The wrongful conviction of Carbon Dioxide

Executive Summary

This note summarises an alternative climate model to the Greenhouse theory, based on a first-principles review of climate processes. The earth itself is the major control on temperatures and carbon dioxide levels, and this summary draws on NZ examples to illustrate these processes.

The IPCC has focussed on atmospheric sciences and this is reflected in the makeup of the technical advisory groups that develop the IPCC reports. This work needs to be integrated with earth science, however, to provide a complete picture of climate change.

New Zealand has a rich history of earth science, represented by such luminaries as Cotton, van Haast, Hector, McKay, Wellman and others. Amongst the world's great scientists is Ernest Rutherford, known as the father of nuclear physics, who proved the earth was generating heat through radiogenic decay in the crust.

Contrary to conventional wisdom, atmospheric carbon dioxide has little to no impact on global climate. Only thermally generated CO_2 is light enough to rise in the atmosphere and it falls into the troposphere cold and absorbing infrared radiation. If anything, it is more likely to be a heat sink - which may be the reason for the falling temperatures recorded in the lower stratosphere.

The change in radiative forcing in the CO_2 frequency band has been measured over a ten year period and indicates the increase in carbon dioxide as a result of human activity contributes 0.001% of the surface temperature. Methane concentrations have risen from 2ppm to 3ppm since the industrial revolution; it also has little influence on climate.

Ozone depletion is proposed as the main cause of warming during the last 100 years. Reduced ozone concentrations allow more short wave solar radiation to reach the surface; this increases evaporation and carries water, warmed by energy from the earth's crust, into the atmosphere where it cools via conductive transfer and emission of longwave radiation. CFCs in the atmosphere react under UV rays to produce hydrochloric acid, which reduces the pH of surface ocean waters.

This, of course, has significant implications in a world where trillions of dollars are being invested to transition to carbon-free economies. This is a futile objective and capital could be directed elsewhere (health, education, infrastructure). The current warming trend could be slowed or stopped by adherence to the 1987 Montreal Accord, which imposed a ban on emission of CFCs.

New Zealand once again has an opportunity to lead the world in correcting this historical detour and directing efforts back to understanding the real controls on climate change.

This note is also intended to counter the relentless negative messages from climate scientists and media that are generating the anxiety, despair and hopelessness being expressed by the current generation. There is no climate crisis and they should be optimistic about the future. They also deserve better from our scientists.

M.Webster

26 August 2020

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Introduction – the Greenhouse Effect

The Greenhouse Effect is the current model used by climate scientists and can be summarised as follows:

- The atmosphere comprises predominantly oxygen and nitrogen, with minor amounts of water vapour (up to 5%) and trace amounts of CO_2, methane, and other gases.

- CO_2, methane and ozone (the Greenhouse Gases) can absorb and emit infrared radiation and are therefore capable of warming. Increasing the concentration of these gases will logically increase the temperature of the atmosphere.

- Solar radiation from the sun enters earth's atmosphere predominantly as ultra violet and short wave radiation (light waves). About half is reflected or absorbed by clouds and the atmosphere. Ultra violet waves are absorbed by Ozone.

- The remaining radiation reaches the surface and warms the surface of the oceans and land. This warmth is radiated back towards space as long wave (infrared) radiation.

- The Greenhouse gases trap some of these infrared waves and re-emit the radiation towards the surface, thereby raising the temperature.

- Without these gases, the temperature of the atmosphere would be some 34 degrees celsius lower than they are, and the average temperature of the earth's surface would be -18 degrees Celsius.

  Modern climate science is built on the Greenhouse theory and the logic applied by the climate science community and IPCC is that:

1. The average global temperature of the atmosphere has increased over the last 150 years;

2. The concentration of CO_2 and methane in the atmosphere have also increased dramatically over the same period as a result of industrialisation, and in particular by the burning of fossil fuels;

3. The carbon cycle is a closed system and was in balance prior to the industrial revolution. The addition of anthropogenic CO_2 has disrupted this balance;

4. CO_2 and methane trap infrared radiation in the atmosphere and act as a thermal blanket, increasing the temperature – this is the Greenhouse Effect;

5. The increased temperature affects weather patterns and accelerates melting of the polar ice caps, resulting in more extreme weather events, sea level rise etc

6. This will lead to flooding of coastal settlements, crop failures due to flooding or droughts, more bush fires and eventually the deaths of millions;

7. The solution is to stop generating the Greenhouse Gases and thereby stop or reverse the temperature increase.

The Greenhouse theory was developed because scientists in the 1800s recognised that incoming solar radiation was insufficient to explain the average temperature of earth's atmosphere. The theory was first presented by Eunice Foote, an American scientist, to a conference in the US in 1856, but was credited to John Tyndell, an Irish physicist who started publishing studies in 1859. These were further developed by Arrhenius, a Swedish Physicist/Chemist who published his results in 1896 to explain the temperature changes that brought about ice ages. The theory that the concentration of carbon dioxide in the atmosphere controls temperature underpins modern climate science.

Beardsmore and Cull (2001) provide an excellent review of the state of knowledge of the earth's structure and thermal state at the time. Baron Kelvin (actual name William Thomson, who formulated the first and second laws of thermodynamics, and after whom the absolute temperature scale is named) proposed in 1862 that a positive geothermal gradient with depth meant that the earth must be cooling and calculated the age of the earth to be 20-400 million years old. Geologists and biologists disagreed because the theory did not fit their data (Darwin published Origin of Species in 1859), but given Kelvin's status and the data available at the time, his position was unassailable (the science was settled).

In 1904 Ernest Rutherford, the New Zealand nuclear physicist, gave an address to the Royal Society in London during which he demonstrated that the earth is heated by radioactive decay of elements in its rocks and the earth must be considerably older than Kelvin's estimate. We now know the earth is around 4.5 Billion years old. Kelvin was wrong because he assumed the earth to be an inert body cooling in space and it wasn't until the discovery of radioactivity in 1896 that science discovered the interior of the earth was a heat source. Coincidentally, 1896 was the year Arrhenius proposed the greenhouse effect to explain ice ages.

Since the development of the Greenhouse Theory, discoveries in earth science have included the discovery of radiogenic decay and isotopes (1904), recognition of the Mohorovicic Discontinuity (1909), the discovery of Milankovitch cycles (1920s) , sea floor spreading (1950) and plate tectonics (1960s). The oil industry has drilled hundreds of thousands of wells and deep mines have been constructed, increasing our knowledge of heat flow in continental crust and the distribution of gases in the subsurface, the Deep Sea Drilling programme has delivered similar data for oceanic crust, satellites and airborne instruments have vastly increased our knowledge of the atmosphere, ocean sondes have provided data on sea temperatures and ocean circulation etc. These data show the underlying premise of climate science – that because of the Greenhouse Effect, increased levels of CO_2 in the atmosphere leads to global warming- to be wrong.

Before addressing the Greenhouse Theory and the IPCC position in more detail, it is worth reviewing some aspects of basic science.

Review of Basic Science

Gravity

Gravity is the force that attracts two objects with mass or energy towards each other, keeping planets in orbit and earth's atmosphere in place. While generally considered a constant of 9.8 m/s^2, gravity varies on the earth's surface dependent on altitude, crustal composition etc. The figure below shows the variation in earth's gravity, as measured by satellites. The gravity field also changes as the distance between sun, earth and moon varies, with changes taking place over a range of timescales.

The effect of gravity on liquids is evident in the daily movement of the tides, and must also affect the movement of liquids and semi-solids within the earth on longer term cycles as the distance between the sun and the earth varies. As I will discuss later, the variations in earth's orbit and attitude will impact the movement of molten mantle material and is a likely driver of plate tectonics and volcanism.

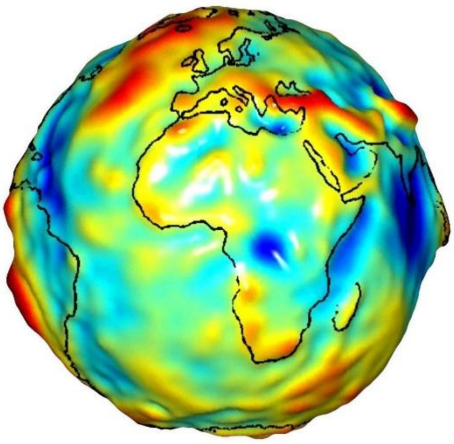


Figure 1 Variations to earth's gravitational field (NASA website)

Light and Heat

Light travels as waves at a range of frequencies on the electromagnetic spectrum. Visible light is a small part of the spectrum. The Sun's energy travels as a spectrum largely in the ultraviolet and visible light wavelengths. Waves can be reflected or refracted when they pass from one medium to another with different densities. Heat is radiated by all objects as infra-red radiation.

Heat is the flow of energy from a warmer body/medium to a cooler body/medium. Heat can be generated by numerous physical, chemical and biological processes and can be transmitted by:

1. Radiation (light waves)
2. Convection (change in density of a liquid or gas, enabling energy transfer)
3. Conduction (energy transmitted via collisions on a molecular scale, thermal conductivity)

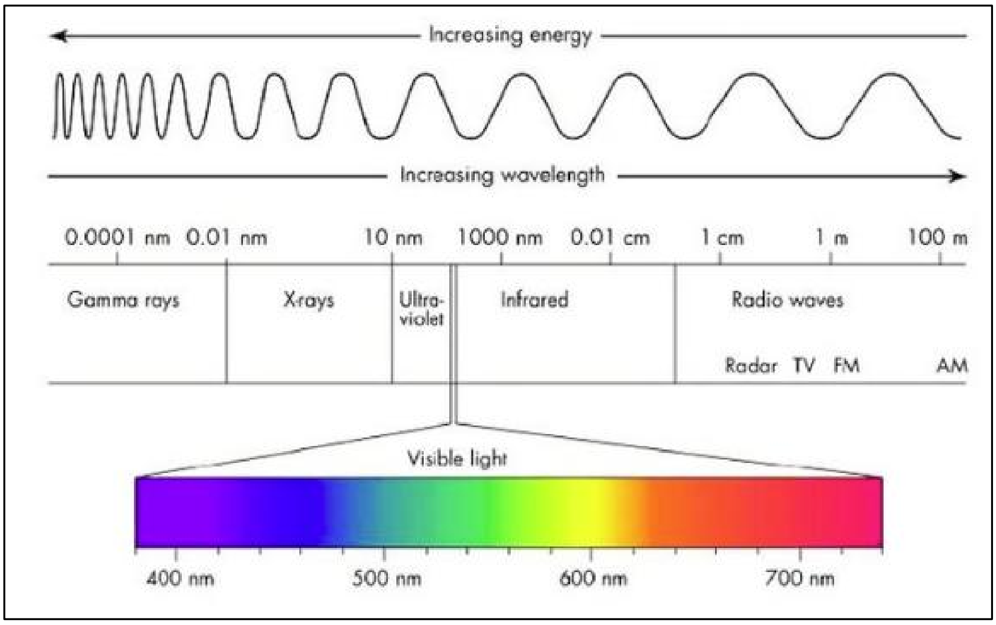


Figure 2: The Electromagnetic Spectrum (https://www.cyberphysics.co.uk/topics/light/emspect.htm)

Energy increases as wavelength gets shorter, but depth of penetration reduces with decreasing wavelength.

Milankovitch Cycles and Solar Activity

The amount of solar radiation (Total Solar Irradiance) reaching the earth is a function of the sun's output of electromagnetic radiation and the distance between the sun and earth. Sunspot activity increases and decreases on a roughly 11 year cycle . Milankovitch cycles describe the variations in earth's orbit around the sun, which are not perfectly circular. The eccentricity varies, as does the obliquity (tilt of the earth's axis) and precession (direction of tilt of axis), so the distance between any point on the earth and the sun can vary significantly through time.

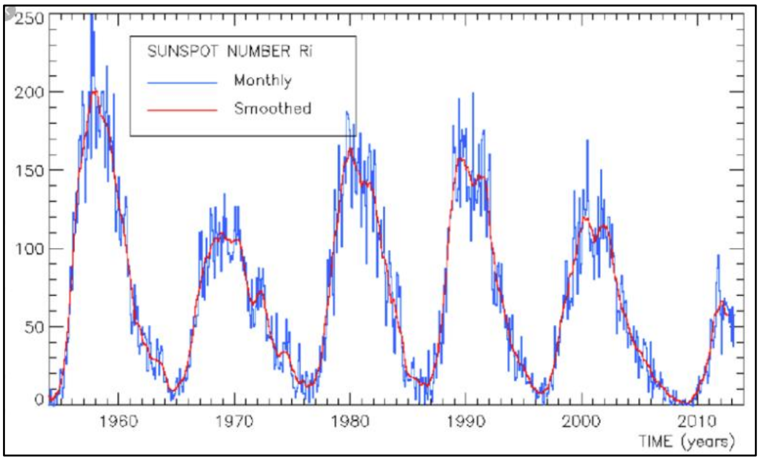


Figure 3: Cycles in sunspot activity (Pasachoff et al, 2014)

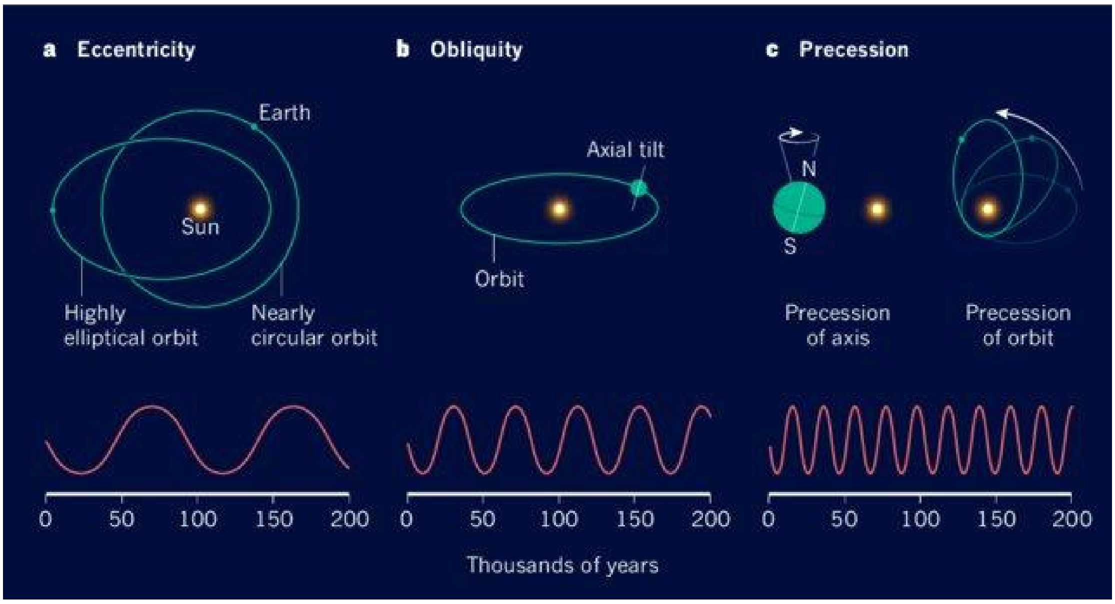


Figure 4: Milankovitch cycles in earth's orbit (Maslin, 2016)

In order to try and quantify any Greenhouse Effect, climate scientists compare the incoming radiation for the planet with the outgoing radiation. In the ideal case (a black body) matter will absorb all of the electromagnetic energy hitting it, will warm up as a result and itself become a radiation source. This eventually results in a state of equilibrium, where outgoing radiation balances incoming. The energy radiated from a black body is distributed over all wavelengths. The distribution, total energy and maximum energy are proportional to the temperature of the body.

The earth, however, is not a black body and a cursory review of historical temperature data confirms it is rarely in thermal equilibrium – temperatures are rising or falling continuously, just on different time cycles, dependant on the cause. A portion of the energy is reflected back into space and the body itself is radiating heat from internal sources. The incoming solar radiation can be measured by satellites and is approximately 1360 W/m^2; this energy of course is not evenly distributed, with half the globe in shadow at any time, and northern and southern hemisphere having opposite seasons .

Structure of the Atmosphere

The earth's atmosphere is composed largely of nitrogen (around 78%), Oxygen (around 21%) Argon (0.9%) and other minor gases, including ozone and CO_2 (which has increased from 0.03% to 0.04% or 400ppm over the last 100 years). Water vapour can constitute up to 5% (50,000 ppm) of the volume of air, dependent on latitude and altitude. The composition of the atmosphere has changed significantly through earth's history, notably with the ongoing depletion of CO_2 and enrichment with oxygen associated with the explosion of plant life and associated photosynthesis. One important consequence of this is that the atmosphere has become less dense.

The atmosphere is held in place by gravity and comprises a number of layers, defined by composition and temperature.

The troposphere is the layer closest to the surface. This is where weather systems develop and convection currents operate, both vertically and between the equator and the poles. Temperature decreases with altitude at around 6.5 degC/km. The atmosphere comprises nitrogen and oxygen, but also up to 5% as water vapour. Evaporation soaks water from the oceans, lakes, rivers and land. This warm air rises in convection currents, cools and condenses to form clouds and rain around 10 km above the surface. At the top of the troposphere jet streams form fast flowing narrow air currents at the boundaries of adjacent air masses with significant differences in temperature . The top of the troposphere varies with latitude and season but can be up to 16km above the surface. The troposphere contains 75% of the gases in the atmosphere.

The stratosphere extends up from the tropopause to around 50km. Temperature remains constant in the lower part (tropopause) and then increases with altitude. Numerous atmospheric changes occur within this zone – ozone increases with altitude, methane decreases with altitude, water vapour is minor, CO_2 remains relatively constant, at least up to 35km. The temperature increase in the upper troposhere is generally interpreted to reflect warming of ozone by incoming solar radiation.

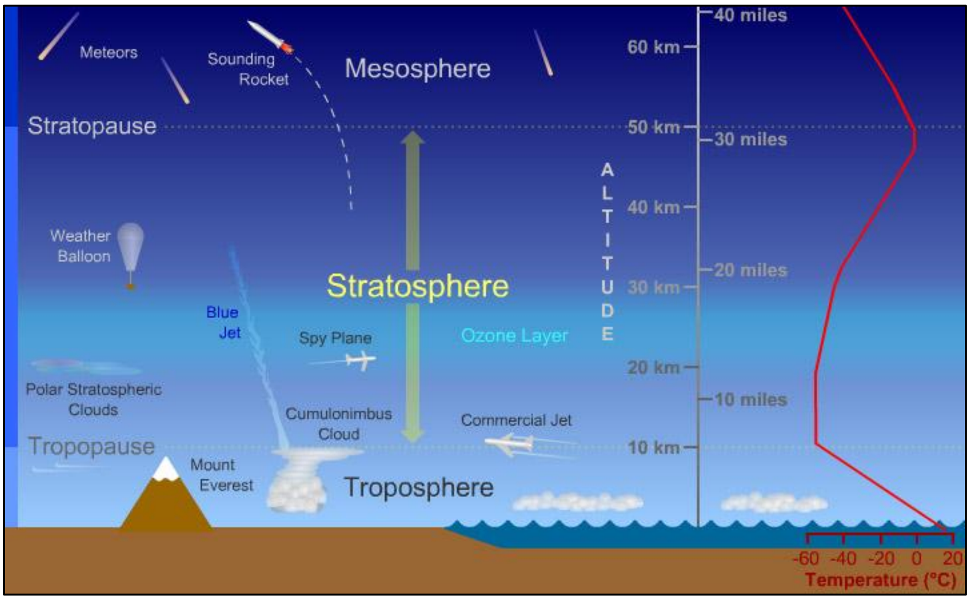


Figure 5: Layers of the atmosphere

(Randy Russell, UCAR [https://scied.ucar.edu/shortcontent/stratosphere-overview)](https://scied.ucar.edu/shortcontent/stratosphere-overview)

An alternative, or complementary mechanism for the temperature inversion could be that it is caused by infrared radiation emitted by material ejected into the stratosphere by volcanic eruptions and the burning of fossil fuels. Volcanoes can throw material to the top of the stratosphere (and probably beyond) – the Mt Pinutbo eruption threw material 45 km into the air.

The stratosphere is also different in that windflow is laminar, where in the troposphere there is vertical mixing via convection currents.

The mesosphere lies above the stratosphere and extends up to 85km above the surface. Temperature again decreases with altitude and the coldest temperatures within earth's atmosphere (-90 deg C) are found near the top of this layer. Meteors burn up in this interval.

The thermosphere. Much of the x ray and uv radiation from the sun is absorbed in the thermosphere, causing molecules of oxygen and nitrogen to split into their component atoms and creating heat. The atomic oxygen and nitrogen cannot radiate the heat, and the temperature increases with altitude. Temperatures in the upper thermosphere can range from 500 deg C to 2000 deg C. The aurora and aurora australis (northern and southern lights) occur in the thermosphere.

Atmospheric Pressure

Atmospheric pressure reflects the density and height of the air column above a specific point. At sea level atmospheric pressure is 14.6 psi (1 bar or 1 atmosphere) and pressure decreases by 80% within 10 km of the surface. As gas rises it expands, hence molecules are further apart – an important factor which reduces capacity to transfer heat.

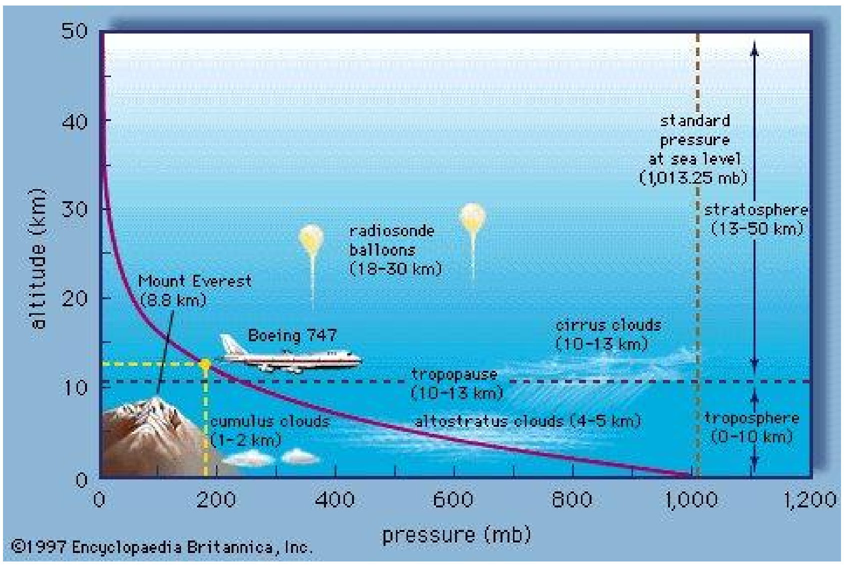


Figure 6: Atmospheric Pressure profile

Structure of the Earth

The earth's crust is made up of a mosaic of plates, comprising oceanic crust or continental crust. The oceanic crust is 7-10 km thick, denser than continental crust and extruded from spreading centres such as the mid-Atlantic Ridge. Continental crust is lighter and thicker (25-70 km). Both ride on convection cells in the mantle and are destroyed in subduction zones or uplifted in collisions to form mountains. Plates margins are either convergent (destructive), divergent (constructive) or transform (plates sliding past each other). NZ has a west dipping subduction zone in the North Island (the Hikurangi Subduction Zone) and an east-dipping subduction zone south of the South Island (the Puysegur Subduction Zone), connected by a major Transform boundary, the Alpine Fault, which runs the length of the South Island. It was a New Zealand geologist, Harold Wellman, who identified the lateral offset on the Alpine Fault.

