which at face value seems unexceptionable but nevertheless displays palpable bias. The first is the stress on the apparently fast growth of fossil fuel emissions between 2000 and 2008 of 3.4 per cent p.a., without mentioning that in that period the atmospheric concentration of carbon dioxide increased by only 0.296 per cent p.a.

This distinction between the respective growth rates of emissions and of the atmospheric concentration is very important but never mentioned either in Garnaut 2008 or in the 2011 Update, and betrays some ignorance of dependence of percentages on respective base levels. Total annual emissions of human-generated carbon dioxide are approaching 10 billion tonnes of carbon-equivalent CO_2 (i.e. GtC), but the absolute atmospheric concentration is nearly 830 GtC. An increase of three percent in the first figure, of which over half is absorbed by the biospheres, becomes just 0.02 per cent of the second figure.[16]

At the observed atmospheric concentration growth rate of 0.295 per cent p.a. over the longer period from 1959 to 2009, it will take until **2134** for the so-called pre-industrial level of the atmospheric concentration of 280 ppm to double to 560 ppm; and the 2009 level of 387 ppm will not double until **2244**. The Review's portrayal of the extreme urgency of preventing these gentle increases is not compelling, unless one accepts the Garnaut projection of 1565 CO_{2e} by 2100.

Update 5 justifies its alarmism by claiming that the strength of the carbon sinks (which have on average absorbed 56 per cent of carbon dioxide emissions since 1958) has been "declining" over the last five decades, which if true would result in an increasing airborne fraction of emissions from the present average level of 44 per cent p.a. It offers no statistical evidence beyond its repeated citations of papers by J.P. Canadell, C. Le Quere, P. Fraser, and M. Raupach, of which none of those cited in section 2.3.2 has been peer-reviewed. Instead in another omission of material facts, *Update 5* ignores the peer-reviewed paper by W. Knorr

[15] This is an unusual form of cost benefit analysis, pioneered by Stern (2007), whereby the cost of one course of action is the benefit if that course of action if not adopted. Normally, costs and benefits should be independent of each other, not one and the same.

[16] Garnaut (Melbourne Institute, 20th May 2010) joined the 21 leading Australian economists led by John Quiggin who by endorsing the Rudd government's proposed Resource Super Profits Tax (2010), accepted the Henry Tax Review's claim (2010) that the existing company tax rate of 30% of taxable profits and the average State royalty rate of 5% of sales revenue were by 2009 generating tax receipts of only 17% of taxable profits - truly a case of New Political Arithmetic.

(2009) in a mainstream journal, which concludes "despite the predictions of coupled climate-carbon cycle models, no trend in the airborne fraction can be found".[17]

A peer-reviewed paper that appeared in the same month as Knorr's provided substantive statistical support for the benefits conferred on mankind by the rising level of atmospheric carbon dioxide through its enhancement of the photosynthesis on which all living matter is wholly dependent.[18] That "externality" is never mentioned in Garnaut 2008 and 2011 even when admitting that expanding agro-forestry can increase the uptakes of carbon dioxide emissions that elsewhere he projects as falling to nil (2008: Fig.2.7). The role of Temperature and CO_2 in raising photosynthesis – and thereby yields – is shown in Fig.1. Evidently the more CO_2 is available at any given temperature the higher is the net primary productivity (NPP). Similarly, the higher the temperature at any level of CO_2, the higher is the NPP (left axis) up to the limits specified. Combining higher temperature with higher CO_2 again leads to higher NPP. We are now at 390 ppm and <15°C, so have some way to reach the optimum implied by the feasible levels of 650 ppm and leaf temperature of 30°C.

