Econometrics and the Science of Climate Change

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1. Introduction

Econometrics has a long history as the technique of choice for testing the merits of alternative hypotheses across most of the social sciences as well as many of the natural and materials sciences, not to mention pharmaceutical science, where it is widely used to evaluate the efficacy of alternative medications, including the use of placebos as counterfactuals. However its greatest value is in the social sciences where laboratory experiments are not feasible, but least squares linear regression can be used to assess the relative significance of alternative independent variables as explanatory factors. The founding texts of climate science, John Tyndall (1861) and Svante Arrhenius (1896), discovered and estimated the radiation absorption effects of what they called aqueous vapour and carbonic acid (now known as water vapour and carbon dioxide), unlike the oxygen and nitrogen that comprise the bulk of our atmosphere. Tyndall's experiments showed that the most powerful radiative effect was that of water vapour. Arrhenius also included water vapour in his more theoretical analysis. Now however most climate scientists' models assume that anthropogenic addition to the atmospheric concentration of carbon dioxide (hereafter denoted $[CO_2]$) and of certain other greenhouse gases like ozone and methane (in aggregate denoted as $[CO_{2e}]$) is the major determinant of climate change, and have relegated Tyndall's primary role for atmospheric water vapour (hereafter $[H_2O]$) to having only a secondary, or "feedback", effect arising from the higher temperatures supposed to result primarily from increasing $[CO_2]$.

This assumption has never been validated by observations of the relative proportions of $[H_2O]$ that stem from solar radiation and rising surface temperature. Moreover the literature of climate science affords no evidence of the use of econometrics to test the core hypothesis that "most" of the temperature change observed over the last century is attributable to the build-up in the atmosphere of anthropogenic emissions of CO_{2e}, of which CO_2 is by far the largest in volume terms, rather than being due to Tyndall's aqueous vapour $[H_2O]$. In particular none of the leading texts such as the IPCC's Solomon *et al.* (2007), Stern (2006) and Garnaut (2008, 2011) performs or reports any econometric analysis of the core hypothesis. This paper seeks to begin filling that gap, and finds that hypothesis is falsified at a wide variety of locations, oceans, and land masses (including Australia) with lengthy time series data on various climatic variables, including atmospheric water vapour $[H_2O]$),and where available, opacity of the sky (OPQ), and solar radiation received at the earth's surface (SSR). Unlike Total Solar Irradiation – TSI – which is relatively constant, SSR is dependent inter alia on the amount of cloud cover. Multi-variate econometric analysis shows that at none of

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these locations, oceans, and landmasses is the role of [CO_2] statistically significant, and even that it can be negatively correlated with changes in temperature, whereas [H_2O] invariably plays a highly significant role. If the core hypothesis of climate science cannot be confirmed at any specific location, ocean, or landmass, then it cannot be confirmed for the globe even if a Popperian black swan could be found somewhere. In short, the econometric analysis of this paper fails to falsify the nul hypothesis of climate science, *that there is no relationship between anthropogenic emissions of the main greenhouse gas, CO2, and observed temperature change.*

2. Air, Water, and Climate Change

In 1853-54 there was a serious outbreak of cholera in London's Soho district. The prevailing mantra of scientists at the time was that cholera - like climate change now - was caused by an invisible miasma in the air, and those espousing the conventional wisdom of the 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 *On the mode of communication of cholera* to challenge the conventional wisdom of the authorities of the day, and was duly put down by them. Had Snow derived only the average number of cholera-related deaths in each street in Central London he would not have been able to challenge the orthodox view. Snow instead 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, to individual houses on the same streets. 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 intake to upstream from the sewerage outlets.[3]

Only 5 years after Snow's death John Tyndall published (1861: 276) the results of his laboratory tests which showed that water vapour was the strongest absorber of radiant heat and was the most important gas controlling the Earth's surface temperature, based on a real laboratory experiment adding or removing water vapour and CO_2 to a tube of air (see Fig.A2 below). He found that while CO_2 is a significant absorber of radiant heat, the quantity of "aqueous vapour" (i.e. [H_2O]) diffused through the atmosphere produced "an absorption at least equal to thirteen times that of the atmosphere itself [including CO_2]. . ." and that among the constituents of the atmosphere, water vapour is the strongest absorber of radiant heat and therefore the most important gas controlling Earth's surface

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[3] Laveran and Ross, discoverers of the parasitic nature of malaria, had similar experiences to Snow's. The weight of scientific opinion at the French and British academies and elsewhere was that like cholera, malaria (as it name implied) was an airborne miasmic disease. Laveran and Ross suspected water-based mosquitos carried a parasite they passed on to those they bit, and like Snow they did counterfactual analysis until they found the particular species of mosquito that carried the parasite (Rocco 2003:250-280).

temperature. Tyndall concluded that without atmospheric water vapour, the Earth's surface would be "held fast in the iron grip of frost". Like Snow, Tyndall's analysis was based on counterfactuals: how much heat is absorbed in air without carbon dioxide and water vapour, and how much when first just the former is added, and then with the latter added?

It is fair to say that the majority of climate scientists does not undertake empirical evaluation of the relative effects on global surface temperature of changes in [H2O] and [CO2]. Instead they use only computer models for their counterfactual, using what they call "fingerprint" detection and comparative attribution of natural and human factors determining climate change. For example, the IPCC's Hegerl and Zwiers *et al.* (2007) use what they call "experiments" whereby they run various global climate models with and without the atmospheric CO_2 variable (but always excluding [H2O]). But that use of language disguises the reality that computers do not and cannot perform real experiments, as they report only what they have been programmed to report.

It is of course not possible to devise a real world experiment with and without global [H2O] and [CO_2]. However Hegerl and Allen (2002) while performing some multiple regressions never include [H2O] as an independent variable, and use only [CO_2] and imputed data on sulphate aerosols. The main models used by these and other contributors to the IPCC's Solomon *et al* (AR4, WG1, 2007), like the GissE of Schmidt *et al.* (2006:156), Bergen (BCCR-BCM2.0, www.bcm.uib.no), and BernCC (Strassmann et al. 2005:5,) do not even consider non-stratospheric [H_2O] to be a constituent of the atmosphere for their model "experiments". Thus BernCC excludes [H2O] from its list of "non-CO2 radiative forcing agents" (2005:7). Similarly Wigley's MAGICC, which is the main model used in Solomon et al. (2007), excludes [H_2O] from its main menu of contributors to radiative forcing, and it also excludes the emissions of H20 that are part and parcel of the hydrocarbon combustion process (see my equation (1) below) (Wigley 2003:6-8). Similarly, Version 2 of the MAGICC model still excludes any role for water vapour as a "forcing" (Wigley 2008: Table 1).

Instead of assuming away [H2O] as a forcing variable, apparently because of an implicit assumption that [H2O] is not a "long-lived" greenhouse gas, given its atmospheric residence time of only about ten days. That is true, but does not mean that on average there is NO atmospheric water vapour, because of course evaporation is a continuous process, even in the Sahara, and there always is measurable [H2O] even at one of the driest locations in the USA, Albuquerque (mean 1.079 cm, standard deviation 0.121). As we report below, temperature changes at Albuquerque are strongly correlated with changes in [H2O], and negatively with changes in [CO2]. This paper follows Tyndall in establishing empirically the relative importance of [H_2O] and [CO_2] by examining a wide range of climatic variables at specific locations in the USA, in three of the world's oceans, and in various continental land masses like Australia. Like Tyndall (1861), it finds that in every case water vapour is a far more significant determinant of temperature change than atmospheric carbon dioxide.

Snow's counterfactual analysis has recently been cited in two advanced econometrics textbooks (Angrist and Pischke 2009, Freedman 2010) that explain how multi-variate regression analysis can be used to evaluate competing theories of causation. This paper

shows how such analysis reveals that changes in atmospheric water vapour provide 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, temperature trends 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. Tyndall's laboratory experiments, extracting CO_2 and H_2O from a tube of air and then re-inserting them one by one, are similar to Snow's expenditure of shoe leather tramping the streets of central London to establish the source of water supply for some 300,000 buildings. Certainly Tyndall would have derided the claims of Wigley and the IPCC (AR4) that airborne carbon dioxide is the main source of changing climate everywhere, just as Snow disproved that miasmic air was the universal cause of cholera.

