Collection of five Surrey Mirror Group Website Articles written by Peter F Gill and posted from about March 2015 to January 2016. They now no longer exist on the Internet unless archived by someone.

WEB ARTICLE I

Changing Climates

Climate change is what Earth's climate does and for a large variety of reasons. Many causal factors have origins external to Earth. These include: the gravitational induced changes to the Earth's orbit around the Sun (probably largely the influence of Saturn and Jupiter); the changing cosmic conditions as our local solar system orbits our own galaxy; the changes in solar emission of electromagnetic radiation and particles (mainly alpha and beta particles which are Helium nuclei and fast electrons respectively): the changes in the magnetic fields of the Sun and Earth and their coupling : the gravitational effects of the Moon.

Internally because of our rotation and the complex chaotic interplay between our atmosphere and our oceans further variability in climate is inevitable. This would be true in a lifeless environment. However, living things have had a major effect on the composition of our atmosphere notably the increase in oxygen content. Mankind is not an exception but are we the dominant cause of climate change which is the current claim by many. Local climates have clearly been modified by mankind for thousands of years mainly through changes in land use, particularly de-forestation. Since the 1970s mankind's effect on the climate has increasingly been focused on the consequences of burning fossil fuels and in particular our emissions of carbon dioxide which is a so-called greenhouse gas. The subject probably first came to the public's attention through warnings of global warming or Anthropogenic (mankind induced) Global Warming (AGW) or the rather direr scenarios of catastrophic AGW (CAGW).

In my first article, published in the paper on February 19^{th,} I explained that quite a number of individual hypotheses comprised the overall AGW notion. By its very nature an hypothesis is a reasonable speculation of a correct explanation of one or more facts. In science it is not a truth or a belief just a working idea and maybe the first step towards a theory and onto a law of science.

I listed six of the main hypotheses that form the overall AGW hypotheses as follows:

(i) the increase in carbon dioxide (CO_2) over the last 200 years has been caused by the burning of fossil fuels,

(ii) effectively all anthropogenic CO_2 emissions since the beginning of the industrial revolution remain in the atmosphere,

(iii) as a greenhouse gas CO_2 absorbs upwelling infra-red radiation from the Earth and re-emits in all direction effectively causing warming,

(iv) the increase in heat evaporates more of the primary greenhouse gas, water vapour thus multiplying the effect of CO_2 increase by a factor of about 3,

(v) further atmospheric heating will release methane from permafrost – a tipping point at which it is postulated run-away global warming will occur,

(vi) the amount of carbon dioxide in the atmosphere is and always has been the main climate driver.

The idea for subsequent columns was to examine and challenge each of the AGW ideas with new facts and alternative hypotheses and to deal with any questions arising.

The second column published on 12th March questioned whether the increase in CO_2 over the last 200 years has been caused by burning of fossil fuels. Further articles will appear only on the web site and will deal with the other five hypotheses listed above.

AGW Hypothesis (i) the increase in carbon dioxide (CO_2) over the last 200 years has been caused by the burning of fossil fuels

Carbon dioxide (CO_2) is a trace gas in our atmosphere weighing about 3,000 Giga tonnes. This may seem a lot but, put another way, over 99.95% of our atmosphere is not CO_2. There is about 50 to 60 times more CO_2 in the seas than in the atmosphere. The gas is responsible for life on Earth. You breath in about 400 parts per million (ppm) with every breath. You then breath out about 40,000 ppm of CO_2! That's about a third of a tonne per year of CO_2 each.

There is a continuous interchange between CO_2 in the atmosphere, in the seas and soils caused by many factors, particularly life itself. In any one year, completely natural emissions, mostly from equatorial areas, can be 600 Giga tonnes with considerable variability from year to year. Our current contribution from all our activities is circa 30 Giga tonnes. Of course, the seas, soils and the ecosystem absorb a similar quantity to yearly emissions but there is never a perfect balance and so atmospheric levels follow trends created by many factors.

Over the past 200 years, atmospheric CO_2 has been increasing. This period coincides with industrialisation and the increased burning of fossil fuels. There is evidence that the nature of atmospheric CO_2 is changing because fossil fuels are richer in a lighter form of carbon (for more detail research the isotopes C_{12}, C_{13} and C_{14}). It would therefore appear reasonable to assume that we are to blame for the increased CO_2 levels.

However, the same period is characterised by us coming out of a Little Ice Age when there were ice fairs on the Thames. Natural variability caused the two most recent warm periods – the Roman Warm Period and the Mediaeval Warm Period and so why not the present warm period? Well this is where things get contentious and it's partly to do with the solubility of CO_2 in water and the chemical reactions that take place particularly in sea water.