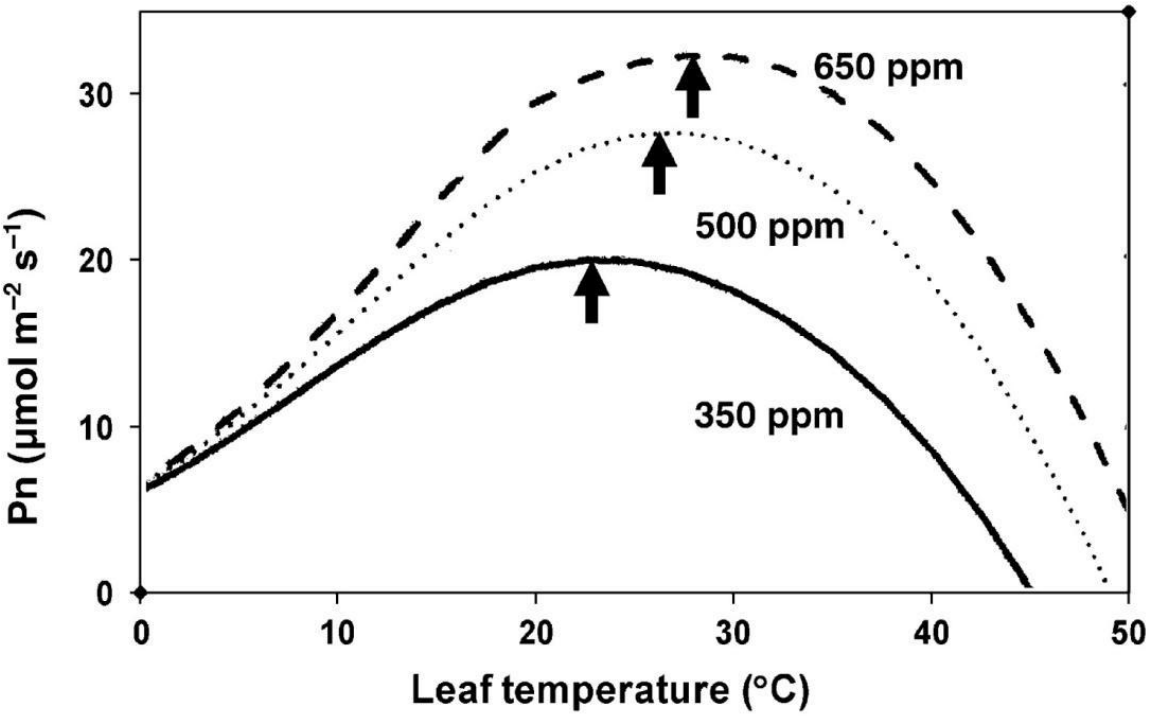

Fig. 1 The response of light-saturated net photosynthesis to changes in leaf temperature at different atmospheric CO2 concentrations. Arrows indicate the shift in optimum temperature with increasing CO2 concentration. Redrawn from Long (1991), with permission of Blackwell Science.

[17] Is the airborne fraction of anthropogenic CO2 emissions increasing? Wolfgang Knorr, *Geophysical Research Letters*, Vol. 36, L21710, doi:10.1029/2009GL040613, 2009.

[18] Tim Curtin, Climate change and food production, *Energy and Environment* (2009, 20.7).

Similarly, Table 6 confirms the concurrence in Fig.1 of rising atmospheric carbon dioxide with rising terrestrial uptakes of carbon dioxide and rising world cereals production both in total and per capita. The Garnaut *Reviews* will incur a heavy burden of responsibility if their efforts to secure a reduction of carbon dioxide emissions succeed in reducing the atmospheric concentration to levels like that shown for 350 ppm in Fig.1 that are unlikely to support the food requirements of a world population of nearly 7 billion now and possibly 9 billion by 2050.

Table 6

Carbon Dioxide and World Cereals Production 1961-2007

	1961	2007	% Increase
Total Atmospheric Carbon Dioxide GtC	673.01	815.10	21.11
Anthropogenic Emissions of CO2, GtC	4.06	9.94	144.83
Total Land Uptakes of CO2 emissions, GtC	0.90	2.98	231.11
Total cereals output, billion tonnes	0.88	2.34	167.14
Carbon content (40%), GtC	0.35	0.94	167.14
Population, billion	3.08	6.60	173.00
Cereals output per capita, tonnes	0.28	0.35	24.64
Carbon content per capita (40%), tonnes	0.11	0.14	24.64

Source: Le Quéré, Canadell *et al.* 2009, FAO 2009.

Note: The world's uptakes of atmospheric carbon dioxide are not limited to cereals - other food and fruit crops, livestock, forestry, and fisheries are all contributors.

Conclusion

Ross Garnaut ends his Update 5 with this comment (p.44):

> Scepticism is an essential part of the scientific process and serves to move the science towards greater understanding and agreement. Once a theory is put forward by a researcher, it is discussed, analysed and criticised by the wider scientific community. Further tests, modelling and research then respond to that questioning. The consequent exchanges determine whether the initial conclusions hold, need refining or are rejected.

I offer this critique of Garnaut's Updates in that same spirit, and look forward to engaging with Ross Garnaut, but from experience I am doubtful of any response being forthcoming. I published a detailed peer-reviewed analysis of Garnaut's 2008 Review in *Quadrant (*January 2009*)*, one of Australia's only two monthly current affairs magazines, and never received any response, despite supportive comments from two ministers in the Hawke and Keating governments and some senior academics. So much for questioning leading to "exchanges", but perhaps this time I may elicit some serious evaluation of the rather serious criticisms here of Garnaut's *Updates*.[19]

[19] For a critique of Garnaut's first Update paper, see Cox and Stockwell (2011).