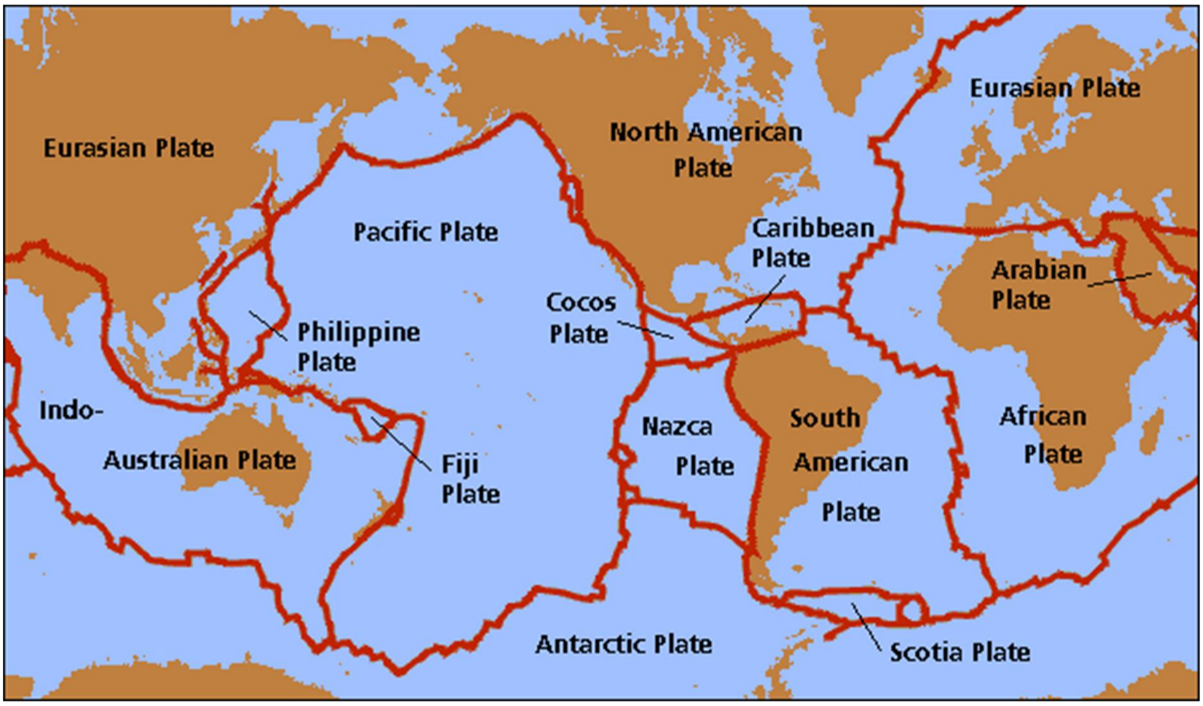


Figure 7: Earth's Tectonic plates (geography.name)

Figure 8 shows the major plate tectonic elements of New Zealand. The Pacific Plate is being subducted benetah the Australian Plate under the North Island, while the reverse is happening to the south of the South Island. Between these subduction zones, plates are sliding past each other along the Alpine Fault.

The New Zealand landmass is the emergent portion of a large continental fragment now called Zealandia (Figure 9). This fragment extends over 4.9 million sq km, of which only 6% is above water.

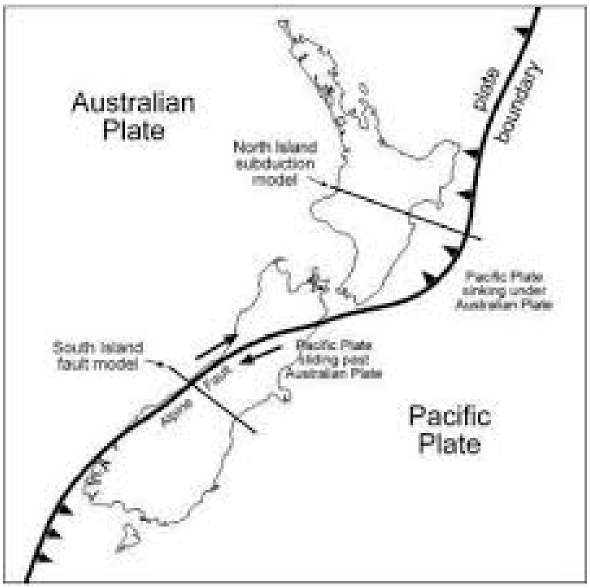


Figure 8: Plate tectonic elements of New Zealand. (Science Learning Hub)

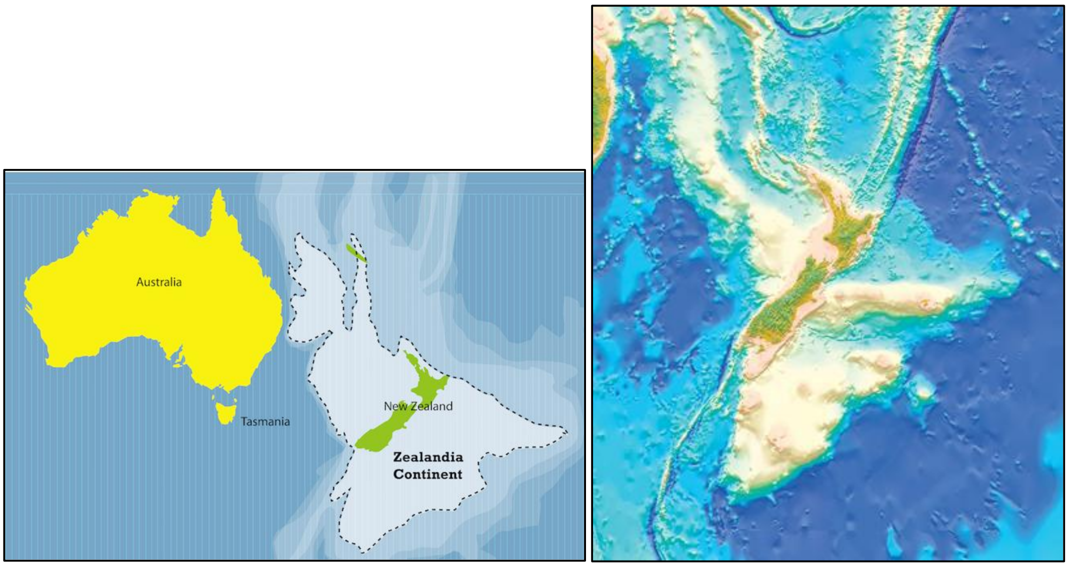


Figure 9: Zealandia (Crystal Eye Studio, GNS).

Beneath the crust is the mantle; this is about 2,900 km thick and comprises semi-solid rock; the upper part is called the asthenosphere and liquifies as molten magma under pressure .

At the centre is the core which comprises two parts; a 2,200 km thick liquid outer core and a 1250k solid inner core. As the earth rotates, the liquid outer core spins, creating the earth's magnetic field. Heat within the earth is transmitted by conduction and convection. Earths's heat flow is partly the decay of the original planet-forming process, but radiogenic sources within the mantle and crust account for as much as 83% of the surface heat flow (Beardsmore and Cull, 2001).

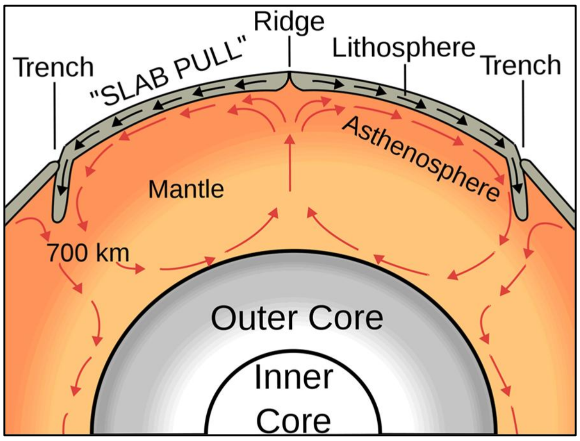


Figure 10 Elements of the earth's interior

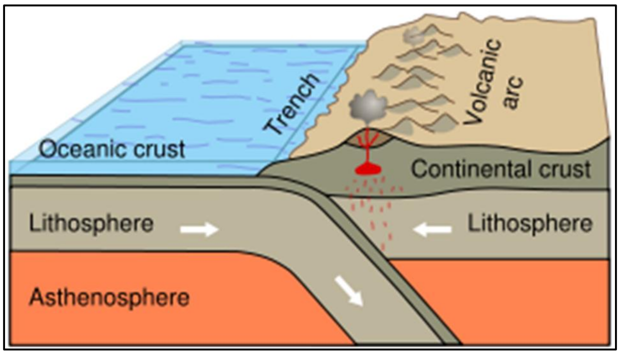


Figure 11   Illustration of a subduction zone with oceanic crust being pulled under continental crust

Sources of CO_2

It is estimated that 99.985% of the earth's carbon is stored in the lithosphere. This includes calcium carbonate (limestones), coal, hydrocarbons and as dispersed preserved organic matter in mudstones plus carbon in all living flora and fauna.

CO_2 from Volcanism

CO_2 is discharged from volcanoes during eruptions, and expelled continuously from geothermal regions. Most volcanoes form on plate margins, either convergent or divergent, and in areas where extensional tectonics result in thinning of the crust. There are also many 'hot spots' where mantle plumes produce a volcano which migrates as the plate moves over them, such as Hawaii or the Galapagos Islands.

Volcanic eruptions vary enormously in their intensity and duration, ranging from the ongoing eruption of basaltic lava with little associated gas that produces shield volcanoes (such as Rangitoto), through to the abrupt and violent Pelean and Plinian eruptions that form stratavolcanoes such as Taranaki and Erebus. The strongest are ultra-Plinian.

New Zealand has both shield volcanoes (the Auckland Field, Banks Peninsula) subduction-related rhyolitic volcanoes (the Taupo Volcanic Zone and White Island) and stratavolcanoes related to extensional tectonics (Taranaki – the youngest cone in a series that extend into the North Taranaki Graben).

The 186 AD eruption of Taupo is classed as an ultra-Plinian eruption and produced over 50 cubic kilometres of volcanic ash and debris and pyroclastic flows that covered over 20,000 square kilometres of the North Island.

Krakatau in Indonesia erupted in 1883 and is estimated to have ejected 45 cubic kilometres of material The average global temperature was around 1.2 deg cooler for the next five years.

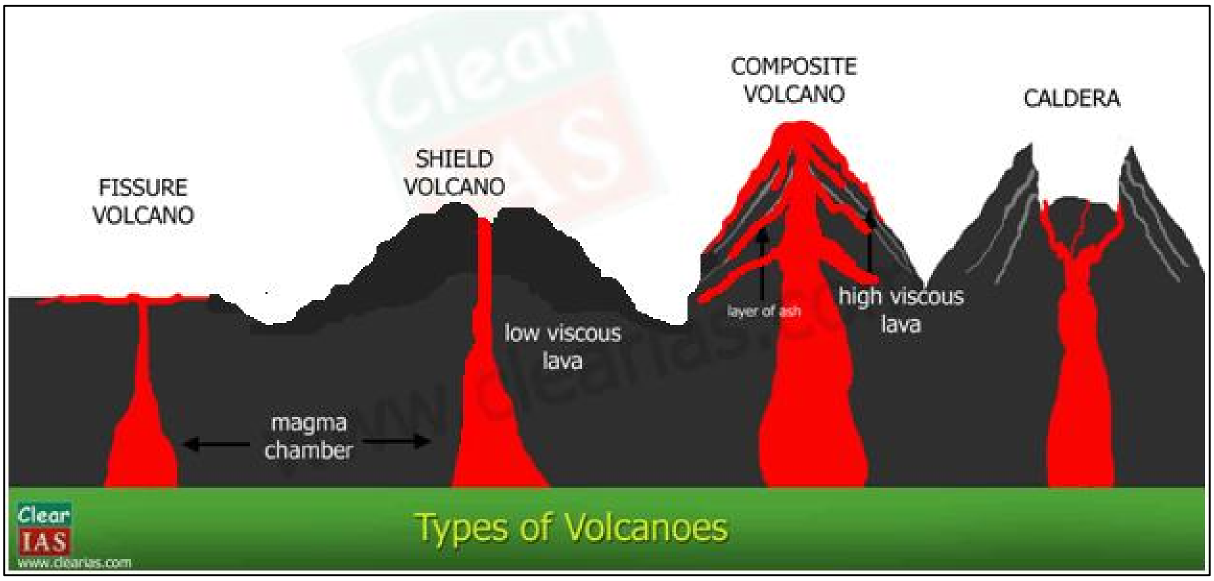


Figure 12: Types of volcanoes (clearias.com)

Interestingly, 5 years is the average period calculated by most researchers for residence time of CO_2 in the atmosphere . The IPCC however, applies a residence time of >100 years. There is a correlation between the frequency and magnitude of volcanic activity and glaciations, with activity increasing by two to six times in interglacial periods (Huybers 2009).

The number of volcanic eruptions has increased sharply over the last 150 years (figure 13b) and shows a very similar trend to atmospheric CO_2.

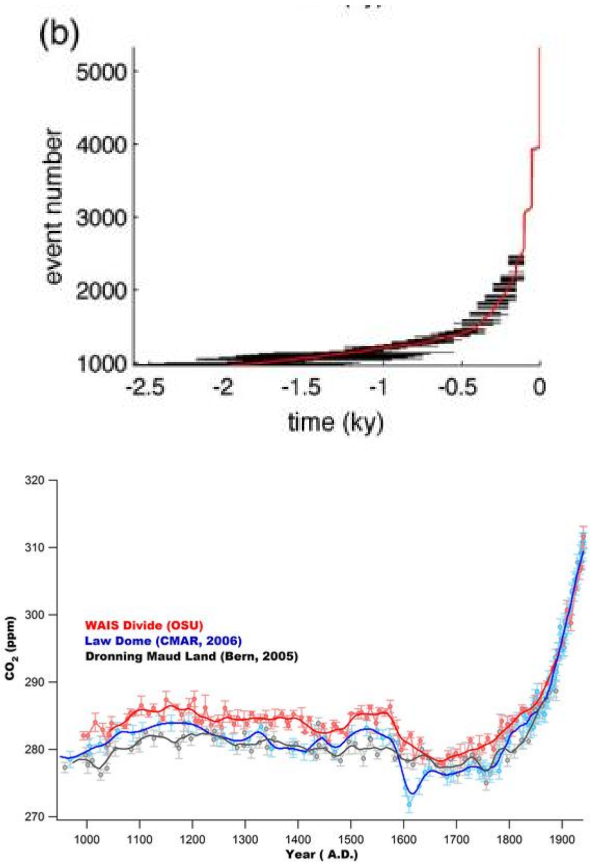


Figure 13: Number of subaerial eruptions over last 2,500 yrs. Lower plot shows atmospheric CO2 levels over last 1000 years. (Huybers,2009)

There are around 1,500 active volcanoes on land, and an unknown number underwater. Only a small fraction of the seafloor has been surveyed.

The frequency and intensity of underwater eruptions is poorly understood; in 2019 there was a lot of excited media coverage of a large pumice raft in the Paciific which was only discovered when crew on a yacht woke to find themselves surrounded by it. The raft covered 150 sq km and was a product of an underwater eruption, and was subsequently traced to a recently discovered (and as yet unnamed) volcano off Tonga. In 2012 the Havre volcano, part of a volcanic chain comprising at least 30 volcanoes that stretches for 1000 km north from the Bay of Plenty, produced an eruption that was strong enough to send ash through 1100m of water and into the atmosphere and produce a pumice raft covering an area of 22,000 sq km. Surveying the earth’s oceans over the next few decades is going to be some of the most exciting science to happen in human history.

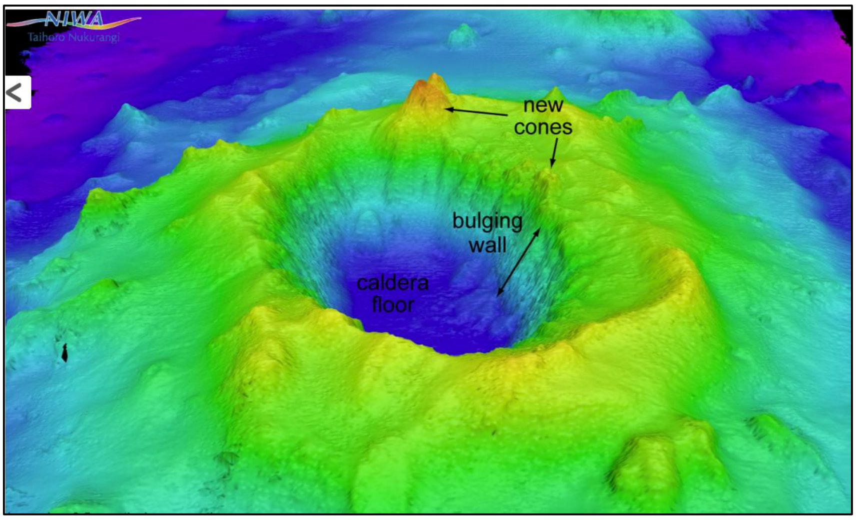


Figure 14: Bathymetric image of the Havre volcano, part of the Kermadec Chain associated with the Hikurangi subduction Zone. The cone is around 600m tall and 8km in diameter. NIWA

The IPCC attribute 0.1 PgC/yr (Petagram = 10^{12} kg) of total atmospheric CO_2 flux of 4 PgC/yr to volcanism. That is just 0.025% of the total. Isotope data tell us that volcanism contributed close to 100% of pre-industrial CO_2, and around 75% of post-industrial. It is very likely that CO_2 emissions from geothermal sources have been grossly underestimated in climate models.

CO_2 from Sedimentary Basins

New Zealand's fossil fuels are derived largely from non-marine organic material (coals and shales). The characteristically waxy crude oils of Taranaki are derived from the waxy cuticles of the leaves of conifers, including *Agathis Australis* (Kauri); great forests use to extend across NZ., Australia, South America and probably Antarctica (when CO_2 concentrations were 10 times what they are now).

New Zealand was originally part of the super-continent of Gondwana and shares a geological history with Antarctica, Australia, and India. When Gondwana broke up, basins formed where the crust had been stretched and faulted. Non marine sediments (coals and shales) were initially deposited in these basins.

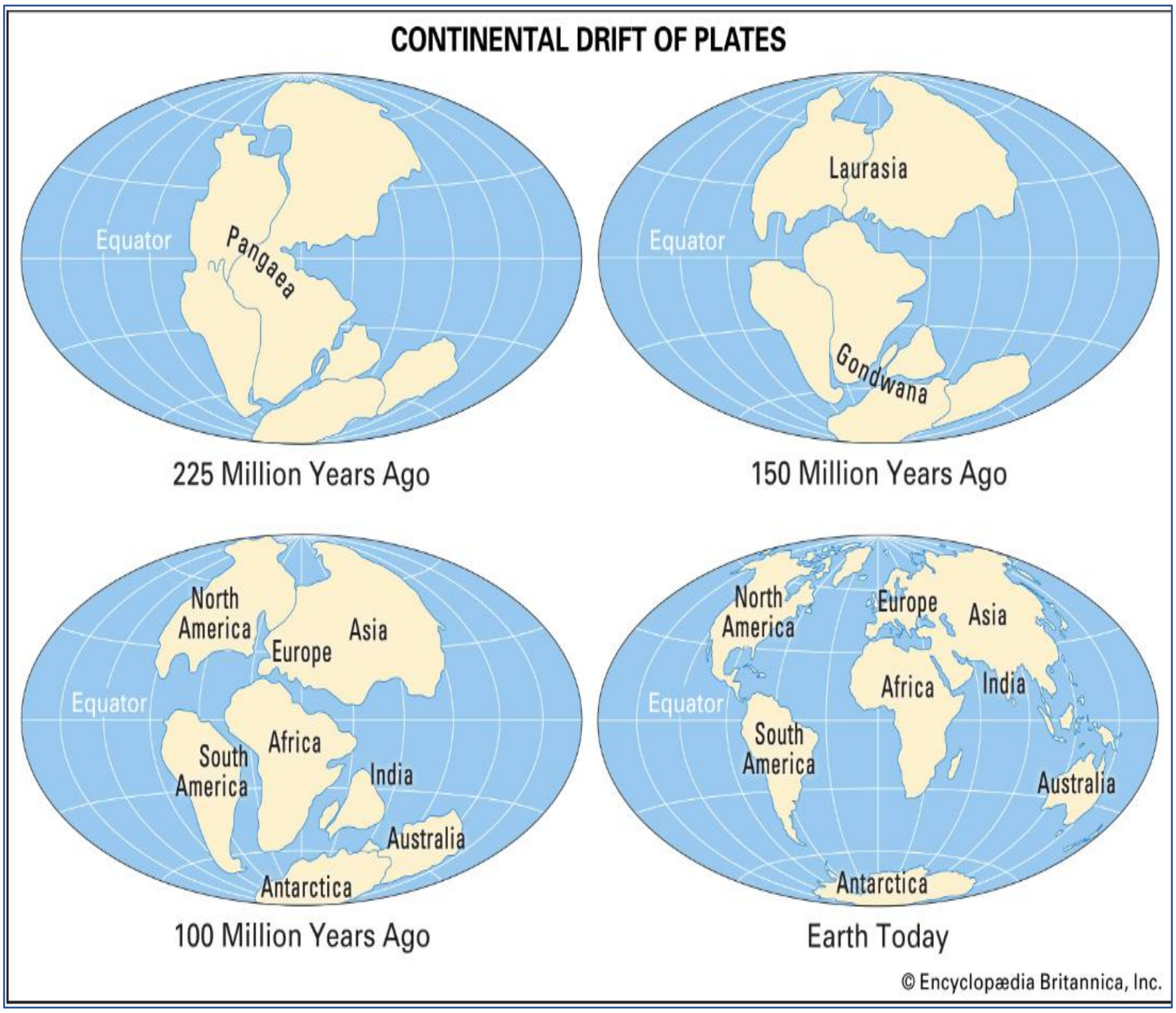
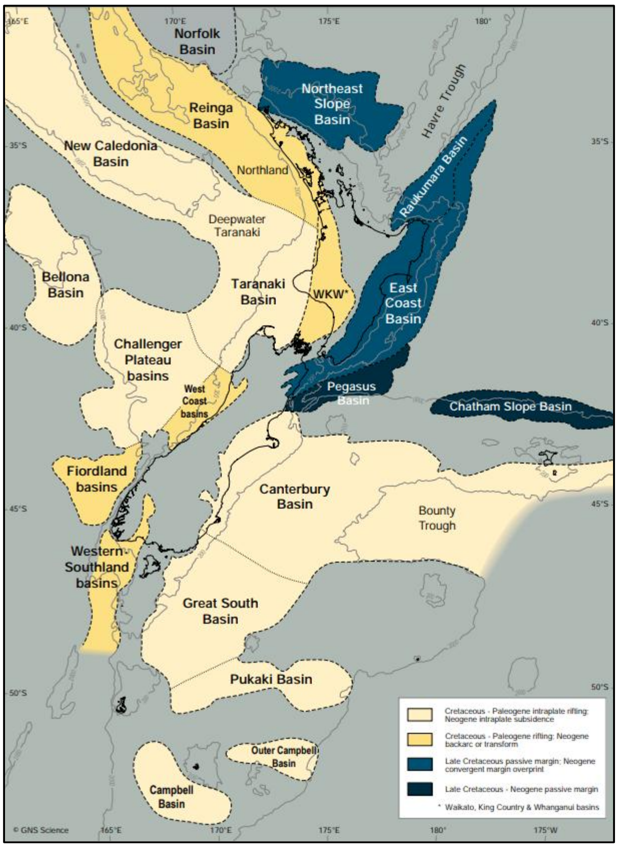


Figure 15: Plate tectonic reconstructions showing the breakup of Pangaea into Laurasia and Gondwana, and the subsequent breakup of Gondwana (Encyclopaedia Brittanica).