Carbon dioxide is very soluble in cold water. As temperature increases solubility decreases. Solubility depends on the pressure of the CO_2 over the water. So let's assume that sea out-gassing is the reason for the increase in CO_2 in a warming world. If we burn fossil fuels, the CO_2 released contributes to the pressure of CO_2 and consequently prevents what would otherwise have come out of the sea. The

overall result could be similar to the natural emissions. If you would like to look into this matter in more detail Google Henry's Law.

AGW Hypothesis (ii) effectively all anthropogenic CO_2 emissions since the beginning of the industrial revolution remain in the atmosphere

This hypothesis is a more extreme version of the hypothesis that all the increase of atmospheric CO_2 is anthropogenic in origin. It uses two assumptions. Firstly, that pre-industrial levels of CO_2 were more or less constant around 280ppm and that this level represents a "correct" amount of CO2 in the atmosphere. It is argued that the increase in the quantity of the light form of carbon (isotope C_{12}) relative to the heavier carbon (C_{13}) demonstrates that the increase in the gas is a consequence of fossil fuel burning. This is not a wholly credible hypothesis for a number of reasons. The assumption of constancy of past CO_2 levels comes from ice core data. This has some known problems. Secondly, the amounts of CO2 emitted and contained in the atmosphere do not tie up. Thirdly, thirty plus experiments, using different methods, have shown that the range of residence times, that an individual molecule of CO_2 remains in the atmosphere, is from 4 to 25 years with 5-6 years being typical. There is a further argument about residence times suggesting that it will take many hundreds of years for atmospheric CO_2 to return to pre-industrial levels. Perhaps I will return to this notion at a later date. Most likely it can be covered when discussing the reason that the International Panel on Climate Change has set-up and its consequent approach.

WEB ARTICLE 2

Greenhouse Gases and Climate Sensitivity

Heat moves from hotter to cooler places in three ways - by conduction, convection and radiation. In a garden greenhouse, sun light passes through the glass (or plastic) roof and walls heating the ground by radiation. The air layer in contact with the soil warms by conduction and then starts moving upwards by convection. It is also true that some of the energy coming off the heated surface is electromagnetic radiation in the infrared part of the spectrum. The physical barrier of glass (or plastic) which stops the warm air escaping by convection is the main reason that a greenhouse works. Any retention of heat by limiting the escape of infrared radiation from the ground is very much a secondary effect.

The third and fourth hypotheses I listed previously (scroll down blogs) as forming the overall Anthropogenic Global Warming (AGW) Hypothesis directly concern the two main so-called greenhouse gases in the Earth's atmosphere. Just to remind you I listed these two hypotheses as:

(iii) As a greenhouse gas CO2 absorbs upwelling infrared radiation from the Earth and re-emits in all directions effectively causing warming.

(iv) The increase in heat (caused by the CO2 warming) evaporates more of the primary greenhouse gas, water vapour, this multiplying the effect of CO2 increase by a factor of about three.

As you can probably appreciate, the Greenhouse Gas (GHG) effect that one hears about in the context of global warming involves rather different mechanisms than what goes on in actual greenhouses. The central idea, but not the only one, is that some types of molecule absorb certain frequencies of upwelling electromagnetic infrared radiation from the warmed surface of the Earth (water, soil etc). Such molecules then re-emit infrared radiation in all directions, including back to the ground. For reasons to do with the laws of physics and thermodynamics in particular, I prefer to describe the effect as one which changes the rate of loss of heat to space which results in a slightly different temperature than if the absorbing gases had not been present. The main infrared absorbing gases present in the Earth's atmosphere are water vapour (highest absorber by far) followed by our old friend carbon dioxide (CO_2) as a poor second. Others include methane, nitrous oxide and ozone.

The idea that some part of the Earth's atmosphere effectively keeps us warmer than could otherwise be expected is attributed to the brilliant French mathematician and physicist Joseph Fourier (1768-1830). John Tyndall (1820-1893) identified water vapour and carbon dioxide as the "heat –trapping" components of the atmosphere. Svante Arrhenius (1879-1927) reasoned that because water vapour fluctuated continually cycling in and out of the atmosphere carbon dioxide is the key component. He argued that increasing atmospheric carbon dioxide would cause warming and this would cause increased evaporation of water. As you can therefore see, the basic idea is far from new.

Water is a remarkable compound. According to its position in the Periodic Table of Elements, oxygen hydride (chemical formula H_2O) should be a gas at room

temperature. Indeed the hydrides of the next three elements in the same series, sulphur, selenium and tellurium are all gases at room temperature. Only the hydride of polonium, the next element in the series, is a liquid at room temperature. Water is in fact rather like a polymer with the formula n (H_2O) with a small amount of ionised component giving it a pH value of seven. In fact, I suspect that the anomalous behaviour of water features in disagreement s between scientists on the sign and extent of the GHG effect.