We have noted above how the models used by the IPCC's *Climate Change 2007 The Physical Science Basis* 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 (Solomon *et al.* 2007:28). Yet as discussed in section 4 below, basic chemistry shows 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 and to the steam produced during the power generation process, their effect on surface temperature is as much as twice as large pro rata.[4] It follows that the Australian Government's proposed tax on carbon, based on the *Garnaut Reviews* (2008, 2011) will also be a tax on increases in water vapour and thereby, unavoidably, on rainfall. The political implications of that remain to be played out, but it is characteristic of all the papers on climate change cited by the *Reviews* that they dwell only on the supposed – and far-off – external costs of hydrocarbon combustion and never mention its demonstrably larger immediate benefits of elevated atmospheric carbon dioxide, increased rainfall, and warmer temperatures on the world's primary production (see section 9 below).

3.   Statistics and the Science of Climate Change

Ross Garnaut's *Science of Climate Change* (SCC) (2011) like his 2008 *Review* is notable as much for what it leaves out as for what it includes. For example, here is its first "key point" (2010:2):

> 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 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.

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[4] Water-vapour feedback has "the capacity to about double the direct warming from greenhouse gas increases", Dessler *et al.* (2008:1).

However, the paper *Global Temperature Trends* by Breusch and Vahid (2011) commissioned by Garnaut for his 2008 *Review*, and updated for SCC, does not claim to provide any support for a warming trend being attributable to human emissions of carbon dioxide.

> 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 [sic] 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 (2011:13, my emphasis).

Thus Breusch and Vahid explicitly do not make any assessment of the possible role of rising [CO_2] in whatever very slight global warming trend is evident in the observed data. Their finding of a rising temperature trend depends partly on the absence of the tropics from all global temperature sets for the period between 1850 and 1910, as it was not until the 1950s that global temperature becomes a valid statistic, for only then did global surface instrumental temperature coverage reach 80 per cent, and it is now well below that level again. Regrettably Breusch and Vahid do not assess the trends in the more truly global satellite temperature data sets, which surely should "corroborate" their surface trends data even though they do not go further back than 1978. The truth is shown in my Fig.1: the linear trend in the UAH satellites' global data from December 1978 to February 2011 has an R^2 of 0.345, which although that is below the minimum for a good fit indicates a rise of 0.0012°C per month since 1978, or 0.0144 p.a., 0.144 per decade, and 1.44°C per century, well below the 3°C predicted by the IPCC, let alone the 5°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 three surface temperature data sets used by Breusch and Vahid, for the period when they overlap.[5] For example, their Gistemp data set shows a very much larger and apparently better fit linear trend since 1978 (see Fig.2), with the annual change in the Gistemp monthly data (1979-2010) at 0.0196°C, which is 36 per cent higher than the UAH trend of 0.0144 °C.

However, the Australian Academy of Science (Allison *et al.* 2010) asserts there is no disagreement between satellite and surface temperature records **-** "**w**hile a disagreement did exist in the 1990s, it has largely been resolved by correction of biases in the satellite data, for

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[5] "The raw surface temperature data from which all of the different global surface temperature trend analyses are derived are essentially the same. The best estimate that has been reported is that 90–95% of the raw data in each of the analyses is the same (P. Jones, personal communication, 2003)"(Pielke snr. *et al.* 2007:13). See Stockwell (2009) for a comment on Rahmstorf *et al.* 2007 and the pitfalls of using the surface sets to determine apparent breaks in trends.

example to account for drift in satellite orbits over time. Given the remaining uncertainties in satellite-derived trends, there is now acceptable agreement between satellite and ground-based measurements of surface temperature (Box 5). However Klotzbach *et al.* confirm my finding that "Surface temperature data sets from the National Climate Data Center and the Hadley Center show larger trends over the 30-year period than the lower-tropospheric data from the University of Alabama in Huntsville and Remote Sensing Systems data sets. The differences between trends observed in the surface and lower-tropospheric satellite data sets are statistically significant in most comparisons, with much greater differences over land areas than over ocean areas. These findings strongly suggest that there remain important inconsistencies between surface and satellite records" (2009:Abstract).
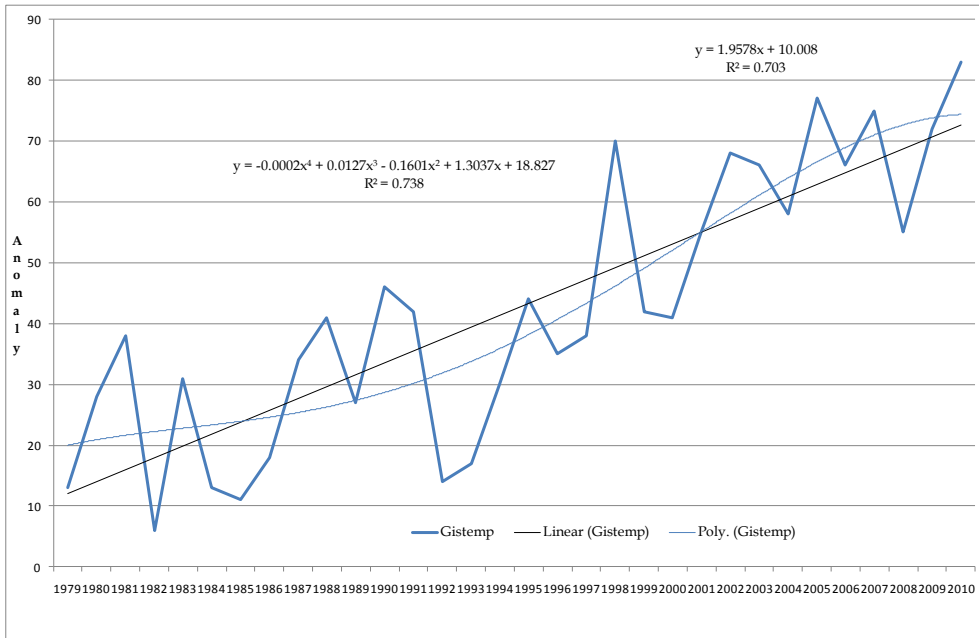
Fig. 1 Global monthly mean temperature UAH satellite data
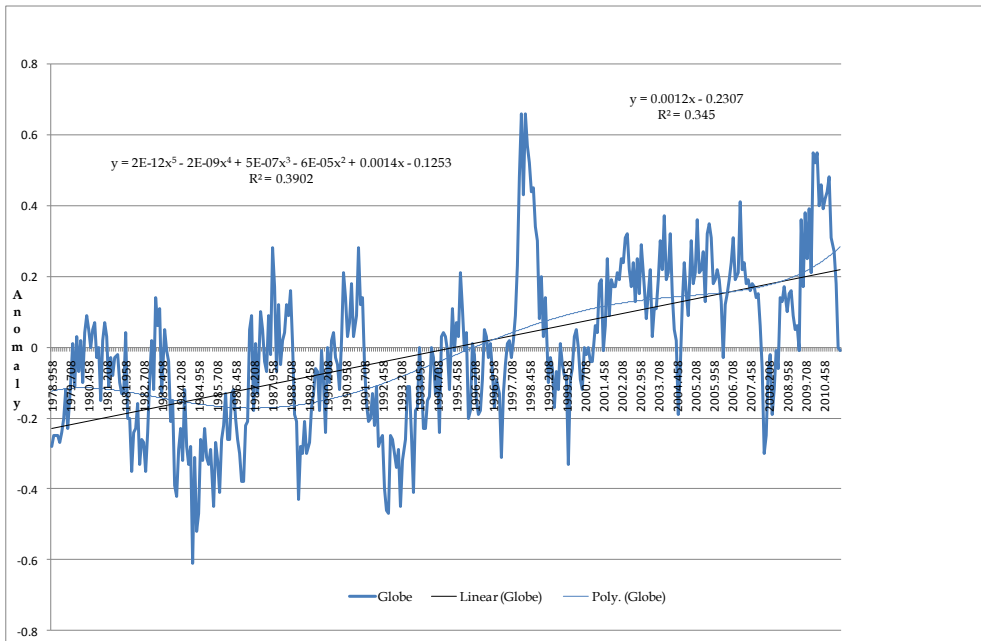
Note: Linear Global Monthly Mean Temperature Trends are 0.0144°C p.a., 0.144°C per decade, and 1.44°C per 100 years (the anomaly is departure from 1981 to 2010 average in °C).

**Fig.2 Annual Surface Instrumental Global Mean Temperatures Anomalies**

Source: http://data.giss.nasa.gov/gistemp

Note: The Gistemp anomalies are expressed in 0.01^oC divergences from the global mean for 1951-1980, so need to be divided by 100 to get ^oC. The linear trends are 0.019^oC p.a, 0.196^oC per decade, and $1.96 ^oC$ to 2110.