Sedimentary basins developed around the margins of each of these continental fragments and most underlie the present day oceans. Carbon Dioxide and hydrocarbon gases are being expelled from these basins into the oceans and will be of far greater magnitude than a sprinkling of atmospheric CO_2 on the surface. We are only beginning to measure this source of gases in the oceans.



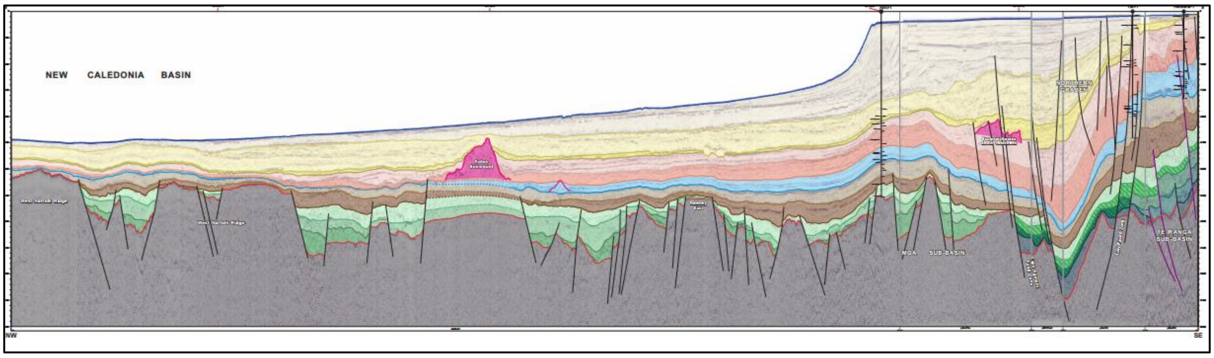
There are 18 sedimentary basins on the Zealandia continental fragment. These cover an area of approximately 1 million sq km and contain thick coal measures (up to several km in Taranaki).

As these are buried, they generate and release CO_2 and hydrocarbons (notably methane). These form cements in fault planes and control fluid flow.

Figure 16 : Sedimentary basins of New Zealand, MBIE

The coal measures can be mapped on seismic data and have been penetrated in wells. They are shown as the green shaded interval on the seismic line below, extending 300km offshore from NZ.

Basin (water depth up to 2500m) Shelf (water <300m)



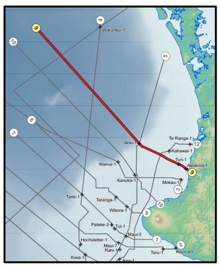


Figure 17 GNS Seismic transect 9 (2014)

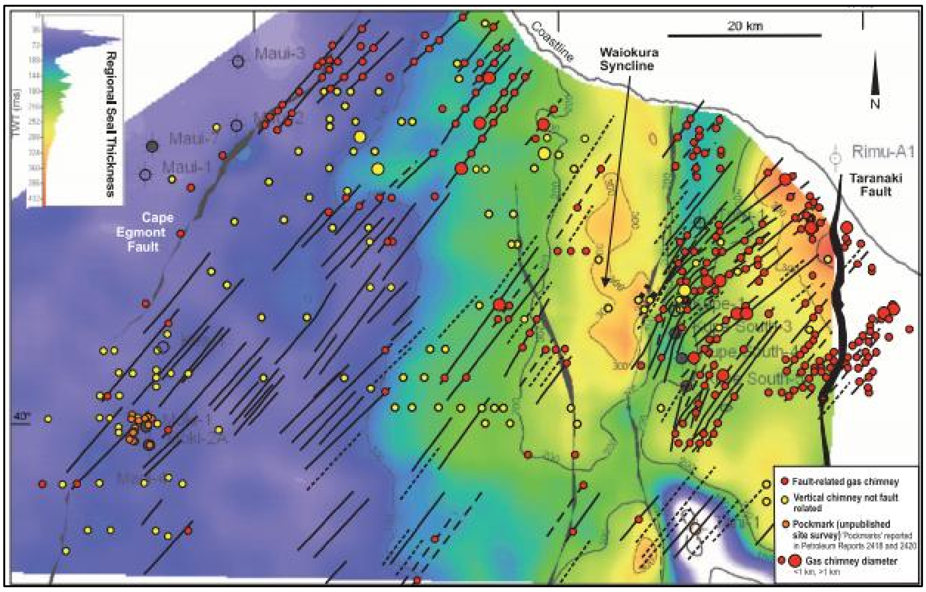


Figure 18: Map of offshore south Taranaki, faults are black lines, evidence of gas seepage shown by dots. Colour grid is Oligocene isochron (regional seal). Ilg 2009

Taranaki is heavily faulted and seeps are evidenced on the sea floor by fluid escape features (pockmarks, mud volcanoes, seeps, shallow gas pools etc). The map above is offshore south Taranaki, faults are black lines, escape features shown as dots.

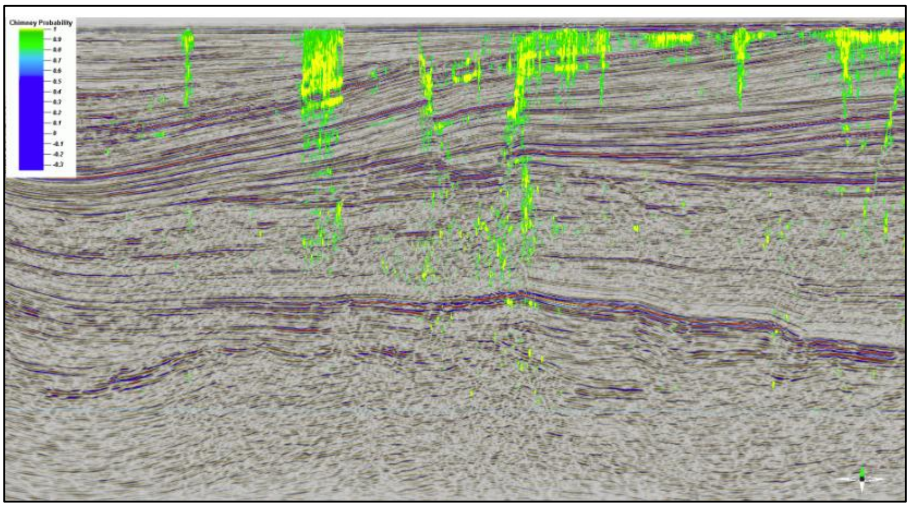


Figure 19: Gas chimneys are evident on seismic data (Ilg 2009)

Gas chimneys associated with faults are evident on seismic data. We have no measurements of the volume of CO_2 and methane escaping from the basins of Zealandia, or of any variation in leakage rate. We are starting, however, to acquire data from Antarctica.

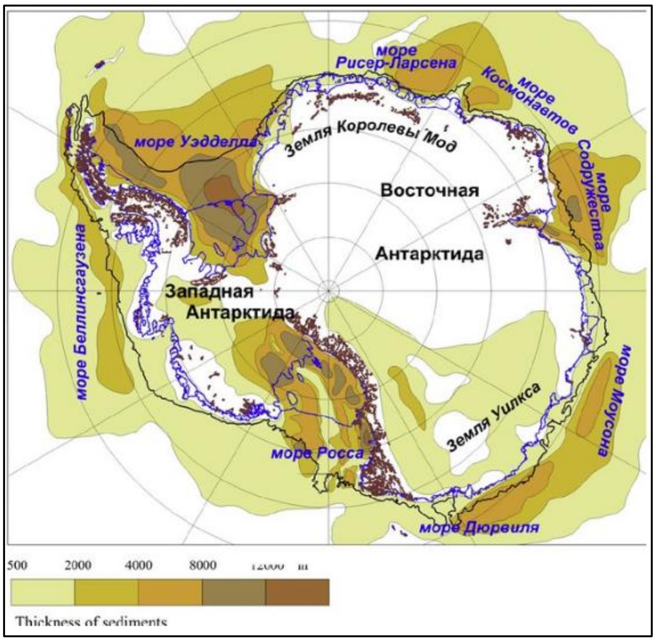


Figure 20 : Map of Antarctica showing sedimentary basins in brown (Grikurov et al 2003)

Antarctica was part of the Gondwana continent and , like NZ, has sedimentary basins around its margins , containing coals and other carbonaceous sediments. There are also a number of active volcanoes, both on the surface and underneath the ice. A system of autonomous floats is being deployed around Antarctica to acquire data that will improve understanding of atmospheric physics, ocean circulation and heat flow etc.

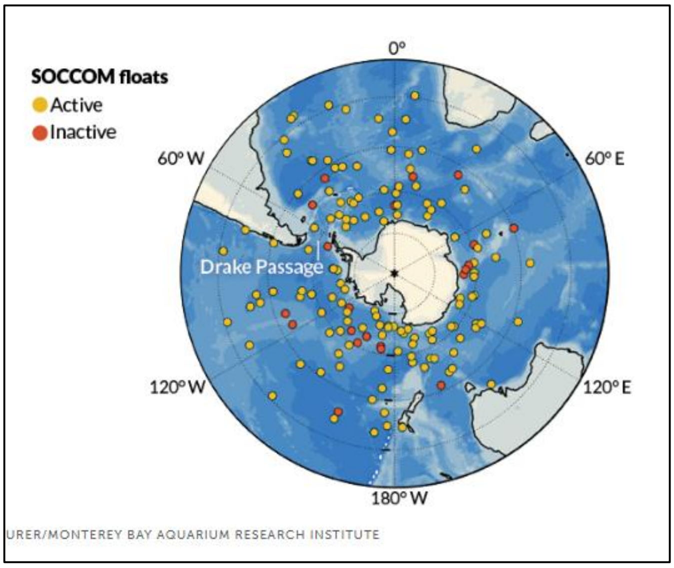


Figure 21: SOCCOM floats 2019 (https://www3.mbari.org/soccom/images/SOOCNMAP.jpg)

The Southern Ocean Carbon and Climate Observations and Modelling Project (SOCCOM) is a US multi-party research project that uses a network of autonomous floats to sample temperature, salinity, oxygen content and pH at various depths in the water column around Antarctica.

CO_2 concentration cannot be measured directly in seawater but is reflected in reduced alkalinity (pH). The age of the water can be estimated from oxygen isotopes. SOCCOM can differentiate young (generally shallow) water and old (generally deep) water. In the Southern Ocean upwelling brings the old water to the surface. The assumption when the programme started was that 40% of human emissions were being absorbed by the Southern Ocean. What they actually found was that degassing of old waters exceeded the uptake in shallow water, or in their words "the ocean was belching CO_2 at various spots around Antarctica" (https://soccom.princeton.edu/content/southern-ocean-may-be-less-carbon-sink-we-thought). The CO_2 being released is from old water i.e. water that pre-dates the industrial revolution. This may be our first time series of data reflecting natural flux of GHG from underlying sedimentary basins into oceans. The SOCCOM programme is also exciting science.

CO_2 from Breakdown of Methane

Methane is known to react with the hydroxyl radical (OH) to form CO_2.

It is proposed that methane is reacting with ozone to produce CO_2 and water as follows:

$$\mathbf{CH_4 + O_3 \rightarrow CO_2 + H_2O + H_2}$$

This results in depleted ozone, low concentrations of methane and elevated CO_2 levels in the troposphere. This is expanded upon in the section on greenhouse gases.

Sources of Heat

There are two primary heat sources for the earth's surface and atmosphere – electromagnetic energy from the sun and conductive/convective energy from the earth itself. The laws of Blackbody radiation state that a body emits a specific spectra of electromagnetic radiation according to its temperature; the spectra for the sun and earth are shown below.

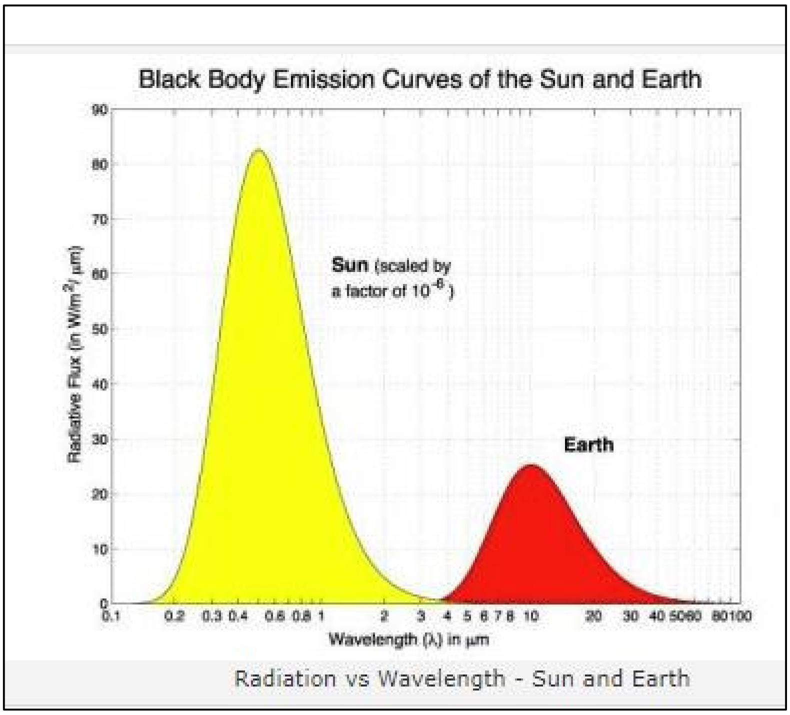


Figure 22 Electromagnetic blackbody spectra for the sun and the earth. (Wikipedia)

The two spectra do not overlap – incoming energy is all less than 4λ wavelength, outgoing is all greater than 4λ wavelength

The Sun

The sun emits electromagnetic radiation. The diagram below shows the incoming spectra (in red) and outgoing spectra (in blue). Below the spectra are the absorption frequencies for different molecules. For example, only oxygen molecules and ozone will absorb very high frequency UV waves. The incoming radiation occupies the UV – visible light and part of the infrared spectrum. CO_2 absorbs elactromagnetic radiation over 3 distinct peaks - (circled in red).

The outgoing blue spectrum is then compared to a modelled spectrum, based on the assumed temperature, and gaps are interpreted to reflect frequencies that have been absorbed by Greenhouse Gases. Note water vapour absorbs energy over a far greater range of wavelengths than CO_2.

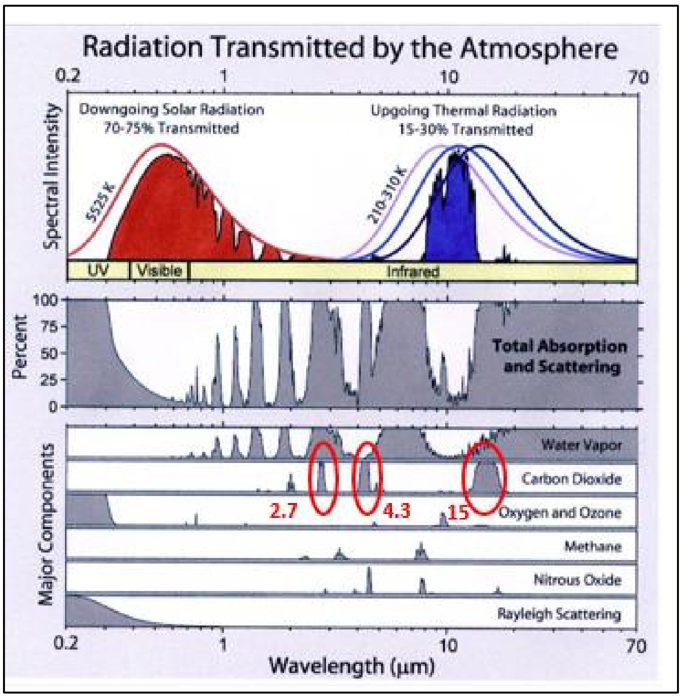


Figure 23: Incoming (red) and outgoing (blue) electromagnetic spectra for earth.

http://www.barrettbellamyclimate.com/page15.htm

The red curve describes the spectra of the sun's electromagnetic energy as it enters earth's atmosphere. The solid red polygon is the spectra at the earth's surface. Energy has been lost (absorbed) at the high end of the spectrum by oxygen and ozone, and at the lower end by water vapour. Any absorption by CO_2 is at the lowest intensity of the spectrum.

The following diagram illustrates the Insolation (radiation that reaches the surface) in the northern hemisphere. This varies hugely by latitude and by season, from zero in winter at the pole to 500 W/m^2 in the summer.

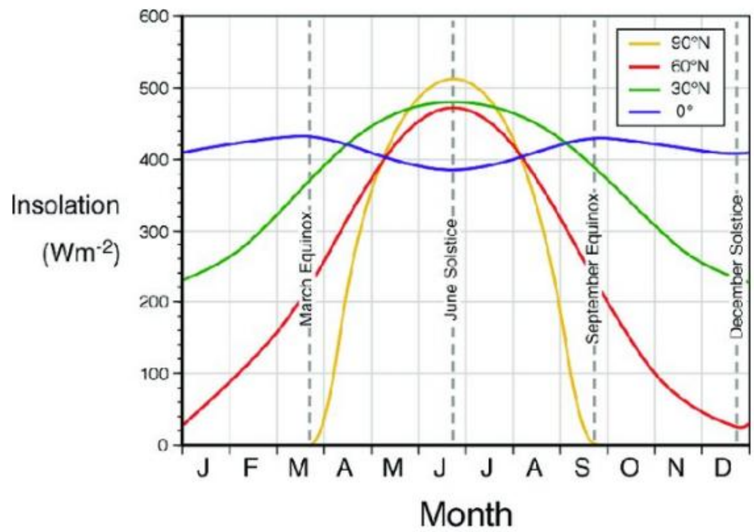


Figure 24: Insolation (radiation reaching the surface) in the northern hemisphere, showing variation through the year at different latitaudes (Ackerman and Knox, 2009)

The Earth

Earths's heat flow is partly the decay of the original planet-forming process, but radiogenic sources within the mantle and crust account for as much as 83% of the surface heat flow (Beardsmore and Cull, 2001).

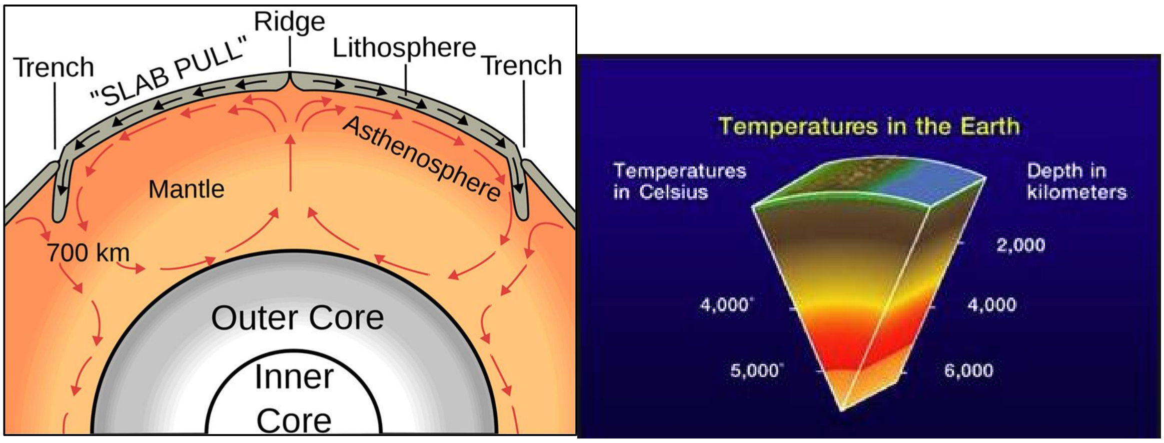


Figure 25: Components of the earth crust and mantle and temperatures

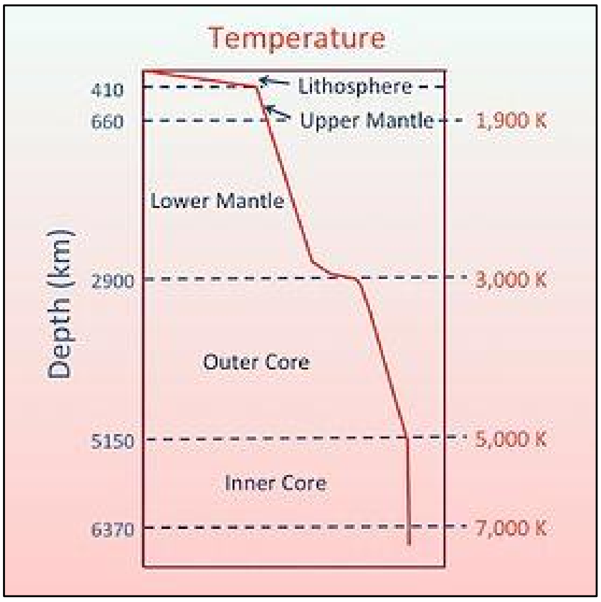


Figure 26 : Temperature profile through the earth (Wikipedia)

Crustal heat flow is typically dismissed as being insignificant compared to solar energy – the average surface heat flow is 87 $mW.m^{-2}$(compared to 341 $W.m^{-2}$ on average from solar). This is not a valid comparison however as crustal heat flow varies over a long term cycle while solar energy is instantaneous.

The interaction between earth and atmosphere is complex. Subsurface temperatures are a function of:

- The magnitude of the heat source (radiogenic decay in the crust plus heat from the core)
- The thermal conductivity of the material it passes through (how efficiently it transfers heat)
- The thermal diffusivity of the material it passes through (the rate at which heat is transferred from the hot side to cold side)
- The heat capacity (how much energy is required to change the temperature)
- The cooling or insulating effects of adjacent materials – rock, air, ocean and snow.

Representative values of thermodynamic properties are shown in the table below:

	Granite	Water	Air
Thermal Conductivity λ $Wm^{-1} K^{-1}$	3.1 average	0.6	.02
Heat Capacity cp $J g^{-1} K^{-1}$	0.79	4.18	1
Thermal Diffusivity ἀ $X10^{-6} m^2 s^{-1}$	1.6	.13	Up to 50 at 200 deg C

The important factors are heat capacity – water has five times the heat capacity of rock and four times that of air – and diffusivity (which is far higher in air than in water or rock). We know heat is generated within the crust (rock generates heat), water stores heat, and air dissipates heat (via diffusion, convection, conduction). Water is present as a liquid phase down to a depth equivalent to 374 deg C (around 10 km in Taranaki). Water is also present in the atmosphere. **Heat is transferred from rock to water by conductive transfer, and from water to water vapour by evaporation, and from water vapour to air by infrared radiation and conduction**.