The changes of state of water, from ice to liquid water, from liquid water-to-water vapour and vice versa, involve large changes in energy, referred to as latent heat. The amount of sunlight reflected from the Earth's surface, called its albedo, depends crucially on the surface type and if H_2O its form being high when the form is snow and ice. All these factors play important roles in the Green House Gas (GHG) Effect. However as mentioned there is considerable argument about the overall effect of GHG on the Earth's energy balance. The majority opinion favours a reduced rate of loss of heat as GHG increase although both effective warming and cooling take place. There is a minority view suggesting a slight overall cooling effect. Unlike politics consensus means nothing in science and so it is possible that the minority are correct. However, for the purpose of the discussion below I shall assume increased GHG have an overall warming effect.

Scientifically the big issues are climate sensitivity to changes in radiative forcing and the nature and extent of positive and negative feedbacks in the climate system. The term "sensitivity" is often used specifically for estimates of the increase in equilibrium atmospheric temperature, when the amount of atmospheric CO_2 is doubled. The range of estimates for sensitivity is very wide from typically 0.6 ^{0}C to 4.5 ^{0}C and perhaps confusingly in computer models it includes for the compounding effect of increased water vapour expected for the increase in temperature caused by the increase of CO_2 by itself. Interestingly, although one would expect an increase in the Earth's atmospheric water vapour content for increasing temperature (for whatever reason), this has not been observed as far as I am aware although it is generally agreed that the Earth has warmed up by almost one degree Centigrade in the last 200 years.

There is a great deal of science hidden in the above remarks and I plan for the moment at least to make just a few comments which I may elaborate on in future. Firstly, when the quantity of any particular infrared absorbing gas increases in the atmosphere each new molecule has less effect than the one before it. The relationship is logarithmic. Secondly, unlike a real greenhouse there is no physical barrier to radiation finding its way to space it just takes a little longer than if there were no GHG present. Thirdly, in recent years despite continuing increases in atmospheric CO_2 there has been no significant change in the Earth's temperature. It had been thought that the effect was being hidden by aerosols, which have a shielding effect on sunlight. However, although real, this effect has been shown to be far less important than previously assumed. In fact, the only place where there is catastrophic global warming (CAGW) is in computer climate models which have been departing considerably from measured values for many years.

Until I have discussed the final two AGW hypotheses I will hold off on two important topics – alternative mechanisms for climate change and appropriate policies for dealing with the consequences of climate change. However, before leaving the CO_2

water vapour issue I will relate a short story, which you may find interesting, frustrating or shocking depending on your understanding and point of view.

In late February 2010, I attended a two-day discussion meeting at the Royal Society in London. The title of the meeting was “Greenhouse gases in the Earth system: setting the agenda to 2030”. Before attending, I had not seen the list of papers. However, I expected that since water vapour is largely responsible to the so-called greenhouse effect on Earth there would be a number of papers on the subject. I was looking forward to those addressing water vapour variability especially since increased water vapour levels are linked to increased CO2 levels and an enhanced greenhouse effect. I was disappointed that there was not one single paper on water vapour, its variability or indeed any on the multiplying effects inherent in one of the main AGW hypotheses. Consequently, at the first opportunity, I asked why there were no such papers. The only answer that I received was that climate models fully account for water vapour. Sadly you will not be able to check exactly what I asked or indeed the response I received because these days the “Philosophical Transactions of the Royal Society do not actually include a record of the question, answer and discussion sessions although for the progress of science these are often the most important parts of a meeting.

In the coffee break immediately following my water vapour question, I got into conversation with David MacKay (then Chief Scientific Advisor of the Department of Energy and Climate Change) in connection with one of my learned society roles. After dealing with that matter and another related topic about which we disagreed, David commented about my question to the meeting – “Very rude” he said.

WEB ARTICLE 3

Is run-away warming likely? Has carbon dioxide always been the main climate driver?

In previous contributions (scroll down to previous of my blogs if you need to catch-up) I have described and, in a limited way, discussed the first four of the main six hypotheses that form the overall Anthropogenic Global Warming (AGW) hypothesis. Now we shall move on to the final two which I listed as: (v) further atmospheric heating will release methane from permafrost causing run-away global warming and finally (vi) the amount of carbon dioxide in the atmosphere is and always has been the main climate driver.

AGW Hypothesis (v) further atmospheric heating will release methane from permafrost and cause run-away global warming

In one sense, we may regard this aspect of concern as a consequence of warming (of any origin) like increased sea levels. However because it is thought that the release of methane would lead to even more warming such a consequence maybe classed as a positive feedback which some have argued could lead to a tipping point and runaway warming.