APPENDIX

Hydrocarbon Taxation – some preliminary comments

Ross Garnaut's Sixth update paper *Carbon Pricing and Reducing Australia's Emissions* was published on 17th March 2011. It argues that for Australia to achieve a contribution to a "moderately ambitious global mitigation effort aimed at limiting the atmospheric concentration to 550 ppm of carbon dioxide equivalent", the carbon (sic) tax the Australian government has announced it will introduce with effect from 1st July 2012 should be set within a range of $20-$30 rising at 4 per cent real p.a., until its replacement around 2015 by an Emissions Trading Scheme with annual reductions in sales of permits based on declining emissions caps.[20]

The Update 6 paper has little to say about the charging and collection basis for the tax. For example, it assumes that with a carbon tax of $20-$30 per tonne of CO2-e and given that 2.29 kilograms of CO2-e are emitted from each litre of petrol (p. 10, footnote 2, citing Grattan Institute 2010b, unpublished), "the impact on the price of petrol of a carbon price in the range discussed in this paper would be about 5-7 cents per litre". It is painfully obvious that this calculation is set to downplay the impact of the "carbon" tax on pump prices of petrol, because it ignores the large energy usage of oil refineries, where energy can account for over 72 per cent of operating costs (Stern 2007:301). That energy usage is almost wholly carbon-based, whether from electricity derived from the grid, which in Australia is heavily dependent on coal-fired power stations, or from its own fuel oil, which will also like the power stations be subject to the "carbon" tax.

Thus Garnaut's Update 6 ignores that 0.27 kg of CO_2 are needed per kWh of electricity and that the refineries themselves have emissions of carbon dioxide. It is difficult to avoid irony when an economist like Garnaut feels qualified to publish *The Science of Climate Change* but proves to be ignorant of the distinction in economics between input costs and output prices. The pump price of petrol will increase not only because of the factoring in of the emissions from petrol when it is used but also from the increased costs of producing and distributing it.

According to Stern (2007:301), energy accounts for 72.8 per cent of the total costs of refined petroleum in the UK, and that this industry has the highest carbon intensity of any British industry apart from gas. Garnaut admits in another context that the wholesale price of petrol is 40 per cent of the pump price, or $0.56 per litre if the latter is $1.40. This implies at least another $0.5-$0.7 increase in pump prices, for a total of $0.10-$0.14 from a "carbon" tax of around $25 per tonne of carbon dioxide, *double* the range indicated by Update 6. However, for reasons that are far from obvious, if the tax is intended to reduce consumption of hydrocarbon fuels, Garnaut recommends it should be offset by a permanent reduction in the petrol excise tax of $0.38 per litre.

[20] It appears that either Australia's education system does not convey the differences between carbon, a solid black substance, and carbon dioxide, a colourless and odourless gas, or that its leaders deliberately mislead the public and mainstream media into believing that they are indistinguishable.

It is even more difficult to fathom why when the objective of the "carbon" tax is to reduce consumption of hydrocarbon fuels, the Garnaut Update recommends that half of the receipts from the tax ($11.5 billion is tax is set at $26 per tonne CO2e) should be used to reduce income taxes collected from lower income households, effectively leaving them better off than before the "carbon" tax – and thereby enabled to continue as much hydrocarbon intensive activity and purchases as before the tax, with no net reduction in hydrocarbon emissions (depending on their collective income and price elasticities for electricity and petrol).[21]

The Update paper implies it is a simple matter to use the income tax system to compensate lower income households for the "carbon" tax, instead of direct payments through Centrelink, but that is far from being true, as raising the tax free threshold or reducing the rates applicable to taxable income below say $30,000 unavoidably reduces tax payable by higher income households, thereby necessitating raising the top marginal rate to above 50 per cent to offset those effects if the "carbon" tax is to have an impact on consumption of hydrocarbons by those households.

These considerations suggest that Garnaut's "carbon" tax paper is as poorly researched – and misleading – as his *The Science of Climate Science*.

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[21] In 2003-04 there were 3 million individuals (over 33 per cent of all individual taxpayers) with taxable income of less than $26,800 who paid net tax of $5.8 billion, which was 6 per cent of total net tax, and their taxable income was 14 per cent of total taxable income in that year (*Taxation Statistics 2003-04*, Australian Taxation Office, 2006).