The net result, however, is temperature.

The plot below is a representative temperature profile for Taranaki. Temperatures immediately below the surface are very close to the mean atmospheric temperature and increase with depth at a rate of 3.5 deg C/100m (the geothermal gradient). Atmospheric temperatures decline with increasing elevation at around 6 deg C/km (the lapse rate). Atmospheric factors (sun, wind, rain, snow, day and night) cause temperatures to vary between -5 and 29 degrees C on a short term basis, but the subsurface temperatures are relatively constant. In the absence of a thermal barrier to isolate subsurface heat from the atmosphere, it seems fairly obvious that the lapse rate is the continuation of the geothermal gradient, but in a different medium (air instead of rock). The same temperature profile continuity is apparent elsewhere e.g on the Kola Peninsula, where the Russians drilled a well to 14,000 km, the geothermal gradient was lower than Taranaki (17 deg C/km cf 35 deg C/km), but the extrapolated subsurface temperature (1 deg C) is very close to the mean atmospheric temperature.

The comparison of solar energy to crustal heat flow is analagous to comparing the heat flow from an open fire to the heat flow from a concrete floor with underfloor heating (where hot water is pumped through pipes in the concrete). In the subsurface heat is transferred via rock and water interacting, in the lower atmosphere the interaction is between water (vapour) and air.

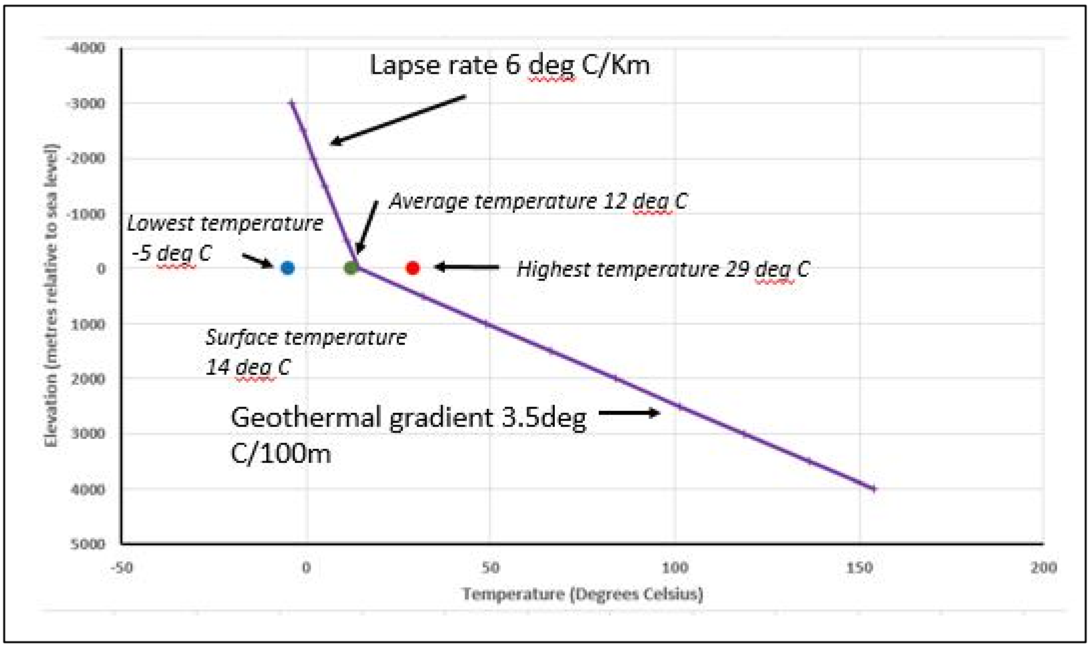


Figure 27: Thermal profile onshore Taranaki Basin.

Current climate science models discount any contribution from crustal heat flow because of the low thermal conductivity of rock, but heat transfer is mostly through the the water phase, which extends deep into the subsurface and high into the atmosphere.

The phase diagram for water (below) illustrates several important points:

- Water vapour can form below 100 deg (steam) if pressures are below atmospheric;
- Water can remain in liquid form above 100 degrees if pressures are higher than atmospheric;
- The transition between liquid and gas states remains constant at 374 deg C above a critical pressure of 218 atm. In this high pressure and temperature region water becomes a supercritical fluid.

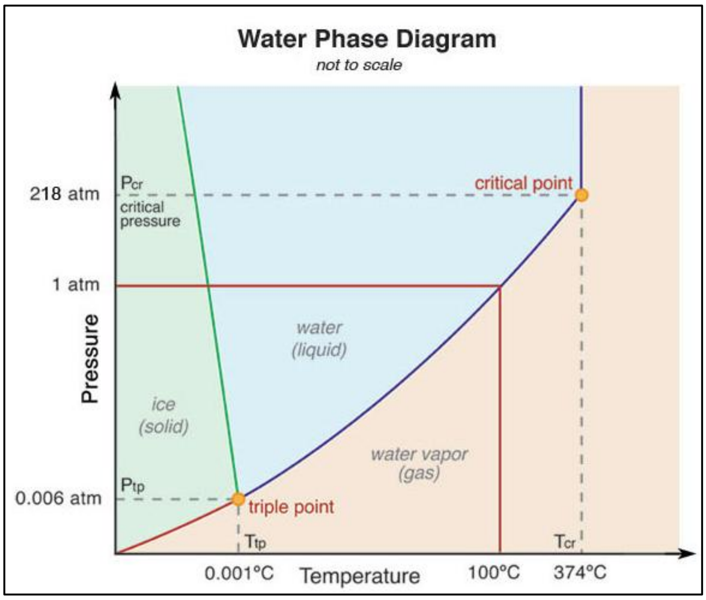


Figure 28 : Phase diagram for water

Water therefore becomes a continuous liquid phase below 374 deg C. The water column is largely independent of the surrounding rock matrix in terms of pressure (figure below) and forms a hydrostatic pressure gradient which is 1.42 psi/m near the surface, decreasing with depth and increasing temperature. The rock matrix forms a lithostatic gradient, typically 2.7 – 3.0 psi/m.

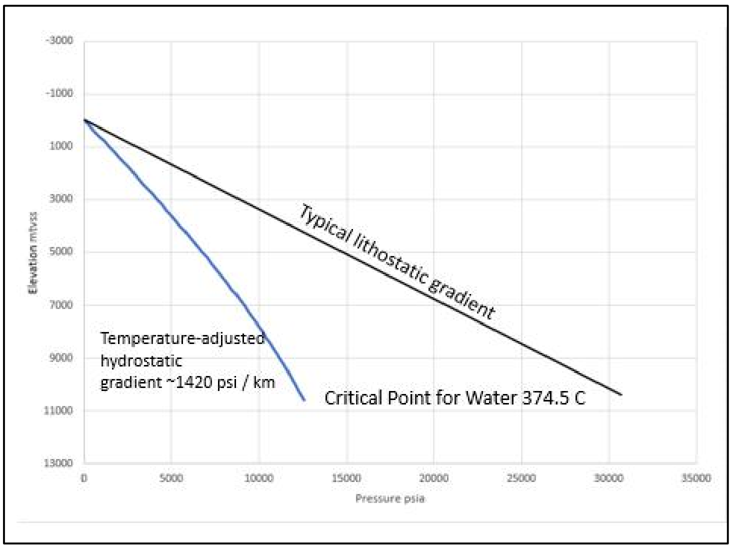


Figure 29: Pressure profile, Taranaki Basin

A similar situation occurs with temperature (Figure 30). Water becomes a liquid phase at 374.5 degrees. From this temperature and depth, the transfer of heat to the atmosphere is dependent on the proportion of water in the overlying rock column. At these high temperatures and pressures water is a liquid, but with a density close to vapour.

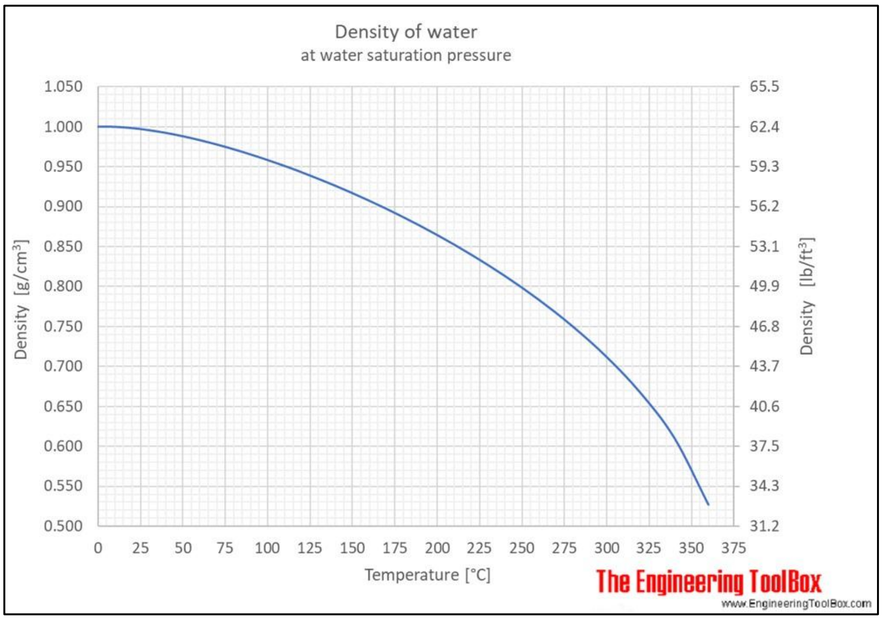


Figure 30 : Density of water at different temperatures

The geothermal gradient for the water column is comparable to the atmospheric lapse rate and results in a surface temperature of around 300 deg C. This is the temperature of the hottest geothermal pools in the Taupo Volcanic Zone (TVZ), suggesting geothermal heat is related to the depth of fracturing rather than the depth of heat source. This also explains the occurrence of geothermal springs associated with fault zones (eg along the Alpine Fault), with no associated volcanism.

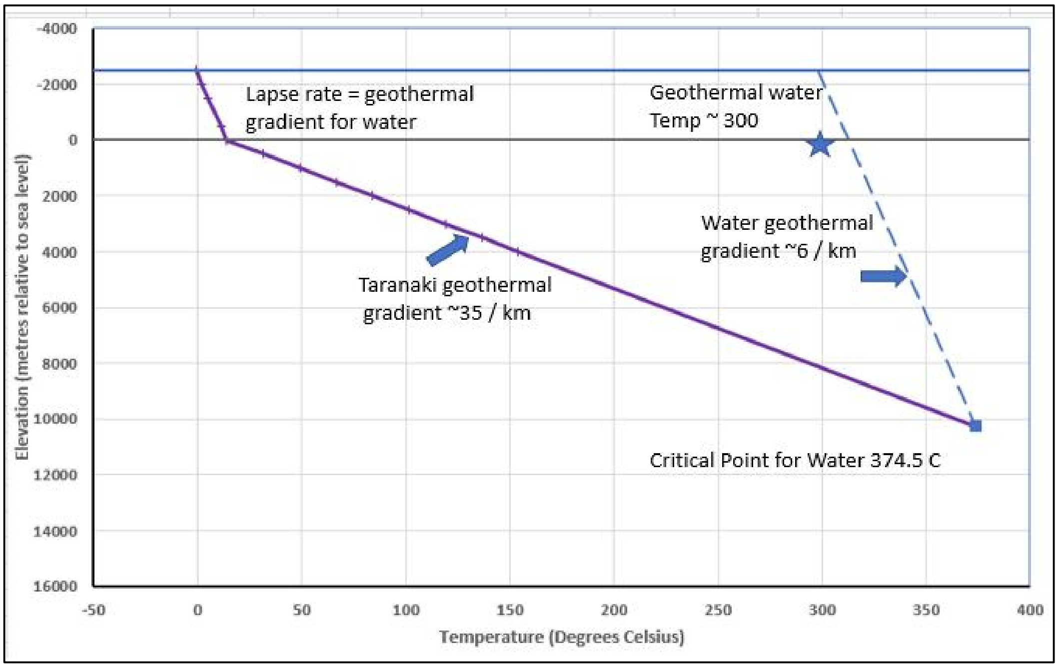


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Figure 31 : Temperature profile for entire water column (subsurface and atmosphere)

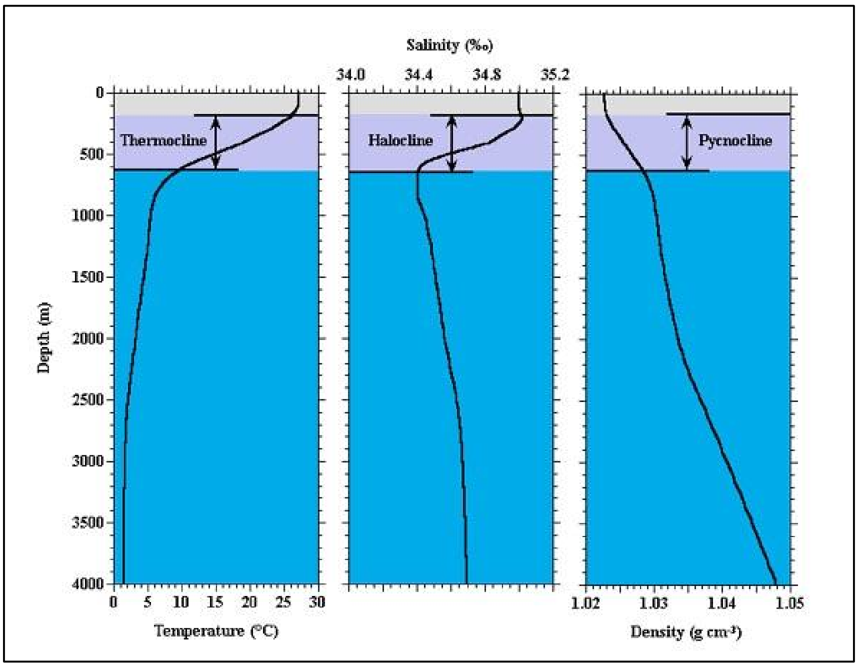

Figure 32: Ocean temperature profile (https://skepticalscience.com)

In the oceans we see the earth and solar systems interacting – surface waters are warmed by incoming shortwave radiation, roughly to the depth to which short wave radiation (sunlight) reaches. The bulk of the water column is heated from the seafloor and, as warm water rises by convection, the column warms as it gets shallower.

Crustal heat flow and evaporation therefore control the baseload temperature in the troposphere. Solar energy and associated atmospheric elements control the short term (daily and seasonal) oscillations. Energy is transferred from subsurface to the atmosphere via evaporation and conduction, then distributed via infra red radiation, conduction and convection. Conduction will cease as gas expands and the distance between molecules increases. This is reflected in the atmospheric pressure profile, as molecules need to be in contact to build a pressure profile. Energy is released as infra-red radiation from water vapor and distributed equally upwards and downwards – this is the downgoing longwave radiation and remains relatively constant through night and day (Figure 33).

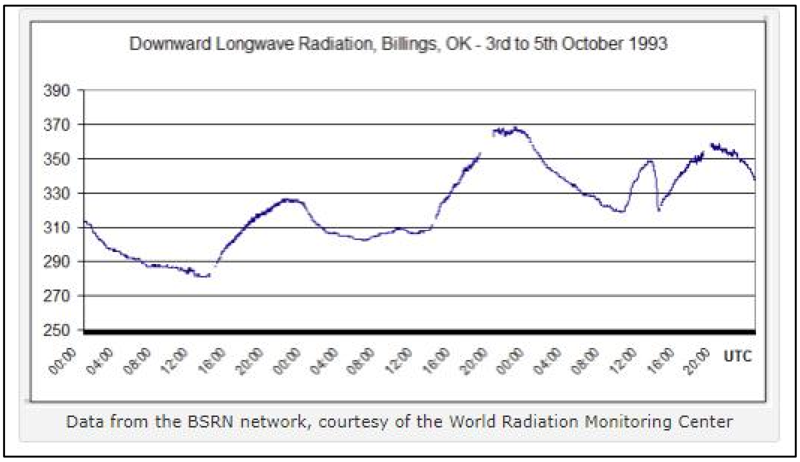

Figure 33 : Example of downward long wave radiation (Varlaton,2010)

Because the temperature profile is a continuum, and presumably changing very slowly, there is little lateral heat transfer. However, we can get an idea of the potential flux from existing data. Climate scientists estimate that, without Greenhouse gases, solar energy would only heat the earth's surface to an average temperature of -18 deg C. In the case of Taranaki, this would create a temperature differential of 30 degrees, which would be reflected by a high heat flux.

These conditions are created in deep mines, such as in South Africa, where modelling indicates a heat flux (Figure 34) of 170 $W.m^{-2}$ when a rock temperature of 50 degrees is cooled by an air temperature of 25 degrees.

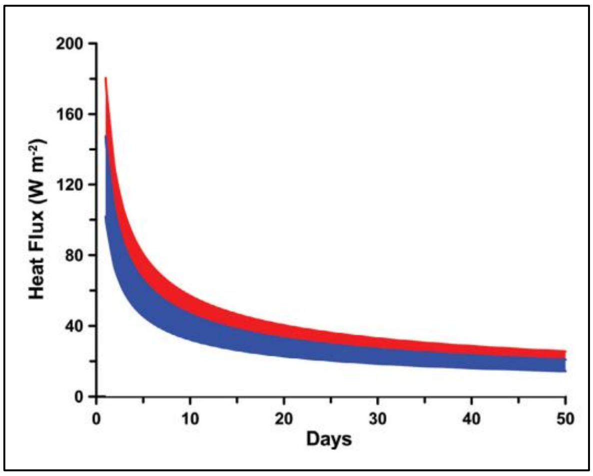

Figure 34: Heat flux with time for surface exposed at 50 deg C and surface temperature of 25 deg C (Jones, 2015)

The Properties and Distribution of Greenhouse Gases

Water Vapour

Water covers over 70% of the earth's surface and accommodates the thermal transition between crustal heat flow and solar energy. Water vapour forms through evaporation and the release of geothermal steam. Data collected by weather balloons up to ~35km show the decrease in water vapour and temperature with altitude. As water vapour rises it expands, cools, and condenses as precipitation. The top Troposphere is a distinct boundary, in this case at around 12 km altitude.

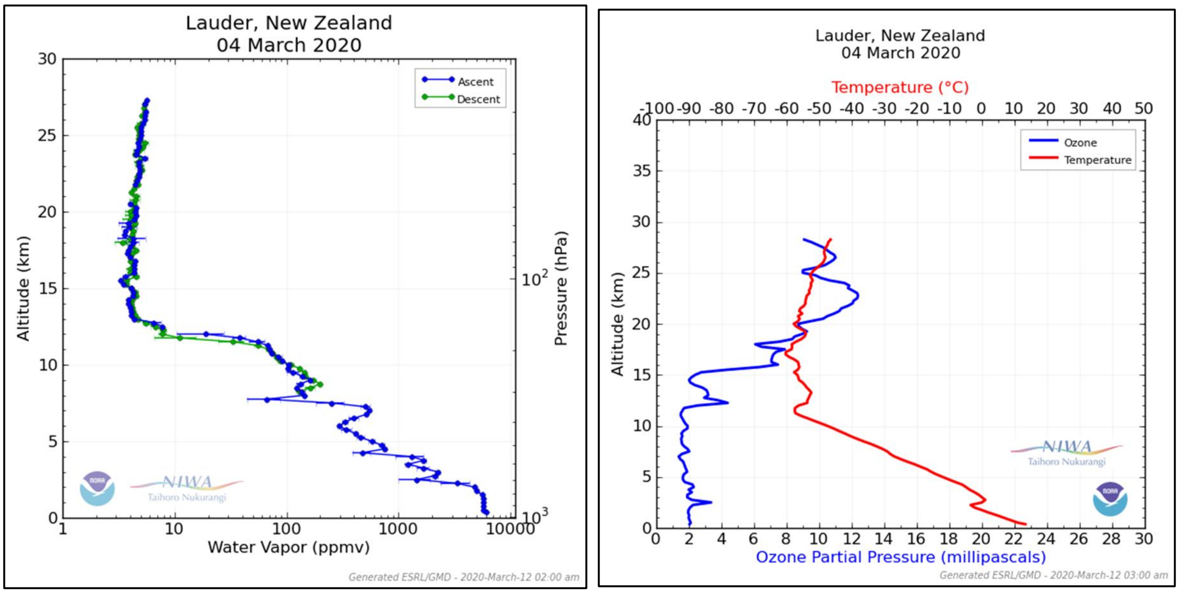

Figure 35: Weather balloon data showing vertical profiles of water vapour and temperature, both decreasing with altitude through the troposphere (NIWA website).

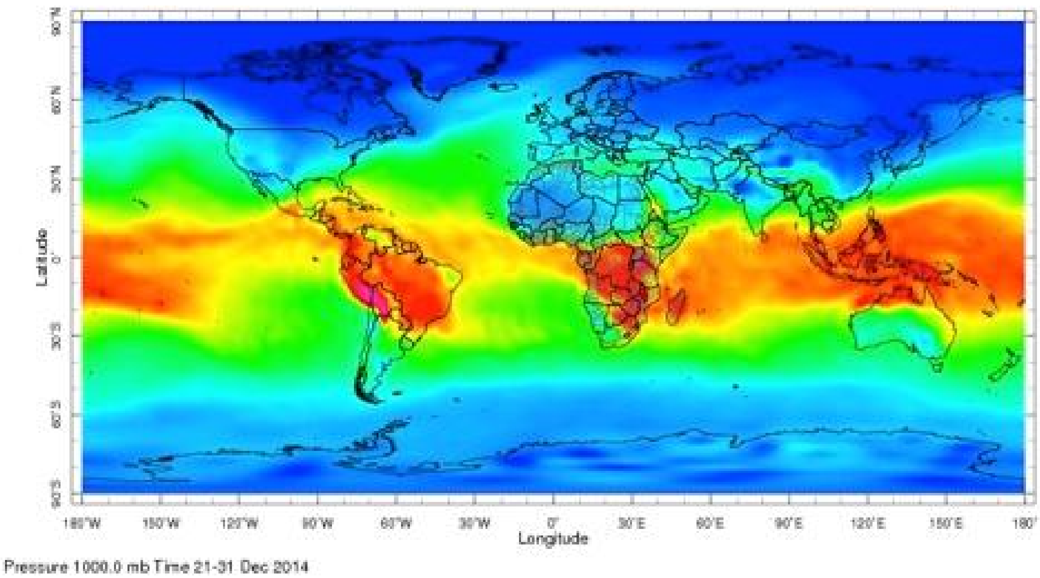

Figure 36: Total water vapour content in atmosphere showing strong correlation with latitude. (NASA website)

Carbon Dioxide

The earth has a fixed amount of carbon, set during the planet's initial formation. CO_2 was produced from this initial cataclysm and is vital because it is used in photosynthesis. If CO_2 levels get too low, plant life dies, as does everything up the food chain (humans included). The level of CO_2 in the atmosphere has been declining throughout earth's history (see figure below), with a notable reversal in the Permo-Triassic, as it has been used for plant growth and stored underground in coals and limestones.