4.   The Science of Climate Change

Real science involves precise formulae, like the formula for complete combustion of a typical hydrocarbon fuel (e.g. C_3H_8) in the presence of air (using pure oxygen tends to raise the proportion of H_2O in the outputs):

$$C_3H_8 + 5O_2 \rightarrow Energy + 3CO_2 + 4H_2O \ \ldots(1)[7]$$

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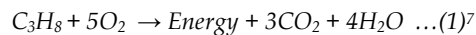
[7] A similar equation is for combustion of petroleum octane: $2C_8H_{18}$ (l) $+25O_2$ (g) $\rightarrow 16CO_2$ (g) $+18H_2O$ (l), where *l* and *g* are litres and grams respectively, and the value for the energy produced, -11020 kJ / mol, tells us that for every one of these reactions (with inputs of 2 gram mol weights(GMW) of octane, 25 GMW of oxygen, and outputs of 16 GMW of carbon

It is not clear why (1) receives no mention in the IPCC's AR4 WG1 (Solomon *et al.,* 2007) despite its demonising of hydrocarbon combustion. Similarly that volume's 996 pages also could not find room for this formula:

$$2CO_2 + 2\,H_2O + photons \;\rightarrow\; 2CH_2O + 2O_2 \;\;...(2)$$
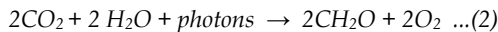
Or, in words, carbon dioxide + water + light energy → carbohydrate + oxygen. This formula relates to the gross primary production (GPP) arising from the process of photosynthesis, of which plants use up some in their own respiration, and the balance, net primary production (NPP), is the rate at which all the plants in an ecosystem produce net useful chemical energy.[8]

It is surprising that just as the IPCC's climate scientists never divulge equation (1) despite its RHS showing how *both* CO_2 *and* H_2O enter the atmosphere when there is combustion of hydrocarbons, they also never mention (2), the formula whereby a large proportion (about 60 per cent) of the emissions of *both* CO_2 *and* H_2O from the RHS of (1) enter the LHS of (2) and are thereby absorbed by photosynthesis both on land and in the oceans.

It would seem that the presence of CO_2 and H_2O on the RHS of equation (1) and on the LHS of equation (2) are inconvenient truths for all climate scientists named in the IPCC's Solomon *et al.* (2007). Although there are three references to photosynthesis in that volume, none of them mention that its main output is the carbohydrates on the RHS of (2) which of course constitute the bulk of the world's food energy supply (see section 9 below).

Yet climate science does not offer alternative formulae to (1) and (2). The closest it gets to producing a formula is for the "radiative forcing" (RF) of greenhouse gases, namely the strength of their ability "forcibly" to radiate heat back to earth, in equations (3) and (4). In (3) the change in equilibrium surface temperature (ΔT_s) arising from RF is given by:[9]

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dioxide, and 18 GMW of water), 11,020 kilojoules of heat is released, rather more than is attributable to the radiative forcing by 16 GMW of CO_2. The words hydrocarbon and combustion do not appear in the Index in the IPCC's Solomon *et al.* 2007. For global estimates of net heat emission from energy production, see Nordell and Gervet (2009).

[8] Breakfast cereal boxes disclose that between 60 grams (rice) and 80 grams (wheat) per 100 grams are carbohydrate, the CH_2O in (2). Cereals accounted for 46.4 per cent of direct global food energy consumption in 2009 – and with meat for over 55 per cent (*Statistical Yearbook*, FAO, 2010:d02). Tubers like potatoes and cassava also contain carbohydrate, 19 per cent in the case of raw unskinned potato, which is derived from CO_2 and H_2O in the soil, but originating in the atmosphere. For an account of the photosynthesis process, see Farquhar *et al.* 1980.

[9] This account is based on the article *Radiative Forcing* in Wikipedia, accessed 14th March 2011. See also Pielke R. snr. *et al.* (2007): "According to the radiative-convective equilibrium concept, the equation for determining global average surface temperature of the planet is

$$\Delta T_S = \lambda \, \Delta F \dots (3)$$

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

$$\Delta F = 5.35 \; X \; ln \; (Ct/Co) \; W/sq.m. \dots (4)$$

where C_t 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 oC for a doubling of CO_2 (from 280 ppm to 560 ppm). Equations (3) and (4) disclose no physical relationships, exclude any reference to [H2O], and equation (4) (derived by Myhre *et al.* 1998, see also Ramaswamy *et al.* 2001:361) also describes no measured *process* whereby changes in the ratio of the present or future levels of [CO_2] to the base level of 280 ppm generate radiative forcing. That is because the parameters λ and 5.35 are not data-based, e.g. by use of linear least squares regression, being set in models only *ex post* at whatever level delivers some sort of match to the observations (see Myhre *et al.* 1998). Clearly the only *variables* in (3) and (4) are the base and projected levels of [CO_2]. But Myhre's equation does have the property that because it takes the *ratio* of current [CO_2] to the base year (1750) level, the radiative forcing F *automatically* increases along with the rising level of [CO_2]. This is contrary to the Arrhenius formulation using only increases in absolute levels of [CO_2]. Ín his words "if the quantity of carbonic acid [i.e. CO_2] increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression" (1896:267 and Table VII), i.e. less than in proportion to the increase in [CO_2].

As a result, this model consistently overstates its hindcast of global temperature from 1959 to 2010 by 0.0112oC p.a. (0.112oC per decade), and higher by 0.59oC for 2010 compared with the Gistemp global temperature of 14.83oC in that year. That is not a trivial difference, and it gets worse over time, especially if the claimed forcings of all the other greenhouse gases are added to that from [CO_2].

Thus the equations (3) and (4) may look impressive but they lack the precision of chemical formulae like (1). Climate scientists should at least attempt to evaluate an equation like:

$$\Delta T_t \;\; = a + b(CO_2)_t + c(H_2O)_t + u_t \dots (5)$$

$dH/dt \;\; = f - T'/\lambda \dots (1)$ where H is the heat content of the land-ocean-atmosphere system. Equation (1) describes the change in the heat content where f is the radiative forcing at the tropopause, T' is the change in surface temperature in response to a change in heat content, and λ is the … climate sensitivity parameter, which denotes the rate at which the climate system returns the added forcing to space as infrared radiation or as reflected solar radiation (by changes in clouds, ice and snow, etc.).''

Here H_2O includes *both* the water vapour generated in the combustion process *and* the steam produced by the cooling water used in generation of electricity (see Kelly 2010). There is no consideration of such a formula in the science academy texts relied on by Garnaut's SCC (e.g. Allison 2010, Royal Society 2010). Climate scientists have never attempted to provide statistically significant values for the coefficients *b* and *c*. Instead, the IPCC's Solomon *et al.* (2007) specifically excludes consideration of any of the (H_2O) outputs of hydrocarbon combustion and power generation, which means its implied derivation of ΔT_t bears no relation to the multi-variable combustion output and power formula (5).

However, it is to be noted that although equation (1) does not lend itself to econometric analysis, because the CO_2 and H_2O variables are not independent of each other, as they are co-determined during the combustion and power generation processes, in the case of (5) the water used for cooling is not part of the chemical process and is a much larger component of the ($H2O$) in (5) than the [$H2O$] in (1). This means that the implied correlations of temperature anomalies and increasing [CO_2] all *unavoidably* include the water vapour component as an ingredient of the radiative forcing in the IPCC's Solomon *et al.* (2007) and the rest. But it is perfectly possible to generate statistics of not just emissions of CO_2 but also of emissions of water vapour and steam in the processes of hydrocarbon combustion and power generation cooling.

Kelly (2010:630) notes that in the various applicable chapters in Solomon *et al.* (2007), there is no mention that most (but not all) anthropogenic water vapour is in the form of steam. That steam is over and above the flue exhaust H_2O in the combustion process. For example, the condensate flow rate of the water used to produce steam by the heating of the combustion process (see equation 1 above) at full load in a 500 MW plant is about 6,000 US gallons per minute (400 L/s) ("Thermal Power Station", *Wikipedia*, accessed 14 April 2011), or c.12.6 million tonnes p.a.[10] Most of the electricity in the United States is produced using steam turbines. Coal is the most common fuel for generating electricity in the United States. In 2009, 45% of the USA's nearly 4 trillion kWh of electricity used coal as its source of energy, but gas, oil, and nuclear power stations also mainly produce steam which is of course used to drive the generators producing their electricity.