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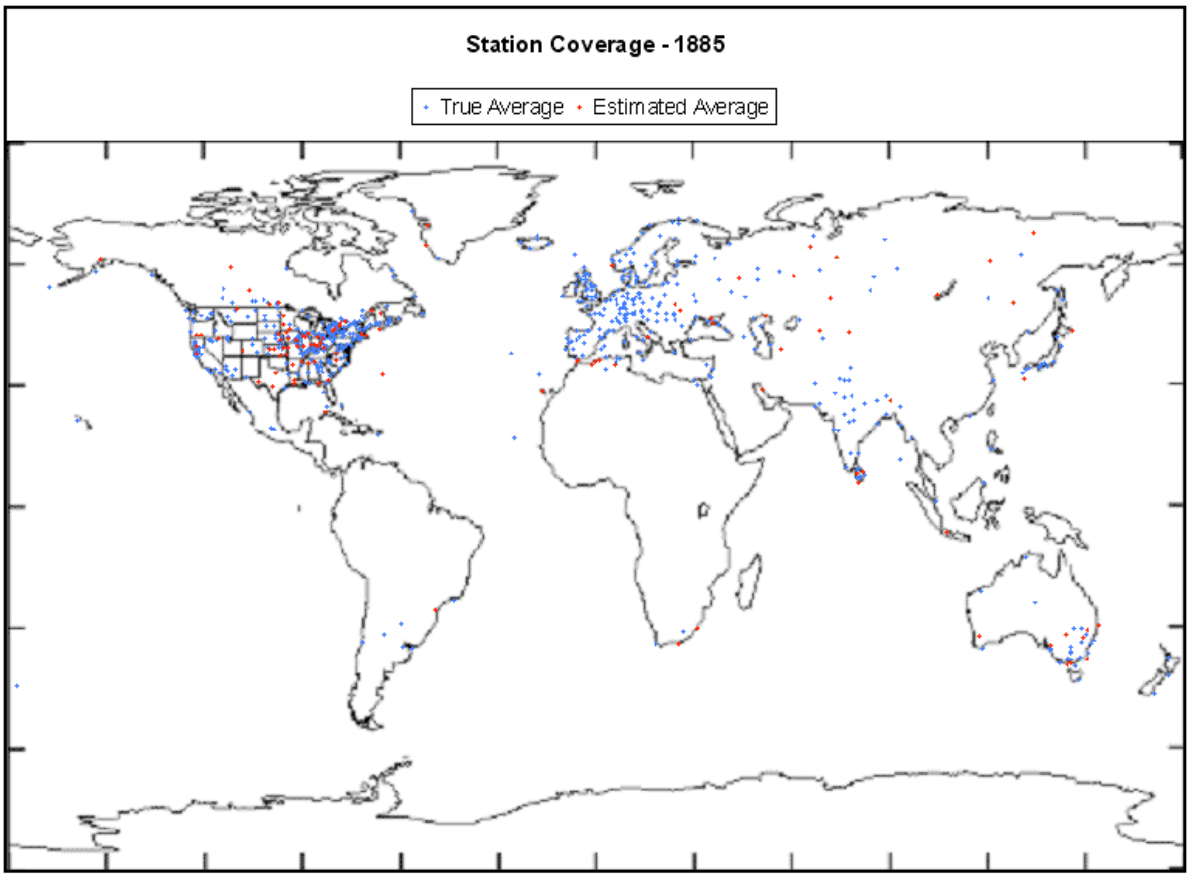
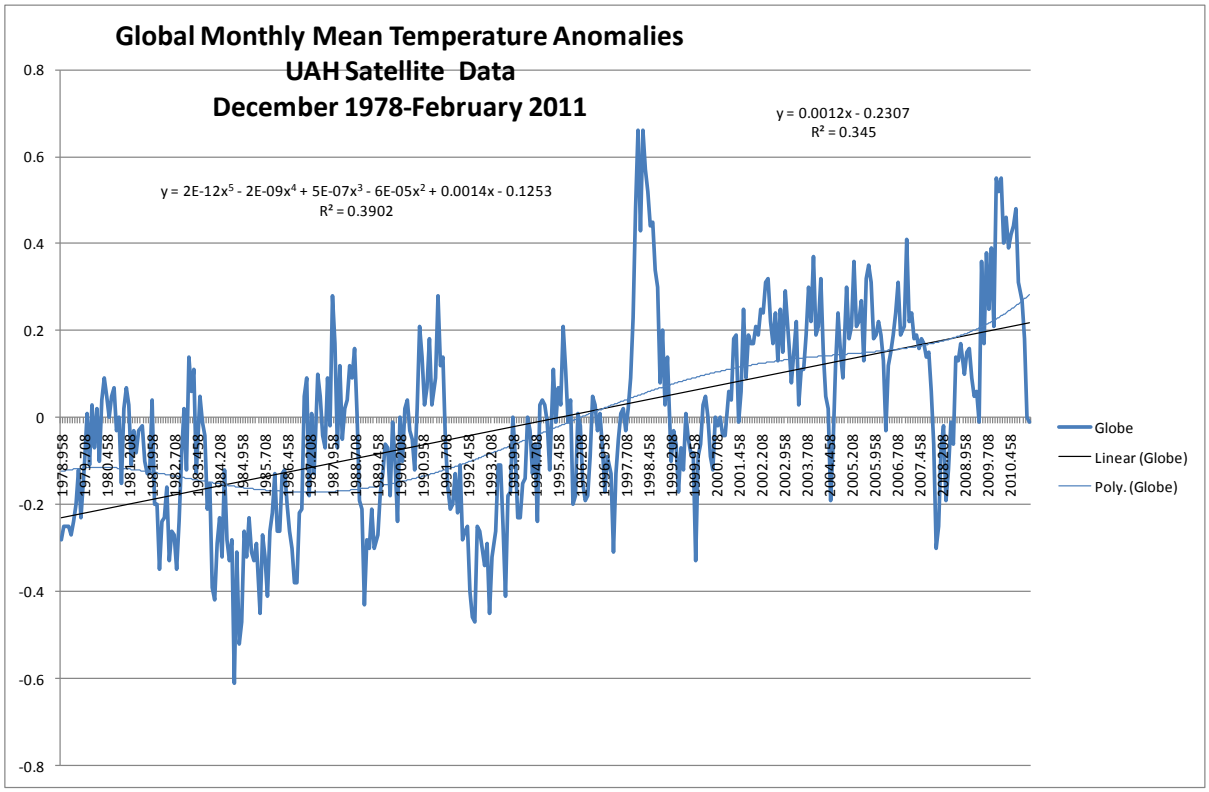
Fig.2 The baseline for the "global" temperature 1880-1900 reported in Garnaut's *The Science of Climate Change*, Fig.1