Note the big dip in CO_2 levels during the Carboniferous (300 Ma) – when huge forests and coal deposits were forming in the northern hemisphere.

Just as CO_2 is liberated by burning fossil fuels in engines, CO_2 is also generated naturally by thermal heating of coal as it gets buried, due to the geothermal gradient. From around 2000m the coals and shales start generating CO_2 and hydrocarbons (including methane).

CO_2 (like water) can exist in several forms – solid, liquid and gas, depending on the pressure and temperature conditions, in the same way methane can be a gas and form hydrates in deep water. Because of this, CO_2 has a wide range of physical properties – particularly density. The density of CO_2 ranges from 1.977 kg/cu m as a gas, to 1101 kg/cu m as a liquid, and 1562 kg/cu m as a solid. The density of water is 997 kg/cu m, and the density of air is 1.225 kg/cu m. In subsurface reservoirs CO_2 is a supercritical fluid, with viscosity of a gas and density of a liquid. The sublimation temperature for CO_2 is -78.5 deg C; at this temperature CO_2 undergoes a phase change from gaseous to solid (dry ice) with no intermediate liquid phase.

The figure below has been presented innumerable times to provide context in the debate about the significance of an increase in atmospheric CO_2 concentrations from 300ppm to over 400ppm.

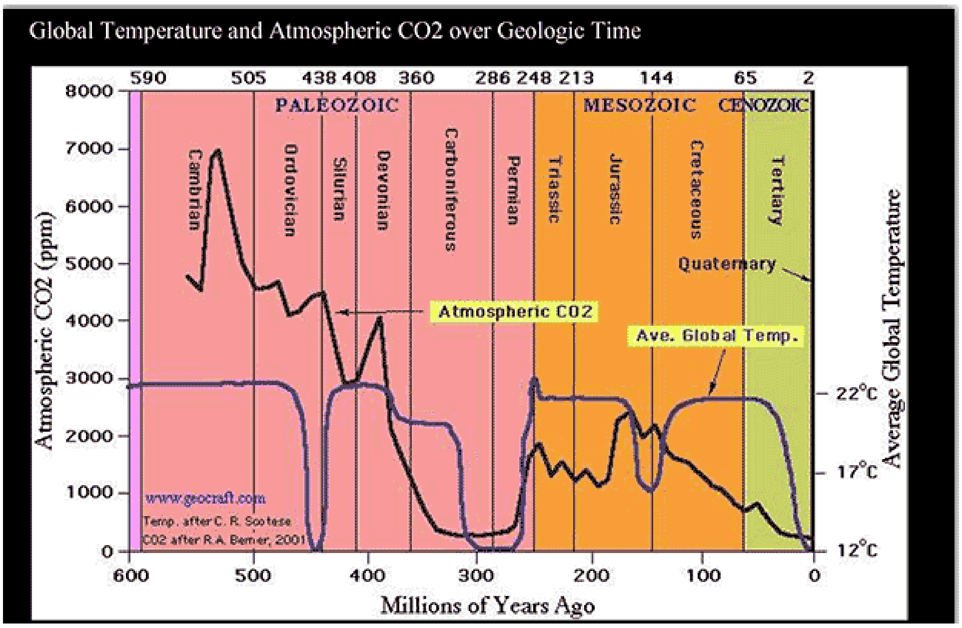

Figure 37: Global temperature and atmospheric CO2 over geological time (www.geocraft.com).

Not only have CO_2 concentrations been higher than 400ppm for most of earth's history, but the atmospheric concentration has been on an inexorable downward slide for the past million years, and is getting perilously close to a point where plant life cannot be sustained – variously stated to be 150ppm or 180ppm (or less if plants continue to evolve to deal with these levels).

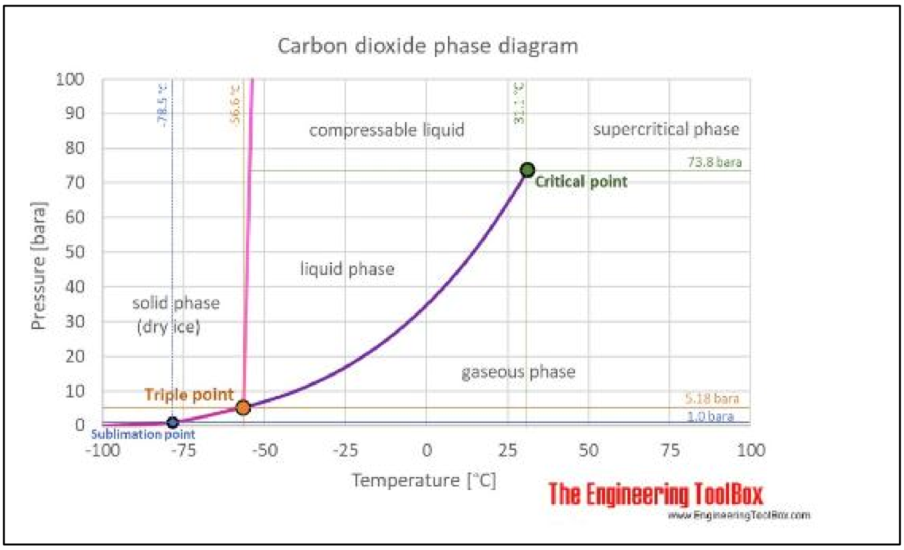

Figure 38: Phase Diagram for Carbon Dioxide.

Figure 39 shows atmospheric profiles for CO_2, as measured by weather balloons. The profiles are remarkably consistent above the troposphere to the top of the measurement window enabled by weather balloons. A small (10ppm or 0.03%) increase in the troposphere probably reflects breakdown of methane by ozone.

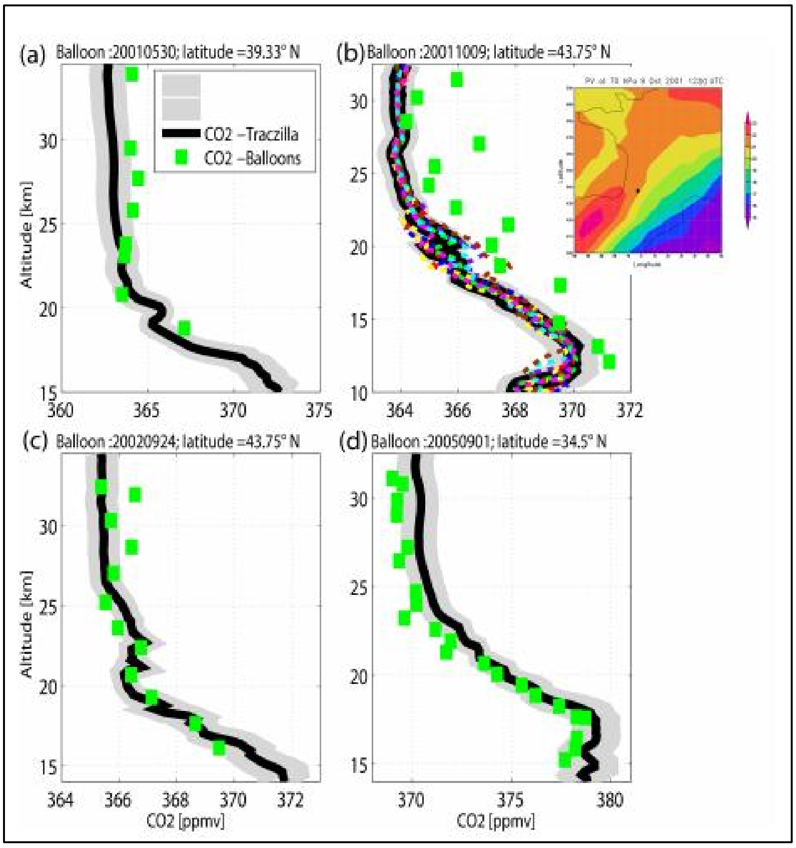

Figure 39 Carbon dioxide profiles with altitude measured by weather balloons.(Diallo, 2017)

Figure 40 shows the rapid decline in CO_2 concentrations that occurs at about 80 km altitude. Temperature-pressure conditions at this altitude are suitable for sublimation to occur (the phase change from gas to solid with no intermediate liquid stage).

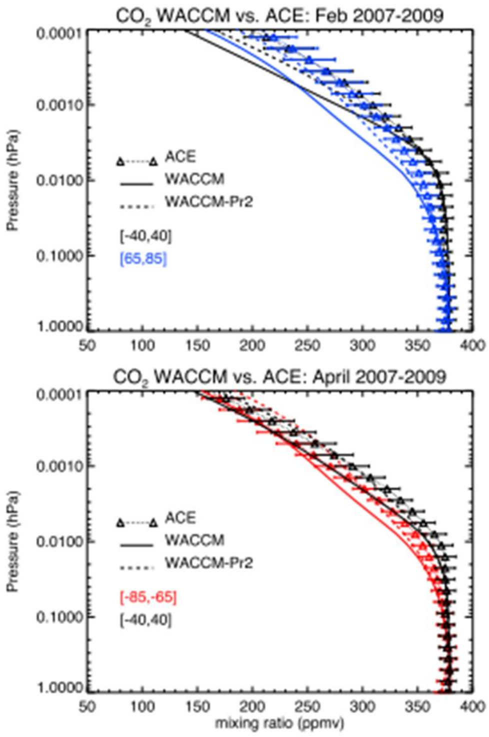

Figure 40 : Carbon dioxide concentrations in mesosphere as measured by satellites (Diallo et al, 2017).

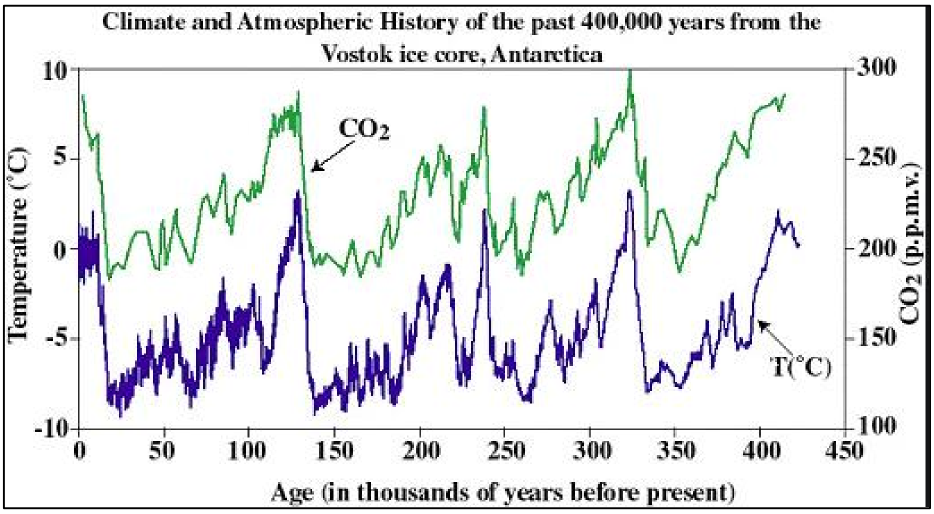

Figure 41 : Temperature variations and carbon dioxide concentrations derived from Vostok ice core, Antarctica (Rubina et al 2013)

Measurements of CO_2 and temperatures (derived from isotopes) from ice cores in Antarctica reveal a consistent recurring cycle over the last 400,000 years; peaks reflect Interglacial periods, while troughs reflect glaciations. These cycles reflect the Milankovich cycles and CO_2 concentrations mirror the temperature trends, but consistently lag behind.

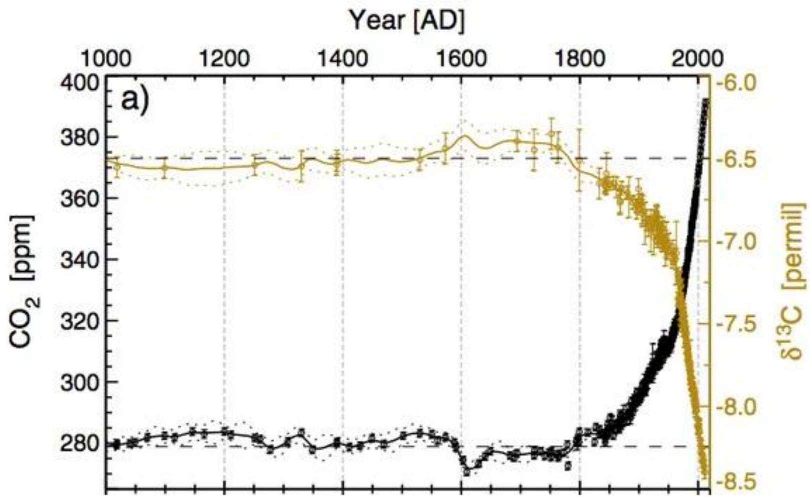

Figure 42 : Carbon dioxide concentrations (black)and carbon isotope compositions (tan) from ice core samples, Antarctica (Rubind et al 2013, from Klemetti, Wired 2015)

Carbon dioxide concentrations (black) and carbon isotopic composition (tan) for Antarctic ice core samples provide valuable insights into the source of pre-industrial CO_2. The isotopic signature of various sources of CO_2 have been calibrated (Figure 43) and can be used to differentiate mantle-derived CO_2 and thermogenic CO_2 . The C13/C12 isotopic ratio of pre-industrial CO_2 in the Antarctic ice cores is consistently -6.5. This correlates with geothermal CO_2 and with mantle-derived CO_2 in sedimentary basins (Figure 44). Isotope data do not support large contributions to atmospheric CO_2 by terrestrial (vegetation) or ocean sources.

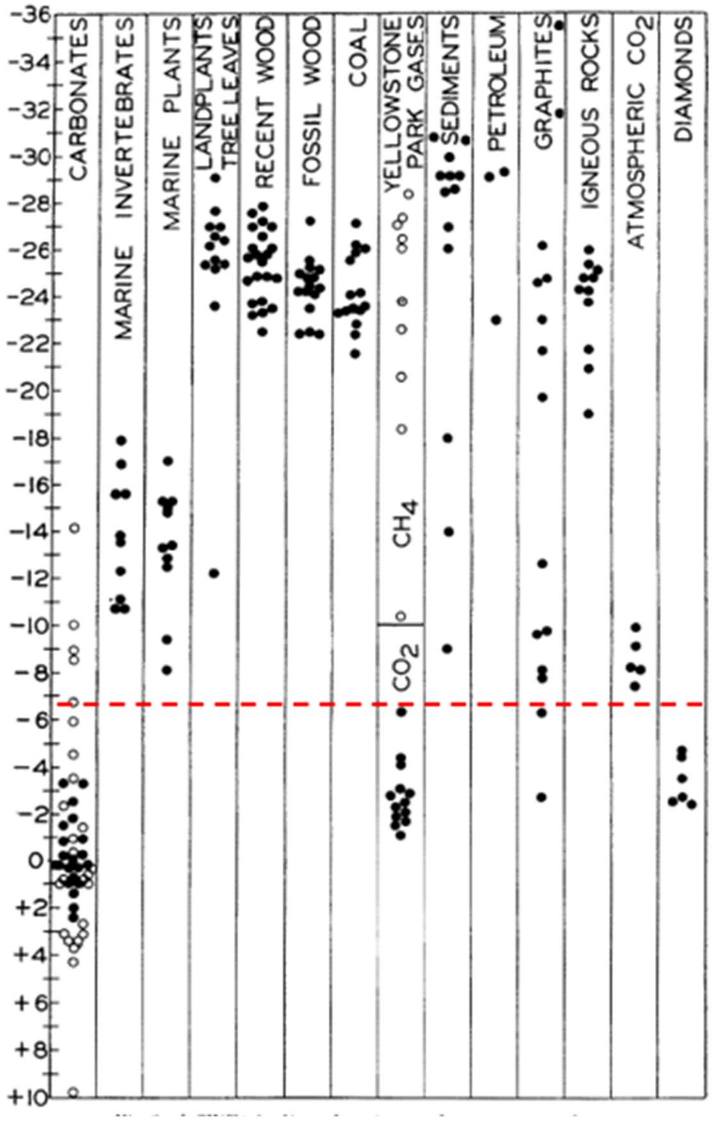

Figure 43 : Measured C13 isotopes showing contrast between terrestrial sources and volcanic gases (Craig, 1953).The red line is the pre-industrial isotope from Antarctic ice cores.

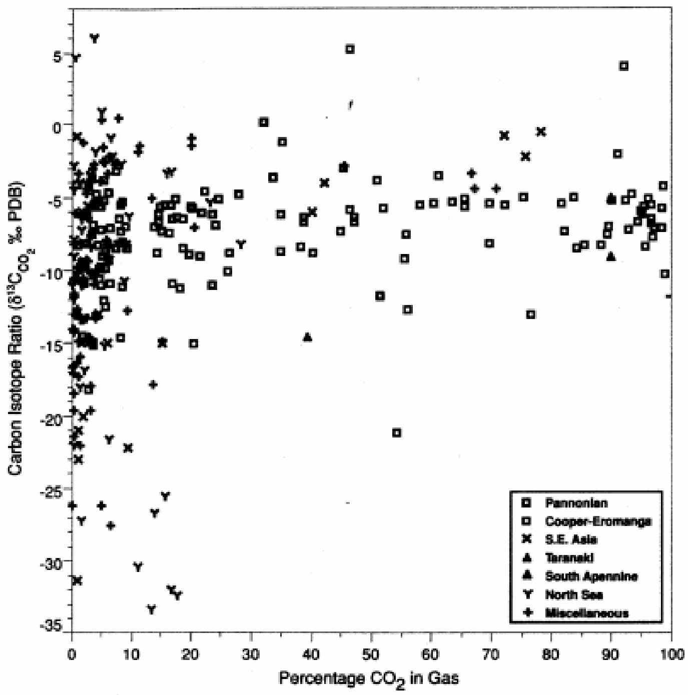

Figure 44 : Calibration isotope data (Thrasher and Fleet,2000)

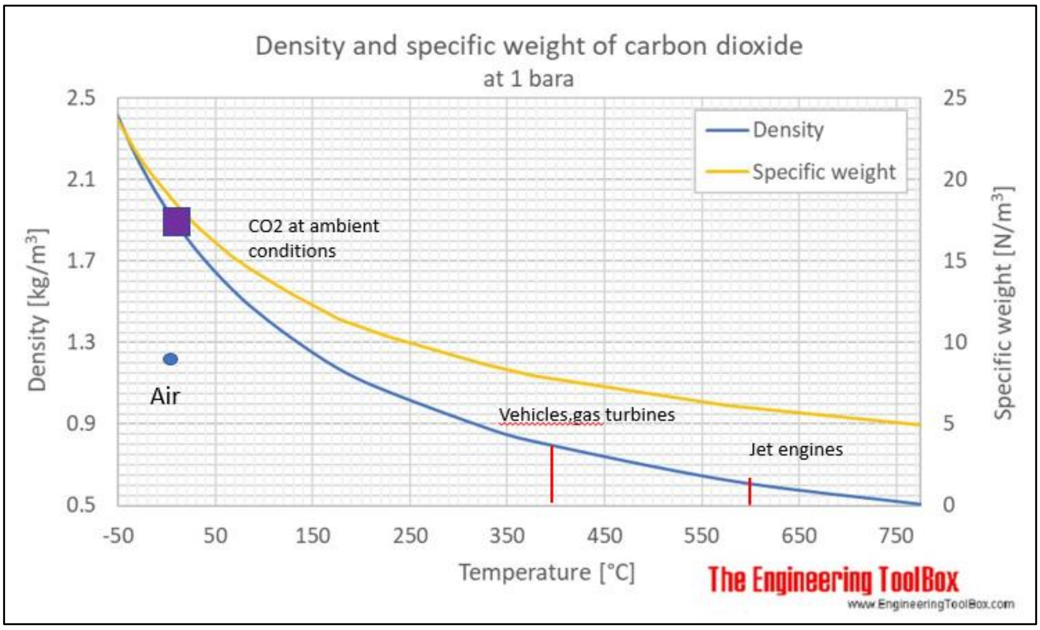

Figure 45 : Carbon dioxide density with temperature

The density of CO_2 at ambient conditions is 1.977 kg/cu m. The density of air varies, depending how much water vapour it contains, but is around 1.225 kg/cu.m. The density of CO_2 varies greatly at different temperatures and pressures (see chart above); it has significantly lower density at high temperatures.

CO_2 does not evaporate as water does and only becomes lighter than air above 150 degrees celsius. Therefore, the only way to get CO_2 into the atmosphere is via thermal processes – volcanism, burning of fossil fuels etc. The plot shows the exhaust temperatures for internal combustion engines, gas turbines (used in power generation) and jet engines. Exhaust temperatures generally exceed 400 degrees C, reducing CO_2 density to less than 0.8 kg / cu m.

Anthropogenic CO_2 generated by thermal processes is considerably lighter than air and so the molecules immediately rise up into the atmosphere as a plume. Volcanic gas is also expelled at high temperatures (400 deg C) and velocity (>200 km/hr) so it also immediately disappears. This has led to a major under-estimation of the contribution of volcanoes to the carbon budget. We know from historical records that volcanic ash can reach 50 km or more into the atmosphere and is carried around the globe; the isotope data indicate that around 280 ppm of the current total atmospheric CO_2 is of volcanic origin.

Evidence for the immediate escape of thermal CO_2 is provided by the ground-based measurements. The recent bushfires in Australia are estimated to have released 250 million tonnes of CO_2, almost half of their annual emissions. The smoke from the fires blew across New Zealand, blocking out sunlight and staining snow with ash. Yet there was no unusual variation in the CO_2 levels recorded at Baring Head (Wellington). Similarly, as a consequence of the Corona virus and subsquent lockdowns, emissions have been drastically reduced, air quality has improved dramatically in urban and industrial areas, yet the CO_2 concentrations have continued to rise. This confirms that the CO_2 concentrations measured at ground level do not reflect the current emissions; there is a time lag.