Global energy use was 98,022 TWh in 2009 (*Wikipedia*, accessed 14 April 2011). That would have had an associated generation of steam of 303.75 GtH_2O (author's calculations), very much larger (ten times) than the gross global output of CO_2 from hydrocarbon combustion of 30 $GtCO_2$ in 2009 (le Quéré *et al* 2009) – and of course a very much larger radiative forcing. Thus in the language of the Garnaut *Reviews*, it is water, not carbon dioxide, that is the "pollutant". As I show below, this is confirmed by multivariate econometric analysis which is fully capable of generating those coefficients from data on levels of [CO_2] and

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[10] "Typical water consumption for a 1000 MWe plant - providing electricity to perhaps 1 million people in an industrial country - might be 75 megalitres per day, or the equivalent of 25 Olympic-sized swimming pools. This equates to about 0.05% of the average flow rate of the Rhine, Rhone and Danube Rivers", World Nuclear Association, nd. This implies that the USA and EU have about 500 1000MWe-equivalent power stations, requiring 25% of the flow of the Rhine, Rhone, and Danube rivers.

[H2O] at specific locations where these variables are spatially independent of each other, and reveals that b is usually close to zero, even negative, while c is large and highly statistically significant.

Climate scientists are aware of the Clausius-Clapeyron relation that 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, but have failed to quantify it accurately in the context of their predicted climate change. This maximum is known as the saturation vapour pressure, e_s:

$$e_s(T) = e_s(T_o)exp^{-L/Rv(1/T} {}_{-T}{}^{/T}{}_0{}^) \;....(6)$$

"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). While this expression shows that the ability of the atmosphere to hold water vapour rises with temperature, it does not imply it is changes in T that increase both the *amount* of that water vapour and the saturation level e_s.

Thus while satellite observations indicate that the response of global evaporation to rising temperature is close to that implied by (6), 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 that increases potential global warming (Kininmonth 2010:61). Hence Pierrehumbert *et al.* 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*" (2007:180, my emphasis). Empirical support for this statement is in the papers by Gifford *et al.* (2007) and Roderick *et al.* (2007), which show decreasing levels of pan evaporation since the early 1970s, and thus that evaporative demand does not increase with global warming, *pace* Trenberth *et al.* (2005) and Forster and Ramaswamy *et al.* (2007).

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 a doubling of [CO2] is enough for them to triple the temperature change due to that by 2100 from 1oC to over 3oC. This artefact is termed the "positive 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, instead they often predict increasing drought in various regions despite the rising water vapour they rely

on for the infinitely spiralling further temperature increases that deliver their "runaway" greenhouse effect.

In addition, Solomon *et al.* (2007) appear to believe that the positive feedback effect of rising temperature on the level of atmospheric water vapour outweighs that of direct solar radiation. However, as Kiehl and Trenberth show (e.g. 1997:206), incoming solar radiation of 342 W/sq.m. generates "evapotranspiration" of 78 W/sq.m., which is 0.228 W/sq.m. of incoming solar radiation, whereas the evapotranspiration of total radiative forcing from long lived greenhouse gases, estimated at 2.63 W/sq.m. in 2005 by Forster and Ramaswamy *et al.* (2007, in Solomon *et al.*, 2007:141), is on that basis only 0.599 W/sq.m., less than 1% of that from solar. Those authors do not mention evapotranspiration arising from solar radiation, but assert that the derisory increase from the GHG forcing of only 2.63 W/sq.m. is enough to raise the increase in global temperature from rising concentrations of greenhouse gases by a factor of at least two.

However, Pierrehumbert *et al.* also assume that increases in atmospheric water vapour [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 just 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" (*ibid*.). They also find that each doubling of water vapour reduces OLR by about 6W/m², and add:

> This is about 50% greater than the sensitivity of OLR to CO_2. 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….   In fact, at each latitude the greenhouse effect of water vapour is approximately twice that of CO_2 (Pierrehumbert *et al.* 2007:146, 148).

For example, we know that in 2008-2009 combustion of hydrocarbon fuels generated emissions of about 8.6 billion tonnes of carbon, which equates to 31.4 billion tonnes of CO_2, (i.e. 31.4 GtCO$_2$) (le Quéré *et al.*, 2010) – and using data in Gaffen and Ross (1999) this implies direct water vapour emissions (just from the combustion process of burning a hydrocarbon fuel using oxygen) of 17.5 GtH$_2$O.[11] But using the first Pierrehumbert *et al.* figure above, the radiative forcing (RF) from this addition to [H_2O] is 50 per cent higher than

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[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).

that of increased atmospheric CO_2.[12] 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 alone (excluding steam) generated total RF of 0.0047 W/sq.m. *per tonne* of H_2O and CO_2 in 2008-09. Thus total RF from just hydrocarbon combustion across the whole surface of the globe was 5.09E+14 Watts, of which 45 per cent was the contribution of the water vapour from fossil fuel combustion. Yet Garnaut's SCC never notices this effect, and it is dismissed as of no consequence by the IPCC's Forster and Ramaswamy *et al.* (2007:185).[13]

The implications are profound, because clearly the RF and resulting global warming from hydrocarbon fuel combustion must be seriously underestimated by disregarding the water vapour component of the total output. However Lim and Roderick (2009) have shown that in reality, while there is some evidence for increasing evaporation between 1970 and 1999, it has been *exactly* matched by increased rainfall. Thus just as the IPCC and Garnaut's *Reviews* generally assume reducing uptakes of CO_2 emissions by the biospheres, they also ignore that rising $[H_2O]$ is matched by rainfall, preferring instead to stress the claimed but as yet undemonstrated positive feedback effect of rising temperature through evaporation to yet higher temperatures. This explains why they always ignore the positive social benefits of increases in both evaporation and rainfall, and implicitly treat the resulting increases in agricultural productivity as negative social "externalities".

5.   Previous Econometric Analysis of Climate Change

There have been surprisingly few attempts to use econometric analysis to separate out the proximate causes of climate change.

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[12] "Specifically, the team found that if Earth warms by 1.8 degrees Fahrenheit, the associated increase in water vapor will trap an extra 2 Watts of energy per square meter (about 11 square feet). That number may not sound like much, but add up all of that energy over the entire Earth surface and you find that water vapor is trapping a lot of energy... we now think the water vapor feedback is extraordinarily strong, capable of doubling the warming due to carbon dioxide alone." Water Vapor Confirmed As Major Player In Climate Change. *ScienceDaily*. NASA/Goddard Space Flight Center (2008, November 18).   This comment refers only to the claimed water vapour "feedback" and ignores all anthropogenic additions to $[H_2O]$ from the steam and direct emissions of water vapour during the combustion and power generation processes.

[13]   Forster and Ramaswamy *et al* state "The emission from water vapour from fossil fuel combustion is significantly lower than the emission from changes in land use (Boucher et al. 2004)" (2007:185). In reality, Boucher *et al.* "estimate a global mean radiative forcing in the range of 0.03 to +0.1 Wm–2 due to the increase in water vapour from Irrigation" (2004:597), and their lower figure is effectively the same as mine (0.028 W/sq.m.) for that from combustion alone (ignoring the much larger contribution from steam emitted during power generation).

Few researchers have used time domain econometrics methods to analyze climate change. Apart from Kaufmann and Stern (1997) and Stern and Kaufmann (1999), only Tol and de Vos (1993, 1998), [and] Tol (1994), explicitly use econometric time series methods to investigate the causes of climate change… (Stern and Kaufmann 2000:412).[14]

Kaufmann *et al.* (2006b) made further use of econometric methods, and comment:

…statistical models of the relationship between surface temperature and radiative forcing that are estimated from the observational temperature record often are viewed skeptically by climate modelers. One reason is uncertainty about what statistical models measure. Because statistical models do not represent physical linkages directly, it is difficult to assess the time scale associated with statistical estimates for the effect of a doubling in CO_2 on surface temperature…The results of this analysis indicate that the statistical methodology used by Kaufmann *et al.* (2006a) to analyze the instrumental temperature record is able to provide an accurate and unbiased estimate for the true (model specific) estimate for the [transient climate response] TCR. This accuracy gives us added confidence in the statistical estimates for the TCR that are estimated from the instrumental temperature record. Although the transient climate response does not include the full effects of deep ocean mixing and feedbacks, it does represent the challenge for the twenty-first century and therefore is important for attributing climate change to human activity and efforts to formulate economically efficient policy.

Hegerl and Zwiers *et al.* (2007, in AR4, Solomon *et al.* 2007) failed to respond to that challenge. Although claiming they would attempt to "understand climate changes that result from anthropogenic and natural external forcings" (p.667), they never report any regression results estimating the relative values of those forcings. They concede (p.668) that "attribution studies … assess whether the response to a key forcing, such as greenhouse gas increases is distinguishable from that due to other forcings (Appendix 9A). *These questions are typically investigated using a multiple regression of observations onto several fingerprints representing climate responses to different forcings… see Section 9.2.2"* (my emphasis).