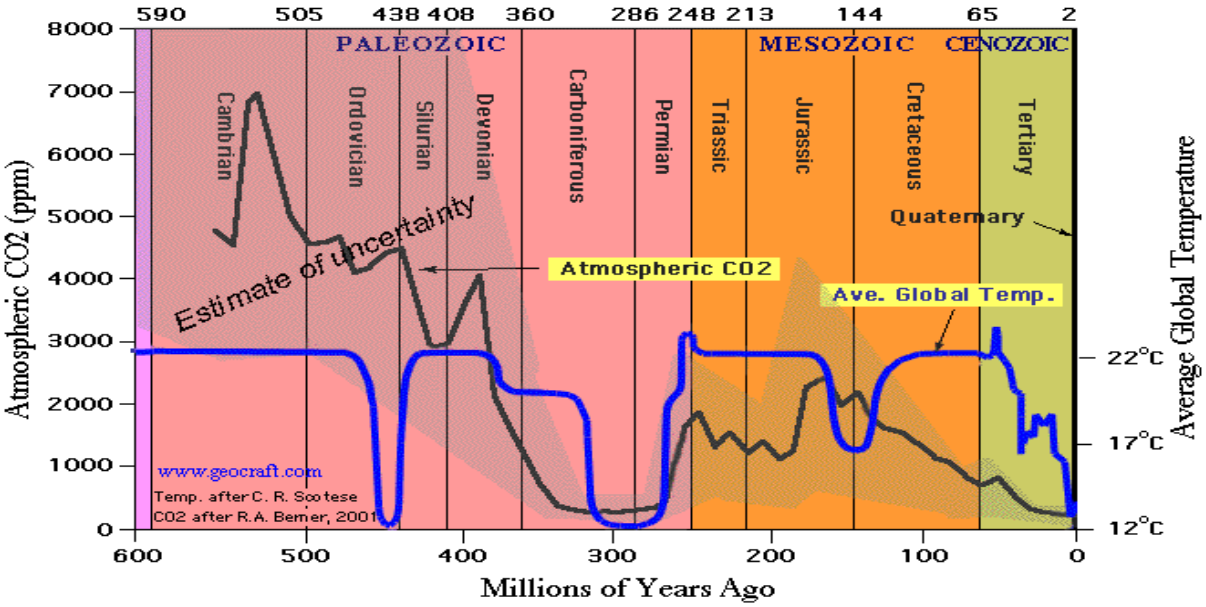
Atmospheric methane (CH_4) levels are very much lower than carbon dioxide (CO_2) levels by volume. Whereas carbon dioxide levels are measured in parts per million (currently circa 400ppmv), methane levels are measured in parts per billion (currently circa 1825 ppbv). As with the origin of the CO_2 increase, there is not universal acceptance about anthropogenic versus natural contributions. CH_4 is a more potent Green House Gas (GHG) than CO_2 by a variable factor currently close to about 30 times.

Whilst there has clearly been warming since the depths of the Little Ice Age (LIA) compared to previous recent warm periods the present warm period is not as far as proxy data shows anything extraordinary. The Roman Warm Period (RWP) was almost certainly warmer than the present warm period. The Medieval Warm Period (MWP) was probably warmer than the present warm period. Going back earlier in the present Holocene era the Holocene optimum was very much warmer than the present. In all of these cases, there is no evidence of runaway warming due to CH_4 released from permafrost.

As we have raised the subject of feedbacks, it is worth mentioning some others. Interestingly those who favour the overall AGW hypothesis tend to concentrate on positive feedbacks of which CH_4 release is clearly one. Loss of snow and ice reduce the amount of electromagnetic energy that is reflected from the Earth and therefore such warming causes further warming. However, that said I suspect that the elephant in the room is the negative feedbacks due to water in its various forms clouds and precipitation from clouds in particular.

AGW Hypothesis (vi) the amount of carbon dioxide in the atmosphere is and always has been the main climate driver.

When I first got involved in the whole notion of AGW back in the 1990s the climate change community readily admitted that there were many factors driving climate change and changes in atmospheric CO_2 was just one of them. Things have apparently changed in recent years. I attended a two-day meeting at the Royal Society in October 2011 entitled "Warm climates of the past – lessons for the future?" Although the meeting only concerned itself with very recent times (the last circa 50 million years) it was concluded that carbon dioxide in the atmosphere is now and has in the past been the main climate driver. This is the most recent main claim by those supporting the AGW hypothesis, which as far as I can see goes contrary to most of the proxy data available for the last 600 million years. In concluding this part of the discussion below, I provide a composite picture of data from C.R. Scotese who generated the average global temperature data and R.A. Berner who generated the atmospheric carbon dioxide data.



I could make many points about this data. However, in relation to the main thrust of the Royal Society meeting the following are appropriate:

1. Whilst the uncertainty in proxy data is large, it is clear that over the last 600 million years there is no obvious correlation between atmospheric carbon dioxide and temperature.
2. The period chosen by the Royal Society for its meeting was one in which in the movement of both temperature and CO_2 were broadly in the same direction. For most of the rest of the period, this is clearly not the case.
3. For approximately 80% of the period the Earth's average temperature has been some 6-8^{0}C above the present average. This was true in the late Devonian and the early Carboniferous despite rapidly reducing atmospheric CO_2.
4. The fact that there seems to be a limit on average global temperature around 22^{0}C suggests a negative feedback mechanism in place for which, in my opinion, water vapour effects are favourite.