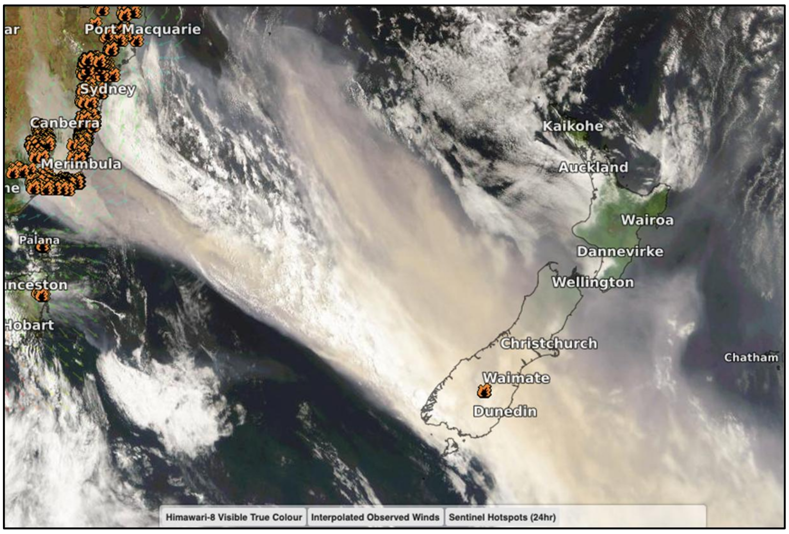

Figure 46 : Satellite image of smoke from Australian bushfires Dec 2019. (WeatherWatch.co.nz)

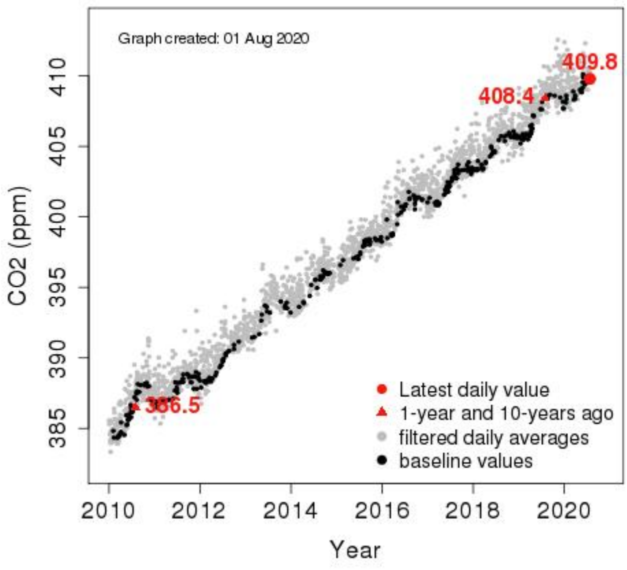

Figure 47 : Carbon dioxide readings from Baring Head (NIWA) showing no spikes during Australian bushfires or CoronaVirus lockdown.

My interpretation is that the CO_2 is ejected into the stratosphere as plumes (Figure 48) which then track lines of latitude (Figure 49) and is then carried further from earth by centrifugal force (Figure 50), until it reaches sublimation temperature in the mesosphere (Figure 51) and changes to a solid, probably as a coating around an aerosol (dust) nucleus. It then descends due to its increased density. The CO_2 is evenly distributed and rains down through the troposphere to be measured on the surface at very consistent concentrations.

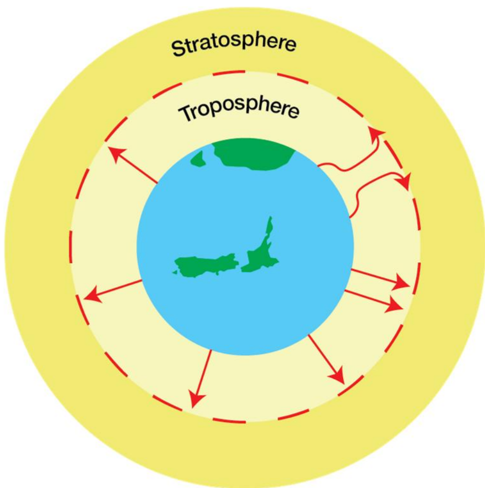

Figure 48 : Initial rapid ascent of hot carbon dioxide from volcanoes, geothermal vents and engines.

Figure 49 shows the flight path of NASA's super balloon in 2015. The balloon imitates a molecule of CO2 and tracks along a line of latitude. The trailing plume would fan out laterally in the stratosphere, resulting in the remarkable consistency in CO_2 around the globe.

The path of the 2015 NASA Super Pressure Balloon engineering flight launched from Wanaka NZ. The flight duration was 32 days.

Figure 49 : Balloon flight shows how a plume would travel in stratosphere (NASA website)

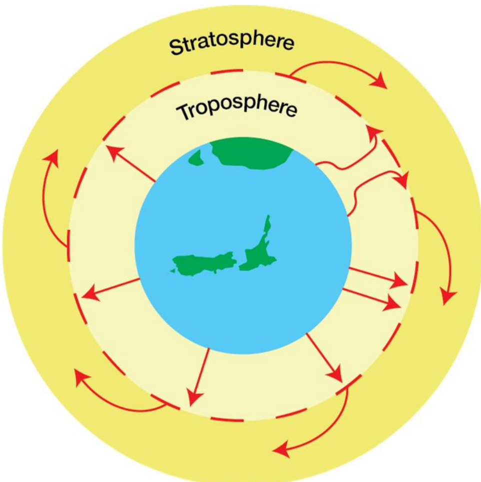

Figure 50 : Carbon dioxide then carried outwards by centrifigul force once cooled

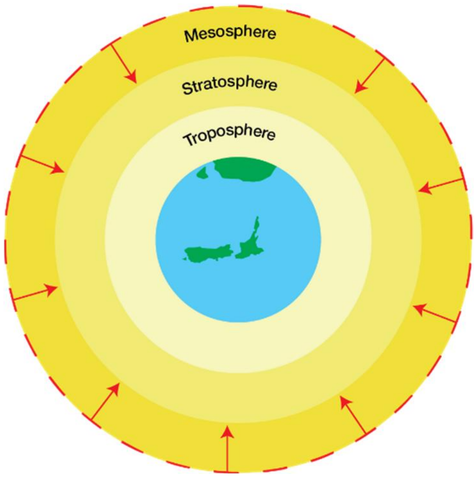

Figure 51 : Carbon dioxide undergoes phase change in mesosphere (~80 km altitude) and falls back through atmosphere

The sawtooth annual variation in CO_2 concentration is attributed by climate scientists to increased photosynthesis in the northern hemisphere during summers. If that were the case, there is more photosynthesis happening in Alaska (Barrow) than in the tropics. The oscillations actually show a consistent trend from south to north and likely reflect seasonal changes in methane and/or CO_2 output associated with the annual ice melt.

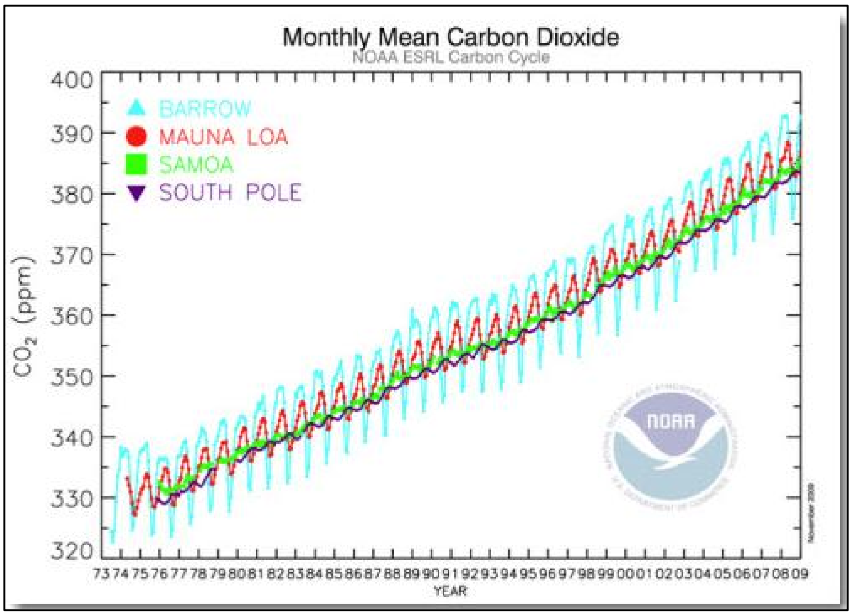

Figure 52 : NOAA plot of carbon dioxide concentrations from 4 stations showing remarkable consistency in baseline trend and annual variations increasing from south to north.

Methane

Methane is ubiquitous on earth and can be of either thermogenic or biogenic origin. Thermogenic methane is generated from organic matter in sediments as they mature with burial (coals or dispersed organic matter), and is expelled from faults, as well as volcanic and geothermal sources. Biogenic methane is associated with digestion and decomposition of organic matter. Methane is produced from landfill sites to generate electriciity. Methane concentrations vary considerably geographically, but methane is well mixed in the troposphere vs the stratosphere (Figure 53). Microbes in soils and in seafloor sediments break down numerous compounds and produce methane. As a result of the different generation mechanisms, the isotopes of biogenic and thermogenic methane are distinctly different.

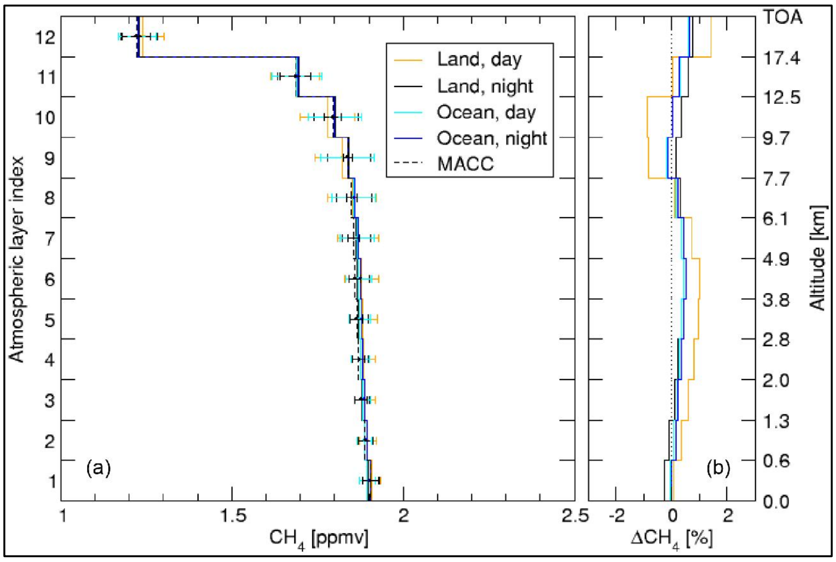

Figure 53 : Methane profiles from GOSAT-TIR over Bialystok (de Lange and Landgraf 2018)

Numerous methane seeps are reported onshore NZ and offshore methane can accumulate in shallow sediments , where it can be a drilling hazard, or leak underwater in spectacular fashion. Most wells drilled in Taranaki , for example, record methane near-continuously from surface to depths exceeding five thousand metres. Huge volumes of methane are locked in permafrost and hydrates in the ocean. These do not necessarily indicate areas of high methane production, but are areas where pressure/temperature conditions trap the methane where otherwise it would escape to the atmosphere.

The surprising thing about methane is how little is in the atmosphere. Methane is lighter than air at atmospheric conditions (methane 0.657 kg/m3, air 1.225 kg/m3) and so should be abundant in the atmosphere, yet methane concentrations have increased from only 722ppb in pre-industrial times to around 1900 ppb now (ie an increase of 1 ppm compared to CO2 which has increased by >100ppm).

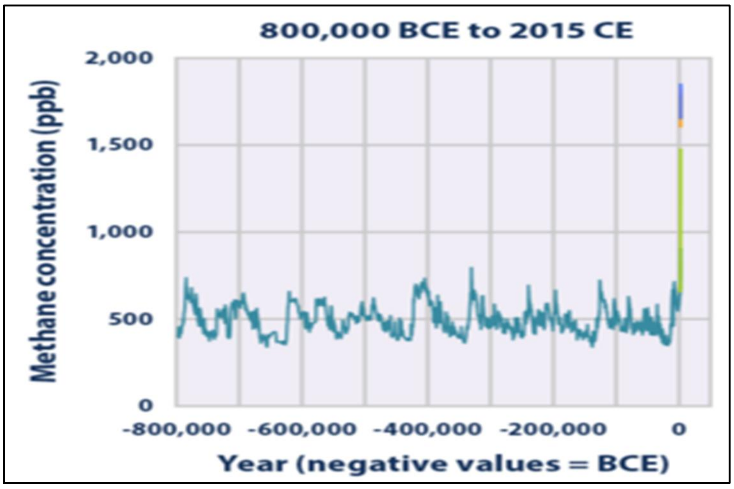

Figure 54 : Average Global atmospheric methane concentrations (Wikipedia)

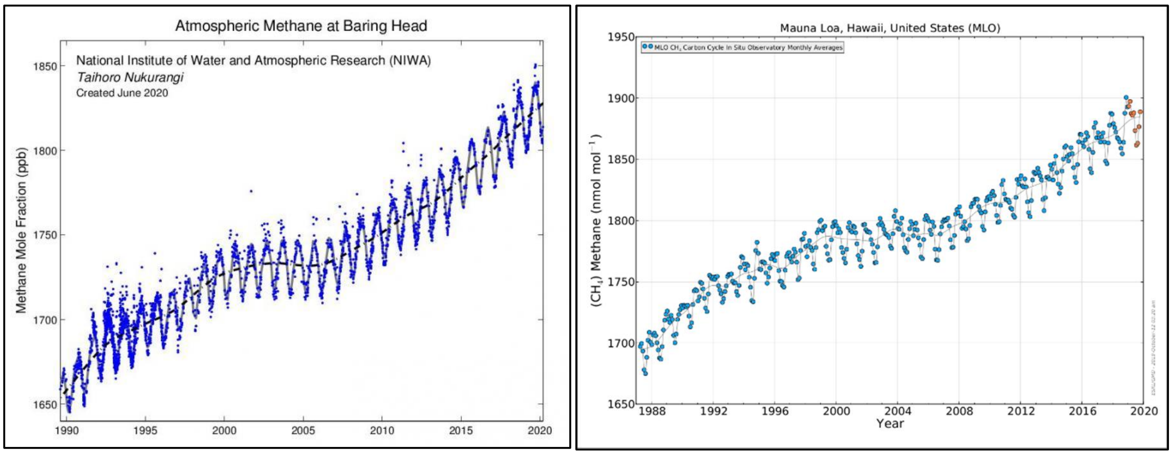

Figure 55: Methane concentration, Baring Head (left) and Hawaii, 1990 – 2020 (NIWA website and Wikipedia)

Measurements of methane consistently show a plateau in methane levels between 1998 and 2012. There is no apparent correlation with the size of the dairy herd in New Zealand (Figure 56) which has grown steadily since the 1970's but plateaued around 5 million since 2005.

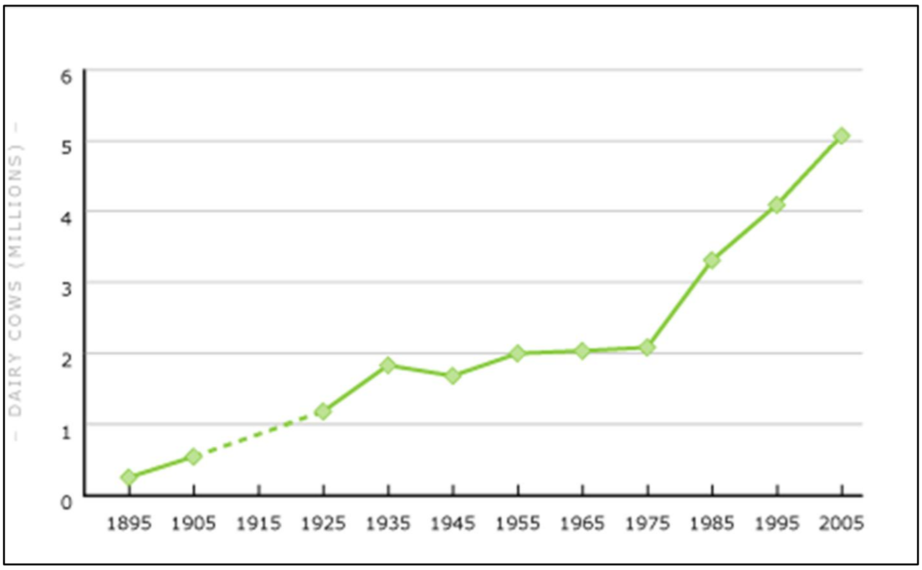

Figure 56: New Zealand Dairy Cow Population

So if there is a virtually unlimited supply of methane for the earth, yet very little in the atmosphere, methane must be broken down and it is the breakdown rate, rather than the supply volume, that is controlling the measured concentrations. Methane concentrations are relatively uniform up to the top of the troposphere. When methane enters the atmosphere, a likely reaction is with ozone, which is unstable and reactive, to produce CO_2, water and hydrogen as follows:

$$CH_4 + O_3 \rightarrow CO_2 + H_2O + H_2$$

Measurements indeed show Ozone is depleted in the troposphere, relative to the stratosphere (Figure 35), and CO_2 concentrations increase (Figure 39), supporting (but not proving) this theory.

Ozone depletion is, of course, a well studied process. Chlorofluorocarbons (CFCs) used in refrigeration and as propellants were found to breakdown ozone, leading to ozone depletion and the ozone holes above the polar regions, allowing dangerous ultraviolet radiation to reach the surface. This led to the Montreal Accord in 1987 and a total ban on use of CFCs.

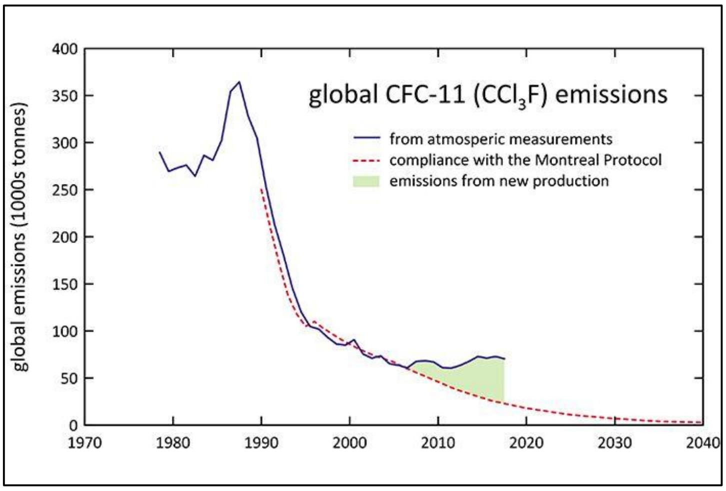

Figure 57: Global CFC Emissions (Paul Krumell, CSIRO)

The CFC ban resulted in an increase in ozone, and reduction in the size of the ozone hole. It became increasingly apparent from 2013, however, that atmospheric concentrations of CFCs were not being reduced, despite the ban. Investigation of satellite data confirmed the source to be eastern China and volumes have been increasing.

Atmospheric methane concentrations show a strong correlation with CFC emissions, ozone depletion and temperature (Figure 58). The connection between CFC production, ozone depletion and temperature was identified by Lu (2013). Figure 59 illustrates significant ozone loss in the southern hemisphere stratosphere from the 1950's.

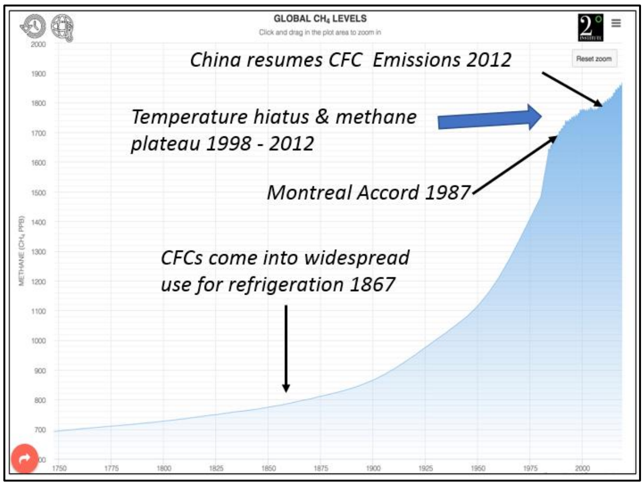

Figure 58: Global methane concentrations and key CFC events.

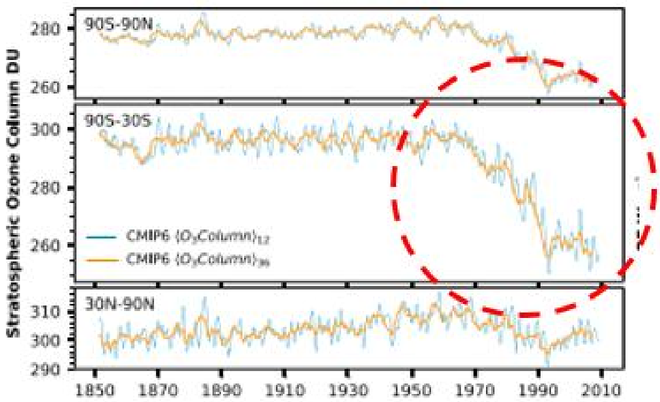

Figure 59 : Ozone column in southern hemisphere (Checa-Garcia et al, 2018)

Climate Indicators

Temperature Records

Much of the climate change debate is around the temperature trends – are temperature(s) increasing, decreasing or stable?

Temperatures are measured by thermometers in land stations, on ships, in weather ballooons, remotely by satellite etc etc. The equipment used has changed over time, and there have been changes to the environments that affect the readings . “Urbanisation bias” is the term used to describe locally increased temperatures due to urban and industrial activity. Thermometer readings go back 150 years, beyond which scientists use proxies – typically biological indicators preserved in the record, such as tree rings.

The temperature trend largely depends on the timescale selected, the area, and which cycle is dominant over this time period. A trend over 24 hours will be different to a trend over a month, a year, a decade, a thousand years, a million years etc etc. In addition, raw temperature records have frquently been adjusted, supposedly to correct for environmental factors. It is important to confirm, therefore, whether the data being presented are raw temperature measurements, or interpreted data to which adjustments have been made. There are numerous examples of editing of temperature data .

Both groups – Alarmists ansd Deniers (not my terminology) – are guilty of cherry picking temperature data to support their respective argument. The graph most commonly presented (example below) is a global average temperature plot, derived from a variety of sources, which can represent a number of scenarios with very different implications.

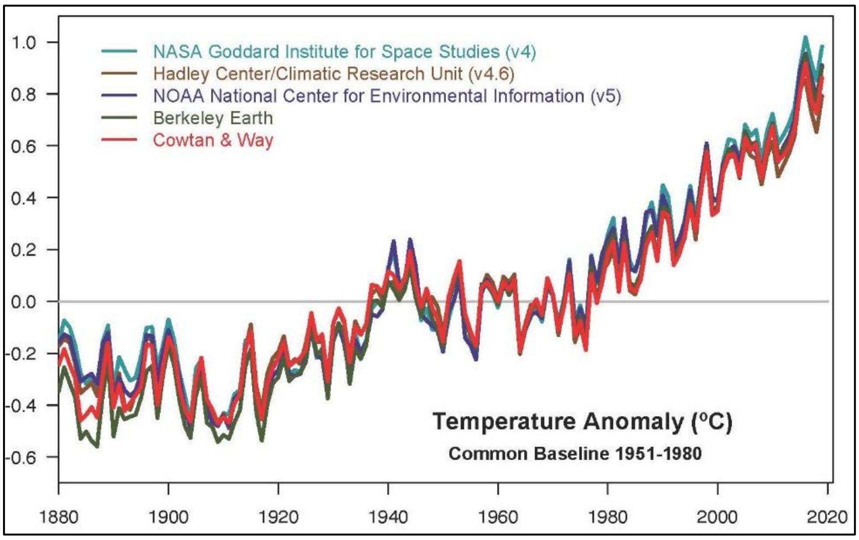

Figure 60 : Temperature Anomaly Record 1880-2020 (NASA)

The plot shows a warming trend from 1951 with an average increase of 0.12^{o}C/decade, except for the period 1998-2012 (known as the temperature hiatus), when the rate decreased to 0.05^{o}C/decade.