There is no trace of the results of any such analysis anywhere in Hegerl and Zwiers et al. 2007, least of all in either their referenced Section 9.2.2 or their Appendix 9A. The latter (pp.744-745) does

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14 Tol and Vellinga (1998) used econometric analysis to separate the enhanced greenhouse effect from the influence of the sun at the top of the atmosphere (TOA), while Tol and de Vos (1998) used Bayesian analysis. Neither paper considers the role of atmospheric water vapour. Most common is the fingerprint method (Hegerl et al., 1996; Santer et al., 1993, 1996b), which claims to produce a human signal but only as calculated by Global Circulation Models (GCM). But "the fingerprint approach is only applicable for detection of (dis)similarities between patterns; it seems impossible to use it to derive a probability distribution of the climate sensitivity. We use time series analysis. We do not rely on GCM results – at the expense of using an (overly) simple representation of the climate – and show that this allows to estimate a probability distribution of the climate sensitivity" (Tol & de Vos 1998:88-89).

have a textbook account of multivariate regression, but reports no results at all. Yet it is Hegerl and Zwiers *et al.* (p.666) who so confidently assert "greenhouse gas forcing has *very likely* caused *most* of the global warming over the last 50 years" (our emphasis), where "very likely" means "more than 90 percent probability" (Solomon *et al.* 2007:121) and "most" must mean more than 50 percent where only two independent variables are considered. Had these authors done some regression analysis they could have been more precise, but they never did, nor do they report any by others.[15]

6.   Regression analysis of climate science counterfactuals

This paper uses the Mauna Loa data set on additions to atmospheric CO2 from 1958 to 2009 as the independent variable, and regressing Gistemp temperature anomalies against it, we have these results:

Table 1 Regression of Gistemp GMT anomalies (oC) against Radiative Forcing of [CO$_2$] (W/sq.m) 1959-2010.

Predictors of Anomalies		t-statistics	p-values
Constant		-8.260	0.000
Radiative Forcing (GtCO2)		12.749	0.000
Adjusted R^2	0.76		
Standard Error	13.97		
Durbin-Watson	1.31		

Sources: NASA-GISS; NOAA-CDIAC; Solomon *et al.* 2007:141.

These results look impressive, with a high R^2 of 0.76 and a statistically significant coefficient on the radiative forcing of the [CO$_2$] 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 1.313, which is well below the benchmark 2.0, shows that to be the case in this instance.

This problem is usually addressed by taking year-on-year differences in the data (see Breusch and Vahid, 2011), with the results shown in Table 2, which may explain why the IPCC (Solomon *et al.* 2007) and Garnaut (2008 and 2011) do not report regression results, for while the Durbin-Watson statistic at 2.85 rules out serial correlation, the R^2 falls to .04, while

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[15] The most recent use of regression techniques in climate analysis is by McKitrick and Nierenberg (2010) who use it to demonstrate that there are statistically significant different socio-economic impacts on temperature trends in urban and rural areas.

the CO_2 variable is totally statistically insignificant. This means there is no basis for the claim by Solomon *et al.* (2007:10) that changes in anthropogenic atmospheric greenhouse gases account for "most" (i.e. more than 50 per cent) of observed temperature change since 1958, as claimed by Garnaut (2008,2011), Stern (2006), and Hegerl and Zwiers *et al.* (2007:670).

Table 2 Regression of changes in surface GMT on changes in [CO_2] Radiative Forcing

Predictors of Changes in Anomalies		t-statistics	p-values
Constant		.095	0.925
Changes in RF (GtCO2)		0.455	0.651
Adjusted R²	-0.016		
Standard Error	16.156		
Durbin-Watson	**2.846**		

Sources: NASA-GISS; NOAA-CDIAC; Solomon et al. 2007:141.

Garnaut's SCC overlooks 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) must have been well aware that standard multivariate regression analysis of changes in temperature as a function of changes in atmospheric CO_2 and natural influences (e.g. water vapour) does not yield their desired outcomes, otherwise how can we explain the absence of any reporting of such analysis by Hegerl and Zwiers *et al.* 2007 when Zwiers is also co-author of the standard text (1999) on statistical analysis of climate change? Instead Hegerl and Zwiers *et al.* (2007) resort to developing a new method of analysis they have named "detection and attribution of fingerprints". 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, in their hands X, the matrix for the independent variables, contains only "signals that are estimated" by climate models, rather than real world data like that I have presented above (Hegerl and Zwiers *et al.* 2007: 744).

7. Counterfactuals, Carbon Dioxide, and Climate Change

I gave above 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 scientific authorities 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 that are, if not deliberately ignored, certainly overlooked by the climate change establishment, perhaps 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 (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. $[H_2O]$. My regressions reported in Tables 3, 4, and 5 analyse the trends in annual mean maximum or minimum temperatures at Point Barrow in Alaska, Hilo (near Mauna Loa) in Hawaii, and New York for the period 1960-2006. The respective trends differ considerably, although the R^2 correlation coefficients do not suggest good fits for linear rather than polynomial trends. The *nil* linear trend in the annual mean temperature at Mauna Loa itself from 1978-2006 with R^2 of 0.1 contrasts with that for atmospheric carbon dioxide (R^2 0.99), and in part explains the poor correlation in Table 4.

The regression analysis (Table 3) of the NOAA climate data for Pt Barrow for 1960 to 2006 (when this data set terminates) provides a striking example of John Snow's counterfactual analysis, as it shows that 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 at night (OPQ). Similar results are found for various locations in Hawaii, such as Hilo (Table 4), and New York City (Table 5, and Fig.3), and many others. The analysis for Hilo reported in Table 4 has changes in average annual maximum temperatures as the independent variable, with changes in solar radiation at ground level ("Avglo") replacing the sky opacity variable, as clearly solar radiation is more relevant to maximum than minimum temperatures.

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

Change in Mean Minimum Temperatures		t-statistics	p-values
Constant		-1.12	0.91
Change in $[CO_2]$		0.06	0.95
Change in $[H_2O]$		4.96	0.000
Change in OPQ		4.19	0.000
Standard Error	1.04		
Adjusted R^2	0.59		
Durbin-Watson	**2.846**		

Note: High p-values with low t-values indicate very low statistical significance of $[CO_2]$, and conversely for high t and low p values for $[H_2O]$ and sky opacity (OPQ) coefficients.

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

Change in Annual Mean Maximum Temperatures		t-statistics	p-values
Constant		-1.13	0.264
Change in $[CO_2]$		1.35	0.186
Change in $[H_2O]$		4.67	0.000
Change in Avglo		3.72	0.000
Standard Error	0.565		
Adjusted R^2	0.356		
Durbin-Watson	**2.834**		

Sources: see Table 3.

Note: Independent variables in Table 4: ΔCO_2 = annual changes in atmospheric carbon dioxide at Mauna Loa Slope Observatory; ΔAvglo =change in annual average daily *in situ* total solar radiation, i.e. sum of direct and diffuse radiation less albedo (Wh/m²); ΔH_2O = annual changes in precipitable water vapour (cm).

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

| Change in Annual Mean Maximum Temperatures		t-statistics	p-values
Constant		-0.39	0.70
Change in $[CO_2]$		0.14	0.89
Change in $[H_2O]$		9.64	0.000
Change in OPQ		-1.49	0.14
Standard Error	1.86		
Adjusted R^2	0.69		
Durbin-Watson	**2.692**		

Sources: see Table 3.

Note: The **i**ndependent variables in Table 5 are: ΔCO_2 = annual changes in atmospheric carbon dioxide at Mauna Loa Slope Observatory; ΔOPQ = changes in annual average opacity of the sky; ΔH_2O = annual changes in precipitable water vapour (cm).

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.