5. Average Earth temperatures in the last part of the Ordovician were quite a lot lower than the current average temperature despite the fact that atmospheric CO2 content was circa 4000ppmv i.e. ten times current levels.
6. The huge changes in climate evident from the proxy data require understanding beyond a simplistic CO2 in charge mantra.

Next time I hope to answer some comments people have made and to move on to a discussion of the missing science in climate change.

WEB ARTICLE 4

Should you trust the Intergovernmental Panel on Climate Change (IPCC)?

If you put "IPCC" into the Google search box, once you get past the Independent Police Complains Commission, your first proper hit will probably be about the Fifth Assessment Report (AR5). You will notice that AR5 "*provides a clear and up to date view of the current state of scientific knowledge relevant to climate change. It consists of three Working Group (WG) reports and a Synthesis Report (SYR)*." This implies that those involved with IPCC consider and study all known or possible mechanisms of climate change. Certainly, no restriction would appear to be applied on IPCC's climate change study scope. Sadly, this is far from the truth. Although Wikipedia is itself strongly biased on the subject of AGW, it accurately reports that "*The aims of the IPCC are to assess scientific information relevant to: (1) Human-induced climate change (2) The impacts of human-induced climate change (3) Options for adaptation and mitigation*." The corollary would appear to be that IPCC does not aim to assess the scientific information relevant to climate change resulting from mechanisms other than those identified with anthropogenic (human) activity. However, this is also misleading. Particularly at the start, the scientists involved well recognised that if there was an anthropogenic signal in climate change data it would be difficult to spot given that climate has always changed for a great variety of known and unknown reasons.

IPCC was established in 1988 by two United Nations organisations. Right from the start the idea of IPCC reports was to support the United Nations Framework Convention on Climate Change and its objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. In other words, the idea was to support the notions (read hypotheses) that (a) humans are the main cause of dangerous climate change and (b) that by implication we should stop burning fossil fuels. The idea of supporting hypotheses or speculations, which is the normal everyday term for such things, is essentially non-scientific. If anything, one seeks to find ways of testing hypotheses and if found wanting rejecting them.

Those contributing to IPCC reports, do so on a voluntary basis. Its assessments are supposed to be based on peer reviewed published literature. IPCC does not conduct any original research. Many prominent scientists in fields important to understanding the mechanisms of climate change initially became involved in the IPCC process but for various reasons do not now participate. If you look into some of those reasons, you are in for a shock. By and large, those that have remained involved are recipients of government grants for work in associated fields and those with rather specific agendas.

IPCC published its first Assessment Report (AR1) in 1990 and updated it in 1992. Subsequently IPCC has treated us to the Second Assessment Report (SAR) in 1996, the Third (TAR) in 2001, the Fourth (AR4) in 2007 and the Fifth (AR5) in 2014. There is much good science in the body of these reports. Authors often highlight the uncertainties involved. However, there are disconnects between the detailed reports and the only material that the press pick up, which is contained in the Summary for Policymakers. Even Wikipedia acknowledges that the Summary *"..is subject to line-by-line approval by delegates from all participating governments. Typically this involves the governments of more than 120 countries*."

The following are paraphrased extracts from each successive assessment report:

AR1: Computer model predictions of the increase in mean surface temperature over the last hundred years due to the anthropogenic enhanced greenhouse effect is of the same magnitude as natural climate variability.

SAR: The balance of evidence suggests a discernible anthropogenic influence on climate.

TAR: Since the mid-20th century, most of the observed warming is "likely" (greater than 66% probability, based on expert judgement) due to anthropogenic factors.

AR4: Most of the global average warming over the past 50 years is "very likely" (greater than 90% probability, based on expert judgement) due to human activities.

AR5: Anthropogenic influence on the climate system is clear. It is extremely likely (95-100% probability) that anthropogenic influence was the dominant cause of global warming between1951-2010.

So, over the last 25 years the IPCC has gone from there could be an anthropogenic effect on climate to it is almost all our fault that the climate is changing. One could easily conclude that great strides have been made in the understanding of climate mechanisms and that even if the science is not completely settled, it's more or less all over bar the shouting.