Sea Level

Sea level is another measure of global warming and is also subject to data manipulation and interpretation. Sea level rise is relative, and so the actual amount of rise and fall can be masked by local tectonism, subsidence etc.

Pacific Islands are a good example. Most are on volcanic edifices, which cool, contract and subside over time. In addition deforestation leads to soil erosion and filling of lagoons and estuaries with sediment. These then flood during storm surges.

The global average rate of sea-level change, as measured by coastal tide guages is ~1.5 mm/yr. Two datasets are shown as Figures 61 (Hawaii) and Figure 62 (Sydney); both show consistent long term trends, with sea level rising 1.51 mm/yr and 1.23 mm/yr respectively (http://www.sealevel.info/).

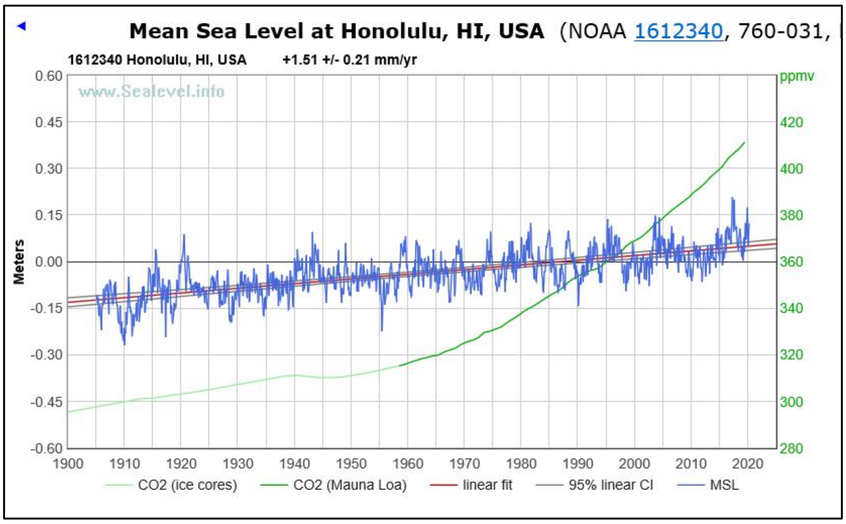

Figure 61 : Tidal gauge data for Hawaii 1900-2020

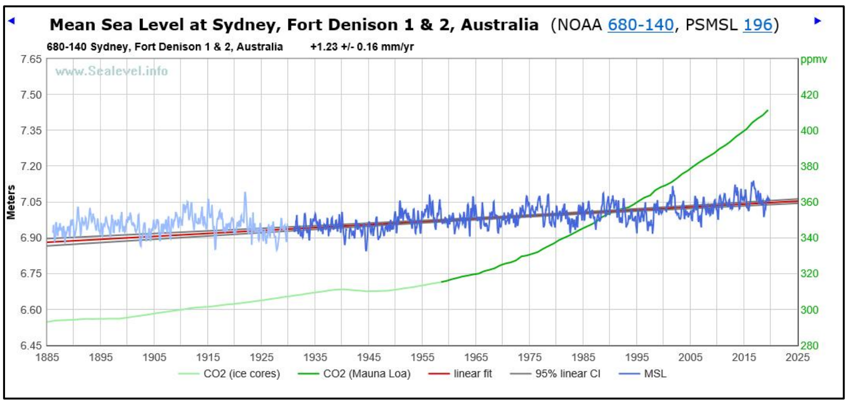

Figure 62 : Tidal guage data for Sydney1885 - 2020

Climate Forecasting

Climate is the net result of multiple cycles stacked on top of each other, solar and lunar cycles ranging from the 24 hour day/night cycle through monthly and seasonal cycles and 11 year sun spot cycles to the Milankovitch 94,000 year cycle, glacials and interglacials, ice ages, mantle convection cycles driving volcanism etc etc. The cycles interfere or reinforce each other, so it is very difficult, based on current knowledge, to make forecasts. We can argue whether temperatures are increasing, remaining static, or dropping and each position can be defended, depending what timescale is adopted and what temperature data are used. Any trend based on 100 years or less of repeatable measurements is highly speculative in the context of global climate change. The key issue is whether human activity has contributed to climate change.

Climate models inevitably generate forecasts of continued warming because they all make the same assumption – increasing atmospheric carbon dioxide concentrations will increase temperatures, so this is the assumption that needs to be tested.

The Models

The Greenhouse Model Revisited

The energy model utilised by the IPCC is shown as Figure 63. Greenhouse Gases are commonly portrayed as a barrier in the sky (hence the name) but this is not the case; the atmosphere begins at ground level.

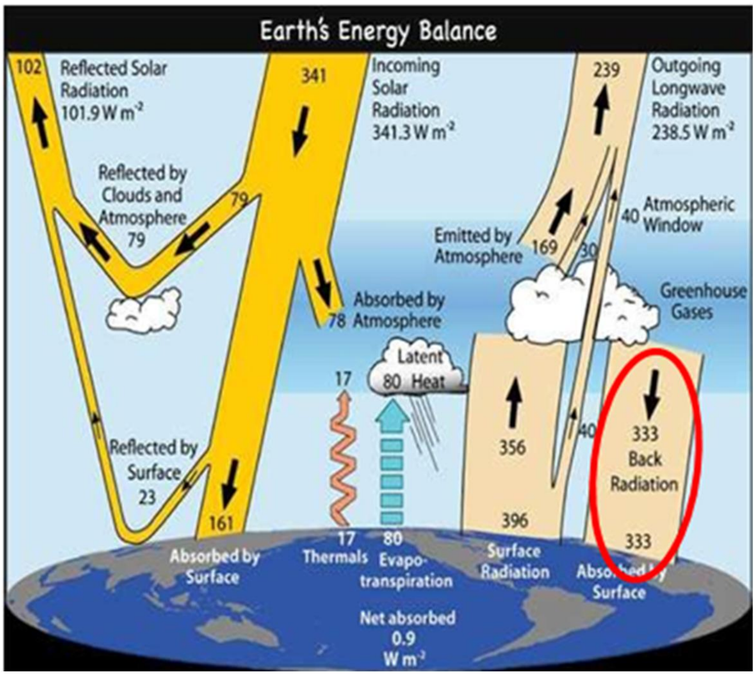

Figure 63 : IPCC Earth Energy Flow

An average of 341 Wm^{-2} of solar radiation arrives at the top of the atmosphere. This spectrum has wavelengths of 0.2– 4µm .

Energy is lost on the way to earth's surface via:

- Reflection off clouds
- Rayleigh scattering
- Absorption by greenhouse gases. CO2 is only absorbing energy in the 2.7 band

Between 0 and 500 $W.m^{-2}$ arrives at the surface, represented by the shaded red area on the spectra; then more is lost via:

- Reflection off earth's surface , particularly snow and ice
- Evaporation
- Photosynthesis.
- The remainder (~64 $W\ m^{-2}$) warms the top few metres of the ocean and land surface.

There is therefore 64 $W\ m^{-2}$ available at the surface for emission as longwave radiation, yet the earth emits 396 Wm^{-2} of longwave radiation (4-70 µm). Fundamentally, it is impossible to emit more energy than is absorbed. The Greenhouse model proposes to fill this gap with Back Radiation from greenhouse gases in the atmosphere.

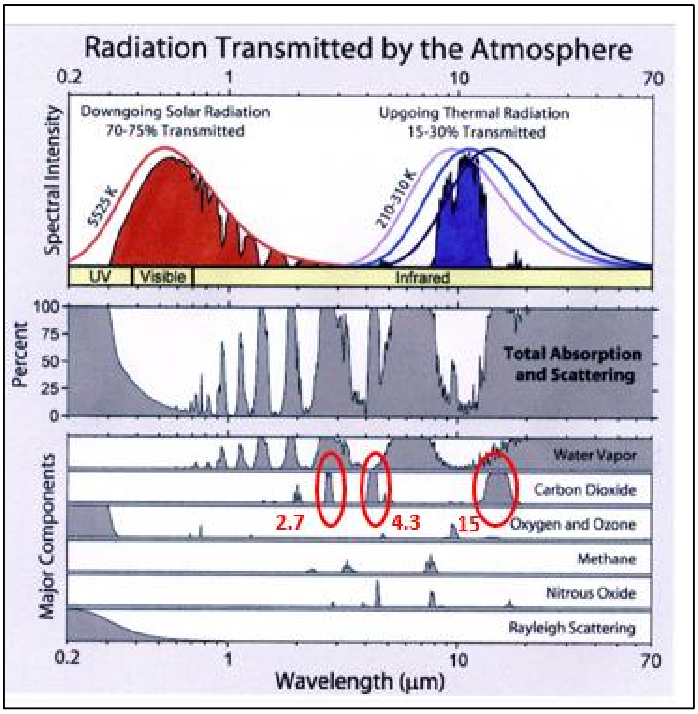

Figure 64 : Incoming and outgoing spectra and absorption frequencies

http://www.barrettbellamyclimate.com/page15.htm

Spectra recorded by satellites of outgoing longwave radiation(Figures 64 & 65) show energy in the frequencies covering the CO_2 range around 15µm are totally absorbed.

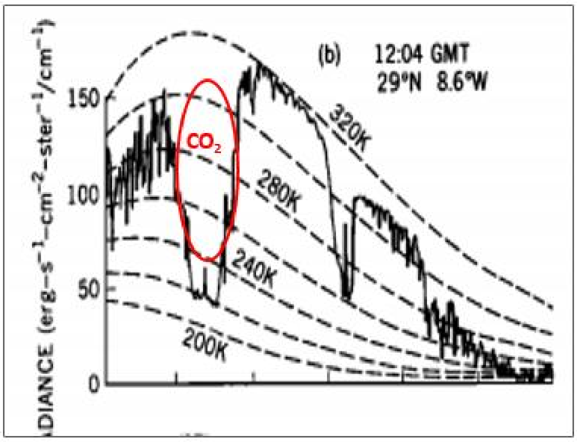

Figure 65 : Longwave infrared spectra of outgoing radiation (Hanlen et al 1972)

In contrast, the spectra of downgoing longwave infrared radiation at surface shows no energy absorption in this range (Figure 66). This is critical as it shows **carbon dioxide molecules in the lower atmosphere are not absorbing infra-red radiation – disproving the very basis of the Greenhouse Theory.**

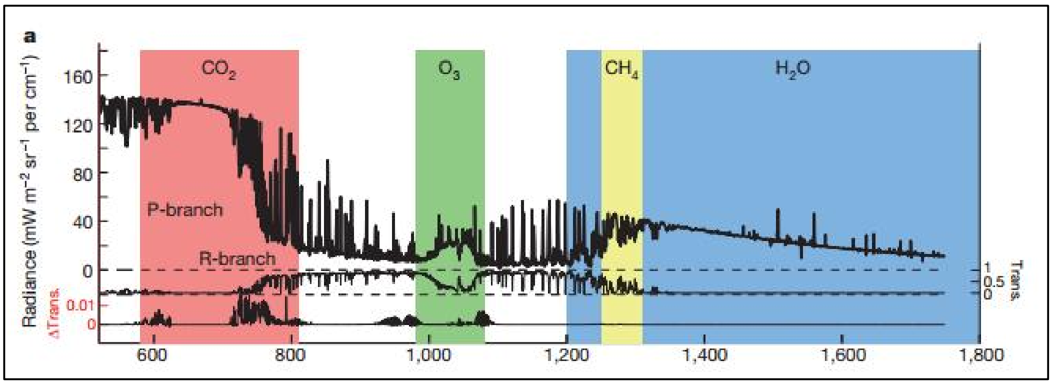

Figure 66 : Spectrum of downgoing longwave radiation (Feldman et al 2015)

This is consistent with CO_2 absorbing energy in the upper atmosphere, warming as it descends, but not absorbing downward long wavelength radiation (back-radiation) at the surface.

The Rutherford Model

The alternative climate model (referred to here as the Rutherford model) is shown below. No changes are necessary for the incoming solar radiation. Outgoing heat from the crust, however, is transmitted via evaporation plus conductive and convective mechanisms through water and vapour. A portion of this energy is emitted as infrared radiation, and travels in all directions, including downward to the surface.

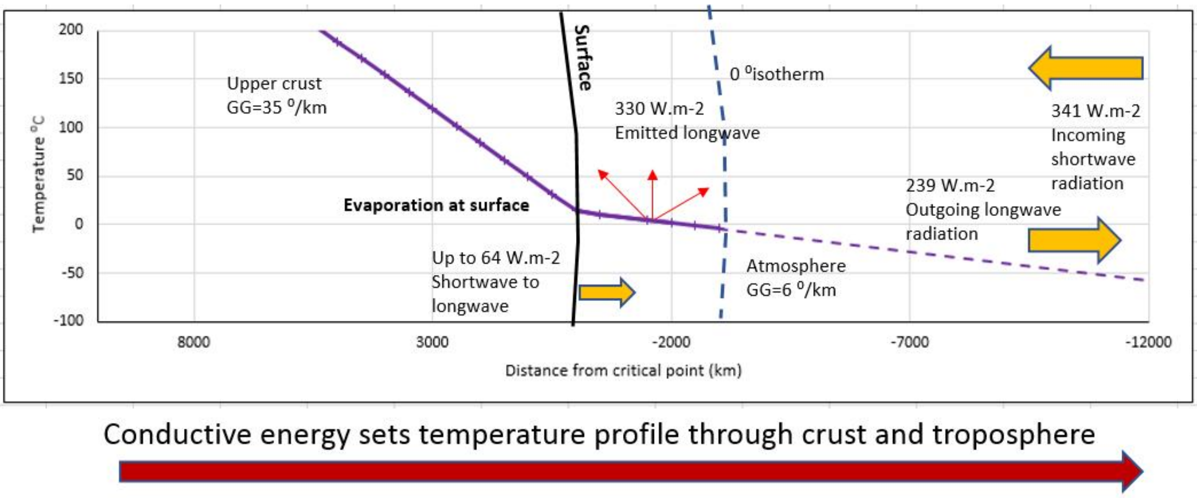

Figure 67 : Summary of the Rutherford Model

The key elements of this model:

Water vapour is transported into the atmosphere by evaporation (driven by incoming shortwave solar radiation) and direct venting from geothermal areas.

Energy is transmitted by evaporation plus convective and conductive transfer from the subsurface to the atmosphere, primarily via the water phase. The lapse rate of atmospheric temperature is the continuation of the subsurface geothermal gradient, but in an air + water vapour medium.

Heat is emitted as infrared radiation from greenhouse gases in the air column. Emissions are in all directions, including downwards. This is the downgoing longwave radiation measured at surface ; the upward component adds to the solar energy re-transmitted as longwave radiation to make up the total earth radiation (~396 W.m^{-2}).

Water is warmed by crustal heat before it enters the atmosphere and is emitting infrared radiation as it rises and cools until it condenses with reduced temperature and pressure and falls as rain and snow. In contrast, CO_2 enters the troposphere from above and from sub-zero temperatures. CO_2 absorbs energy as it falls, and will always be lower energy than surrounding water molecules

CO_2 does not start emitting infrared radiation until close to the surface .

A straightforward test of the Greenhouse and Rutherford models is to compare temperatures at the world's highest spot (Mt Everest, 8,848m) and lowest (Dead Sea, -430m). Both are at the same latitude (28 deg N) and therefore receive about the same solar energy. Both have similar concentrations of GHG in the atmosphere, and so, according to the Greenhouse Effect, should experience similar temperatures. They obviously don't. According to the Rutherford Model, however, the temperatures should lie on the geothermal gradient (6 deg C/km). Mean annual temperatures are -27 deg C and 30.5 deg C respectively, giving a temperature gradient of 5.8 deg C/km.

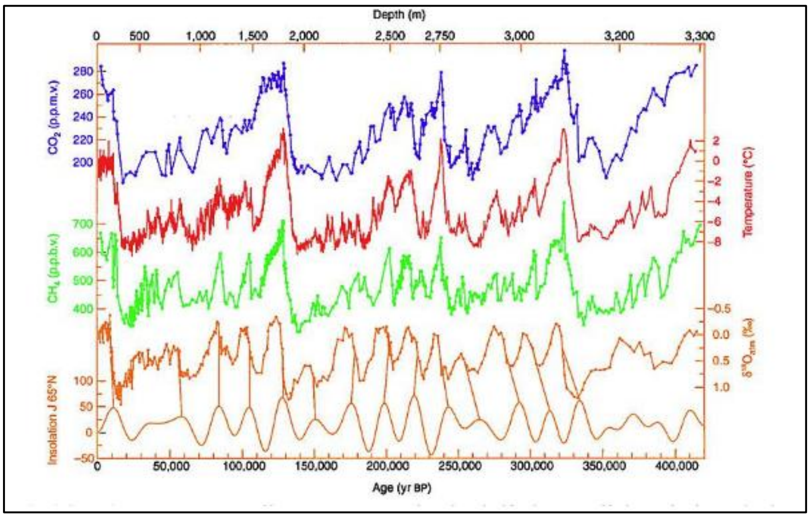

Figure 68 : Vostok Ice Core Data (Tom Ruen, Wikipedia)

The Rutherford Model also provides a better expalanation for the apparent correlation between temperature, CO_2 content and CH_4 concentrations that are observed in the Vostok core (Figure 68). As temperature rises, ice is progressively melted and methane liberated; this interacts with surface water, evaporates and reacts with ozone to generate CO_2.

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Ocean Acidification

pH is a measure of amount of free hydrogen and hydroxyl ions. The scale ranges from 0 (acidic) to 14 (alkaline), with 7 as neutral. Fresh water has a pH of around 6.5 to 7.5 (neutral). Just as an apparent correlation between atmospheric carbon dioxide and temperature has been used to infer CO_2 levels control temperature, a correlation between CO_2 and ocean pH has been used to infer CO_2 controls ocean acidity. A dataset from Hawaii (Figure 69) shows surface CO_2 concentrations, increasing in line with atmospheric CO_2 concentrations, and an inverse relationship with pH. The pH of surface waters has decreased from 8.3 to 8.1 since 1990. Deeper waters are generaly below 8.0 (Figure 70).

CO_2 reacts with water to form carbonic acid (H_2CO_3). This is highly unstable , however, and rapidly disassociates to form carbonate.ie CO_2 fizzes when it falls into water but then breaks up. Carbonate is then combined with calcium via organic activity to form calcium carbonate.

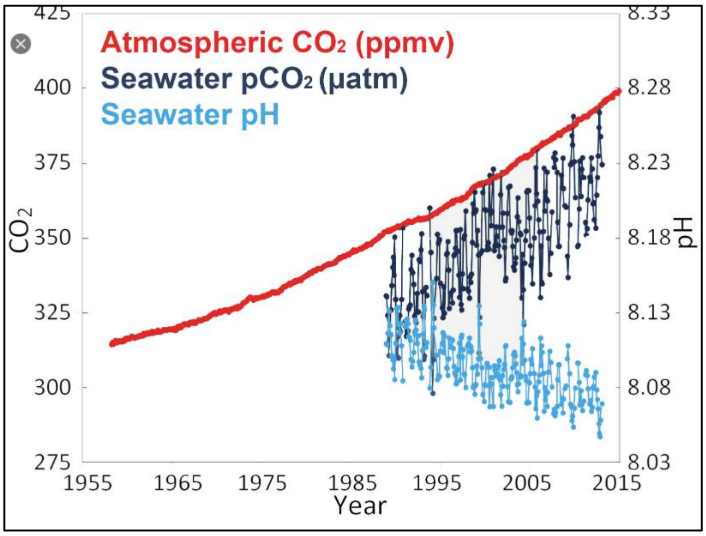

Figure 69 : Time series of carbon dioxide and ocean pH, Mauna Loa, Hawaii (NOOA)

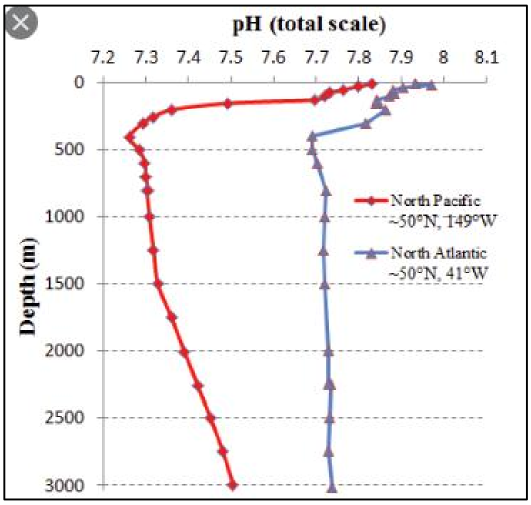

Figure 70 : Ocean pH profiles (Wang, 2012)

Another source of acid is the reaction between ozone and methane. In the presence of Chlorine (emitted chlorofluorocarbons) a photoelctrical reaction occurs in ultraviolet light:

$$CH_4 + O_3 + Cl \rightarrow CO_2 + H_2O + 2HCl$$

Methane + ozone + chlorine → carbon dioxide + water + Hydrochloric Acid

HCL is a lot more stable than carbonic acid and is soluble in water. HCL also disolves calcium carbonate. Changes in ocean water acidity and dissolution of shells are therefore more likely to reflect changes in chlorofluorocarbon emissions.

Quantifying the impact of atmospheric CO_2

Feldman et al (2015) reported on high resolution measurements, taken at two locations, of the changing intensity of the 15 µm CO_2 band of the downgoing spectrum and calculated a change in radiative forcing of 0.2 $W.m^{-2}$ over a decade (2000-2010). Atmospheric CO_2 increased by 22ppm over this period. So for each 1 ppm increase in CO_2 there was a change in radiation of .009 $W.m^{-2}$ (or 0.00002275% of total).

The total energy at surface is at least 400 $W.m^{-2}$ with either model. Assuming half the incremental CO_2 has been added by human activities (the remainder by increased volcanism), human activities account for approximately 0.0011% of the earth's surface temperature. Given that each CO_2 molecule re-enters the atmosphere cold, and cannot emit more energy than it absorbs, the net effect is neutral, and probably negative ie CO_2 absorbs more than it emits.

The only other effect of increasing concentrations in the atmosphere is increasing photosynthesis.