Fig.3 Annual changes in mean temperature, [CO2] and [H2O], New York 1960-2006
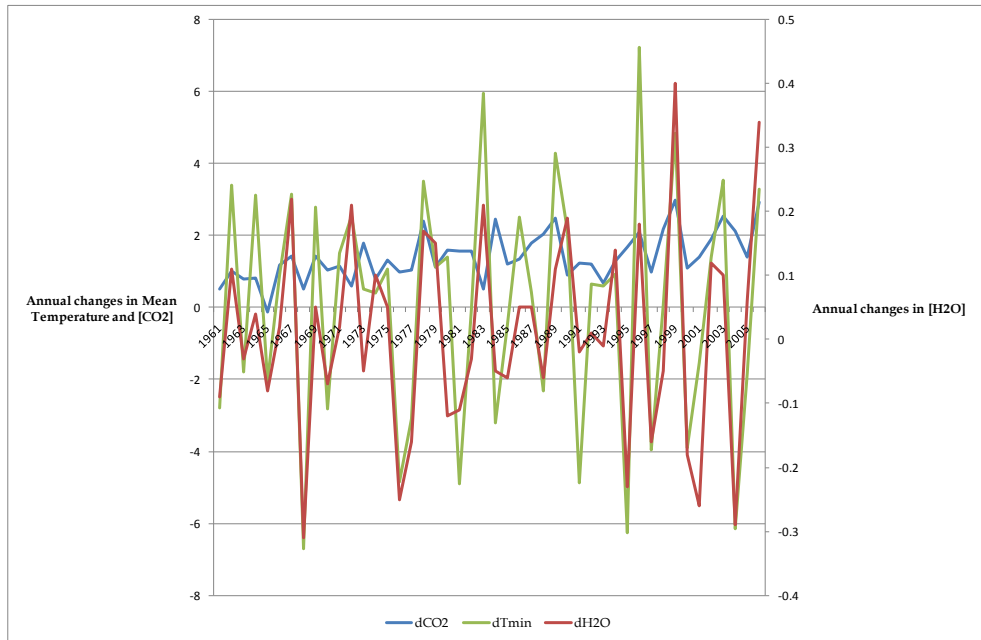

Sources: see Table 3.

Note: This graph explains the regressions reported in Table 5, showing why the annual changes in atmospheric carbon dioxide concentrations do not explain temperature variability in New York, unlike changes in atmospheric water vapour.

8. Proximate causes of Temperature change in Australia (if any)

The results of the locational analysis of temperature change in three hugely different locations in the USA in the previous section are amply confirmed by the econometric analysis here of temperature change across the whole of Australia since 1959.

First, I show in Fig.4 the trends in Australia's mean annual temperatures since 1960:

Fig.4 Annual changes in mean temperature – Australia 1960-2010.
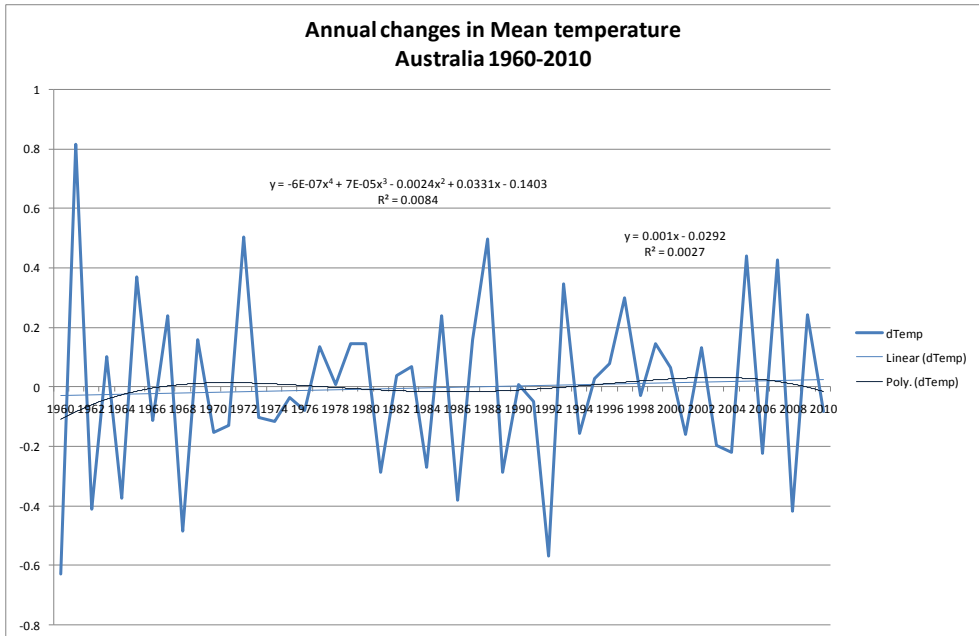
Evidently the *linear* trend of changes in temperature in Australia since 1960 has an abysmally poor fit (R^2 = 0.0027). The level 5 polynomial does much better, with R^2 = 0.0084, but is still very bad. For all except climate scientists, Fig.4 shows *nil* climate change in Australia since 1960, as the trend is flat whichever way one looks at it. The confidence level for the changes is as low as 28%, unlike the claim in Hegerl and Zwiers *et al.* 2007 that there is better than 90% certainty that there has been AGW since 1960.

Turning to econometric analysis, it is clear that the amount of precipitable water (PW, or $[H_2O]$) in the atmosphere is related to temperature, since as Lim and Roderick show (2009), there is greater evaporation in the tropics than there is in the higher latitudes. But at the same time, regressions show that temperature changes are much more closely correlated with changes in $[H_2O]$ or PW than in $[CO_2]$:

Table 6 Regression of climate data, Australia 1960-2010

Change in Annual Mean Maximum Temperatures		t-statistics	p-values
Constant		0.23	0.817
Change in $[CO_2]$		-0.267	0.79
Change in $PW[H_2O]$		5.61	0.000
Standard Error	0.233		
Adjusted R^2	0.37		
Durbin-Watson	**3.01**		

It can be argued[19] that a more appropriate regression analysis would assess changes in temperatures, not against changes in $[CO_2]$ and $[H_2O]$, but against the absolute values of those variables. Table 7 shows the results of doing that. Evidently the failure of even the actual levels of $[CO_2]$ to outperform those of $[H_2O]$ as explanations of changes in temperature remains unaltered.

Table 7 Regression of climate data, Australia 1960-2010

Change in Annual Mean Maximum Temperatures v. absolute values of $[CO_2]$ & $[H_2O]$		t-stat	p-values
Intercept		-2.5	0.0144
Annual level of $[CO_2]$		-0.53	0.597
Annual level of $PW[H_2O]$		2.564	0.014
Standard Error	0.09		
Adjusted R^2	0.28		
Durbin-Watson	**2.86**		

9. Water Vapour and Climate Change

Projections of global surface warming as large as 5.8°C over the next 100 years are based not on the direct contribution to atmospheric water vapour $[H_2O]$ from combustion of hydrocarbons but on increases in $[H_2O]$ arising from rising temperatures attributed to increasing $[CO_2]$, hence the term "feedback" to describe a second round impact of increasing $[H_2O]$ on temperature (Minschwaner and Dessler 2004, Dessler *et al.* 2008). In most global climate models, an initial warming caused by additional CO_2 and other greenhouse gases

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[19] Juan Blanco, pers.comm.

leads to enhanced evaporation at the surface and higher specific humidity of the atmosphere. Since water vapour is a strong infrared absorber (Arrhenius 1896), the added moisture causes further warming. But how much? Minschwaner and Dessler (2004:1281) estimate the change in water vapour in the Upper Troposphere (near 215 mb pressure or altitude of about 12 km.) is between 8.5 and 9.5 ppmv per 1^oC increase in surface temperature. That implies a total increase in $[H_2O]$ from the 0.7^oC rise in global surface temperature between 1900 and 2000 of just 5.95-6.65 ppmv., to be compared with the apparent increase in $[CO_2]$ from 1900 to 2010 of 110 ppmv. Using that calculation, it is difficult to see how Minschwaner and Dessler (2004:1272) arrived at "projections of surface warmings as large as 5.8^oC over the next 100 years" because of the "positive water vapour feedback in the atmosphere".

However, Dessler *et al.* (2008) claim to have demonstrated a substantial water-vapour climate feedback by comparing satellite data on tropospheric specific humidity q in the El Niño of December 2006-February 2007 with that in the cooler La Niña of December 2007-February 2008, with q higher in the former. Their paper does not explain why it was cooler in the La Niña despite higher $[CO_2]$ than a year before, and it shows no feedback impact on temperature in La Niña from the higher q during the earlier El Niño.

Moreover, Hansen *et al.* (2011) note that "the latent energy associated with increasing atmospheric water vapour in a warmer atmosphere is an order of magnitude too small to provide an explanation for the high estimates of atmospheric heat gain" (like those in Dessler *et al.* 2008), and thereby confirms the findings of this paper, that the direct anthropogenic contributions to $[H_2O]$ of currently over 300 GtH_2O p.a. are much more significant than the claimed positive $[H_2O]$ feedback effects from the essentially trivial *annual* increase in global temperature since 1900 of only 0.007^oC.