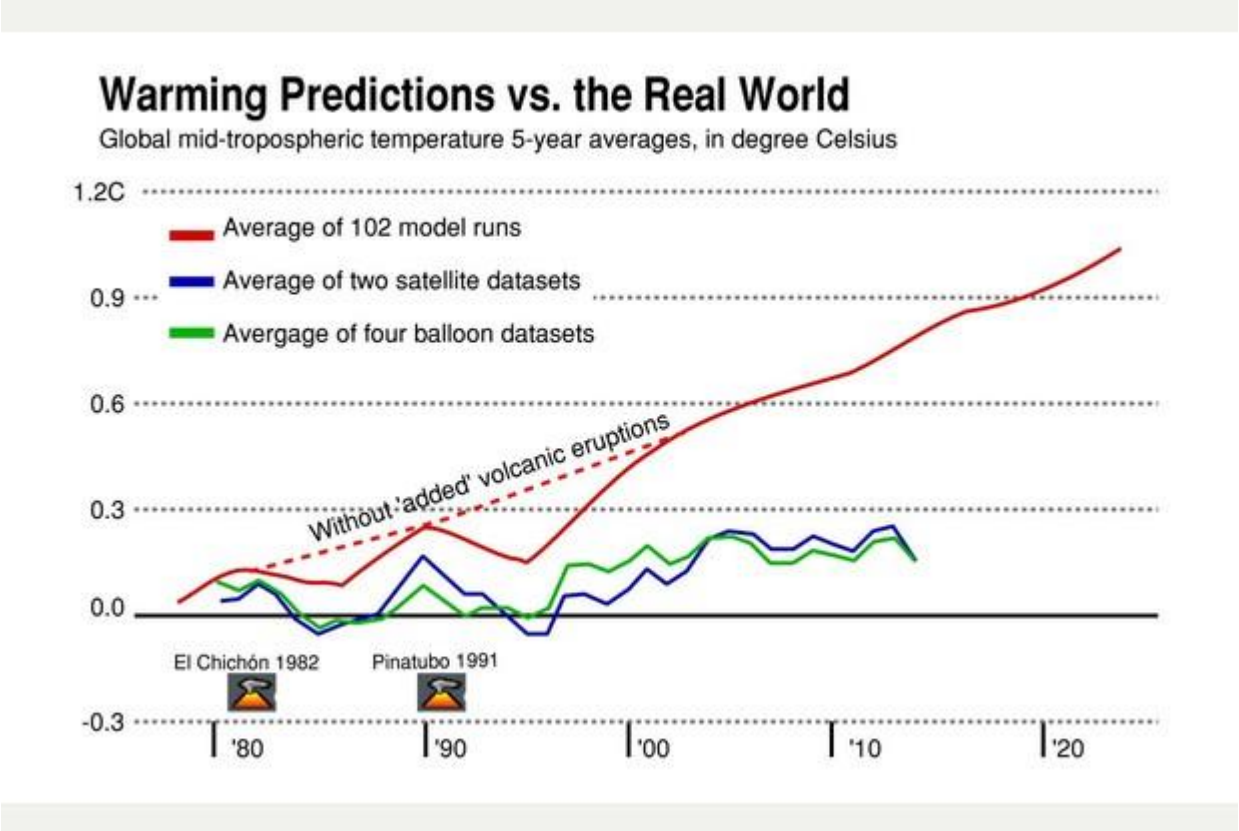
The clear message is that we should move on to adapting to increasing temperatures and to mitigating actions to prevent or reduce predicted AGW. The emphasis has been very much on the latter. In the UK for example we have the Climate Change Act introduced by Ed Milliband and largely written by Friends of the Earth activist Bryony Worthington (now Baroness Worthington for her good work). The Act calls for the UK to decarbonise its energy conversion activities by 80% of its 1990 levels by 2050. This is impossible in the timescale postulated for a number of reasons including: current absence of proven alternative energy conversion technologies, the time it takes to develop alternative technologies and the killer - very high costs. It is now being realised (at last) that to make serious attempts to reach the Act's aims would be disastrous for the UK economy and would push many more people into fuel poverty and death.