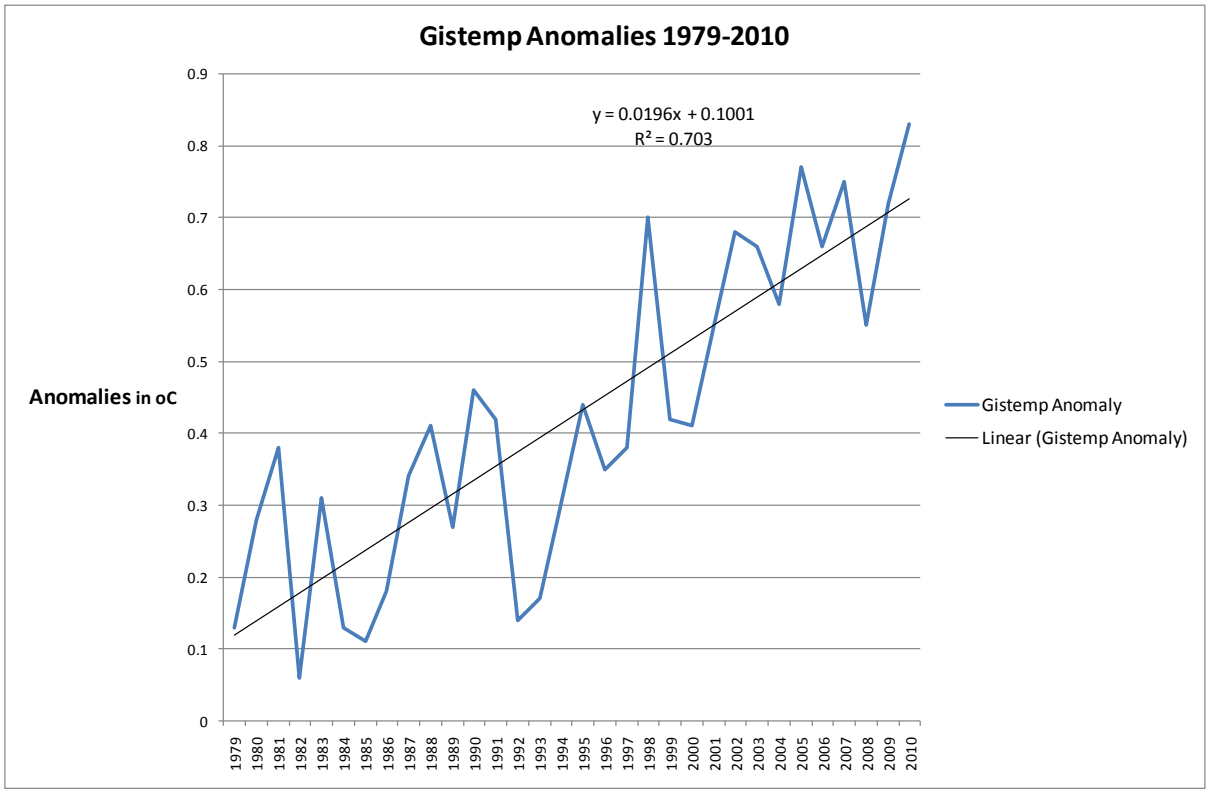
Source: CDIAC.

Fig. 3 UAH satellite data – Global Monthly Mean Temperatures (Trends are 0.0144 oC p.a., 0.144 per decade, and 1.44 per 100 years)



