

## 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 more dire scenarios of catastrophic AGW (CAGW).

In my first article, published in the paper on February 19<sup>th</sup>, 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<sub>2</sub>) over the last 200 years has been caused by the burning of fossil fuels,
- (ii) effectively all anthropogenic CO<sub>2</sub> emissions since the beginning of the industrial revolution remain in the atmosphere,
- (iii) as a greenhouse gas CO<sub>2</sub> 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<sub>2</sub> 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 12<sup>th</sup> March questioned whether the increase in CO<sub>2</sub> 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<sub>2</sub>) over the last 200 years has been caused by the burning of fossil fuels**

Carbon dioxide (CO<sub>2</sub>) 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<sub>2</sub>. There is about 50 to 60 times more CO<sub>2</sub> 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<sub>2</sub>! That's about a third of a tonne per year of CO<sub>2</sub> each.

There is a continuous interchange between CO<sub>2</sub> 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<sub>2</sub> has been increasing. This period coincides with industrialisation and the increased burning of fossil fuels. There is evidence that the nature of atmospheric CO<sub>2</sub> is changing because fossil fuels are richer in a lighter form of carbon (for more detail research the isotopes C<sub>12</sub>, C<sub>13</sub> and C<sub>14</sub>). It would therefore appear reasonable to assume that we are to blame for the increased CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> over the water. So let's assume that sea out-gassing is the reason for the increase in CO<sub>2</sub> in a warming world. If we burn fossil fuels, the CO<sub>2</sub> released contributes to the pressure of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> is anthropogenic in origin. It uses two assumptions. Firstly, that pre-industrial levels of CO<sub>2</sub> were more or less constant around 280ppm and that this level represents a "correct" amount of CO<sub>2</sub> in the atmosphere. It is argued that the increase in the quantity of the light form of carbon (isotope C<sub>12</sub>) relative to the heavier carbon (C<sub>13</sub>) 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<sub>2</sub> levels comes from ice core data. This has some known problems. Secondly, the amounts of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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.