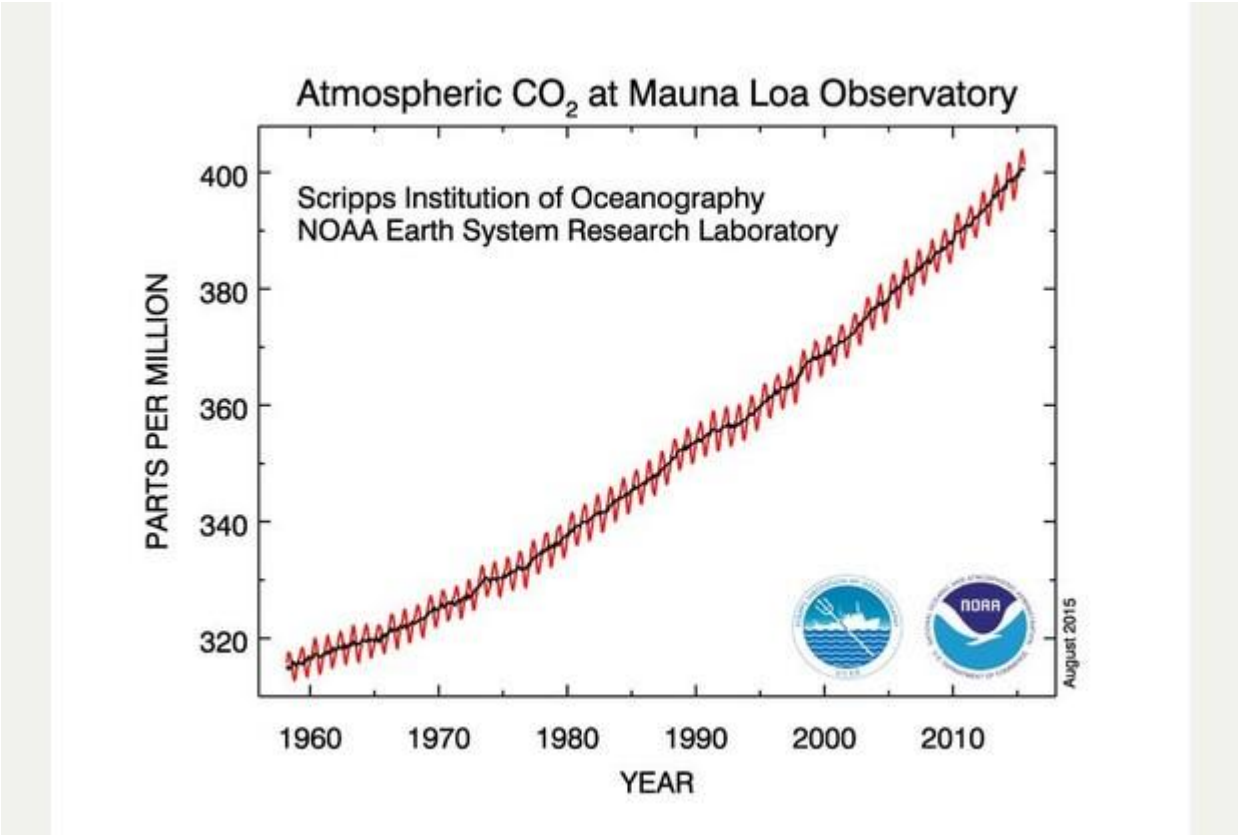
Of course, those reading this who are convinced that IPCC's findings are valid believe that developed and strongly developing countries worldwide should accept that the price has to be paid to save the Earth from ecological disaster.

There are of course other stories to tell about IPCC. Donna Laframboise covers many of them in her exposé "The Delinquent Teenager who was mistaken for the World's Top Climate Expert" (Ivy Press 2011 ISBN 978 1466453487). Donna makes clear, that the extent to which IPCC has been infiltrated by activists from Friends of the Earth, Greenpeace and the World Wildlife Fund, is truly alarming.

Sadly, the IPCC authors have either ignored or underplayed many climate change mechanisms. If as indicated AR5 really did provide "*a clear and up to date view of the current state of scientific knowledge relevant to climate change"* then we would be hearing about those significant climate change factors that I shall talking about in future.

Below are two pictures, one a graph of the increase in carbon dioxide through time, the other of computer model projections of atmospheric temperatures compared with actual measurements of temperature. The computer models are the main source of alarm as regards atmospheric temperature development. As programmed, increases observed in atmospheric carbon dioxide levels are the main driver of the computer model outputs. If you compare actual temperature data (see satellite measurement) you may notice that nature has not obliged by following the projections of the computer models.





Source: Bulletin of the American Meteorological Society, August 2013

My final story in this brief discussion of IPCC concerns the main alarmist worry about global warming – that of consequent rising sea levels. Some years ago, I attended a presentation by the Lead Author on the Working Group looking at Sea Levels. In the Q&A session, I posed some questions. The answers seemed to me to display a lack of a fundamental grasp of the importance of some factors of which I was aware. However, I did not challenge the responses. Sitting behind me was a friend who realised that I was not happy with the answers to my questions. He asked if I had read any of the papers of the acknowledged world expert in the field, Nils-Axel Mörner. I had to admit that whilst I had read at least one paper by Mörner it was for a specific reason and once satisfied I looked no further. My friend suggested I persue my interest direct with Mörner. A little research revealed that Mörner had written a huge number of papers on all aspects of sea level change. So, I e-mailed him asking him to list his key papers. I had in mind that reading a small number of papers would give me a proper handle on understanding the subject. He replied by return supplying an A4 page with approximately one paper per line in 10 point. At that stage, I realised that I would never have the time to reach a good understanding of the subject. I guess the Lead Author on the subject for IPCC was in a similar position