10. The Benefits of Hydrocarbon Fuel Combustion's Emissions of CO_2 and H_2O.

Garnaut's first Update paper (2011) has the title "Weighing the costs and benefits of climate change action", but at no point mentions the benefits of hydrocarbon combustion in terms of the fertilization effect of elevated atmospheric carbon dioxide and water vapour (shown in equations (1) and (2) above) on global food production. For Garnaut (2008 and 2011), hydrocarbon combustion produces 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 and longer growing seasons in all non-tropical latitude zones), and the benefits of restricting use of hydrocarbons consist *only* of avoidance of the supposed costs of rising temperatures.

Ironically, there is a contradiction between the SCC's basic position that hydrocarbon emissions produce only costs, and that the biospheric sinks are close to saturation, as claimed by Raupach *et al.* (2008, etc.) while in both his 2008 and 2011 *Reviews*, Garnaut 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, which would not be possible if Raupach *et al.* were correct. Yet the 2008 *Review* raises 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). This is justified in section 2.3.2 (in SCC*)* 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 CO_2 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 in either the 2008 or 2011 *Reviews*, and may betray 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 55 percent is absorbed by the biospheres, becomes just 0.016 per cent of the second figure.

At the observed growth rate of [CO_2] 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 *Reviews'* portrayal of the extreme urgency of preventing these gentle increases is not compelling, unless one accepts their projection of 1565 ppm CO_{2e} by 2100.

Garnaut's SCC (2011) 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 Quéré, P. Fraser, and M. Raupach, of which none of those cited in SCC section 2.3.2 has been peer-reviewed. Instead, as already noted above, with another omission of material facts, the 2011 *Review* ignores the peer-reviewed paper by Knorr (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".

My own peer-reviewed paper (Curtin 2009) 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 global cereal production based on the increasing photosynthesis - on which all living matter is wholly dependent - facilitated by increases in [CO_2]. 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 rising temperature and CO_2 in raising photosynthesis – and thereby yields – is shown in Fig.5. 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.

Similarly, my Table 6 confirms the concurrence in Fig.5 of rising atmospheric carbon dioxide with rising terrestrial uptakes of carbon dioxide and rising world cereals production both in total and per capita. Those demanding stringent reductions in carbon dioxide emissions like Stern (2007), the *Garnaut Reviews (2008,2011),* and Hansen (*passim*) will incur a heavy burden of responsibility, if their proposals succeed in reducing the atmospheric concentration to levels like that shown for 350 ppm in Fig.4 that are unlikely to support the food requirements of a world population of nearly 7 billion people now, and possibly 9 billion by 2050.[22]

**Table 6 Carbon Dioxide and World Cereals Production 1961-2007**

	1961	2007	% Change
Atmospheric concentration of CO_2 (ppm)	317.45	384.22	21
Anthropogenic emissions of CO_2 (GtC)	4.06	9.94	144
Total terrestrial uptakes (GtC)	0.9	2.98	231
Total cereals production, Gt	0.88	2.34	166
Carbon content (average 40%) GtC	0.35	0.94	59
World population (billions)	3.08	6.6	114
Cereal production per capita, tonnes	0.28	0.35	168
Carbon content per capita, 40% average, tonnes	**0.11**	**0.14**	**27**

Source: Le Quéré, Canadell *et al.* 2009, www.globalcarbonproject.org, 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 absorbers though photosynthesis.

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[22] "The fundamental reason why carbon dioxide in the atmosphere is critically important to biology is that there is so little of it. A field of corn growing in full sunlight in the middle of the day uses up all the carbon dioxide within a meter of the ground in about five minutes. If the air were not constantly stirred by convection currents and winds, the corn would stop growing" (Dyson 2007).

Fig. 5 The response of light-saturated net photosynthesis (Pn) to changes in leaf temperature at different atmospheric CO2 concentrations.
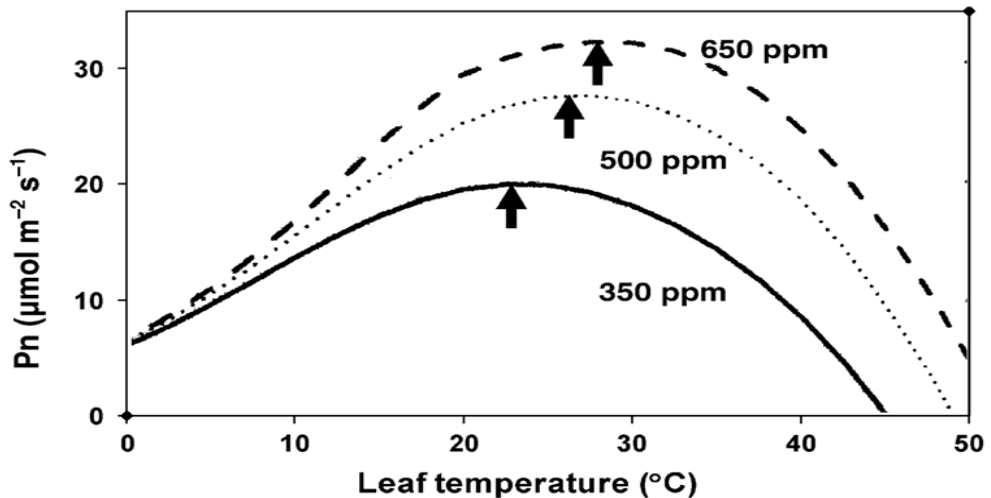
Sources: Norby and Luo (2004) and Long (1991), with permission of Blackwell Science.
Note: Arrows indicate the shift in optimum temperature with increasing CO2 concentration.

11. Conclusion

This paper has produced statistical and econometric analysis showing that the mainstream science of climate change has been too focussed on a single supposed causative agent, carbon dioxide emissions (about 30 $GtCO_2$ p.a), to the serious neglect of the much larger volumes of anthropogenic water vapour produced by the combustion of hydrocarbon fuels, both by direct creation of water vapour in the combustion process (18 GtH_2O p.a.), and by the much larger volume of steam created by the cooling needed in the power generation process (300 GtH_2O). It is true that individual injections of water vapour to the atmosphere have a short residence time there before forming clouds descending as precipitation (Kelly, 2010), but increases in both the average level of $[H_2O]$ over a year and the frequency of the hydrological cycle are highly significant.

The implications of full accounting for the radiative forcing attributable to anthropogenic water vapour are confounding. On the one hand, it is conceivable that it has been unwittingly included in the radiative forcing ascribed to rising $[CO_{2e}]$, while on the other it may be an addition to that forcing, which would mean that temperature projections are being understated. Alternatively, it may be that the forcing ascribed to positive feedbacks from rising evaporation due to the observed annual global temperature increase of 0.007°C p.a., which raises the IPCC's projected temperature increase from a doubling of $[CO_{2e}]$ to 3°C from the 1°C due to $[CO_{2e}]$ alone, given the lack of evidence for this effect, should be reassigned to primary anthropogenic additions to water vapour.

This paper's findings imply all governments should reconsider their hitherto unquestioning support of the IPCC's AR4 (2007) assertion that only anthropogenic greenhouse gases can explain "most" of climate change over the last half-century and longer. In particular the Australian government should at the least refer in future more accurately to its proposed "carbon (sic) tax" as a "Tax on Plant Growth and Rainfall", given the data here showing (1) that the respective radiative forcings from emissions of water vapour and carbon dioxide during hydrocarbon combustion and power generation are much more potent from the former than the latter, and (2) that rises in temperatures, levels of atmospheric carbon dioxide, and atmospheric water vapour have all been consistent with the increases in global per capita cereals and other food production since 1960.

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Appendix I

An outline of econometric analysis for climate scientists and non-statisticians.

The purpose of econometric analysis is to test whether any given hypothesis is consistent with the available evidence or not. The first step in the process of establishing the viability of a hypothesis is to set up what is known as the nul (i.e. negative) form of the hypothesis, H_o, for example that climate change is NOT the result of anthropogenic emissions of greenhouse gases, or that a new drug should NOT be introduced to combat some ailment because it has on balance no beneficial effects. The aim of econometric research is then "to determine whether the nul hypothesis should be rejected" (Feinstein and Thomas 2002:152). If it is rejected, then the research hypothesis H_1, that global warming IS the result of anthropogenic emissions of GHG, and that a new drug is beneficial, should be accepted, at least until such time as new evidence does not reject the nul, H_o.

Kevin Trenberth recently (2011) proposed that in the case of climate science, the nul hypothesis above, Ho, should be replaced by a new nul, that global warming IS caused by anthropogenic GHG emissions, so that the onus would be on disbelievers in human-induced climate change to disprove this new "nul". But Trenberth betrays that he is indeed no statistician, because by its very name the nul has to be a negative, not a positive.