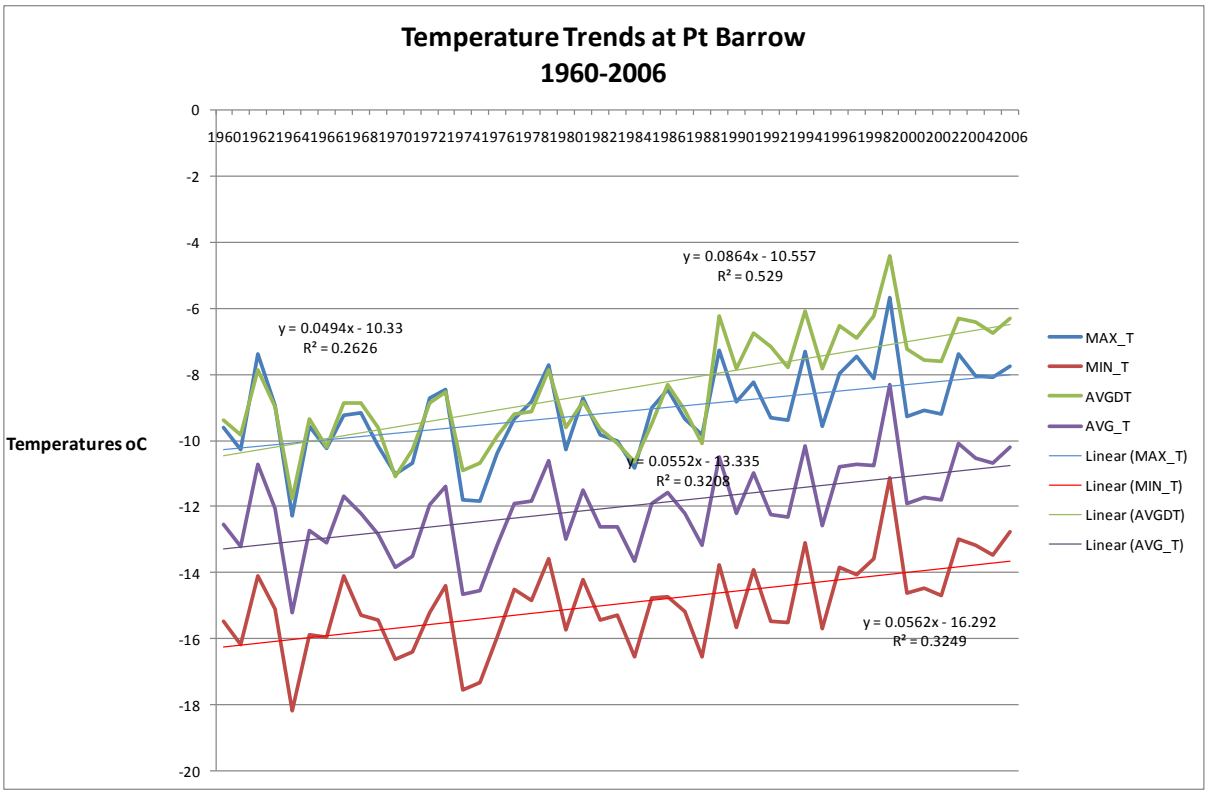
Source: J. Christy *et al*., UAH.

Fig.4 Annual Surface-measured Global Mean Temperatures Anomalies (Trend 0.0196 p.a., 0.196 per decade, 1.96 oC per 100 years)



Source: NASA-GISS.

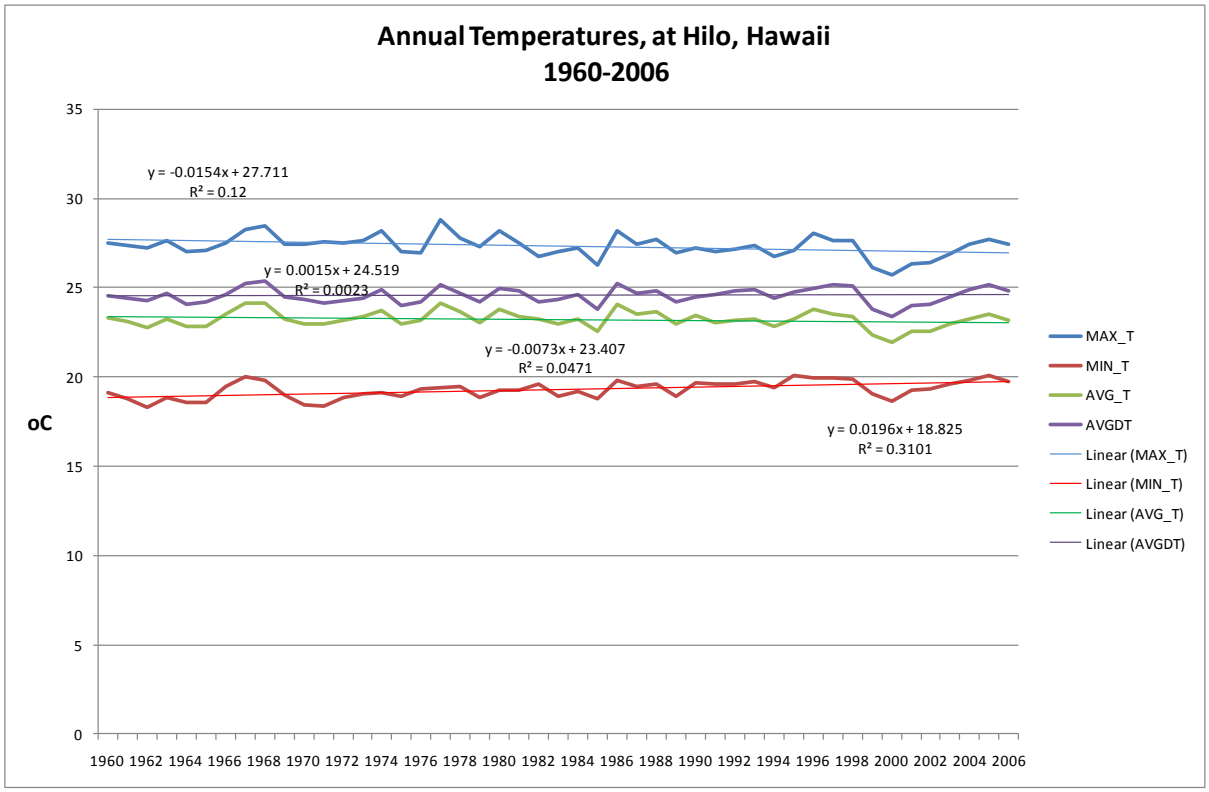
Fig.5 Annual temperature trends at Pt Barrow 1960-2006 (Source: NOAA)