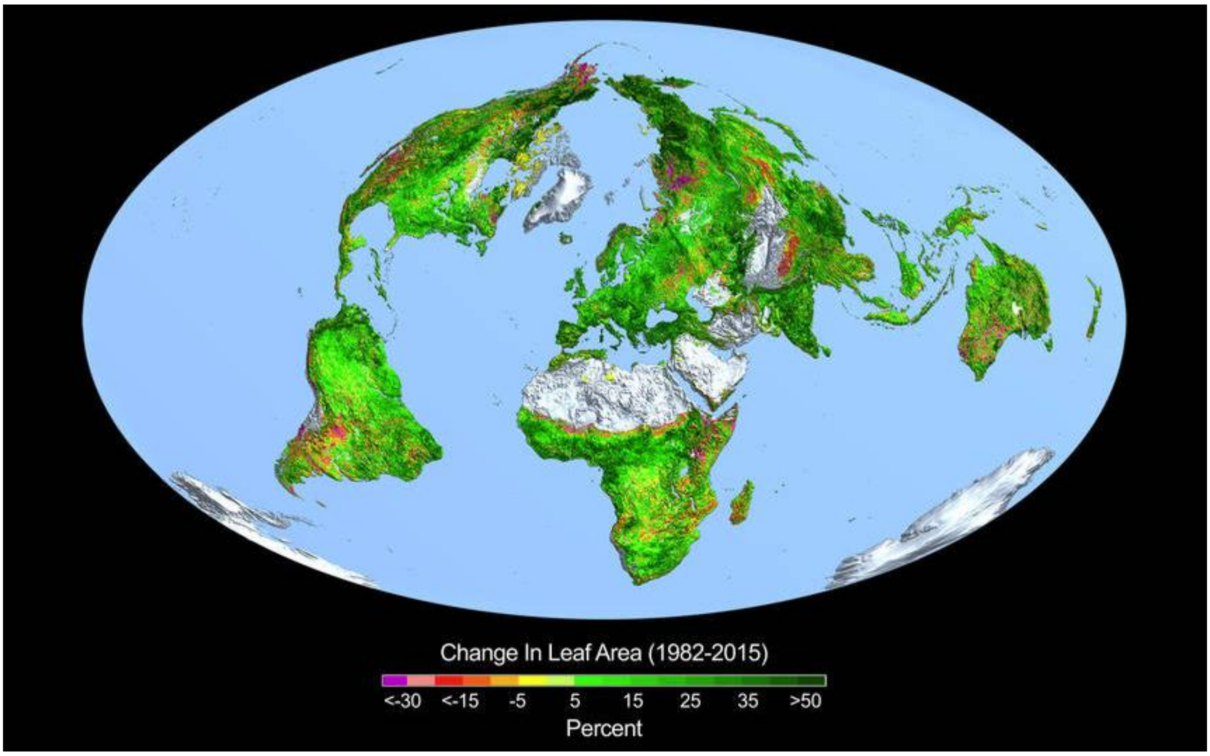

Figure 71 : Change in green leaf area 1982 - 2015 (NASA 2016)

NASA estimate the annual increase in vegetation cover (including planting) to be in excess of 5 million square kilometres , of which 60-70% is attributable to increasing CO_2 levels. Over the last 20 years, this represents an area equivalent to the Amazon rainforests.

Similarly in the oceans, increased CO_2 concentrations increases the growth of phytoplankton and that flows up the food chain.

Impact of Methane

The change in radiative forcing resulting from increased concentrations of atmospheric CO_2 has been measured; for each 1 ppm increase in CO_2 there was a change in radiation of .009 $W.m^{-2}$ (or 0.00002275% of total). Methane is supposedly 35 times more 'potent' than CO_2 which indicates the change in concentration of 1ppm over the last 100 years has increased surface radiative forcing by 0.0008%.

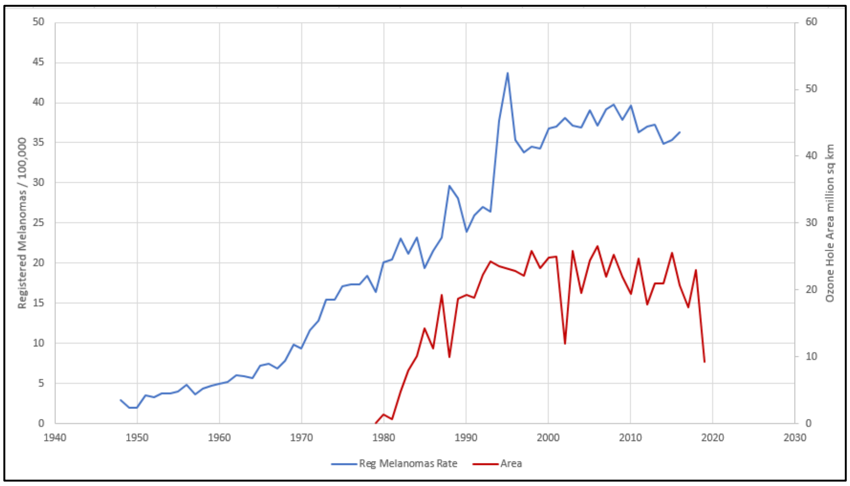

Figure 72: Correlation between area of ozone hole (red, sq km) and melanoma rates (blue, cases per 100,000) in NZ.

The major impact of ozone depletion for NZ, however, is the impact on melanoma rates (Figure 72) which during the second half of the 20th century increased from 5 cases/100,000 people to 45 cases per 100,000.

The True Role of Carbon Dioxide

- Carbon dioxide is essential for life on earth. It is necessary for photosynthesis and during recent glacial periods has been approaching critically low levels.
- Nearly all of earth's carbon has been sequestered in the subsurface; only trace amounts of CO_2 remain in the atmosphere.
- Less CO_2 in the atmosphere will inevitably lead to in mass extinctions.
- The plot of CO_2 concentrations through time certainly shows a dramatic increase over the last 100 years. There is little doubt that a large portion of this can be attributed to human activity, and specifically to thermal outputs, chiefly the burning of fossil fuels.
- The most straightforward strategy to reduce atmospheric CO_2 concentrations (if you are determined to cling to that paradigm) is to chill exhausts. This technology exists today and the existing vehicle fleet could be retro-fitted at a fraction of the cost of decarbonisation.

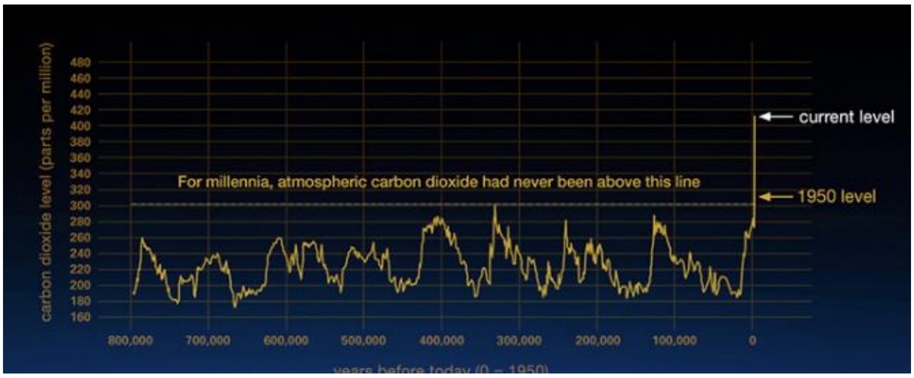

Figure 73 : Carbon dioxide concentrations over the last 800,000 years (NASA)

- Humankind has inadvertently been conducting a massive geo-engineering project, recycling carbon from the lithosphere and using thermal processes to place it in the atmosphere.
- Increasing CO_2 concentrations have no significant impact on climate
- Increasing CO_2 concentrations lead to greening of the planet, increased crop yields and increased biomass in the oceans.

Figure 74 shows the cycle for atmospheric carbon dioxide :

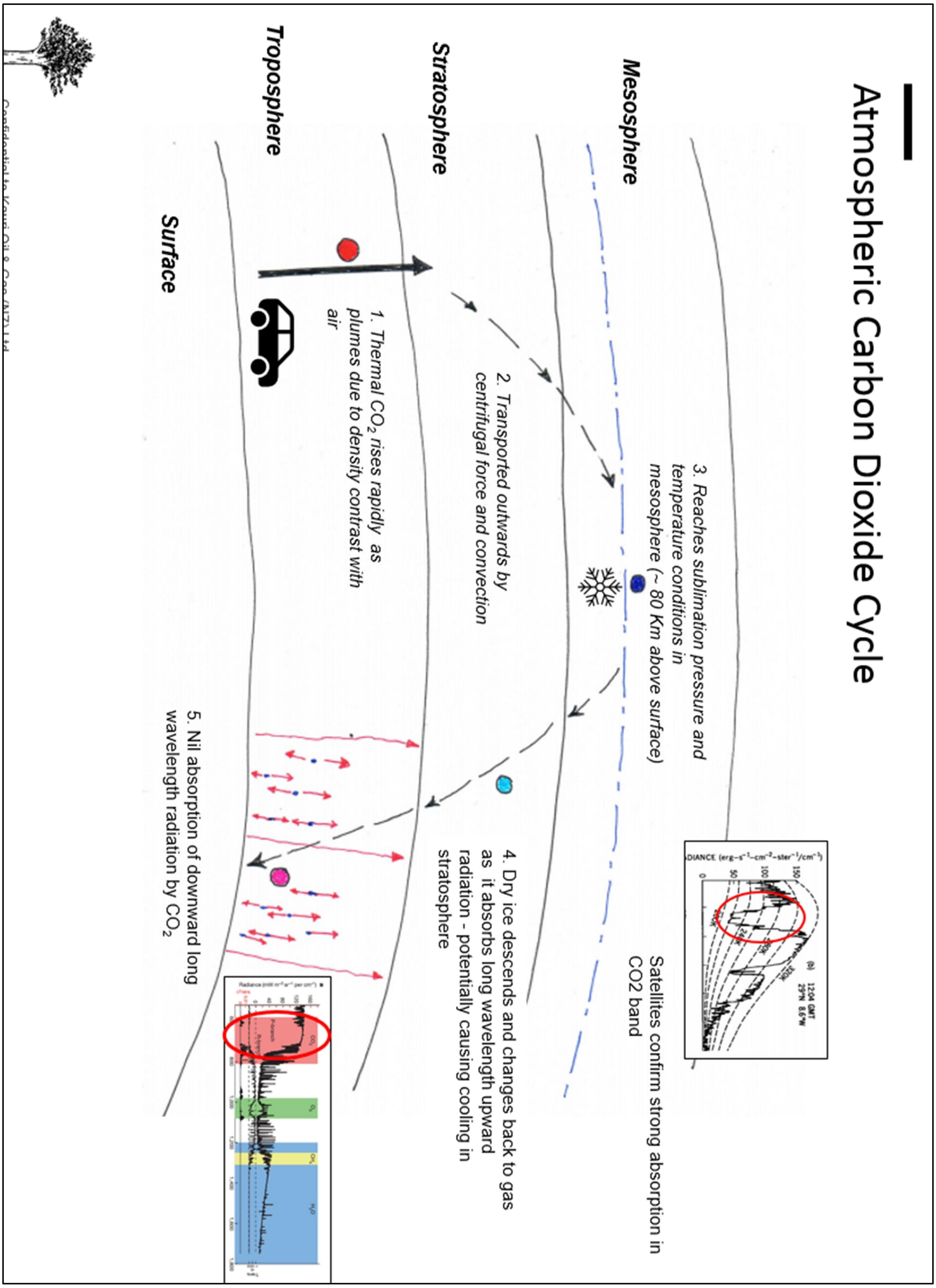

Figure 74 : Atmospheric carbon dioxide cycle

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Conclusions

- Climate change is very real, and is caused by the interaction of numerous earth and planetary processes, operating at different scales and with different timelines/frequencies.

- The increase in temperature since 1950 is most likely caused by the emission of CFCs into the atmosphere. These destroy ozone, allowing more shortwave UV light to reach the surface. This, in turn, increases evaporation, which carries water (already warmed by the earth's crustal heat flow) into the atmosphere. The water vapour releases energy as long wavelength infrared radiation.

- The interaction of methane, ozone and CFCs produces hydrochloric acid, which reduces the pH of surface ocean waters.

- These trends were slowed or reversed following the Montreal Accord of 1987 banning the use of CFCs, but have been renewed following resumption of CFC emissions by China in 2012.

- Climate change cannot be stopped or reversed, but the recent rate of temperature increase, driven by CFC emissions, can be reduced by stopping these emissions. We know from experience that it will take decades for ozone to be replenished, but this could be accelerated by generating ozone in the stratosphere.

- Burning fossil fuels and farming cows has little to no impact on climate.

- The Greenhouse Model is flawed. It was based on an assumption made with data available at the time to explain a shortfall in energy and has subsequently been shown to be wrong. **Electromagnetic spectra measured at surface show carbon dioxide molecules are not absorbing infrared radiation.**

- The earth and it's climate are not static or benign. The system is dynamic with forces and processes interacting to dominate, not work in harmony. The average global temperature and sea level are increasing slowly, but consistent with previous cycles.

- Historical and geological records tell us nothing that is happening now is unprecedented. The impact on humans may, however, be becoming more severe as a result of the expanding population and geographic cover.

- Most of earth's carbon is stored in the lithosphere, but trace amounts of CO_2 are in the atmosphere. This CO_2 is generated by thermal events (volcanism, fires, and the burning of fossil fuels). It rises quickly as plumes into the stratosphere/mesosphere where it is spread evenly around the globe, cools, then rains down through the troposphere. It is cold when it re-enters the troposphere and absorbs infrared radiation being emitted from water vapour in the atmosphere. The easiest way to reduce atmospheric CO_2 concentrations would be to chill exhuast streams from vehicles and gas turbines and this technology already exists shttps://www.nextbigfuture.com/2019/12/90-of-truck-co2-emissions-could-be-captured-and-liquified-into-fuel.html.

- Human activity generates many things – CO_2 , methane, NO_2, particulates and pollution, etc but most importantly, heat – by burning fossil fuels, altering the landscape with reflective surfaces etc This heat is both conductive and infrared radiation but is localised to urban and industrial areas and areas where vegetation is cleared and burned. Raw temperature records show that temperatures in these areas have increased more than those in areas away from population and industry. 95% of the world's population occupy 3% of the earth's surface area, so the heat output is certainly not a factor in global climate.

- By combining these temperature datasets, and adjusting historical data, an increase in global average temperature has been presented by climate scientists to fit an apparent correlation with CO_2 concentrations. Increased CO_2 concentrations in the atmosphere do not drive local, regional, or global temperatures, they simply reflect the increase in thermal sources of CO_2. To eliminate CO_2 in the atmosphere is as futile as removing mercury from thermometers to reduce the temperature.

- We are conditioned to believe human interaction with nature can only lead to negative outcomes, but human use of fossil fuels has been beneficial, not only for humans, but for all species on the planet. It has deferred the ultimate and final mass extinction and reversed a significant portion of the deforestation caused by humans.

- Climate science, or at least 97% of climate scientists, has not only got the CO_2 story wrong, they have got it completely back to front. 180 degrees wrong. Simply because they based a lot of very good science on a faulty assumption.

In my view, we live in an age of hope and opportunity, not anxiety and despair. Technology is enabling us to explore, measure and observe on all scales as never before in human history. There are still huge gaps in our knowledge and understanding and it's this generation and future generations that will discover the answers. It's a time of unprecedented possibilities.

To claim a change in atmospheric methane concentrations from 2 ppm to 3 ppm is affecting global climate is akin to adding a cup of salt to the ocean – technically it increases the average salinity, practically it makes no difference.

Immediate Research Opportunities

Once the assumptions regarding carbon dioxide are corrected, and it is no longer demonised as a pollutant,resources for research neeed to be redirected. Of course we need to keep measuring and improving our knowledge of the many cycles influencing climate, but in New Zealand the more immediate threat is from natural hazards, particularly earthquakes, volcanic eruptions and flooding. The cost , in both financial and human terms, is huge:

Christchurch earthquake : $22 billion and 185 lives

Kaikoura earthquake : $2.2 billion and 2 lives

Whakaari/White Island 21 lives, costs as yet unknown

Flooding (last 5 years only) :>$260 million

There are several programmes we could initiate immediately to reduce the risk of loss and harm.

Flood forecasting

Current coastal flood foreacasts are based on an exaggerated global sea level rise that is not supported by measurements. However, with the accuracy of modern satellites, ground movements can be measured in millimetres. It should therefore be possible to construct a global subsidence/uplift map. When combined with the actual sea level data, this will identify coastal areas that are subsiding and likely to be prone to flooding. This has already beeen applied to the Pacific Islands to confirm which islands are sinking and those which are stable or rising.

Crustal Heat Flow

Crustal heat flow is probably the most important control on climate, yet very little monitoring is carried out. Subsurface temperature measurements are largely gathered from oil & gas drilling and research wells. These are short duration, however, and are heavily influenced by temperature equilibration issues – the cooling effect of drilling mud, movement of oil, gas and water etc

A network of dedicated temperature-monitoring wells would allow temperatures to equilibrate and small changes at any location to be identifed. The beauty of this project is that dry exploration wells could be fitted with permanent temperature devices to constantly monitor the thermal profile.

In addition, dedicated temperature monitoring wells close to volcanic vents , such as Whakaari/White Island, may provide warning capability of mobile hot fluids.

Climate

There is a wealth of existing subsurface temperature data available that could be used to construct a global surface temperature map based on extrapolated subsurface gradients. By mapping key isotherms these data may also provide insights to crustal heat flow mechanisms.

Ocean Surveying

Even a cursory review of climate science reveals the large data/knowledge gaps relating to oceans - heat flow, volcanism, rates and volumes of carbon dioxide and other hydrocarbon gases (including methane) emitted via faults etc. Detailed ocean surveying is required, and is in progress, but expanding this research would be far more valuable than NZ’s investment in satellite detection of CO_2 and methane.

Calculations

Calculations could validate the following:

1. The IPCC model for energy identified 80 $W.m^2$ being used for evaporation. Since we know the volume of water in the atmosphere it would be worth checking whether the solar energy is suffficient to lift that volume of water.
2. We know the temperature at which CO_2 molecules are ejected from exhausts. We can therefore check the buoyancy force, acceleration and altitude achieved by CO_2 molecules.

Specific Issues with IPCC Assumptions and Models – Questions for Climate Science Experts

In reviewing IPCC reports, it is apparent that the focus is on atmospheric sciences, with little consideration of earth science. The panels that wrote, reviewed and revised the reports did not include any geologists, and particularly petroleum geologists, who routinely deal with these issues.

There are a number of fundamental issues that need to be addressed by those endorsing the Greenhouse Model:

1. The carbon budget identifies the major contributors to annual atmospheric flux as plant respiration (IPCC AR5) and fossil fuel use. Major exchange of CO_2 is proposed over oceans (degassing) and land. Volcanoes are shown to contribute only 0.1 of the annual flux of 4 PgC.yr -1. **This is inconsistent with the density issue, supported by the pre-industrial isotopic evidence, which indicate atmospheric CO_2 originates from thermal (volcanic and fossil fuels) sources only.**
2. Similarly, no provision is made in the carbon budget for natural seepages of gas, including CO_2 and methane. These are documented in numerous sedimentary basins (both onshore and offshore) and are likely to be far greater than emissions generated by human activities. These have been dismissed on the basis of lack of data, not a true assessment. New Zealand has over 1 million square kms of sedimentary basin on it's continental shelf, known to contain thick coal measures that are generating CO_2 and methane.
3. The energy budget proposes a net input of 67 $W.m^{-2}$ of downgoing shortwave solar radiation, yet outgoing longwave radiation of 396 $W.m^{-2}$. This is impossible without an additional energy source. Storing and re-emitting energy as infrared radiation can only re-distribute the existing energy in the cycle.
4. To disregard or dismiss crustal heat flow is to dismiss the evidence of geothermal areas, the geothermal gradients logged in hundreds of thousands of wells, and the heat flux observed in deep mines etc etc. It also ignores Ernest Rutherford's Nobel-prize winning science.
5. Spectra of downgoing longwave radiation show carbon dioxide in the lower atmosphere is not absorbing infra-red radiation, the very basis of the Greenhouse Theory.
6. The annual variation in CO_2 is attributed to greater photosynthesis in the northern hemisphere. Yet there is a consistent trend from south to north, and the variation in Alaska is larger than in the tropics.
7. The predictions being made now are the same as those made 30 years ago and they have simply proven to be wrong. Attached to this report is a copy of a forecast issued by the U.N in 1989.

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U.N. Predicts Disaster if Global Warming Not Checked

PETER JAMES SPIELMANN June 30, 1989

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UNITED NATIONS (AP) _ A senior U.N. environmental official says entire nations could be wiped off the face of the Earth by rising sea levels if the global warming trend is not reversed by the year 2000.

Coastal flooding and crop failures would create an exodus of ''eco- refugees,' ' threatening political chaos, said Noel Brown, director of the New York office of the U.N. Environment Program, or UNEP.

He said governments have a 10-year window of opportunity to solve the greenhouse effect before it goes beyond human control.

As the warming melts polar icecaps, ocean levels will rise by up to three feet, enough to cover the Maldives and other flat island nations, Brown told The Associated Press in an interview on Wednesday.

Coastal regions will be inundated; one-sixth of Bangladesh could be flooded, displacing a fourth of its 90 million people. A fifth of Egypt's arable land in the Nile Delta would be flooded, cutting off its food supply, according to a joint UNEP and U.S. Environmental Protection Agency study.

''Ecological refugees will become a major concern, and what's worse is you may find that people can move to drier ground, but the soils and the natural resources may not support life. Africa doesn't have to worry about land, but would you want to live in the Sahara?'' he said.

UNEP estimates it would cost the United States at least $100 billion to protect its east coast alone.

Shifting climate patterns would bring back 1930s Dust Bowl conditions to Canadian and U.S. wheatlands, while the Soviet Union could reap bumper crops if it adapts its agriculture in time, according to a study by UNEP and the International Institute for Applied Systems Analysis.

Excess carbon dioxide is pouring into the atmosphere because of humanity's use of fossil fuels and burning of rain forests, the study says. The atmosphere is retaining more heat than it radiates, much like a greenhouse.

The most conservative scientific estimate that the Earth's temperature will rise 1 to 7 degrees in the next 30 years, said Brown.

The difference may seem slight, he said, but the planet is only 9 degrees warmer now than during the 8,000-year Ice Age that ended 10,000 years ago.

Brown said if the warming trend continues, ''the question is will we be able to reverse the process in time? We say that within the next 10 years, given the present loads that the atmosphere has to bear, we have an opportunity to start the stabilizing process.''

He said even the most conservative scientists ''already tell us there's nothing we can do now to stop a ... change'' of about 3 degrees.

"Anything beyond that, and we have to start thinking about the significant rise of the sea levels ... we can expect more ferocious storms, hurricanes, wind shear, dust erosion."

He said there is time to act, but there is no time to waste.

UNEP is working toward forming a scientific plan of action by the end of 1990, and the adoption of a global climate treaty by 1992. In May, delegates from 103 nations met in Nairobi, Kenya - where UNEP is based - and decided to open negotiations on the treaty next year.

Nations will be asked to reduce the use of fossil fuels, cut the emission of carbon dioxide and other greenhouse gases such as methane and fluorocarbons, and preserve the rain forests.

"We have no clear idea about the ecological minimum of green space that the planet needs to function effectively. What we do know is that we are destroying the tropical rain forest at the rate of 50 acres a minute, about one football field per second," said Brown.

Each acre of rain forest can store 100 tons of carbon dioxide and reprocess it into oxygen.

Brown suggested that compensating Brazil, Indonesia and Kenya for preserving rain forests may be necessary.

The European Community istalking about a half-cent levy on each kilowatt- hour of fossil fuels to raise $55 million a year to protect the rain forests, and other direct subsidies may be possible, he said.

The treaty could also call for improved energy efficiency, increasing conservation, and for developed nations to transfer technology to Third World nations to help them save energy and cut greenhouse gas emissions, said Brown.