There is a reason for that, because in general, there is considered to be more risk of adverse consequences if the nul H_o is falsely not rejected when it should be, for example, because a new drug does have adverse side effects and thereby H_1 is wrongly accepted and the drug is approved for sale. This outcome is known as a Type I error. However if H_o is false, and the drug is not approved, then its beneficial effects will be lost, and this is termed a Type II error, in this case failing to reject the false nul H_o. In the case of drug trials "the consequences of introducing a drug with adverse side effects are usually viewed as far more serious than the consequences of not introducing a drug with potential life-saving or life-enhancing properties" (Feinstein and Thomas, 2002:158). Thus by convention the main thrust of hypothesis testing is avoidance of Type I errors, namely false rejection of the nul H_o.

The primary role of econometrics is to determine a general rule for acceptance or rejection of the nul H_o. The general rule has become the level of significance, where that is "the probability of making a Type I error", which is accepting as true a hypothesis that is really untrue (Feinstein and Thomas 2002:156-158).[23] Clearly, the lower is the probability of wrongly rejecting the nul hypothesis, the better. By convention, there are three levels of significance, known as p-values, 1%, 5%, and 10%, which represent 99%, 95%, and 90% confidence respectively that the nul hypothesis can be rejected.[24] To illustrate these concepts here again are some of the results of this paper's regression results (Table 5) for alternative determinants of change in annual mean maximum temperature in New York from 1960 to 2006. The p-value for annual changes in atmospheric CO_2 is 0.89, indicating only 11% confidence that the nul that CO_2 has NO influence on temperature can be rejected, whereas for atmospheric water vapour ($[H_2O]$) the p-value is 0.0001 indicating virtually 100% confidence that the nul for $[H_2O]$ having no influence on temperature should be rejected.

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[23] "Roughly speaking, if a coefficient estimate is more than two standard errors away from zero, it is called statistically significant", Gelman and Hill, 2009.

[24] However, that is not quite the end of the story, because high confidence that a particular variable's coefficient is significant statistically does not ensure that it is necessarily very meaningful in economic or scientific contexts (Feinstein and Thomas 2002: 160).

Appendix II

Tyndall's Ratio Spectrophotometer
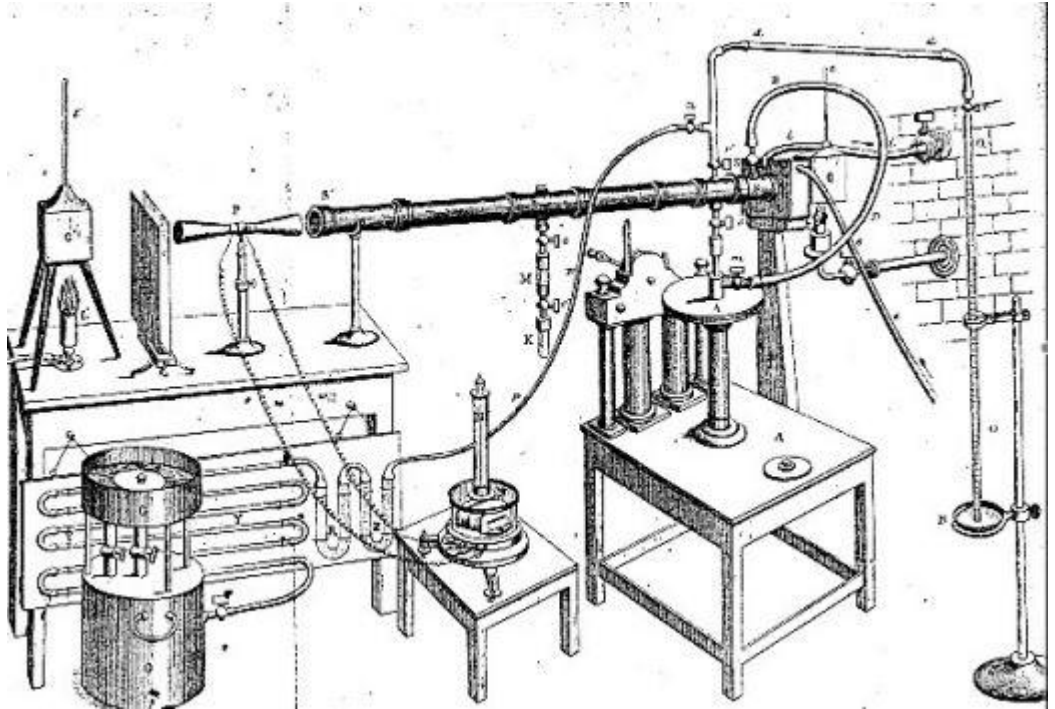
The apparatus essentially compared two stable heat sources, the cubes labeled "C", each of which was filled with water kept at the boil. The one at the left is a reference; the one at the right, however, sends its heat through the tube, which may be evacuated or filled with the gas or vapor to be measured. A thermopile converts the difference in received radiation to a voltage, which deflects a needle proportionately. Tyndall could thus directly compare the absorption of heat by water vapor, oxygen, carbon dioxide—which nineteenth century chemistry usually referred to as "carbonic acid"—or any other gas or vapor he chose.

His results were as interesting as they are robust. He wrote:

I am unable at the present moment to range with certainty oxygen, hydrogen, nitrogen, and atmospheric air in the order of their absorptive powers, though I have made several hundred experiments with the view of doing so. Their proper action is so small that the slightest foreign impurity gives one a predominance over the other.

By contrast, "olefiant gas" — we call it ethene or ethylene today, and know it as the naturally produced gas which ripens many fruits — absorbed an astounding 81% of the heat passing through the sample tube. Tyndall was amazed:

Those who like myself have been taught to regard transparent gases as almost perfectly diathermous, will probably share the astonishment with which I witnessed the foregoing effects. I was indeed slow to believe it possible that a body so constituted, and so transparent to light as olefiant gas, could be so densely opake (sic) to any kind of calorific rays; and to secure myself against error, I made several hundred experiments with this single substance.

(It is fortunate that ethene is not very stable in the atmosphere, or it would be a very troublesome "greenhouse gas," as it occurs naturally and is produced in large quantities as a feedstock for industrial chemistry.)

Comparative Absorption Of Various Gases

```
Air   .   .   .   .  A fraction of a degree
Oxygen  .   .   .      „        „
Nitrogen    .   .      „        „
Hydrogen  .   .       „        „
Carbonic oxide   .   .   . 18°
Carbonic acid   .   .   .   . 25°
Nitrous oxide   .   .   .   . 44°
Olefiant gas   .   .   .   . 61°
```

A reproduction of Tyndall's table of comparative absorption of various gases. Note that the results are given in degrees, referring to the deflection of the galvanometer's needle. "Carbonic oxide" is called "carbon monoxide" today.

Signficance for climate science.

As the table above shows, the compounds "carbonic oxide" (CO, or carbon monoxide) and "carbonic acid" (CO_2, or carbon dioxide), though not as effective as "olefiant gas", are much better absorbers than dry air, or its main constituents, nitrogen and oxygen. Dry air — but air is not usually dry. What of air containing water vapor? On November 20, 1860, Tyndall differentially compared the absorptive power of the ambient air to that same air scrubbed of its water vapor and "gaseous acids." He

. . .found that the quantity of aqueous vapour diffused through the atmosphere on the day in question, produce an absorption at least equal to thirteen times that of the atmosphere itself. . . It is exceedingly probable that the absorption of the solar rays by the atmosphere, as established by M. Pouillet, is mainly due to the watery vapour contained in the air.

Tyndall did not fail to underline the significance of the facts he had uncovered:

De Saussure, Fourier, M. Pouillet, and Mr. Hopkins regard this interception of the terrestrial rays as exercising the most important influence on climate. . . every variation [in aqueous vapour] must produce a change of climate. Similar remarks would apply to the carbonic acid diffused through the air, while an almost inappreciable admixture of any of the hydrocarbon vapours would produce great

effects on the terrestrial rays and produce corresponding changes of climate. It is not, therefore, necessary to assume alterations in the density and height of the atmosphere to account for different amounts of heat being preserved to the earth at different times; a slight change in its variable constituents would suffice for this. Such changes in fact may have produced all the mutations of climate which the researches of geologists reveal.

Fourier and Pouillet had shown the importance of atmospheric absorption and re-emission of radiation to climate; Tyndall had now, for the first time, identified water vapor and carbon dioxide gas as the most important substances responsible for this effect.

Source: "Doc. Snow", nd, Global Warming Science in the age of Queen Victoria.