Notes: 1. The low R_2 for all except the top line (average daily temperature) indicate the trends are not highly statistically significant.

2. Extrapolating the trends to 2105 would still leave Barrow with negative annual average temperatures.

Fig. 6 Annual temperature trends, Hilo, Hawaii 1960-2006 (Hilo is a town at sealevel at the foot of Mauna Loa)



Notes: 1. Both the maximum and average (maximum and minimum) temperatures show slight cooling trends, but neither is statistically significant.

2. The positive trends for the average daytime and minimum temperatures are significantly lower than those at Pt Barrow, and are consistent with the IPCC's prediction that temperatures would rise faster in high latitudes than in the tropics.

3. None of the trends if projected to 2105 confirms the IPCC and Garnaut predictions of increases of 3-5^{o}C under BAU assumptions for CO_2 emissions.

Fig.7 Temperature trends at Honolulu and Mauna Loa Observatories 1978-2006

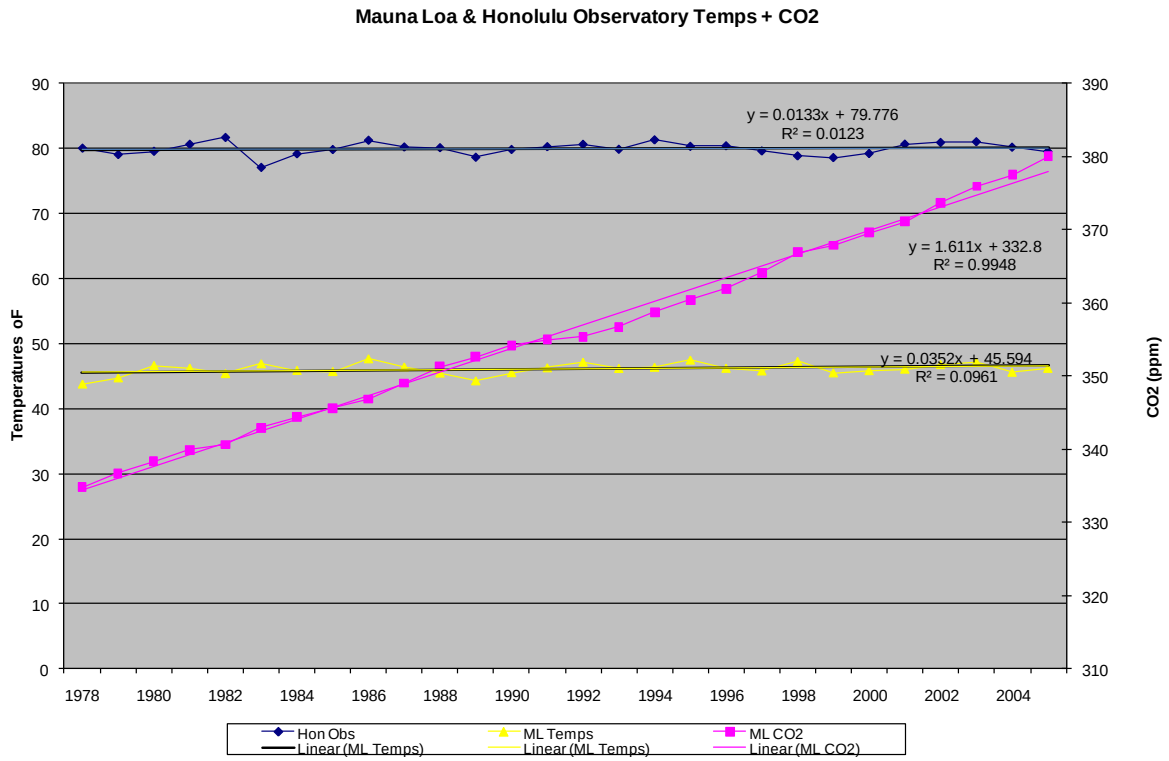


Fig. 8 Observed and Modelled Temperature Change

(using the IPCC model, Myhre 1998)