WEB ARTICLE 5

Smoke and Mirrors?
Some comparisons between Earth and Venus

Scientists and non-scientists often give Venus as an example of a planet with a runaway greenhouse effect. However, some years ago I came across an analysis with a different conclusion. I shall say more about this later. Firstly, let us look at some vital statistics:

	Earth	**Venus**
Average Distance from Sun	149.6 million km	108.2 million km
Diameter	12,756 km	12,104 km
Mass	5.972×10^{24} kg	4.867×10^{24} kg
Density	5520 kg/m^3	5250 kg/m^3
Atmosphere	78% N_2, 21% O_2, 1% Ar	96% CO_2, 3% N_2
Albedo (reflectivity)	0.37	0.76
Acceleration due to gravity at surface	9.8 m/s^2	8.9 m/s^2
Pressure at surface	1 bar	90 bar
Average Surface Temp.	288^0 K (15^0C)	738^0K (465^0C)
Orbital period	365 days	225 days
Rotation period	Approximately 1 day	Approx. 225 Earth days
Moons	1	None

Although the size and density of the two planets are similar, the factor that most people find striking, is the extreme difference between the planets' surface temperatures. On Venus, the surface temperature is well over the melting pint of lead and some 45^0C above the melting point of zinc whilst on Earth the average temperature is only 15^0C above the freezing point of water. Is the difference due to the fact that most of Venus' atmosphere is composed of carbon dioxide? Well many scientists think not (some examples: H.D Huffman, A. Miatello and D J Cotton). To explain why, I will have to get into a little bit of physics and a little bit of mathematics. Please accept my apologies in advance to those who struggle with these disciplines.

Firstly for reasons that may become obvious a little later let's look at the temperature at the height in the atmosphere of Venus where its atmospheric pressure is the same as that on Earth at ground level (approximately 1000 millibars). On Venus, the average temperature at that height is about 338.6 degrees Kelvin (about 65.5^0C) compared with an average of 287.4^0K just above the earth's surface (14.3^0C). Of course, as we have seen from the data above, Venus is closer to the sun than Earth. The amount of solar radiation received depends on the inverse square of the distance of the planet

from the sun. So roughly the radiation received by Venus in comparison with Earth is $(149.6/108.2)^2 = 1.911$. To convert this difference in radiation received to equilibrium temperatures then according to the Stefan-Boltzman Law we have to take the fourth root of 1.911, which is 1.176. So, if Venus was at the same distance from the sun as Earth it would have a temperature at the pressure altitude of 1000mb of 338.6/1.176 or about 287.9^0K (about 14.7^0C). You will notice that, although I have ignored the difference in reflectivity (albedo) for the two planets, the small difference in the planet disc facing the sun, the fact that the Earth's rotation is fast compared to Venus and some other factors, this simple calculation appears explain the temperature difference without the need to call upon a greenhouse effect!

In case you think that this is all smoke and mirrors let's take a slightly different approach and only talk about Earth. You may know that generally as one goes higher the atmospheric temperature reduces. The rate at which this proceeds depends on whether the air is dry or contains water vapour. We call this reduction in temperature with height the lapse rate. The simplest lapse rate is the dry adiabatic lapse rate or the DALR. It can be expressed as a rate of change of temperature T with height h as: $dT/dh = -g/c_p$ where g is the acceleration due to gravity and c_p is the specific heat of air in the atmosphere at constant pressure. Although g changes slightly with h and c_p changes slightly with T to a first approximation one can regard both g and c_p as constants. So using integral calculus, we can generate the formula:

$$\mathbf{T_s - T_h = -g/Cp * (h_s - h)}$$

Where: Ts is the average temperature at the Earth's surface and T_h is the temperature at height h and h_s is height at sea level which by definition is zero. Now the moist lapse rate has many more terms in it but we are interested only in a rough calculation so I will insert the average moist lapse rate for $-g/c_p$ as -6.5^0K/km (or C) the equation simplifies to: $T_s = T_h + 6.5*(h)$. Now let us substitute two numbers for height and temperature at that height. Typically, at say 5km above sea level the air temperature is about 255^0K. So using this information let us calculate the surface temperature. It is 255+6.5*5, which is 222.5^0K or 287.5^0K (about 14.4^0C). So, again, without using any radiation formulae we have deduced the average surface temperature correct to within less than one degree Kelvin.

This leaves us with the thought that, if there is a greenhouse effect, it is likely to be small. It also follows that, a change in the amount of carbon dioxide in the atmosphere, is not likely to have very much effect on temperature. On the other hand, because the solubility of carbon dioxide in water (and sea water in particular) varies inversely with temperature one expects to see increasing levels of carbon dioxide in the atmosphere when, for whatever reason, the atmosphere heats up. Interestingly is what we have been seeing since we emerged from the little ice age. Nevertheless, if I was an English Literature graduate I may still be thinking that it is all smoke and mirrors.