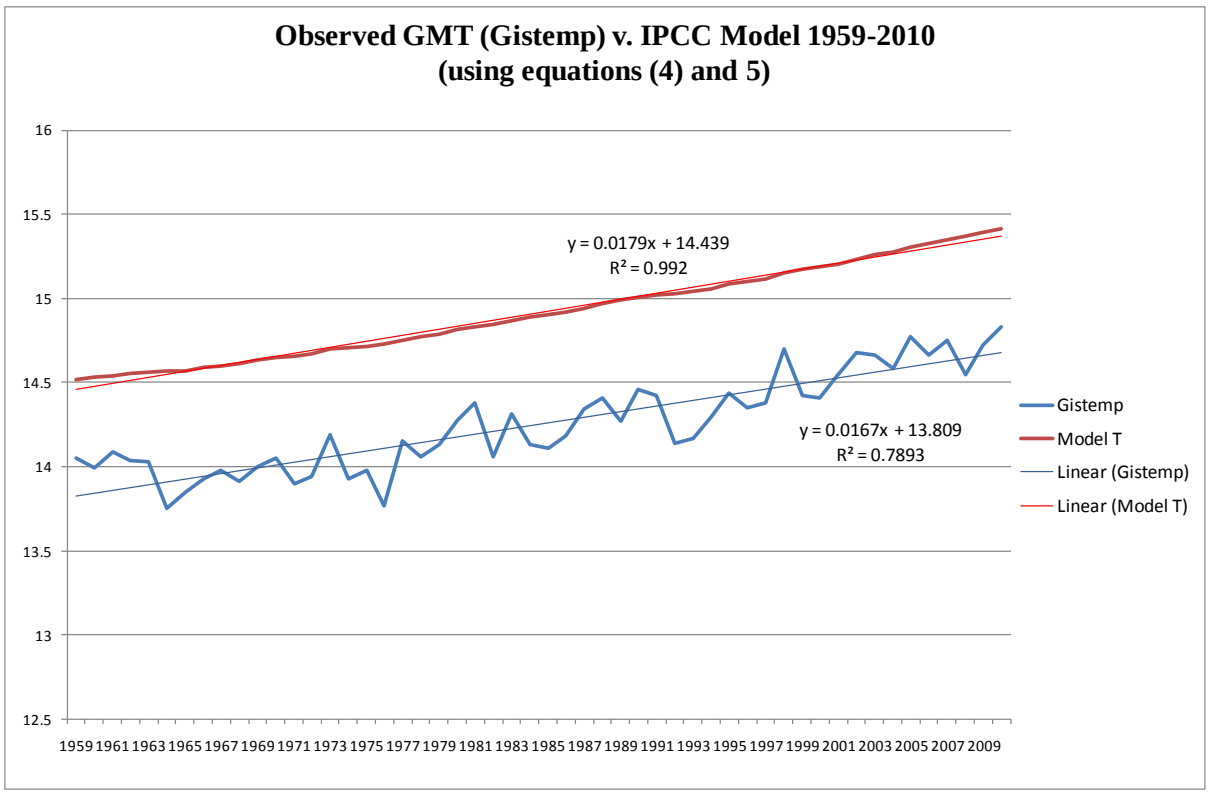
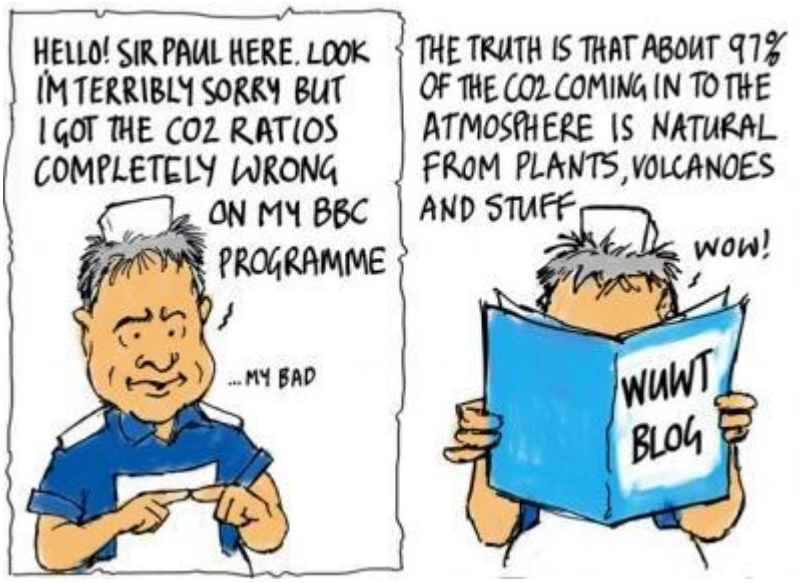


Fig.9 Garnaut says climate science is stronger

Fig.10 Cartoon by Josh on misstatements of the carbon cycle by Sir Paul Nurse, President of the Royal Society, one of the authorities relied on by the Garnaut Updates.



Sources: various websites (Bishop Hill, Watt's Up With That, Tamino's Open (sic) Mind).